STUDY TO DETERMINE THE IFR OPERATIONAL PROFILE AND PROBLEMS OF THE GENERAL AVIATION SINGLE PILOT

Stacy Weislogel
The Ohio State University

ABSTRACT

A study of the general aviation single pilot operating under instrument flight rules (GA SPIFR) has been conducted for NASA Langley Research Center. The objectives of the study were to (1) develop a GA SPIFR operational profile, (2) identify problems experienced by the GA SPIFR pilot, and (3) identify research tasks which have the potential for eliminating or reducing the severity of the problems. To obtain the information necessary to accomplish these objectives, a mail questionnaire survey of instrument rated pilots was conducted. Complete questionnaire data is reported in NASA CR-165805, "Statistical Summary: Study to Determine the IFR Operational Profile and Problems of the General Aviation Single Pilot" (ref. 1). Based upon the results of the GA SPIFR survey, this final report presents the general aviation IFR single pilot operational profile, illustrates selected data analysis, examples, identifies the problems which he is experiencing, and recommends further research.

INTRODUCTORY COMMENTS

Perhaps a few preliminary comments are in order before we get too far along.

First, let's define GA SPIFR: "A general aviation IFR flight operation which requires, by Federal Aviation Regulation or company policy, that only one instrument rated pilot perform all of the piloting functions. If another person is on board (instrument rated pilot or not) and assisting (with communications and navigation, for example), it is still considered a single pilot IFR operation."

Second, I am reporting to you the results of a survey, so that the operational problems that we have identified are the result of the pilot's personal perceptions of his problems. The relative importance of these perceptions must be weighed against the findings of other GA SPIFR problem identification efforts. Remember, however, that what the pilot perceives the real world to be is the real world to him, and he acts upon those perceptions as if they are real whether or not they are real in fact.

Third, as experienced researchers, many of you will not experience, overall, any revelations in the findings - indeed, it may be that instead you are seeing numbers to support your intuitive feel for GA SPIFR operational problems.

BACKGROUND

There are about 827,000 pilots, 260,000 (31%) of whom have instrument ratings. As you are surely aware, general aviation's participation in IFR flight operations has been impressive. Instrument operations at airports with FAA Traffic Control Service included 11 million air carrier and 20 million general aviation operations in 1980. By 1992 the FAA forecasts 13 million air carrier instrument operations (a 21% increase) and 31 million general aviation instrument operations (a 56% increase). The number of instrument rated pilots is expected to increase 48% during the same period.

Presently, many GA SPIFR operations are conducted by highly trained and experienced pilots flying modern, well equipped airplanes. However, a proportion of the general aviation IFR operations involves relatively inexperienced single pilots, often having limited equipment, who are expected to perform in the system at the same level of competency as the professional air carrier crews. As you know, concern has been expressed by aviation agencies and user organizations that the level of competency expected to be demanded of the future SPIFR will not be attained unless significant improvements in the design of the aviation system are achieved.

It is my opinion that because NASA sincerely believes that there should be a place for the GA SPIFR in the system of the future, NASA LaRC initiated a research program which has as its objective "to provide the background research and develop the technology required to improve the safety and utility of single pilot general aviation aircraft operating under instrument flight rules." An important element of this research program is problem identification. The GA SPIFR problems identified then become the bases for future NASA GA research.

SPIFR RESEARCH OBJECTIVES

As part of the problem identification effort, NASA LaRC retained the services of The Ohio State University Department of Aviation to conduct a questionnaire survey of instrument rated pilots. The objectives of this research are:

FIRST, TO
- DEVELOP AN OPERATIONAL PROFILE OF THE GA SINGLE PILOT OPERATING IFR

AND SECOND, TO
- IDENTIFY AREAS FOR RESEARCH

SPIFR RESEARCH METHODOLOGY

The Research Methodology has three elements:

FIRST, TO
- CONDUCT MAIL QUESTIONNAIRE SURVEY FOR INSTRUMENT RATED PILOTS

SECOND, TO
- DEVELOP A GA SPIFR DATA BASE

AND THIRD, TO
- ANALYZE DATA BASE
  - DEVELOP GA SPIFR OPERATIONAL PROFILE
  - IDENTIFY RESEARCH TOPICS

The research is complete, and the project is discussed in reference 2.

