

**Operational Evaluation
Sierra Flight Systems Multi Function Display**

QUICK LOOK REPORT

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INTRODUCTION

This project utilized a three year Cooperative Agreement, (Number 97-G-022) between the FAA and the Experimental Aircraft Association (EAA) in which the EAA has provided an experimental aircraft for use by the FAA's William J. Hughes (WJH) Technical Center near Atlantic City, New Jersey.

The test bed aircraft was a Stoddard-Hamilton GlaStar capable of being manually flown by a single pilot. The test aircraft GlaStar was a kit aircraft, provided by the EAA. The aircraft was built for the EAA Young Eagles in 1996 at the EAA Weeks facility by EAA volunteers, with help from Stoddard Hamilton, the kit's manufacturer.

The instrument panel of the GlaStar was configured to provide standard avionics flight instrumentation for the safety pilot in the right seat. The left seat pilot position was set up to accommodate subject pilots who were used in the avionics evaluations.

The EFIS-2000 is a multifunction display unit. Its objective is to gather a tremendous amount of data and convert it to useful information at a fast processing speed - thereby giving the pilot the right information at the right time. The pilot is freed to concentrate on aircraft control, systems management, and critical decision-making and hence increasing flight operation safety. Sierra Flight Systems claims that the EFIS-2000 has been designed to give the aircraft pilot situational awareness previously unavailable. The EFIS-2000 system consists of three software pages (primary flight display, moving map, and engine monitor) displayed on one, two, or three high-resolution, full-color multi-function displays (MFD). Its own CPU drives each MFD and all sensor data is fed to each CPU in parallel. Therefore, any MFD can display any of the three pages at any time, offering maximum flexibility and redundancy. The test bed is equipped with a single MFD. This test only evaluated the PFD mode.

The primary flight display (PFD) combines pitot-static information from an air data computer, attitude and heading data from a solid-state three-axis gyro, and position input from a GPS receiver to generate a state-of-the-art display. The PFD displays airspeed, groundspeed, altitude, altitude above ground, density altitude, vertical speed, angle of attack, heading, decision height, actual winds aloft, crosswind component, outside air temperature, timers, and an heading situation indicator.

Test flights were conducted from March 2000 until July 2000 at the WJH Technical Center near Atlantic City, New Jersey.

The Test Procedures written by ACT-340 were developed to evaluate the Sierra Flight Systems Primary Flight Display EFIS-2000. Test flights were conducted using volunteer subject pilots with various experience levels. Each flight was conducted under the auspices of the Technical Center R&D Flight Program, ACT-370, and used FAA project test pilots from ACT-370. The subject pilots were always accompanied by the FAA test pilots during the aircraft operations.

The tests were designed and written by:
Ralph Yost, Project Manager, ACT-340

The FAA test flights were conducted by:
Keith Biehl, ACT-370, Lead Test Pilot for General Aviation
Larry Vanhoy, ACT-370
John Geyser, ACT-370
Fred Karl, ACT-370

The subject pilots were assigned a control number. Names were not used.

TEST AND EVALUATION DESCRIPTION

The subject pilots were given an initial Pre Test briefing describing the flight test scenario, avionics interface requirements and aircraft instrumentation. The project manager and project pilot provided the briefing which included a description of the purpose of the test and a discussion of the test conditions to which the subject pilot would be exposed. Pre Test Questionnaires were administered prior to the Pre Test briefing. The subject pilots were permitted to ask any questions concerning the testing.

2.1 DATA RECORDING

The project collected three types of data. The first was the preflight data collected from each subject pilot. The second was the written questionnaires administered to the subject pilot by the safety pilot during key points of the flight. The third was the Project Pilot Flight Test Mission Debriefing Form.

RESULTS AND DISCUSSION

Test Results

The test results data are shown in Appendix A. The data collection forms and questionnaires are shown in the appendices that follow (B-G). Test results show that the EFIS-2000 PFD displays flight information in a manner generally favored by the subject pilot group in these tests. However, the EFIS-2000 test unit did exhibit reliability problems that prevented many data collection flights from taking place. Responses were generally from "GOOD" to "MINOR DEFICIENCY". There were no "EXCELLENT" scores nor were there any "MODERATE" or greater deficiency noted by the subject pilot test group. A matrix of the subject pilot responses is provided in table 1. The range of possible answers were from 1 to 7, with 1 representing "Clearly Adequate" and 7 being "Inadequate". The complete set of possible answers are shown in Appendix B.

Discussion Items

- ˆ During the months of testing, Sierra Flight System redesigned the EFIS-2000 hardware and software. The EFIS-2000 system in the test aircraft is an older model than is currently available for purchase from the manufacturer.
- ˆ Due to limitations of the weather imposed and the aircraft used in these flight evaluations, only a cursory evaluation of the EFIS-2000 could be accomplished.
- ˆ The results of this test should be applied in a general context to digital display of primary flight information to general aviation pilots in small aircraft.

SYNOPSIS/CONCLUSIONS

The EFIS-2000 PFD provides a very different way of displaying flight information to the pilot. Several standard views of flight information are no longer used with the EFIS-2000. Pilots had mixed reactions to the new technique used by Sierra Flight Systems to display this information. The data does not support a strong conclusion either in favor of nor against this method.

RECOMMENDATIONS

ACT-340 recommends further study of other digital display PFDs and the use of PFDs by other manufacturers. The subject aircraft to use should be one that has a wider range of flight capability in more diverse wind and weather conditions. The flight test aircraft should be selected after the subject equipment has been selected to better ensure an appropriate flight platform to evaluate the system under test.