QUESTIONS CAN BE ASKED OF THE GA SPIFR DATA BASE

In addition to the profile of the typical GA SPIFR, what else have we learned from the survey? Well, one thing we have learned is that we can ask the GA SPIFR data base questions and get answers.

QUERY 1: IS THE TASK OF TUNING COMMUNICATIONS AND NAVIGATION RADIOS A MAJOR PROBLEM OR DISTRACTION?

CONCLUSION: THE TASK OF TUNING COMMUNICATIONS AND NAVIGATION RADIOS IS CLEARLY IDENTIFIABLE AS A PROBLEM IN THE RESPONSES, ALTHOUGH ON THE BASIS OF SPECIFIC RESPONSES (RATHER THAN A GENERAL PROBLEM RESPONSE LIKE "WORKLOAD"), IT DOES NOT APPEAR TO BE A MAJOR PROBLEM OR DISTRACTION.

RELATIONSHIP BETWEEN OPERATIONAL PROBLEMS AND EXPERIENCE

Another query resulted in an interesting hypothesis.

QUERY 7: ARE THE OPERATIONAL PROBLEMS EXPERIENCED BY THE SPIFR INDEPENDENT OF EXPERIENCE?

CONCLUSION: BASED UPON THIS ANALYSIS, WHICH REVEALS THE RELATIVELY HIGH COMMONALITY OF RESPONSE CODES REPORTED BETWEEN CATEGORIES OF PILOTS OF DIFFERENT EXPERIENCE LEVELS, IT APPEARS THAT THE OPERATIONAL PROBLEMS EXPERIENCED BY THE SPIFR ARE INDEPENDENT OF EXPERIENCE. IF THIS HYPOTHESIS IS VALID, THEN IT IS SUGGESTED THAT REMEDIES TO SPIFR OPERATIONAL PROBLEMS DO NOT LIE IN IMPROVING SPIFR CAPABILITIES THROUGH MORE TRAINING AND EXPERIENCE. RATHER, THE NATURE OF THE SPIFR TASK SHOULD BE CHANGED THROUGH THE REDESIGN OF COCKPIT SYSTEMS AND ATC PROCEDURES IN HANDLING THE SPIFR.

GA SPIFR PROBLEM AREAS

One way in which an insight can be gained into what areas trouble the GA SPIFR and in what priority is to rank order Questions 13 through 21 by percentage of respondents supplying a usable problem answer. The questions permitted the respondent to state the most common problem encountered in each of these nine areas:

QUESTION	PROBLEM AREA	PERCENT OF RESPONDENTS SUPPLYING USABLE PROBLEM ANSWER
13	INSTRUMENT APPROACHES	51%
19	WEATHER INFORMATION	51
14	COCKPIT ENVIRONMENT	48
21	COMMUNICATIONS	44
20	WEATHER ENCOUNTERS	38
17	TRAINING AND PROFICIENCY	36
15	NAVIGATION	31
16	OPERATIONS AND PROCEDURES	24
18	AIRPLANE STABILITY AND CONTROL	18

GA SPIFR PROBLEMS REPORTED BY MORE THAN 10% OF THE RESPONDENTS

Another approach to identifying GA SPIFR operational problems is to look at the top problem code responses appearing in Questions 13 through 21. Those reported by more than 10% of the respondents are:

QUESTION	PROBLEM CODE	PERCENT OF RESPONDENTS	PROBLEM DESCRIPTION
13	04	15%	ATC DEMANDS
14	01	14	INADEQUATE LIGHTING
19	05	12	RELIABILITY OF FSS WEATHER INFORMATION
14	02	11	HIGH CABIN NOISE LEVEL

MOST COMMON ERROR MADE BY THE GA SPIFR

A third approach is to inspect the most frequent responses within a question and aggregate them into another descriptive category. For example, the top three responses to Question 3 can be combined into a category of "Pilot Judgment and Decision Making," which accounts for 35% of the responses to the question "What is the most common error made by IFR single pilots?"

QUESTION 3

IN YOUR OPINION, WHAT IS THE MOST COMMON ERROR MADE BY IFR SINGLE PILOTS?