APPENDIX A
FLIGHT DATA RESULTS

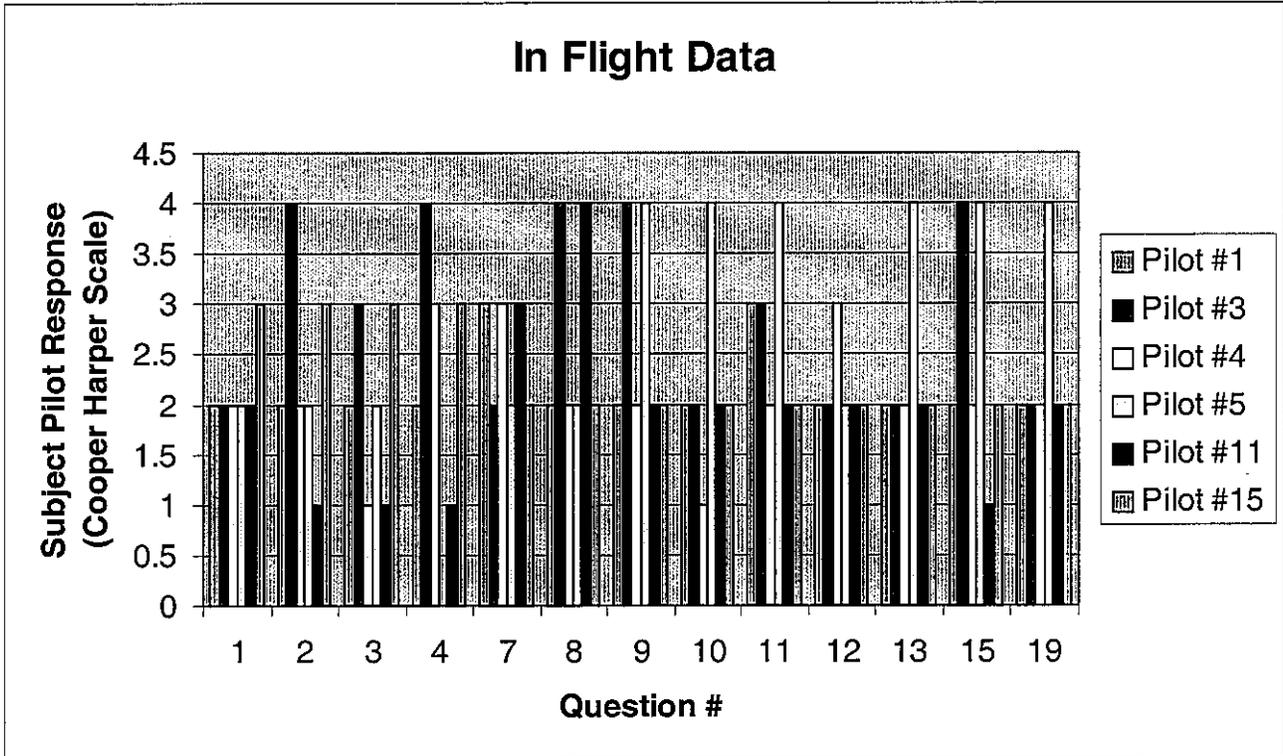


Figure 1: Pilot Responses during flight, grouped per question

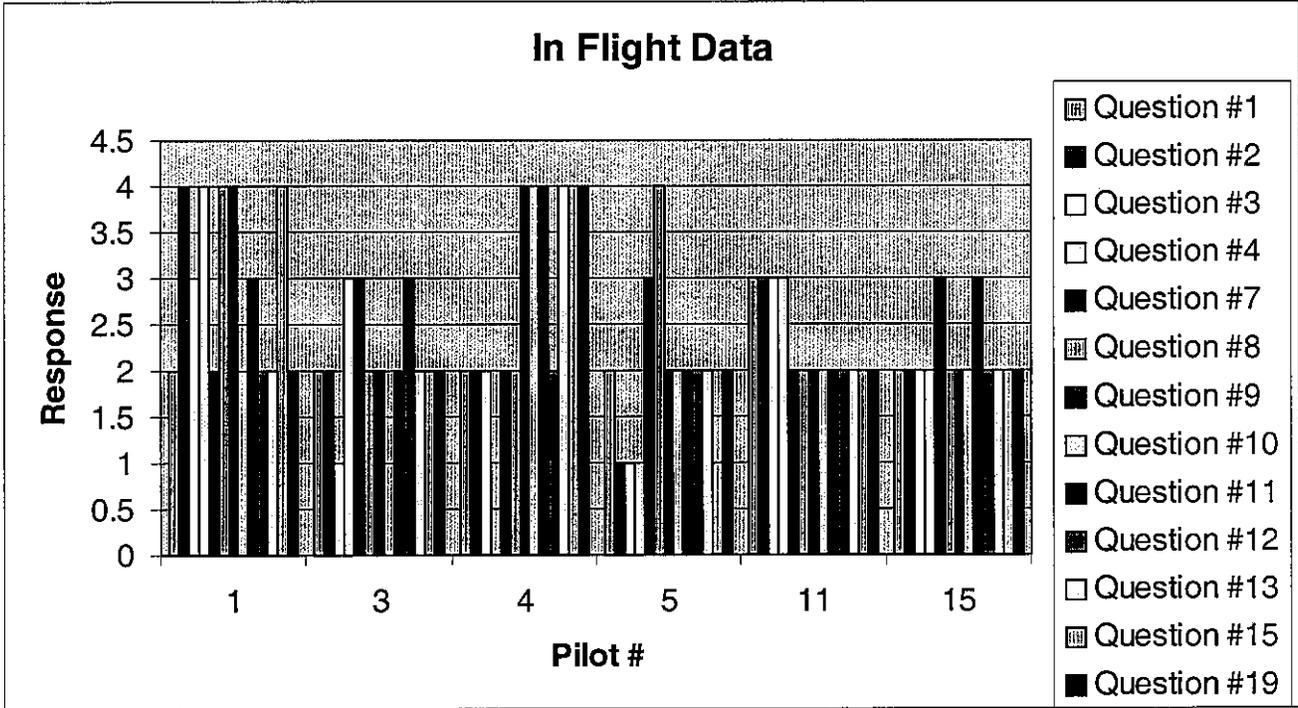


Figure 2: Pilot Responses during flight, grouped per pilot

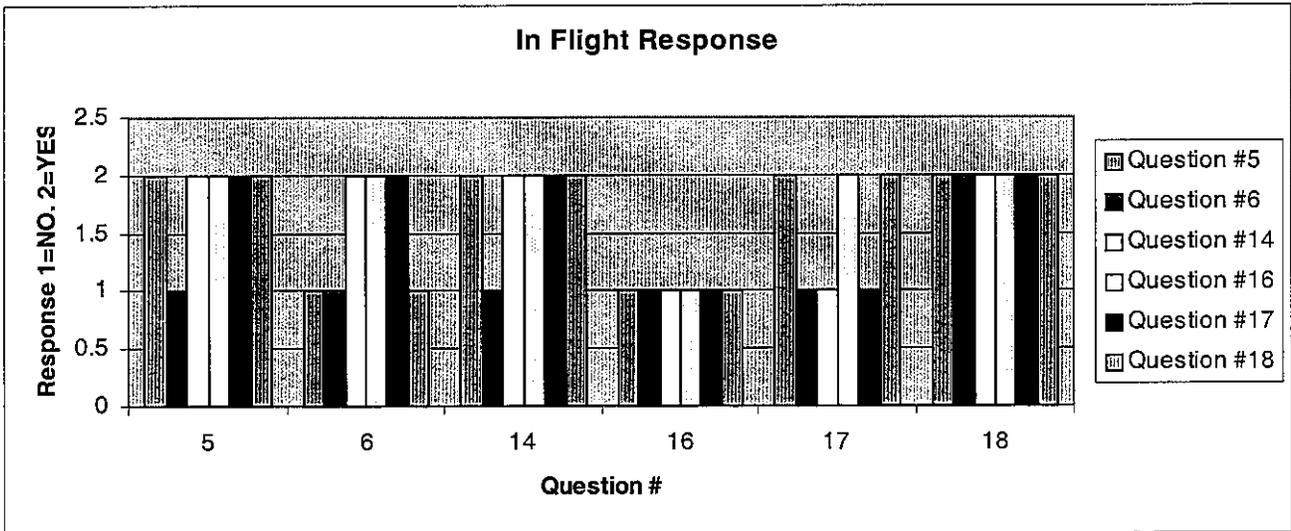


Figure 3: Pilot Responses during flight YES=2, NO=1

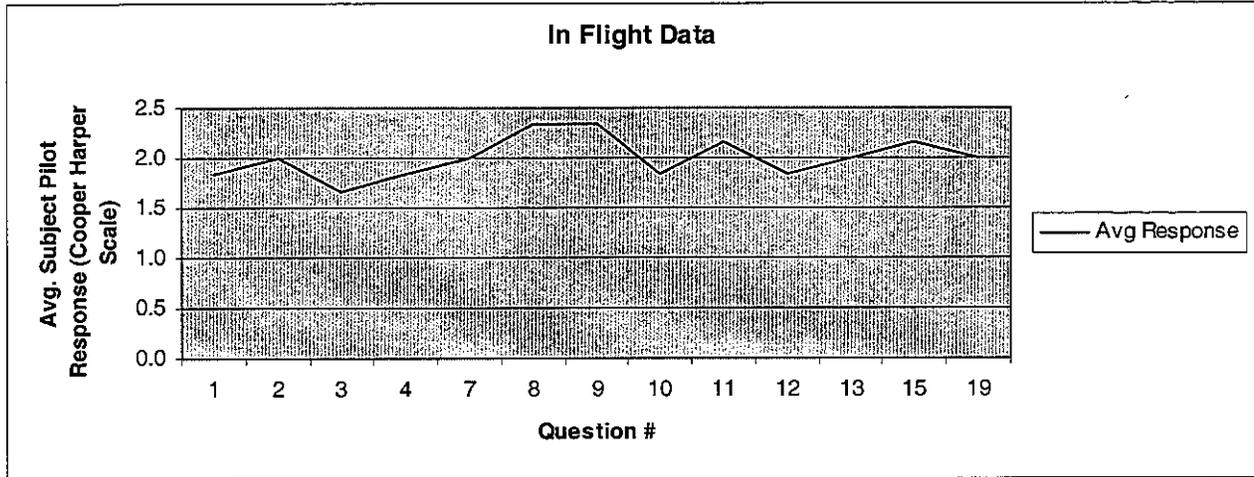


Figure 4: Pilot Responses during flight, grouped per question

Question#	1	3	4	5	11	15	Summary:
1	2	2	2	2	3	2	1.8
2	4	2	2	1	3	2	2.0
3	3	1	2	1	3	2	1.7
4	4	3		1	3	2	1.8
7	2	3	2	3	2	3	2.0
8	4	2	2	4	2	2	2.3
9	4	2	4	2	2	2	2.3
10	2	1	4	2	2	2	1.8
11	3	2	4	2	2	3	2.2
12	2	3	2	2	2	2	1.8
13	2	2	4	2	2	2	2.0
15	4	2	4	1	2	2	2.2
19	2	2	4	2	2	2	2.0
5	2	1	2	1	2	2	
6	1	1	1	1	1	2	
14	2	2	2	1	1	2	
16	2	2	2	1	2	2	
17	2	2	2	1	1	2	
18	2	1	2	1	2	2	

Table 1: Pilot responses for each question

**APPENDIX B
RATING SCALE**

The following rating scale, derived from the Cooper Harper Rating Scale, will be used during the test scenario. It will be administered following each procedure, and in the post-test debrief. Each rating is described below.

1	2	3	4	5	6	7
Excellent	Good	Fair	Minor Deficiencies	Moderate Deficiencies	Objectionable Deficiencies	Major Deficiencies

Pilot Rating	General Characteristics	Safety Margins	Demands on the Pilot
1	Excellent Highly Desirable	Clearly Adequate	Pilot compensation not a factor for desired performance