PROBLEM CODE	ERROR DESCRIPTION	NUMBER	PERCENT
(02)	NOT PLANNING AHEAD	266	16%
(06)	OVER CONFIDENCE IN BEING ABLE TO HANDLE WEATHER	185	11
(01)	EXCEEDING PERSONAL CAPABILITIES	133	08
(04)	MISUNDERSTANDING ATC	92	07
(20)	VIOLATING MINIMUMS	90	06

MOST SERIOUS PROBLEM ENCOUNTERED AS A GA SPIFR

An inspection of the most frequent responses to a particular question without aggregating the responses is also instructive in gaining insights into GA SPIFR operational problems. For example, in Question 4 the respondent had an opportunity to report the one most serious problem which he had encountered in his experience as a GA SPIFR.

PERCENT OF RESPONDENTS	MOST SERIOUS PROBLEM ENCOUNTERED AS A GA SPIFR
16%	ICING
07	THUNDERSTORMS
07	UNFORECAST/UNANTICIPATED WEATHER
05	WORKLOAD
04	LACK OF PROFICIENCY

Another approach is to inspect the most frequent responses between questions and aggregate them into another descriptive category. For example, the two most frequent responses to Question 4, "What has been the one most serious problem which you have encountered in your experience as an IFR single pilot?" and Question 20, "Weather Encounters" were icing and thunderstorms. Weather reporting information can be considered of concern to the GA SPIFR when the responses to Questions 4, 6, 7, 19, and 20 are aggregated.

ONE CHANGE IN THE SYSTEM WHICH WOULD MAKE GA SPIFR FLIGHT OPERATIONS EASIER

The GA SPIFR's perception about the one change in the system which would make his SPIFR flight operations easier also provides an insight into his operational problems.

QUESTION 7

WHAT ONE CHANGE IN THE SYSTEM (E.G., ATC, REGULATIONS, PROCEDURES, WEATHER DISSEMINATION), YOUR AIRPLANE AND EQUIPMENT, OR FLIGHT TRAINING, WOULD MAKE YOUR IFR SINGLE PILOT FLIGHT OPERATIONS EASIER?

CODE	DESIRED CHANGE	NUMBER	PERCENT
(40)	BETTER, MORE TIMELY WEATHER INFORMATION	119	07%
(14)	USE AUTOPILOT	102	06%
(52)	MORE STRINGENT INSTRUMENT RATING REQUIREMENTS	73	05%
(16)	WEATHER INFORMATION THROUGH ATC	66	04%
(08)	REQUIRE ACTUAL IFR TRAINING	52	03%

AREAS OF POTENTIAL GA SPIFR RESEARCH

As a result of our work with the survey data, these broad areas of GA SPIFR research emerge from our analyses as having the greatest potential for improving the safety and utility of the single pilot general aviation aircraft operating under instrument flight rules.