2	Good Negligible Deficiencies	Clearly Adequate	Pilot compensation not a factor for desired performance
3	Fair - Some mildly unpleasant deficiencies	Clearly Adequate	Minimal pilot compensation required for desired performance
4	Minor but annoying deficiencies	Clearly Adequate	Desired performance requires considerable pilot compensation
5	Moderately objectionable deficiencies	Adequate	Adequate performance requires considerable pilot compensation
6	Very objectionable but tolerable deficiencies	Marginal	Adequate performance requires extensive pilot compensation
7	Major deficiencies	Inadequate	Adequate performance not attainable with maximum tolerable pilot compensation. Controllability not in question.

APPENDIX C
Pre Test Questionnaire
Pilot Number _____

The purpose of this questionnaire is to collect information concerning your aeronautical experience, and this information will be used only for test purposes. For all questions concerning flight hours, answer *airplane/helicopter* if you are qualified in both.

1. Subject pilot Number _____.
2. List all pilot certificates, ratings, and type ratings: _____
3. Total flight hours: _____/_____. 4. Flt. hrs. last 6 months: _____/_____.
5. Total IMC flt. hrs: _____/_____. 6. IMC flt. hrs. last 6 months: _____/_____.
7. Test aircraft: GlaStar N231YE. 8. Total flt. hrs./date of last flt. in this make and model aircraft: _____/_____.
9. Last date instrument instruction received (aircraft or simulator): _____.
10. Date of last biennial flight review: _____.
11. What aircraft do you most often fly pilot check rides in: _____.
12. For each aircraft that you fly, list the aircraft and the average cruise airspeed in knots that you normally use for longer distance flight: _____.
13. How many ILS approaches have you flown in the last year with/without an autopilot: _____/_____.
14. How often do you fly ILS approaches without being vectored to the final approach course:
 0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
15. Total flight hours in "Experimental" classified aircraft: _____.
16. Circle all GPS equipment that you have used: Cars, Boats, Non-aviation hand held on the ground, Non-aviation hand held in the air, Aviation hand held in the air, Certified IFR GPS, Certified VFR GPS.
17. Reference question 16, which GPS equipment have you used the most: _____.
18. Number of hrs. navigating IFR with GPS avionics: _____.
19. List all multifunction display (MFD) avionics you have flown with: _____.
20. Which MFD avionics have you used the most: _____.
21. How often do you use GPS for enroute/terminal operations: _____/_____.
22. Rate your personal proficiency at using moving map displays:
 Never Used ; Seldom Used; Occasionally Use; Frequently Use