WORKLOAD

PILOT JUDGMENT AND DECISION MAKING

INSTRUMENT APPROACHES

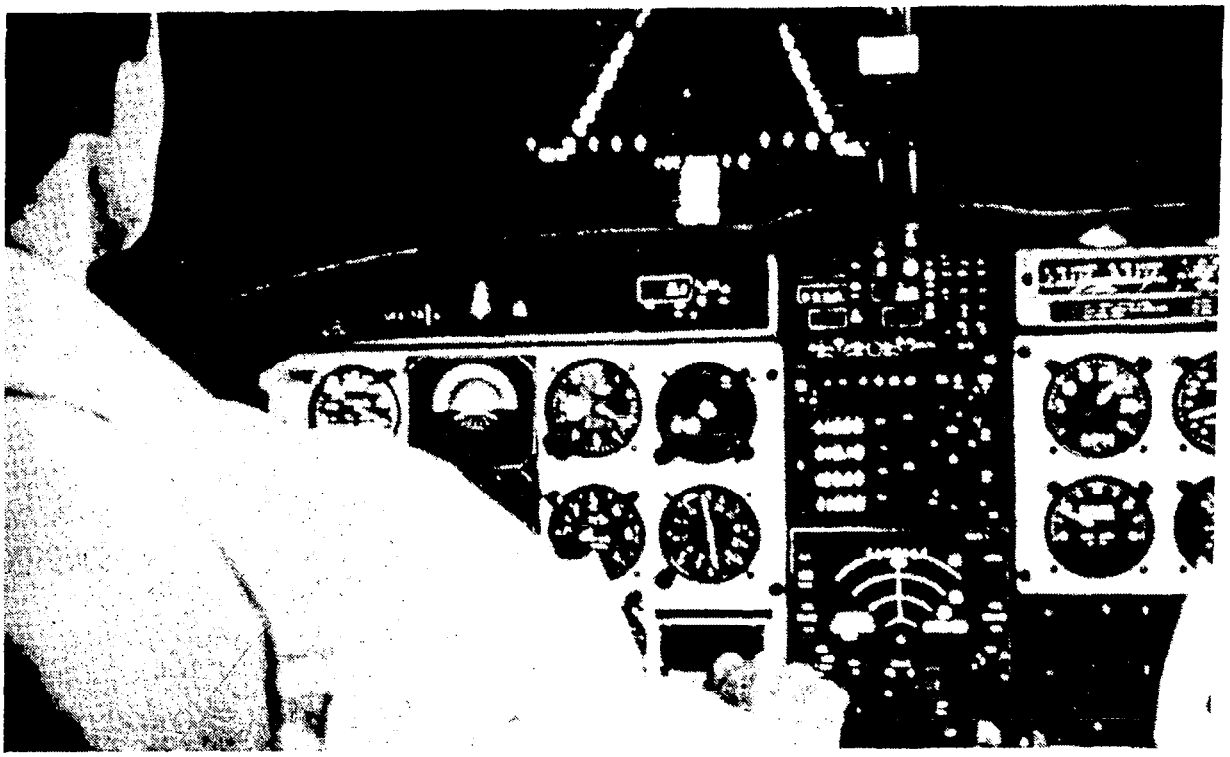
WEATHER INFORMATION

COCKPIT ENVIRONMENT

COMMUNICATIONS

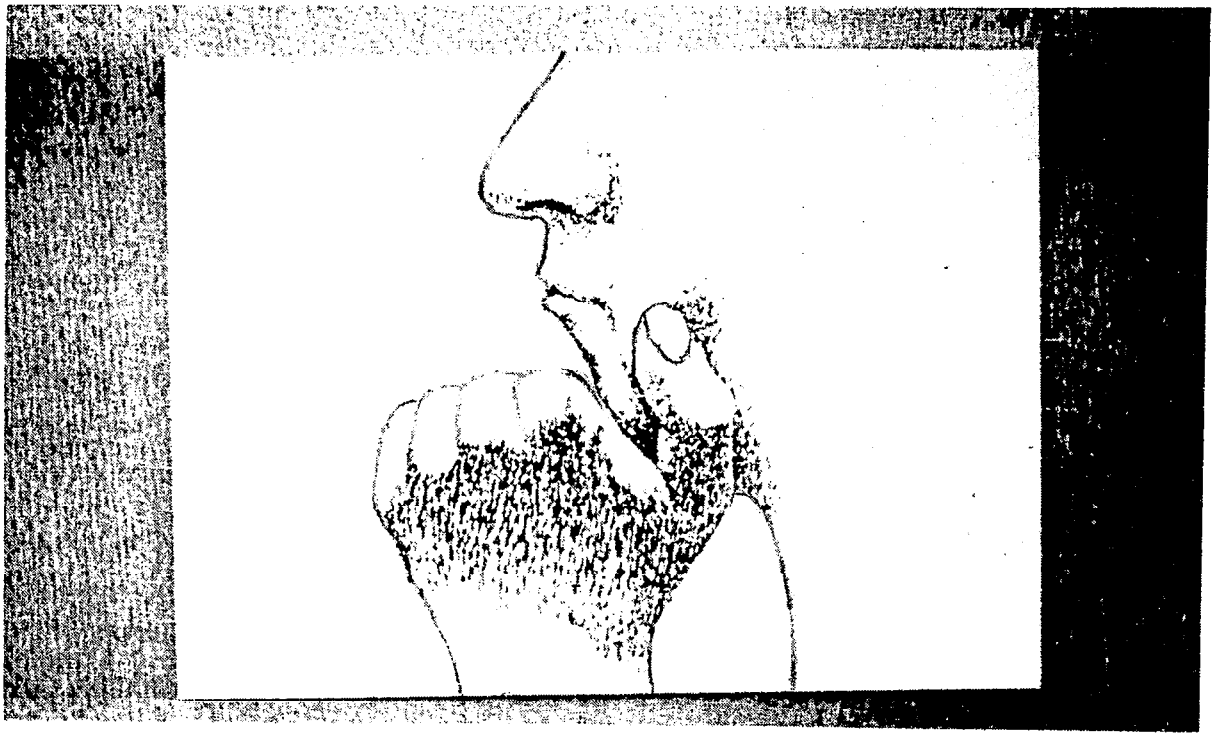
PILOT WORKLOAD

Workload reduction will result in increasing the effectiveness and safety of the GA SPIFR operation. Documentation and analysis of actual pilot performance and workload during IFR flight using conventional cockpit displays and autopilots is required to provide baseline data against which to compare advanced control and display concepts.