23. In your opinion, rate the moving map display system you have the most experience with

1	2	3	4	5	6	7	8
Excellent	Good	Fair	Minor	Moderate	Objectionable	Major	
Not			Deficiencies	Deficiencies	Deficiencies	Deficiencies	Applic.

**APPENDIX D
QUESTIONNAIRE**

Subject pilot File Preflight Questionnaire

1. Subject pilot Number: _____ . 2. Name: _____ .
3. Daytime phone: _____ .
4. Address: _____
5. Name, phone number, and address of person to notify in the event of an accident (work supervisor):

APPENDIX E
SUBJECT PILOT IN FLIGHT QUESTIONNAIRE

Questions for Subject Pilots: Primary Flight Display

Pilot Number _____

All questions pertain to your ability to fly the aircraft with the PFD as compared to standard, analog gauges

DEP: ACY

Page 1 of 3 **FLIGHT SEGMENT 1**

TO: Ocean City

Flight Parameters: straight and level flight; altitude holding, constant speed

1. Referring to your use of the PFD during flight, rate how well you were able to maintain a heading and fly a straight course.

1	2	3	4	5	6	7
Excellent	Good	Fair	Minor Deficiency	Moderate Deficiency	Objectionable Deficiency	Major Deficiency

2. Referring to your use of the PFD during flight, rate how well you were able to climb to and level off at the specified altitude.

1	2	3	4	5	6	7
Excellent	Good	Fair	Minor Deficiency	Moderate Deficiency	Objectionable Deficiency	Major Deficiency

3. Referring to your use of the PFD during flight, rate how well you were able to maintain altitude and level flight.

1	2	3	4	5	6	7
Excellent	Good	Fair	Minor Deficiency	Moderate Deficiency	Objectionable Deficiency	Major Deficiency

4. Using the PFD as a reference, rate how you were able to maintain the aircraft at the desired speed with the digital readouts of the PFD.

1	2	3	4	5	6	7
Excellent	Good	Fair	Minor Deficiency	Moderate Deficiency	Objectionable Deficiency	Major Deficiency

5. Did you notice a difference in speed indicator markings, as compared to what you are used to reading? YES NO

5. Do you prefer dual airspeed indications on the PFD (Kts and MPH)? YES NO

TO: Woodbine

Flight Parameters: shallow and steep turns, slow flight at constant altitude, heading and altitude changes, and responds to simulated air traffic control vectors at the direction of the safety pilot. Unusual attitudes may also be utilized.

7. Referring to your use of the PFD during flight, rate how well you were able to perform shallow and steep turns.

1	2	3	4	5	6	7
Excellent	Good	Fair	Minor Deficiency	Moderate Deficiency	Objectionable Deficiency	Major Deficiency

8. Referring to your use of the PFD during flight, rate how well you were able to perform slow flight while maintaining the specified altitude.

1	2	3	4	5	6	7
Excellent	Good	Fair	Minor Deficiency	Moderate Deficiency	Objectionable Deficiency	Major Deficiency

9. Referring to your use of the PFD during flight, rate how well you were able to perform heading and altitude changes.

1	2	3	4	5	6	7
Excellent	Good	Fair	Minor Deficiency	Moderate Deficiency	Objectionable Deficiency	Major Deficiency

10. Referring to your use of the PFD during flight, rate how well you were able to respond to simulated air traffic control vectors at the direction of the safety pilot.