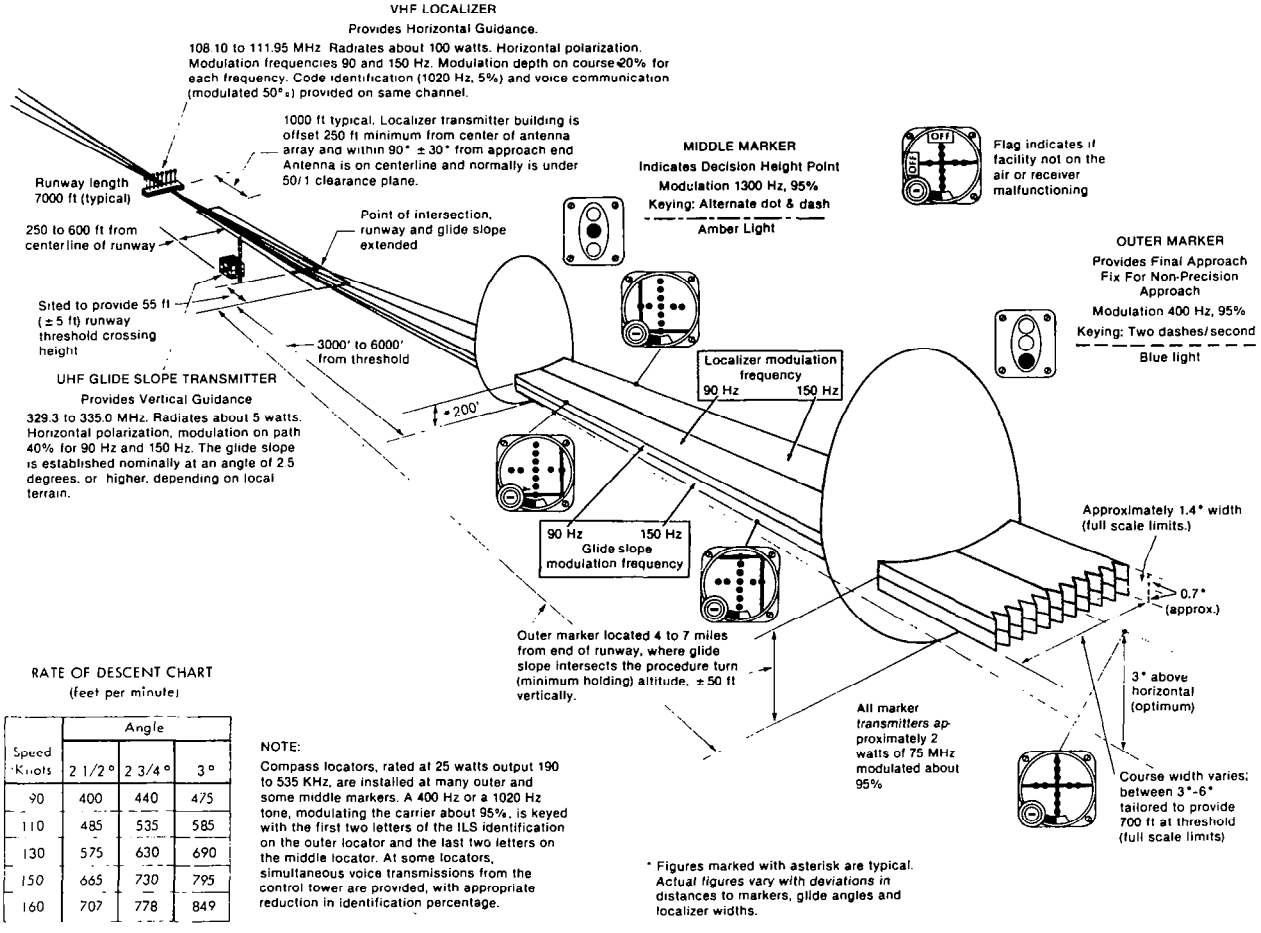
PILOT JUDGMENT AND DECISION MAKING

Improving pilot judgment and decision making with respect to his ability to plan ahead and more accurately assess his own capabilities and limitations is another means of increasing the effectiveness and safety of the GA SPIFR. This requires that the GA SPIFR's psychological state and the nature and quality of information available and being used by him be defined and characterized. Although the Federal Aviation Administration has recently begun to study the topic of pilot judgment, the research has not been focused on the GA SPIFR.



INSTRUMENT APPROACHES

The two problem areas troubling the greatest number of respondents were instrument approaches, with emphasis on workload, and weather information, with emphasis on improving its availability, reliability, and timeliness. Automatic flight control systems, advanced cockpit displays, and the development of GA SPIFR oriented ATC procedures are potential areas of research which can contribute to the reduction of workload during the approach phase of a GA SPIFR instrument flight.



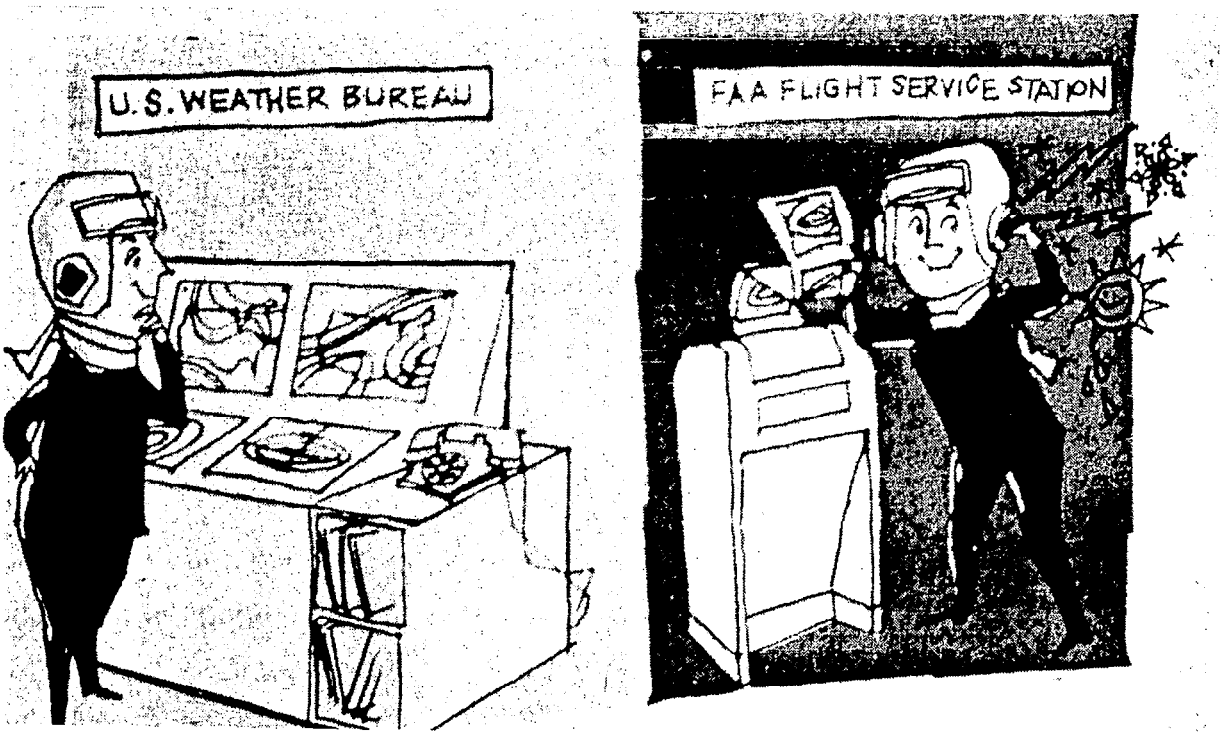
RATE OF DESCENT CHART
(feet per minute)

Speed Knots	Angle 2 1/2°	2 3/4°	3°
90	400	440	475
110	485	535	585
130	575	630	690
150	665	730	795
160	707	778	849

NOTE:
Compass locators, rated at 25 watts output 190 to 535 KHz, are installed at many outer and some middle markers. A 400 Hz or a 1020 Hz tone, modulating the carrier about 95%, is keyed with the first two letters of the ILS identification on the outer locator and the last two letters on the middle locator. At some locators, simultaneous voice transmissions from the control tower are provided, with appropriate reduction in identification percentage.

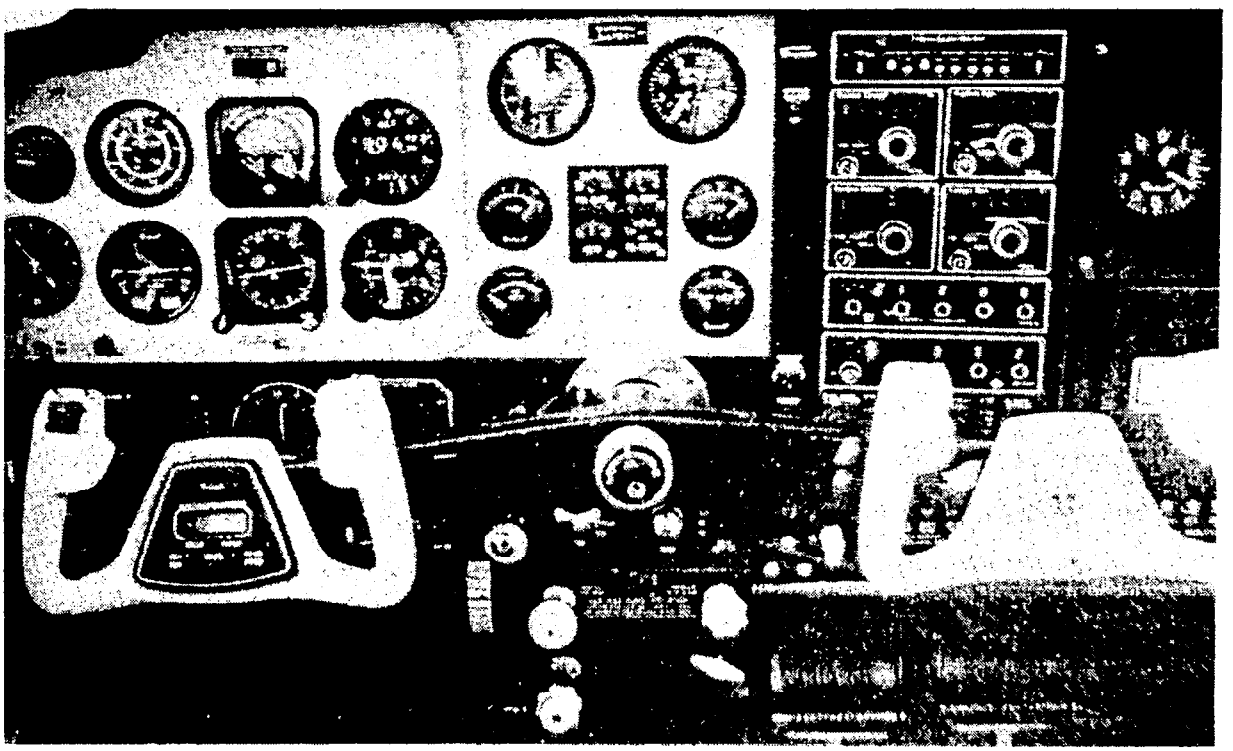
WEATHER INFORMATION

An investigation of improved preflight and inflight weather information dissemination methods to improve the availability, reliability, and timeliness of weather information for the GA SPIFR also emerges as a recommended area of research.



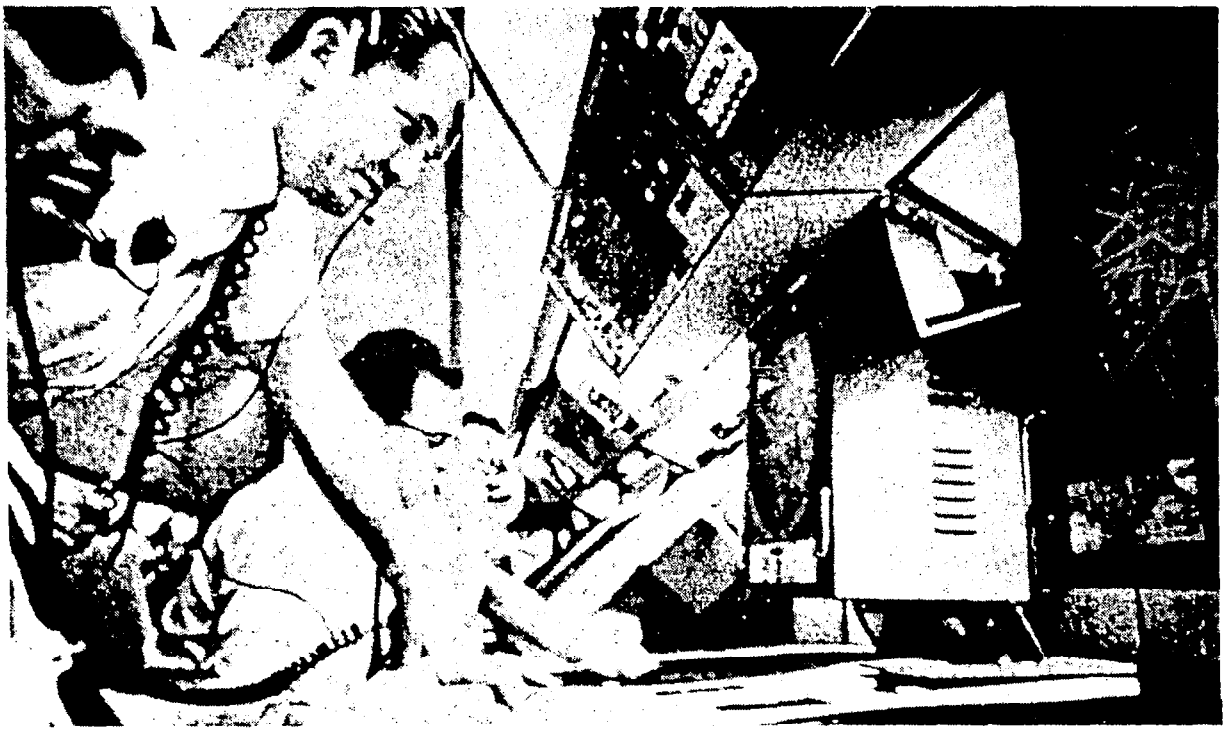
COCKPIT ENVIRONMENT

Improving the cockpit environment is of considerable interest to the GA SPIFR. It seems that a modest research effort could produce information useful in improving the cockpit environment with respect to improved lighting and noise protection.



COMMUNICATIONS

The GA SPIFR also has a high interest in reducing the radio communications workload, in terms of both too many frequency changes and excessive communications. Research into more efficient frequency assignment methods, automatic frequency switching, and improved information transfer methods has the potential for alleviating this concern of the GA SPIFR.



FSS WEATHER BRIEFING INADEQUACIES

It is interesting to note that certain of the needed areas of research which have emerged from the GA SPIFR study have been independently identified as needing attention by others. In addition to the FAA's research interest in pilot judgment, the NTSB in August 1981 issued a Special Investigation Report on FSS weather briefing inadequacies (NTSB-SIR-81-3) (ref. 3). The board found that in a significant number of fatal weather related accidents, pertinent weather information was not made available to pilots during weather briefings.

COCKPIT NOISE

The NTSB has also determined that cockpit noise levels interfering with direct voice communications aboard commercial aircraft were a factor in commercial aircraft accidents, and it has asked FAA to establish maximum cockpit noise levels in commercial aircraft. Perhaps this recommendation also has validity with respect to the GA SPIFR operation (ref. 4).

AIAA PAPER

The GA SPIFR survey research has generated three publications. The first was an AIAA paper presented at the Aircraft Systems and Technology Meeting in Dayton, OH, August 11, 1981 (ref. 5).

STATISTICAL SUMMARY

A statistical summary report prepared for NASA Langley, contains raw data, frequency counts, and frequency distributions of data from the GA SPIFR survey (ref. 1).

FINAL REPORT

A final report on the IFR operational profile and problems of the GA single pilot has been prepared (ref. 2). This report contains the GA SPIFR operational profile, selected data analysis examples, problem identification, and recommended research. All 1980 usable questionnaires and the 231 unusable responses are on file at LaRC. Further, two magnetic data tapes have been prepared, one containing data from the 1980 usable questionnaires returned, the other containing data from the 1619 questionnaires forming the GA SPIFR data set. Interested organizations and individuals may obtain copies of the data tapes from NASA LaRC.

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