1	2	3	4	5	6	7
Excellent	Good	Fair	Minor Deficiency	Moderate Deficiency	Objectionable Deficiency	Major Deficiency

11. Rate your ability to efficiently and accurately turn correctly on course when directed to do so by the safety pilot.

1	2	3	4	5	6	7
Excellent	Good	Fair	Minor Deficiency	Moderate Deficiency	Objectionable Deficiency	Major Deficiency

12. Rate your ability to perform stalls using the PFD.

1	2	3	4	5	6	7
Excellent	Good	Fair	Minor Deficiency	Moderate Deficiency	Objectionable Deficiency	Major Deficiency

TO: ACY

Flight Parameters: Preparation for landing, departure

13. When entering the landing pattern and preparing for landing, rate how well you were able to fly the airplane as prescribed.

1	2	3	4	5	6	7
Excellent	Good	Fair	Minor Deficiency	Moderate Deficiency	Objectionable Deficiency	Major Deficiency

14. Did you notice that the PFD does not have a course heading "bug" to set as some directional gyros have? YES NO

15. When entering the landing pattern and preparing for landing, rate how you were able to fly the airplane as prescribed without a heading "bug."

1	2	3	4	5	6	7
Excellent	Good	Fair	Minor Deficiency	Moderate Deficiency	Objectionable Deficiency	Major Deficiency

16. Do you normally fly an aircraft with a heading "bug"? YES NO

17. If your aircraft has a heading bug, do you normally use it? YES NO

18. Do you want/need a heading bug? YES NO

19. Rate how well you were able to fly the airplane with vectors from ATC.

1	2	3	4	5	6	7
Excellent	Good	Fair	Minor Deficiency	Moderate Deficiency	Objectionable Deficiency	Major Deficiency

COMMENTS:

Please provide any additional comments. If the comments applies to a question, please specify the question it applies to.

APPENDIX F QUESTIONNAIRE

Post Test Questionnaire for Airplanes

Date: _____ Subject pilot #: _____

The following ratings and questions pertain to your **overall perception** of the flight maneuvers you just flew using the EFIS-2000, for design and information presented on the EFIS-2000, your ability to maintain orientation to the desired flight path, and the general usability of the EFIS-2000 during flight. The first 12 ratings consist of a statement with the following seven points from the Cooper/Harper scale:

1	2	3	4	5	6	7
Excellent	Good	Fair	Minor Deficiencies	Moderate Deficiencies	Objectionable Deficiencies	Major Deficiencies

A rating of "1" will always indicate excellent general characteristics, clearly adequate safety margins, and pilot compensation not a factor for desired performance. A rating of "7" will always indicate major deficiencies in the general characteristics, inadequate safety margins, and adequate performance not attainable with maximum tolerable pilot compensation.

1. Rate your **initial** ability to use the EFIS-2000 MFD for maintaining the basic flight maneuvers you just flew.

1 2 3 4 5 6 7

2. Rate the **display presentation of flight information** ease of recognizing the flight data you needed at the time you needed it.

1 2 3 4 5 6 7

3. Rate your **ability to change functions** of the EFIS-2000 to accommodate the need to fly the basic flight maneuvers you just flew.

1 2 3 4 5 6 7

4. Rate your **ability to use the flight information** displayed on the EFIS-2000.

1 2 3 4 5 6 7

5. Compared to standard instrument gauges, rate the **pilot workload** of flying the aircraft for the maneuvers you just flew.

1 2 3 4 5 6 7

6. Compared to standard instrument gauges, rate the **flyability** of the basic flight maneuvers you just flew using the EFIS-2000.

1 2 3 4 5 6 7

7. Compared to standard instrument gauges, rate the overall **safety aspects** of the basic flight maneuvers you just flew using the EFIS-2000.

1 2 3 4 5 6 7

Comments:

**APPENDIX G
PROJECT PILOT FLIGHT TEST MISSION DEBRIEF**

Pilot Number _____

Project Title: Low GA Cost Avionics

Date:

PIC:

SIC:

FE:

Technical Crew:

Aircraft: GlaStar N231YE

Altitude:

Speed:

Weather:

Objectives:

Test Comments: