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Investigation and Evaluation of a Computer Program to Minimize VFR Flight Planning Errors

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INVESTIGATION AND EVALUATION OF A COMPUTER PROGRAM TO MINIMIZE VFR FLIGHT PLANNING ERRORS

by
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This thesis was prepared under the direction of the candidate's thesis committee chairman, Dr. Charles Richardson, Department of Aeronautical Science and has been approved by the members of this thesis committee. It was submitted to the School of Graduate Studies and Research and was accepted in partial fulfillment of the requirements for the degree of Master of Aeronautical Science.

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ABSTRACT

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Title: Investigation and Evaluation of a Computer Program to Minimize VFR Flight Planning Errors

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The purpose of this study was to investigate the effect of computer aided flight planning on flight planning errors. Subjects were selected from the introductory flight courses at Embry-Riddle Aeronautical University. After the subjects completed a conventional VFR navigation log, they were asked to plan the return trip of the flight using a computer aided flight plan. It was initially expected that the computer aided flight plans would have fewer flight planning errors than those calculated using conventional methods. The results supported the hypothesis that flight planning errors are greatly reduced when computer aided flight planning techniques are used.

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Review of Related Literature

General aviation is just months away from beginning the automatic forwarding of flight plans to the Federal Aviation Administration (FAA) from home computers. Direct flight plan filing is a giant step toward a totally automated system. The pilot now has to make only one call (via a terminal or home computer) to download a weather briefing, generate a flight log, and file a flight plan. Before the FAA permitted direct filing, the weather/flight plan vendor personnel had to telephone file on behalf of the end user. This personalized service was relatively expensive, especially for the businessman pilot (Aarons, 1988).

Microcomputers on the market today can help the pilot fly more inexpensively, more often, more safely, and with more confidence and enjoyment (Barnhart & Wiener, 1988). Computers can solve complicated weight and balance, airspeed/groundspeed, altitude, and navigational problems more comprehensively and with greater accuracy. They can perform complex calculations that might otherwise not get done, and give the pilot a clearer picture of the capabilities and limitations of an aircraft in certain conditions over a given route.

We are three to six months away from the beginning of automatic forwarding of flight plans to the FAA from computerized weather/flight plan vendors such as EMI, JetPlan, and others (Aarons, 1987). We are probably a few years away from the delivery of weather and flight plan services from some of these vendors to the end user, with the FAA picking up the tab under the Direct User Access Terminal (DUAT) program. The Flight Service Station (FSS) system of the 1990s is based on the concept that at least 70 percent of all flight plans will be filed automatically by computerized weather/flight plan vendors. Richard N. Aarons (1987) believes some of these computer services will be paid for by the end user of the system, and others will be paid for by the taxpayers. But all weather/flight plan services will forward flight plans to the originating Air Traffic Control (ATC) facilities. This means that there will be fewer facilities offering "human to human" weather briefings and fewer phone numbers to call to file a flight plan.

Most flight schools still teach the use of the E6-B for flight operations even though newer hand-held electronic calculators are supposed to be faster and more accurate (Barnhart & Wiener, 1988). An E6-B is a mechanical flight computer that was used before the advent of electronic flight computers. Veteran aviators will argue that the E6-B works anywhere, is never affected by the elements, does not require a battery, and once you get used to it, it is hard to go anywhere without one. They generally claim that the E6-B is easier to use than its electronic successors. The convenience, low price, and power of the E6-B is the most common reason cited by pilots when asked why they have not purchased a flight computer. In fact, a few pilots who own electronic computers rarely use them, and rather prefer the E6-B.

General aviation pilots can file flight plans with the FAA via personal computers in an experimental system being used by the Virginia Department of Aviation. But while the system shows promise as a first step toward fully automated flight plan filing, further development will be needed to maximize its potential. The system allows flight-planning information to be transmitted between computer weather-briefing units at Danville, Virginia Municipal Airport and the Leesburg, Virginia Automated Flight Service Station. According to Virginia Department of Aviation Director Kenneth Rowe, filing flight plans computer-to-computer eventually should be faster and more efficient than the traditional method of filing them verbally over toll free phone lines (Airport Services Management, 1988).

STARbrief, a computerized optimal flight plan, has been introduced to its subscribers by WSI Corporation of Bedford, Massachusetts. Arlo Gambell, WSI's aviation business line manager, explained that STARbrief provides an extremely accurate flight plan that is processed and returned to the user in a matter of seconds. While the various options may seem confusing to the beginner, Gambell said, "The first-time user will have no problem running a plan without an instruction manual" (Aviation International News, 1987).

Computer flight planning's value as a training aid and continued proficiency tool for pilots of all experience levels might well be its greatest asset for student pilots. A few hours spent with one flight planning software package, planning a variety of actual and theoretical flights, is analogous to using a cockpit simulator for primary flight training. It can give a pilot valuable insights into the fine points of aviation that might otherwise never be developed. A pilot in training could easily spend a few hundred dollars on dual time and cross country (X-C) work and not learn everything that a good flight planning program can teach (Barnhart & Wiener, 1988).

To date there has not been any comprehensive software to run on the machines that could add to, or further simplify, the accumulation of data needed along with the gadgetry used in flying. With the $125 "Professional" version of Flitesoft from RMS Technology comes just such a program. "We put Flitesoft through its paces on an IBM PC, for which it was specifically designed. We tried to get it to stall, spin, crash and burn by making every possible dumb mistake and computer-user-equivalent of cross-controlled stalls low to the ground. We were able to find some bugs, but by and large the program passed with flying colors" (Davids, 1986).

Statement of the Hypothesis

The are many potential benefits derived from computerized flight planning. First, the information is accurate and well organized. Second, a significant amount of time can be saved before each flight, particularly on those routes which have been flown before and are pre-recorded on the computer disk. Finally, by utilizing a computer there is less chance for computational error. Therefore, it is hypothesized that general aviation VFR flight planning errors are greatly reduced when flight planning is computer aided.

Method

Subjects

Subjects were selected from the population of flight students enrolled in the introductory flight courses at Embry-Riddle Aeronautical University. Subjects enrolled in Basic Navigation (AS 180), Aeronautics II (AS 255), and Aeronautics III (AS 256) were selected to participate in the study (see Appendix A). Embry-Riddle Aeronautical University offered 6 sections of Basic Navigation with enrollment of approximately 170 students, 9 Sections of Aeronautics II with enrollment of approximately 300 students, and 5 Sections of Aeronautics III with enrollment of approximately 150 students; however, approximately 300 of the 620 students were qualified to participate in this study. Participants were required to have either a student pilot certificate or a private pilot certificate and be capable of planning a cross-country flight. One section of Basic Navigation (AS 180), two sections of Aeronautics II (AS 255), and one section of Aeronautics III (AS 256) were randomly selected to participate in this study. Random selection was done by using a table of random numbers. Two sections of AS 255 were selected because proportionally it was nearly twice as large as the other courses. A total of thirty subjects participated in this study. The following statistics help to define the sample: 43.3% of the subjects hold a private pilot certificate and have an average of 97.63 total flight hours with approximately 15.71% of the total flight hours logged as cross country flying (see Table 1).

Table 1

Subject Statistics: Birthdate, Rating Held, Total Flight Hours, X-C Flight Hours, and X-C Flight Hours as a Percentage of Total Flight Hours

Subject	Birthdate	Sex	Rating Held	Total Flight Hours	X-C Flight Hours	X-C Hours as a % of Total Flight Hours	Personal Computer Use
1	8/25/67	M	Private	150	36	24.00%	Monthly
2	11/5/68	M	Private	200	15	7.50%	Monthly
3	10/13/70	M	Student Pilot	40	4	10.00%	Weekly
4	3/26/69	M	Private	113	34	30.09%	Monthly
5	7/26/70	M	Private	200	80	40.00%	Weekly
6	4/13/64	M	Student Pilot	64	17	26.56%	Never
7	8/15/67	M	Private	90	21	23.33%	Monthly
8	10/25/68	M	Student Pilot	31	2	6.45%	Daily
9	1/9/68	M	Student Pilot	32	0	0.00%	Never
10	9/22/70	M	Student Pilot	42	8	19.05%	Weekly
11	8/28/69	M	Student Pilot	35	0	0.00%	Monthly
12	10/1/63	M	Private	120	20	16.67%	Monthly
13	9/9/69	M	Student Pilot	25	0	0.00%	Never
14	2/11/70	M	Student Pilot	50	10	20.00%	Daily
15	3/7/68	M	Private	420	40	9.52%	Never
16	10/15/69	M	Student Pilot	38	0	0.00%	Weekly
17	2/24/70	M	Student Pilot	39	2	5.13%	Weekly
18	4/2/68	F	Private	174	63	36.21%	Never
19	3/20/68	M	Student Pilot	1	0	0.00%	Monthly
20	12/24/69	M	Student Pilot	0	0	0.00%	Monthly
21	9/19/68	M	Student Pilot	20	0	0.00%	Never
22	12/3/69	M	Student Pilot	75	12	16.00%	Weekly
23	1/7/62	M	Private	240	60	25.00%	Weekly
24	1/29/68	M	Private	107	34	31.78%	Weekly
25	8/25/70	M	Private	126	23	18.25%	Daily
26	12/15/69	M	Student Pilot	27	0	0.00%	Weekly
27	7/23/67	M	Private	105	20	19.05%	Monthly
28	7/2/70	M	Student Pilot	50	12	24.00%	Daily
29	7/10/70	M	Student Pilot	145	55	37.93%	Monthly
30	9/21/67	M	Private	170	42	24.71%	Daily
Averages: 21 years 2 months				97.63	20.33	15.71%	
			Standard Deviation:	89.13	22.22	12.88%	

Instrument

The software package that was used was entitled Flight Plan 2.5 and was produced by Insanely Great Software (IGS) International (Fischette, 1988). The software was stored and run from a hard disk connected to a Macintosh Plus computer. The Macintosh was chosen for its flexibility, speed, and ease of use. Flight Plan 2.5 consists of eight different program modules called "Templates" and one or more libraries of airports and navaids called "Directories" which customize a spreadsheet program and allow it to perform aviation flight planning calculations. These Templates and Directories will allow the pilot to rapidly prepare a comprehensive, accurate flight plan, and an appropriate Navigation Log for use during the flight. Spreadsheet macros are often the best way to process a large number of complex variables. A macro consists of a list of software commands which the spreadsheet program follows robotically. It is almost as if there were another person typing at the keyboard, moving the cursor to the proper places within the spreadsheet. Flight Plan works with several databases throughout the flight planning process.

Experimental Design

It was decided that the Pseudo Posttest-Only Control Group Design would be used in this research (Gay, 1987). Subjects would be part of the control group when conventional methods of flight planning are used and then become part of the experimental group when the computer aided methods of flight planning are used. This experimental design controls nearly all threats to internal and external validity. Validity is the degree to which a test measures what it is intended to measure; a test is valid for a particular purpose for a particular group. Subjects were pretested using conventional methods of flight planning and posttested using the computer aided flight plan. Pretest and posttest scores were then compared to a known correct flight plan to determine error frequencies and the effectiveness of the computer flight plan program. Subjects were randomly selected. Random sampling is the best single way to attempt to control many extraneous variables.

Procedure

The subjects were required to plan two VFR cross country flights. The first flight, using the conventional methods of flight planning, originated from Flagler Beach Airport, Florida (X47), and terminated at New Smyrna Beach Airport, Florida (34J), with Ormond Beach Airport (OMN) and Daytona Beach Regional Airport (DAB) being used as checkpoints (see Figure 1). The flight plan was short enough to insure accuracy and consistency using the conventional methods of flight planning and long enough to demonstrate all pertinent functions of the computer aided flight planning program. The standard VFR navigation log was used for planning the conventional flight plan (see Figure 2). After the subjects had completed the conventional VFR flight plan, they were asked to plan the return trip of the flight using the computer aided flight plan. Subjects were taught how to use the computer program prior to planning the return flight. Each subject was given a questionnaire and the flight planning information (see Figure 3). Information such as total flight time, cross country time, and current rating was gathered from each subject. After each subject had completed the conventional and computer VFR flight plans, a copy of each was made for later comparison.

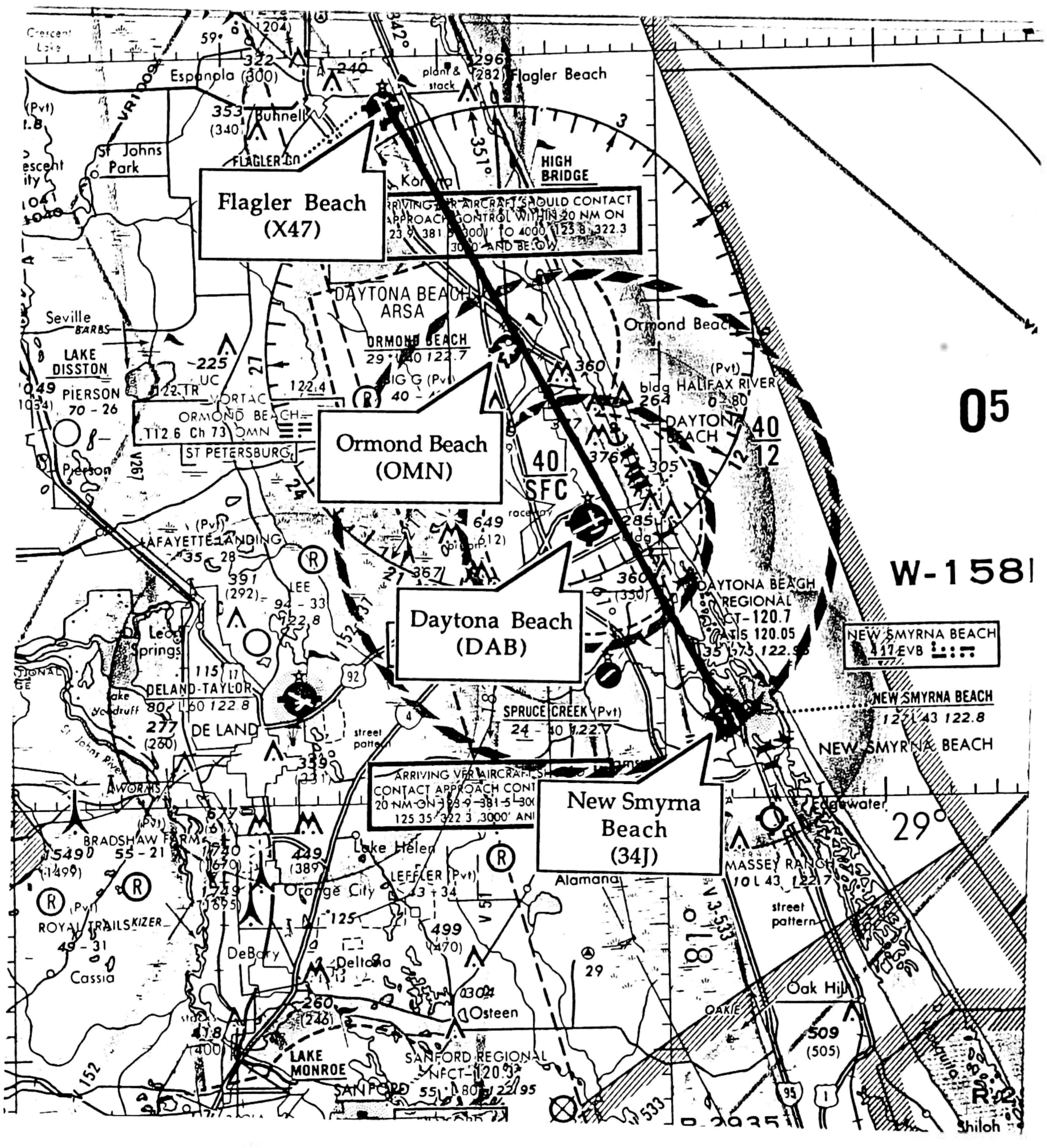

Figure 1. Route of Flight

VFR NAVIGATION LOG

PREFLIGHT LOG

COURSE CHANGE CHECK POINTS	TRUE CRS	WIND	VAR	MAG HEAD	DIST	EST GS	ETE	FUEL BURN
—TOC								
TOC—								
—								
—								
—								
—								
TOTAL								

FLIGHT LOG

	MAG HEAD	TOTAL DIST / LEG / REM	GS	ETE / ETA	ATA / ATE	FUEL / LEG / REM	NOTES
DEPARTURE PT.							
TOP OF CLIMB							

CRUISE DATA

MSL ALT	PA	TEMP	DA	RPM	%BHP	KTAS	GPH

WEATHER LOG

	DEPARTURE	ENROUTE	DESTINATION	NOTES
REPORTED				
FORECAST				

WINDS ALOFT	3,000	6,000	9,000	12,000

NOTAMS & SIGNIFICANT WX.

1 TYPE (VFR / IFR / DVFA)	2 AIRCRAFT IDENTIFICATION	3 AIRCRAFT TYPE/ SPECIAL EQUIPMENT	4 TRUE AIRSPEED (KTS)	5. DEPARTURE POINT	6. DEPARTURE TIME: PROPOSED (Z)	ACTUAL (Z)	7 CRUISING ALTITUDE

8. ROUTE OF FLIGHT

9. DESTINATION (Name of airport and city)	10 EST TIME ENROUTE: HOURS	MINUTES	11 REMARKS

12. FUEL ON BOARD: HOURS	MINUTES	13. ALTERNATE AIRPORT(S)	14. PILOT'S NAME, ADDRESS & TELEPHONE NUMBER & AIRCRAFT HOME BASE	15. NUMBER ABOARD

16 COLOR OF AIRCRAFT

CLOSE VFR FLIGHT PLAN WITH __________ FSS ON ARRIVAL

Figure 2. VFR Navigation Log

EMBRY-RIDDLE
AERONAUTICAL UNIVERSITY

Daytona Beach, FL 32014 904-239-6000, Telex: 258052 SAND UR

Name: ______________________________

Birthdate: ______________

Sex: ☐ M ☐ F

Phone Number: ______________________________

Pilot Ratings Held: ______________________________

Rating presently working on: ______________________________

Total Flight Hours: ______________

Cross Country Flight Hours: ______________

How long have you been flying: ______________

Have you ever used a computerized flight planning program? ☐ Yes ☐ No
If yes, which one(s)?

How often do you use a personal computer?

☐ Daily ☐ Weekly ☐ Monthly ☐ Never

Please plan the following VFR cross country flight using the methods you were taught at ERAU:
Flagler Beach (Flagler Co.) to New Smyrna (New Smyrna Beach).
Use the following airports as checkpoints: Ormond Beach, and Daytona Beach Regional airports.

Use the following information: Aircraft Number: 388ER (Cessna 172)
Equipment: Transponder with altitude encoding
Departure Time: 13:30 Local
Fuel: Full Tanks
Cruising Altitude: 2500 feet

Weather at Flagler:
Temperature: 88
Altimeter: 30.00"
Wind: 240 at 11 knots

Weather at New Smyrna:
Temperature: 90
Altimeter: 29.98"
Wind: 240 at 11 knots

Winds aloft Forecast:

	2000	2500	3000
Wind Direction:	240	210	200
Wind Velocity (knts):	11	14	15
Temperature (c):	23	22	21

Please bring this completed flight plan to your scheduled appointment

Figure 3. Subject Questionnaire

The 1985 Cessna 172P was the aircraft used by the subjects in this research project. The Cessna 172s are used for primary training at Embry-Riddle Aeronautical University and the aircraft manuals are studied in depth in the introductory flight courses (Cessna 172P manual, 1985). Subjects were to plan the conventional flight plan using the aircraft performance information shown in Appendix B, and flight planning methods taught in their courses. Many subjects were taught to use 65% Brake Horse Power (BHP), while others were taught to use 75% BHP. Both brake horse power settings were accepted and dealt with accordingly.

Conventional flight plans for 65% BHP and 75% BHP were completed by flight instructors as well as faculty members to insure accuracy. These flight plans were accepted as correct and were used to determine error frequencies on the subjects' conventional and computer aided flight plans (see Figures 4-7). The number of errors was determined by comparing the following 15 variables of both conventional and computer aided flight plans to the correct flight plan: true course, wind direction, wind velocity, magnetic heading, distance, ground speed, estimated time en route, fuel burn, temperature, true airspeed, fuel flow, departure time, aircraft identification and special equipment, departure point, and fuel on board. Any variables that were affected by previous errors were recomputed using values to verify that they were computed correctly. The number of errors was computed for each flight plan.

The chi square method and the measures of central tendency have been used to analyze the data (Elzey, 1971). Chi square is a nonparametric test of significance appropriate when the data are in the form of frequency counts occurring in two or more mutually exclusive categories. The chi square will be used to compare frequencies of errors occurring in the different flight planning processes.

Figure 4. Correct Flight Plan (75% BHP 34J to X47)

75% 34J-X47

VFR NAVIGATION LOG

PREFLIGHT LOG

COURSE CHANGE CHECK POINTS	TRUE CRS	WIND	VAR	MAG HEAD	DIST	EST GS	ETE	FUEL BURN
34J —TOC	332	240/11	+3	327	4		:04	0.6
TOC— X47	332	210/18	+3	328	24	120	:13	1.8
—								
—								
—								
—								
TOTAL					28		:17	3.5

FLIGHT LOG

DEPARTURE PT.	MAG HEAD	TOTAL DIST 28 / LEG / REM	GS	ETE / ETA	ATA / ATE	FUEL 40 / LEG / REM	NOTES
34J							
TOP OF CLIMB	327	4					
DAB	328	5					
OMN	328	8					
X47	328	11					

CRUISE DATA

MSL ALT	PA	TEMP	DA	RPM	%BHP	KTAS	GPH
2500	2430	22°C	3796	2500	75	113	8.4

WEATHER LOG

	DEPARTURE	ENROUTE	DESTINATION	NOTES
REPORTED				
FORECAST				

WINDS ALOFT	3,000	6,000	9,000	12,000

NOTAMS & SIGNIFICANT WX.

1. TYPE	2. AIRCRAFT IDENTIFICATION	3. AIRCRAFT TYPE/ SPECIAL EQUIPMENT	4. TRUE AIRSPEED	5. DEPARTURE POINT	6. DEPARTURE TIME PROPOSED (Z)	ACTUAL (Z)	7. CRUISING ALTITUDE
X VFR / IFR / DVFR	388ER	172/U	113 KTS	34J	1730		2500

8. ROUTE OF FLIGHT

34J Direct X47

9. DESTINATION (Name of airport and city)	10. EST. TIME ENROUTE HOURS	MINUTES	11. REMARKS
X47	0	17	

12. FUEL ON BOARD HOURS	MINUTES	13. ALTERNATE AIRPORT(S)	14. PILOT'S NAME, ADDRESS & TELEPHONE NUMBER & AIRCRAFT HOME BASE	15. NO. ABOARD
4	45			

16. COLOR OF AIRCRAFT

CLOSE VFR FLIGHT PLAN WITH ________ FSS ON ARRIVAL

75% X47-34J

VFR NAVIGATION LOG

PREFLIGHT LOG

COURSE CHANGE CHECK POINTS	TRUE CRS	WIND	VAR	MAG HEAD	DIST	EST GS	ETE	FUEL BURN
X47 —TOC	153	240/11	+3	163	4		:04	0.6
TOC— 34J	153	210/14	+3	163	24	105	:14	2.0
—								
—								
—								
—								
				TOTAL	28		:18	3.7

FLIGHT LOG

DEPARTURE PT. X47	MAG HEAD	TOTAL DIST 28 LEG / REM	GS	ETE / ETA	ATA / ATE	FUEL 40 LEG / REM	NOTES
TOP OF CLIMB	163	4					
OMN	163	7					
DAB	163	8					
34J	163	9					

CRUISE DATA

MSL ALT	PA	TEMP	DA	RPM	%BHP	KTAS	GPH
2500	2430	22°C	3796	2500	75	113	8.4

WEATHER LOG

	DEPARTURE	ENROUTE	DESTINATION	NOTES
REPORTED				
FORECAST				

WINDS ALOFT	3,000	6,000	9,000	12,000

NOTAMS & SIGNIFICANT WX.

1. TYPE	2. AIRCRAFT IDENTIFICATION	3. AIRCRAFT TYPE/ SPECIAL EQUIPMENT	4. TRUE AIRSPEED	5. DEPARTURE POINT	6. DEPARTURE TIME PROPOSED (Z)	ACTUAL (Z)	7. CRUISING ALTITUDE
X VFR / IFR / DVFR	388ER	172/U	113 KTS	X47	1730		2500

8. ROUTE OF FLIGHT: X47 Direct 34J

9. DESTINATION (Name of airport and city)	10. EST TIME ENROUTE HOURS	MINUTES	11. REMARKS
34J	0	17	

12. FUEL ON BOARD HOURS	MINUTES	13. ALTERNATE AIRPORT(S)	14. PILOT'S NAME, ADDRESS & TELEPHONE NUMBER & AIRCRAFT HOME BASE	15. NUMBER ABOARD
4	45			

16. COLOR OF AIRCRAFT

CLOSE VFR FLIGHT PLAN WITH ________ FSS ON ARRIVAL

Figure 5. Correct Flight Plan (75% BHP X47 to 34J)

65% 34J-X47

VFR NAVIGATION LOG

PREFLIGHT LOG

COURSE CHANGE CHECK POINTS	TRUE CRS	WIND	VAR	MAG HEAD	DIST	EST GS	ETE	FUEL BURN
34J —TOC	332	240/	+3	327	4		:06	0.9
TOC— X47	332	210/	+3	328	24	112	:12	1.4
—								
—								
—								
—								
TOTAL					28		:18	3.4

FLIGHT LOG

	MAG HEAD	TOTAL DIST 28 / LEG / REM	GS	ETE / ETA	ATA / ATE	FUEL 40 / LEG / REM	NOTES
DEPARTURE PT. 34J							
	327	4					
TOP OF CLIMB							
	328	5					
DAB							
	328	8					
OMN							
	328	11					
X47							

CRUISE DATA

MSL ALT	PA	TEMP	DA	RPM	%BHP	KTAS	GPH
2500	2430	22°C	3796	2400	65	106	7.3

WEATHER LOG

	DEPARTURE	ENROUTE	DESTINATION	NOTES
REPORTED				
FORECAST				

WINDS ALOFT	3,000	6,000	9,000	12,000

NOTAMS & SIGNIFICANT WX.

1. TYPE	2. AIRCRAFT IDENTIFICATION	3. AIRCRAFT TYPE/ SPECIAL EQUIPMENT	4. TRUE AIRSPEED	5. DEPARTURE POINT	6. DEPARTURE TIME PROPOSED (Z)	ACTUAL (Z)	7. CRUISING ALTITUDE
X VFR / IFR / DVFR	388ER	172/U	106 KTS	34J	1730		2500

8. ROUTE OF FLIGHT

34J Direct X47

9. DESTINATION (Name of airport and city)	10. EST. TIME ENROUTE HOURS	MINUTES	11. REMARKS
X47	0	18	

12. FUEL ON BOARD HOURS	MINUTES	13. ALTERNATE AIRPORT(S)	14. PILOT'S NAME, ADDRESS & TELEPHONE NUMBER & AIRCRAFT HOME BASE	15. NUMBER ABOARD
5	28			

16. COLOR OF AIRCRAFT

CLOSE VFR FLIGHT PLAN WITH ________ FSS ON ARRIVAL

Figure 6. Correct Flight Plan (65% BHP 34J to X47)

VFR NAVIGATION LOG

PREFLIGHT LOG

COURSE CHANGE CHECK POINTS	TRUE CRS	WIND	VAR	MAG HEAD	DIST	EST GS	ETE	FUEL BURN
X47—TOC	153	240/11	+3	163	4		:06	0.7
TOC—34J	153	210/14	+3	163	24	98	:15	1.8
—								
—								
—								
—								
TOTAL					28		:21	3.6

FLIGHT LOG

TOTAL DIST 28 | FUEL 40

DEPARTURE PT.	MAG HEAD	LEG / REM	GS	ETE / ETA	ATA / ATE	LEG / REM (FUEL)	NOTES
X47							
TOP OF CLIMB	163	4					
OMN	163	7					
DAB	163	8					
34J	163	9					

65% X47-34J

CRUISE DATA

MSL ALT	PA	TEMP	DA	RPM	%BHP	KTAS	GPH
2500	2430	22°C	3796	2400	65	106	7.3

WEATHER LOG

	DEPARTURE	ENROUTE	DESTINATION	NOTES
REPORTED				
FORECAST				

WINDS ALOFT	3,000	6,000	9,000	12,000

NOTAMS & SIGNIFICANT WX.

FLIGHT PLAN

1. TYPE	2. AIRCRAFT IDENTIFICATION	3. AIRCRAFT TYPE/ SPECIAL EQUIPMENT	4. TRUE AIRSPEED	5. DEPARTURE POINT	6. DEPARTURE TIME PROPOSED (Z)	ACTUAL (Z)	7. CRUISING ALTITUDE
X VFR / IFR / DVFR	388ER	172/U	106 KTS	X47	1730		2500

8. ROUTE OF FLIGHT: X47 Direct 34J

9. DESTINATION (Name of airport and city)	10. EST. TIME ENROUTE HOURS	MINUTES	11. REMARKS
34J	0	21	

12. FUEL ON BOARD HOURS	MINUTES	13. ALTERNATE AIRPORT(S)	14. PILOT'S NAME, ADDRESS & TELEPHONE NUMBER & AIRCRAFT HOME BASE	15. NUMBER ABOARD
5	28			

16. COLOR OF AIRCRAFT

CLOSE VFR FLIGHT PLAN WITH ________ FSS ON ARRIVAL

Figure 7. Correct Flight Plan (65% BHP X47 to 34J)

Analysis

The results of this study support the research hypothesis that general aviation VFR flight planning errors are greatly reduced when flight planning is computer aided. The number of errors made by each group was compared to determine if flight planning errors were less likely to occur when flight planning was computer aided.

Subjects had a total of 112 conventional flight planning errors and 55 computer aided flight planning errors, with standard deviations of 3.73 and 1.83, respectively (see Table 2 & Figure 8).

Table 2

Number of Flight Planning Errors in Conventional and Computerized Flight Plans by Subject

Subject	No. of Errors in Conventional Flight Plan	No. of Errors in Computerized Flight Plan	Subject	No. of Errors in Conventional Flight Plan	No. of Errors in Computerized Flight Plan
1	5	1	16	8	1
2	3	6	17	4	1
3	5	1	18	4	1
4	7	5	19	6	3
5	2	1	20	5	1
6	6	1	21	5	2
7	4	1	22	4	2
8	0	2	23	1	2
9	1	3	24	7	1
10	4	1	25	3	1
11	4	3	26	5	2
12	3	2	27	3	2
13	4	1	28	0	1
14	3	1	29	1	1
15	2	1	30	3	4
			Average:	3.73	1.83
			Std. Dev.:	2.02	1.29
			Total:	112	55

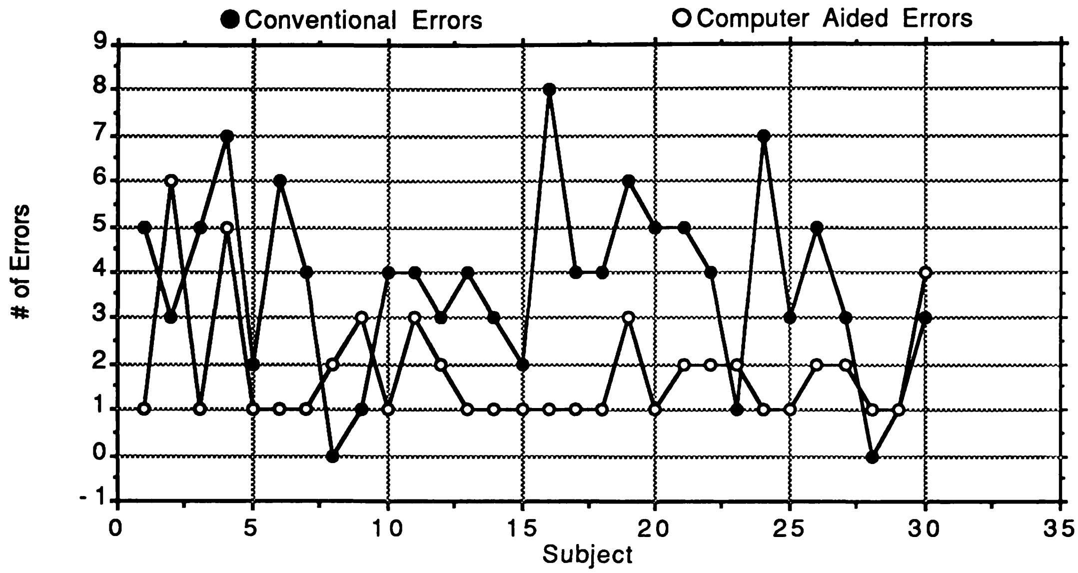

Figure 8. Number of Flight Planning Errors in Conventional and Computerized Flight Plans by Subject (graphically).

Chi square is a nonparametric test of significance appropriate when the data are in the form of frequency counts; it compares proportions actually observed in a study with proportions expected to determine if they are significantly different. The chi square value increases as the difference between observed and expected frequencies increases.

Formula: $$\chi^2 = \sum \frac{((| O - E |) - 0.5)^2}{E}$$

Where:

O is observed error frequencies

E is expected error frequencies

Calculation of Chi Square:

Flight Planning Method	O	E	$(\lvert O-E \rvert)-0.5$	$((\lvert O-E \rvert)-0.5)^2$
Conventional	112	83.5	28	784
Computer Aided	55	83.5	28	784

$$\frac{((\lvert O-E \rvert)-0.5)^2}{E}$$

9.39
9.39
18.78

$\chi^2=18.78$ $df=1$

Using a 95% confidence interval ($p=.05$): $\chi^2=3.84$

Because the obtained χ^2 of 18.78 is larger than is required for significance at the $p=.05$ level, the null hypothesis that there is no difference between error frequencies in the conventional and computer flight planning categories is rejected. On the basis of the rejection of the null hypothesis at the $p=.05$ level, it was determined that in the population from which this sample was selected, errors are made more frequently when using the conventional flight planning method.

The subjects' calculations of true course, wind direction, wind velocity, magnetic heading, distance, ground speed, estimated time en route, fuel burn, temperature, true airspeed, fuel flow, departure time, aircraft identification and special equipment, departure point, and fuel on board must be within the following tolerances to be considered correct:

	Variable	Tolerance
1.	True Course	±3 degrees
2.	Wind Direction	Exact
3.	Wind Velocity	Exact
4.	Magnetic Heading	±3 degrees
5.	Distance	±1 nautical mile (nm)
6.	Ground Speed	±3 knots
7.	Estimated Time En Route (ETE)	±3 minutes
8.	Fuel Burn	±3 minutes
9.	Temperature	Exact
10.	True Airspeed	±3 knots
11.	Fuel Flow	±0.1 gallons
12.	Departure Time	Exact
13.	Aircraft Id. & Special Equip.	Exact
14.	Departure Point	Exact
15.	Fuel on Board	±3 minutes

These error tolerance values were chosen by taking into consideration the distance of the flight, built in instrument errors, computational complexity, and Embry-Riddle Aeronautical University standards of flight planning proficiency.

In 12 of the 15 variables tested, the conventional method produced a greater number of errors; in 2 of the 15 variables, the conventional and computer aided methods produced the same number of errors; and in only 1 of 15 variables tested did the computer aided flight method produce more errors than its conventional counterpart. Fuel burn made up more than 52% of the total errors when using the computer aided flight method compared to only 3.57% of the total errors using the conventional flight planning methods. Because of the high incidence of fuel burn error on the computer aided flight plan, it is believed that the error was caused by a programming error, something the subject had no control over (see Table 3 & Figure 9).

Table 3

Number of Flight Planning Errors in Conventional and Computerized Flight Plans for Each Variable Tested

Variable #	Conventional Method	% of Total	Computer Aided Method	% of Total
1	3	2.68%	0	0.00%
2	9	8.04%	1	1.82%
3	0	0.00%	0	0.00%
4	6	5.36%	0	0.00%
5	2	1.79%	2	3.64%
6	6	5.36%	4	7.27%
7	7	6.25%	2	3.64%
8	4	3.57%	29	52.73%
9	16	14.29%	0	0.00%
10	6	5.36%	3	5.45%
11	6	5.36%	3	5.45%
12	7	6.25%	4	7.27%
13	16	14.29%	0	0.00%
14	2	1.79%	1	1.82%
15	22	19.64%	6	10.91%
Total:	112	100.00%	55	100.00%

Subjects with more than 100 hours of total flight time had a total of 44 conventional flight planning errors and 28 computer aided flight planning errors, with standard deviations of 1.94 and 1.72, respectively. A large number of subjects (92%) in this category hold a private pilot certificate and have an average of 174.62 total flight hours with approximately 24.67% of the total flight hours logged as cross country flight hours (see Table 4).

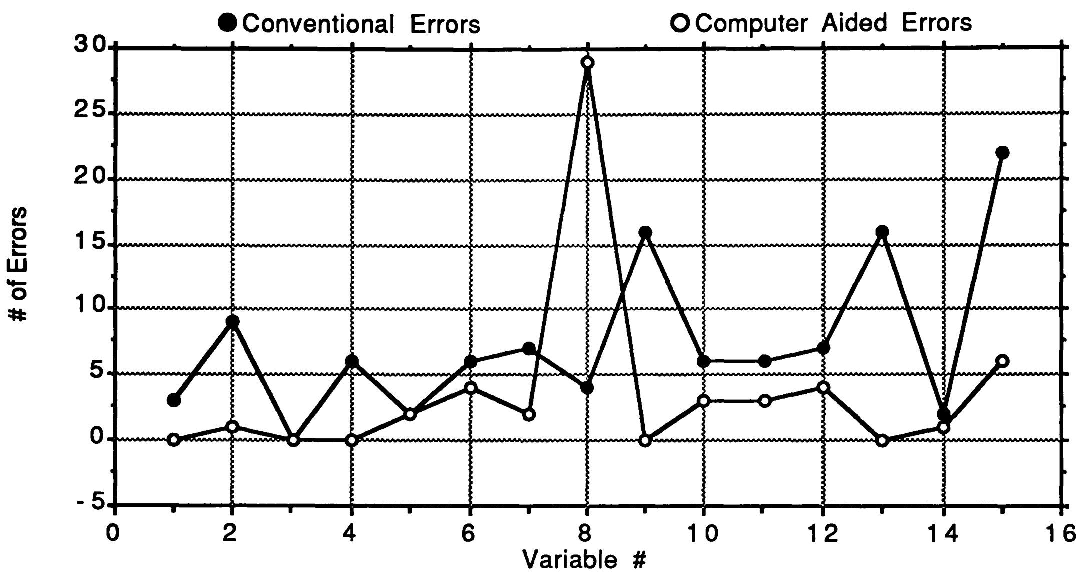

Figure 9. Number of Errors in Conventional and Computerized Flight Plans for Each Variable Tested (graphically).

Table 4

Number of Flight Planning Errors in Conventional and Computerized Flight Plans for Pilots with More than 100 Hours of Total Flight Time

Subject	Sex	Rating Held	Total Flight Hours	X-C Flight Hours	X-C Hrs. as a % of Total Flight Hours	No. of Errors in Conventional Flight Plan	No. of Errors in Computerized Flight Plan
1	M	Private	150	36	24.00%	5	1
2	M	Private	200	15	7.50%	3	6
4	M	Private	113	34	30.09%	7	5
5	M	Private	200	80	40.00%	2	1
12	M	Private	120	20	16.67%	3	2
15	M	Private	420	40	9.52%	2	1
18	F	Private	174	63	36.21%	4	1
23	M	Private	240	60	25.00%	1	2
24	M	Private	107	34	31.78%	7	1
25	M	Private	126	23	18.25%	3	1
27	M	Private	105	20	19.05%	3	2
29	M	Student Pilot	145	55	37.93%	1	1
30	M	Private	170	42	24.71%	3	4
N=13		Averages:	174.62	40.15	24.67%	3.38	2.15
				Standard Deviation:		1.94	1.72
				Total # of Errors:		44	28

Pilots with fewer than 100 hours of total flight time had a total of 68 conventional flight planning errors and 27 computer aided flight planning errors, with standard deviations of 2.16 and 0.81, respectively. A large number of subjects (94%) in this category hold a student pilot certificate and have an average of 38.76 total flight hours, with approximately 8.85% of the total flight hours logged as cross country flight hours (see Table 5).

Table 5

Number of Flight Planning Errors in Conventional and Computerized Flight Plans for Pilots with Fewer than 100 Hours of Total Flight Time

Subject	Sex	Rating Held	Total Flight Hours	X-C Flight Hours	X-C Hrs. as a % of Total Flight Hours	No. of Errors in Conventional Flight Plan	No. of Errors in Computerized Flight Plan
3	M	Student Pilot	40	4	10.00%	5	1
6	M	Student Pilot	64	17	26.56%	6	1
7	M	Private	90	21	23.33%	4	1
8	M	Student Pilot	31	2	6.45%	0	2
9	M	Student Pilot	32	0	0.00%	1	3
10	M	Student Pilot	42	8	19.05%	4	1
11	M	Student Pilot	35	0	0.00%	4	3
13	M	Student Pilot	25	0	0.00%	4	1
14	M	Student Pilot	50	10	20.00%	3	1
16	M	Student Pilot	38	0	0.00%	8	1
17	M	Student Pilot	39	2	5.13%	4	1
19	M	Student Pilot	1	0	0.00%	6	3
20	M	Student Pilot	0	0	0.00%	5	1
21	M	Student Pilot	20	0	0.00%	5	2
22	M	Student Pilot	75	12	16.00%	4	2
26	M	Student Pilot	27	0	0.00%	5	2
28	M	Student Pilot	50	12	24.00%	0	1
N=17		Averages:	38.76	5.18	8.85%	4	1.59
					Standard Deviation:	2.16	0.81
					Total # of Errors:	68	27

The data are inconclusive in determining whether or not pilot experience has an effect on flight planning errors. Although the average number of conventional flight planning errors is smaller for the more experienced pilots, the average number of errors in the computerized flight plan for each group suggests pilot experience has no effect on error frequency when flight planning is computer aided. However, the increase in conventional flight planning errors in the less experienced pilot group may suggest experience has an influence on the frequency of conventional flight planning errors.

Pilots with at least 20% of total flight hours logged as cross country hours had a total of 43 conventional flight planning errors and 20 computer aided flight planning errors, with standard deviations of 2.35 and 1.37, respectively. Subjects have an average of 129.42 total flight hours, with approximately 28.63% of the total flight hours logged as cross country flight hours (see Table 6).

Table 6

Number of Flight Planning Errors in Conventional and Computerized Flight Plans for Pilots with at Least 20% of Total Flight Hours Logged as X-C Time

Subject	Sex	Rating Held	Total Flight Hours	X-C Flight Hours	X-C Hrs. as a % of Total Flight Hours	No. of Errors in Conventional Flight Plan	No. of Errors in Computerized Flight Plan
1	M	Private	150	36	24.00%	5	1
4	M	Private	113	34	30.09%	7	5
5	M	Private	200	80	40.00%	2	1
6	M	Student Pilot	64	17	26.56%	6	1
7	M	Private	90	21	23.33%	4	1
14	M	Student Pilot	50	10	20.00%	3	1
18	F	Private	174	63	36.21%	4	1
23	M	Private	240	60	25.00%	1	2
24	M	Private	107	34	31.78%	7	1
28	M	Student Pilot	50	12	24.00%	0	1
29	M	Student Pilot	145	55	37.93%	1	1
30	M	Private	170	42	24.71%	3	4
N=12		Averages:	129.42	38.67	28.63%	3.58	1.67
					Standard Deviation:	2.35	1.37
					Total # of Errors:	43	20

Pilots with less than 20% of total flight hours logged as cross country hours had a total of 69 conventional flight planning errors and 35 computer aided flight planning errors, with standard deviations of 1.87 and 1.28, respectively. Subjects have an average of 76.44 total flight hours, with approximately 7.09% of the total flight hours logged as cross country flight hours (see Table 7).

Table 7

Number of Flight Planning Errors in Conventional and Computerized Flight Plans for Pilots with Less than 20% of Total Flight Hours Logged as X-C Time

Subject	Sex	Rating Held	Total Flight Hours	X-C Flight Hours	X-C Hrs. as a % of Total Flight Hours	No. of Errors in Conventional Flight Plan	No. of Errors in Computerized Flight Plan
2	M	Private	200	15	7.50%	3	6
3	M	Student Pilot	40	4	10.00%	5	1
8	M	Student Pilot	31	2	6.45%	0	2
9	M	Student Pilot	32	0	0.00%	1	3
10	M	Student Pilot	42	8	19.05%	4	1
11	M	Student Pilot	35	0	0.00%	4	3
12	M	Private	120	20	16.67%	3	2
13	M	Student Pilot	25	0	0.00%	4	1
15	M	Private	420	40	9.52%	2	1
16	M	Student Pilot	38	0	0.00%	8	1
17	M	Student Pilot	39	2	5.13%	4	1
19	M	Student Pilot	1	0	0.00%	6	3
20	M	Student Pilot	0	0	0.00%	5	1
21	M	Student Pilot	20	0	0.00%	5	2
22	M	Student Pilot	75	12	16.00%	4	2
25	M	Private	126	23	18.25%	3	1
26	M	Student Pilot	27	0	0.00%	5	2
27	M	Private	105	20	19.05%	3	2
N=18		Averages:	76.44	8.11	7.09%	3.83	1.94
					Standard Deviation:	1.87	1.28
					Total # of Errors:	69	35

As with overall flight time, the data prove to be inconclusive in determining whether or not pilot cross country experience has an effect on flight planning errors. Although the average number of conventional flight planning errors is smaller for the more experienced cross country pilots, the average number of errors of 3.58 and 3.83 for conventional flight planning and the average number of errors of 1.67 and 1.94 for computer aided flight planning suggests cross country experience has very little effect on flight planning errors, whether it be conventional or computer aided.

How often a person uses a computer may have an effect on computer aided flight planning errors. Computer use may be considered by some to be an advantage when planning a flight which is computer aided. If another more complex flight planning program were used, computer use may prove to be an asset. However, because of the ease of use of the program used in this research project, computer use is examined to determine if flight planning is more or less prone to error for those who use a computer often.

Subjects who used a computer daily had an average error rate of 1.8 and a total of 9 errors for both conventional and computer aided methods. This may suggest that flight planning errors, either conventional or computer aided, are not a function of daily computer use. Approximately 16% of subjects used a computer daily (see Table 8).

Subjects who used a computer weekly had an average error rate of 5 when planning the flight using conventional methods and 1.5 when planning the flight using computer aided methods. Subjects who used a computer weekly had a higher conventional average error rate than those who used a computer daily. However, no appreciable difference was found in the average error rates using the computer aided method between the two groups. Approximately 30% of subjects used a computer weekly (see Table 9).

Table 8

Number of Flight Planning Errors in Conventional and Computerized Flight Plans for Subjects Who Used a Computer Daily

Subject	Sex	Rating Held	Total Flight Hours	X-C Flight Hours	Personal Computer Use	No. of Errors in Conventional Flight Plan	No. of Errors in Computerized Flight Plan
8	M	Student Pilot	31	2	Daily	0	2
14	M	Student Pilot	50	10	Daily	3	1
25	M	Private	126	23	Daily	3	1
28	M	Student Pilot	50	12	Daily	0	1
30	M	Private	170	42	Daily	3	4
N=5		Averages:	85.40	17.80		1.8	1.8
				Standard Deviation:		1.64	1.3
				Total # of Errors:		9	9

Table 9

Number of Flight Planning Errors in Conventional and Computerized Flight Plans for Subjects Who Used a Computer Weekly

Subject	Sex	Rating Held	Total Flight Hours	X-C Flight Hours	Personal Computer Use	No. of Errors in Conventional Flight Plan	No. of Errors in Computerized Flight Plan
3	M	Student Pilot	40	4	Weekly	5	1
5	M	Private	200	80	Weekly	2	1
10	M	Student Pilot	42	8	Weekly	4	1
16	M	Student Pilot	38	0	Weekly	8	1
17	M	Student Pilot	39	2	Weekly	4	1
22	M	Student Pilot	75	12	Weekly	4	2
23	M	Private	240	60	Weekly	1	2
24	M	Private	107	34	Weekly	7	1
26	M	Student Pilot	27	0	Weekly	5	2
N=9		Averages:	89.78	22.22		5	1.5
				Standard Deviation:		2.33	0.46
				Total # of Errors:		40	12

Subjects who used a computer monthly had an average error rate of 4.1 when planning the flight using conventional methods and 2.5 when planning the flight using computer aided methods. There was a slight decrease in the average conventional error rate of subjects using a computer monthly compared to those who used a computer weekly; however, a significant difference was found in the average computer aided error rates between the two groups. Approximately 33.3% of subjects used a computer monthly (see Table 10).

Table 10

Number of Flight Planning Errors in Conventional and Computerized Flight Plans for Subjects Who Used a Computer Monthly

Subject	Sex	Rating Held	Total Flight Hours	X-C Flight Hours	Personal Computer Use	No. of Errors in Conventional Flight Plan	No. of Errors in Computerized Flight Plan
1	M	Private	150	36	Monthly	5	1
2	M	Private	200	15	Monthly	3	6
4	M	Private	113	34	Monthly	7	5
7	M	Private	90	21	Monthly	4	1
11	M	Student Pilot	35	0	Monthly	4	3
12	M	Private	120	20	Monthly	3	2
19	M	Student Pilot	1	0	Monthly	6	3
20	M	Student Pilot	0	0	Monthly	5	1
27	M	Private	105	20	Monthly	3	2
29	M	Student Pilot	145	55	Monthly	1	1
N=10		Averages:	95.90	20.10		4.1	2.5
					Standard Deviation:	1.73	1.78
					Total # of Errors:	41	25

Subjects who never used a computer had an average error rate of 3.67 when planning the flight using conventional methods and 1.5 when planning the flight using computer aided methods. There was a doubling in the average conventional error rate of subjects who never used a computer compared to subjects who used a computer daily and a decrease to those subjects who used a computer weekly or monthly. However, only a slight difference was found in the average error rates between groups when using the computer aided method. Approximately 20% of subjects never used a computer (see Table 11).

Table 11

Number of Flight Planning Errors in Conventional and Computerized Flight Plans for Subjects Who Never Used a Computer

Subject	Sex	Rating Held	Total Flight Hours	X-C Flight Hours	Personal Computer Use	No. of Errors in Conventional Flight Plan	No. of Errors in Computerized Flight Plan
6	M	Student Pilot	64	17	Never	6	1
9	M	Student Pilot	32	0	Never	1	3
13	M	Student Pilot	25	0	Never	4	1
15	M	Private	420	40	Never	2	1
18	F	Private	174	63	Never	4	1
21	M	Student Pilot	20	0	Never	5	2
N=6		Averages:	122.50	20.00		3.67	1.5
				Standard Deviation:		1.86	0.84
				Total # of Errors:		22	9

Subjects who used a computer daily, as well as those who never used a computer, were able to complete the computer aided flight plan in 30 minutes or less. The data suggest that the amount of computer use had little effect on the average error rate of both conventional and computer aided flight planning methods. Subjects had few problems understanding and working with the program. Overall, the subjects became very proficient in its use.

Previous use of other flight planning programs may have an influence on the number of computer aided flight planning errors. Again, because of the ease of use of the program used in this research project, previous flight planning experience is examined to determine if previous use of a computer aided flight plan is more or less prone to error for those who have used other computer aided flight planning programs.

The data show that the two groups have very similar average error rates for both the conventional methods of flight planning, but differ significantly in average error rates for the computer aided methods of flight planning. The average error rates of those who used a computer aided flight plan were more than twice that of subjects who never used a flight planning program (see Tables 12 & 13). However, it should be recognized that only a fraction of subjects, approximately 10%, had previously used a computer aided flight plan. A larger sample and a better balance of subjects who have previously used a computer aided flight plan may help determine if there are significant differences in average error rates.

Table 12

Number of Flight Planning Errors in Conventional and Computerized Flight Plans for Subjects Who Have Never Used a Computerized Flight Plan

Subject	Sex	Rating Held	Total Flight Hours	X-C Flight Hours	Flight Plans Used	No. of Errors in Conventional Flight Plan	No. of Errors in Computerized Flight Plan
1	M	Private	150	36	None	5	1
2	M	Private	200	15	None	3	6
3	M	Student Pilot	40	4	None	5	1
5	M	Private	200	80	None	2	1
6	M	Student Pilot	64	17	None	6	1
7	M	Private	90	21	None	4	1
8	M	Student Pilot	31	2	None	0	2
9	M	Student Pilot	32	0	None	1	3
10	M	Student Pilot	42	8	None	4	1
11	M	Student Pilot	35	0	None	4	3
12	M	Private	120	20	None	3	2
13	M	Student Pilot	25	0	None	4	1
14	M	Student Pilot	50	10	None	3	1
15	M	Private	420	40	None	2	1
16	M	Student Pilot	38	0	None	8	1
17	M	Student Pilot	39	2	None	4	1
18	F	Private	174	63	None	4	1
19	M	Student Pilot	1	0	None	6	3
20	M	Student Pilot	0	0	None	5	1
21	M	Student Pilot	20	0	None	5	2
22	M	Student Pilot	75	12	None	4	2
24	M	Private	107	34	None	7	1
25	M	Private	126	23	None	3	1
26	M	Student Pilot	27	0	None	5	2
27	M	Private	105	20	None	3	2
28	M	Student Pilot	50	12	None	0	1
29	M	Student Pilot	145	55	None	1	1
N=27		Averages:	89.11	17.56		3.74	1.63
				Standard Deviation:		1.95	1.11
				Total # of Errors:		101	44

Table 13

Number of Flight Planning Errors in Conventional and Computerized Flight Plans for Subjects Who Have Previously Used a Computer Aided Flight Plan

Subject	Sex	Rating Held	Total Flight Hours	X-C Flight Hours	Computer Flight Plans Used	No. of Errors in Conventional Flight Plan	No. of Errors in Computerized Flight Plan
4	M	Private	113	34	Pan-Am Flight Plan	7	5
23	M	Private	240	60	Pan-Am Flight Plan	1	2
30	M	Private	170	42	Pan-Am Flight Plan	3	4
N=3	Averages:		174.33	45.33		3.67	3.67
					Standard Deviation:	3.06	1.53
					Total # of Errors:	11	11

Conclusions

The hypothesis of this study stated that general aviation VFR flight planning errors are greatly reduced when flight planning is computer aided. On the basis of the data presented, it was determined that in the population from which this sample was selected, errors are made more frequently in conventional flight planning methods than in computer aided planning methods. Because of these findings, the hypothesis was accepted. The data suggest that the errors associated with cross country pre-planning can be reduced significantly when computer aided. It was also found that pilot experience in the initial stages of training has little effect on conventional or computer aided flight planning errors. Similarly, subjects who had greater than 20% of their flight time logged as cross country flying performed no better than subjects who had less than 20%. It was also determined that computer use or previous use of a computer aided flight plan had little effect on error rates between the two methods of flight planning. This is primarily attributed to the fact that the computer and computer flight planning software were very easy to use and understand.

One variable that was not included in this study but was in error in the computer aided flight plan was variation; conventional flight plans had no occurrences of variation error compared to computer aided flight plans which had a 100% error occurrence. Because of the high incidence of some errors on the computer aided flight plan, such as fuel burn and variation, it is believed that the error was caused by an error in programming, something the subject had no control over. If variation were considered a variable, it is believed that most conclusions would not have differed significantly. Variation was not selected as a variable because it required no calculation or recall of important information. It is important that the author of the computer flight program take the necessary actions to correct these errors.

These experimental results may be able to determine if marked improvements in flight planning can be made by utilizing a computer flight planning program. Although both methods of flight planning provided relatively few errors, the computerized flight planning provided a much more comprehensive flight plan which included a navigation log, FAA flight plan, and VFR flight summary (see Figures 10, 11, & 12).

Although frequencies of errors between methods varied considerably, the study raises many interesting questions for future research. Could error rates be in part explained by the pilots' relative inexperience? It has been suggested that as pilots gain experience, flight planning errors are made less often; thus, frequency of errors could conceivably be a function of pilot experience. Are the findings applicable to flight students outside of Embry-Riddle Aeronautical University? Embry-Riddle has a highly structured flight program and may, in some instances, better prepare students for cross-country flying. If other computer aided flight planning programs were utilized, would the outcome be the same? Depending upon the complexity of the computer aided flight planning program and computer used, results may differ significantly. Could computer aided flight planning eliminate the risk of some general aviation accidents? Many pilots only partially plan a cross country, they forget how to calculate certain items, feel the flight is short enough to be free of hazard or, like so many pilots, count on having good weather for the duration of the flight. If a pilot can quickly process an accurate flight plan and understand the output, could cross country flying become less risky?

Computer aided instruction is by no means new, nor is it a technique restricted to certain industries. American Airlines began using computers to train its pilots as early as 1975 (Madlin, 1989). Today, pilots at American are trained with state of the art computer programs that reproduce the same buttons, switches, and steering apparatus that are found on their Boeing 767 (Hochwarter, LaVan, Mathys, & Rasmussin, 1989). Similarly, flight planners' value as a training aid and continued proficiency tool for pilots of all experience levels might well be their greatest asset for student pilots. A few hours spent with one of these packages, planning a variety of actual and theoretical flights, is analogous to using a cockpit simulator for primary flight training (Barnhart & Wiener, 1988). They are fun to work with and can give a pilot valuable insights into the fine points of aviating that might otherwise never be developed.

This study can be viewed as an initial attempt to determine if computer aided VFR flight planning is any more susceptible to error than the conventional methods used by most VFR pilots today. Aviation must move beyond the computer's computational superiority and analyze its user friendliness, clarity of instruction and usefulness, readability and reliability of its output, as well as its time-saving qualities. This study represents a first step in this direction.

Flight Plan™

VFR Navigation Log

Aircraft 388ER Blue/White Cessna 172

Plan Name Peter J McAlindon Prepared 24-Oct-89 11 40

Id	Description	Location	VAR	TC	VAR	MC	WCA	MH	DEV	CH	GS	Leg	Cum	Rem	Fuel 40 0 Used / Remain	ETE	ETA	ATE	ATA
												Distance 28 0				Depart 17 30 UTC			
Dep	NEW SMYRNA BEACH (34J) Elev 12 Rwy 4,300	N29 033 W80 569	W1 4																
				323	# #	325	E07	318		318	91	9 5	9 5	18 5	0 8 / 39 2	0 06	17 36		
1	DAYTONA BEACH DAB 35	N29 109 W81 034	W1 4																
				337	# #	338	E06	332		332	110	7 5	17 0	11 0	0 5 / 38 7	0 04	17 40		
2.	ORMOND BEACH OMN 29	N29 178 W81 068	W2 0																
3																			
4																			
5																			
6																			
7																			
8																			
				333	# #	335	E07	328		328	102	11 0	28 0	0 0	0 6 / 38 1	0 06	17 46		
Dest	BUNNELL (X47) Elev 34 Rwy 5,000	N29 276 W81 125	W1 4																
				Total or Average							100				1 9 / 38 1	0 16			

Figure 10. VFR Navigation Log Produced by the Computer Aided Flight Plan

<table>
<tr><td colspan="8">FAA FLIGHT PLAN</td></tr>
<tr><td colspan="2">1. Type</td><td>2. A/C Id</td><td>3.A/C Type/Equip.</td><td>4. TAS</td><td>5. Departure Point</td><td>6.Time</td><td>7. Alt.</td></tr>
<tr><td>X</td><td>VFR</td><td rowspan="2">388ER</td><td rowspan="2">C-172/U
Cessna 172</td><td rowspan="2">104 Kts</td><td rowspan="2">NEW SMYRNA BEACH, FL
Muni (34J)</td><td rowspan="2">17:30</td><td rowspan="2">2,500</td></tr>
<tr><td></td><td>IFR</td></tr>
<tr><td colspan="8">8. Route Of Flight
Direct-DAYTONA BEACH-ORMOND BEACH-
Direct</td></tr>
<tr><td colspan="4">9. Destination</td><td>10. ETE</td><td colspan="3">11. Remarks</td></tr>
<tr><td colspan="4">BUNNELL, FL
Flagler County (X47)</td><td>0:16</td><td colspan="3"></td></tr>
<tr><td colspan="3">12. Fuel On Board</td><td colspan="2">13. Alternate Airport(s)</td><td colspan="2">14. Pilot & A/C Home Base</td><td>15.Abd</td></tr>
<tr><td colspan="3">5:27</td><td colspan="2"></td><td colspan="2">Peter J. McAlindon
ERAU Box #8428
Daytona Beach, FL 32114
(904)257-7842
Daytona Beach</td><td>1</td></tr>
<tr><td colspan="3">16. Color Of Aircraft
Blue/White</td><td colspan="5">Close VFR Flight Plan With ________ FSS on Arrival</td></tr>
</table>

Figure 11. FAA Flight Plan Produced by the Computer Aided Flight Plan

Flight Plan™

VFR Flight Summary

Plan Name: Peter J. McAlindon Prepared: 24-Oct-89 11:40

Departure Point:

Departure Point Name:	===>	NEW SMYRNA BEACH, FL-Muni (34J)		
Departure Time:	===>	17:30	UTC	
Aircraft:	===>	388ER Blue/White Cessna 172		
Fuel Carried:	===>	40.0	Gallons	
Location (Lat., Lon., Var.):	===>	N29.033	W80.569	W1.4
Field Elevation:	===>	12	Ft. MSL	
Longest Runway:	===>	4,300	Ft.	
Field Temperature:	===>	90	°F (32.2°C)	
Field Altimeter:	===>	29.98	In. Hg	
Pressure Altitude:	===>	-43	Ft. MSL	
Density Altitude:	===>	1,918	Ft. MSL	

En route:

Route Distance: ===> 28.0 NM. Direct: 27.9 NM. Efficiency: 99.6%

Estimated Airspeed: ===> 97 KIAS (65% Power)

En route Altitude: ===>	2,500	2,000	2,500	3,000
Relative Efficiency: ===>	93.5%	85.4%	96.6%	100.0%
Wind Direction (Degrees): ===>	217	240	210	200
Wind Velocity (Knots): ===>	13	11	14	15
Temperature (°C): ===>	22.0	23.0	22.0	21.0
Fuel Consumption (Gallons/Hour): ===>	7.4	7.4	7.4	7.4
Estimated True Airspeed (Knots): ===>	104	103	104	104
Average Groundspeed (Knots): ===>	100	96	101	102
Time To Climb: ===>	0:03	0:02	0:03	0:04
Distance To Climb (nm): ===>	4.6	3.4	4.7	6.0
Est. Total Fuel Used (Gallons): ===>	1.9	2.0	1.9	1.8
Estimated Time En route (HH:MM): ===>	0:16	0:17	0:16	0:16

Destination Point:

Destination Point Name: ===> BUNNELL, FL-Flagler County (X47)

Time To Descend: ===>	0:04	0:03	0:04	0:04
Distance To Descend (nm): ===>	6.6	5.0	6.7	8.3
Estimated Time Of Arrival (UTC): ===>	17:46	17:47	17:46	17:46
Fuel Remaining (Gallons): ===>	38.1	38.0	38.1	38.2
Cruise Fuel Remaining (HH:MM) ===>	5:10	5:10	5:11	5:11

Location (Lat., Lon., Var.):	===>	N29.276	W81.125	W1.4
Field Elevation:	===>	34	Ft. MSL	
Longest Runway:	===>	5,000	Ft.	
Field Temperature:	===>	88	°F (31.1°C)	
Field Altimeter:	===>	30.00	In. Hg	
Pressure Altitude:	===>	-40	Ft. MSL	
Density Altitude:	===>	1,799		

Figure 12. VFR Flight Summary Produced by the Computer Aided Flight Plan

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Appendix A

Description of Introductory Flight Courses

AS 180 Basic Navigation

The course is designed to develop the knowledge and skills necessary for the safe execution of cross-country flying through the practical application of basic aircraft navigation methods. Upon successful completion of this course, the student will be proficient in preflight planning of VFR cross-country flights and be knowledgeable of the in-flight procedures to smoothly execute the planned flight. The student will also be introduced to IFR flight planning and the conduct of an IFR flight.

AS 255 Aeronautics II

The course is designed to provide a study and review of the operations, regulations, and procedures necessary to perform competently as a Commercial Pilot. Subjects include: complex and multi-engine aircraft operations, advanced weight and balance computations, and cross-country planning, meteorology, FAR, AIM, and other flight publications. Study includes a discussion of precision flight maneuvers required for Commercial Pilot Certification. At the completion of this course, the student will be prepared to take the FAA Commercial Pilot Written Examination.

AS 256 Aeronautics III

The course is designed to provide a study of the techniques, procedures, and regulations pertaining to instrument flight in the National Airspace System. Topics include: attitude instrument flying, navigational equipment and facilities, the airway system, and air traffic control procedures. At the completion of this course, the student will be prepared to take the FAA Instrument-Airplane Written Examination.

Appendix B

Aircraft Performance Information

Model: 1985-172P Skyhawk

Speed	
Top Speed at Sea Level:	123 kts
Cruise, 75 percent power:	120 kts
Rate of Climb at Sea Level:	700 fpm
Service Ceiling:	13,000 ft
Takeoff	
Ground Run:	890 ft
Over 50 ft Obstacle:	1280 ft
Stall Speed	
Flaps Up, Power Off:	51 kts
Flaps Down, Power Off:	46 kts
Fuel Capacity	
Standard:	40 gal
Gross Weight:	2407 lbs
Empty Weight:	1433 lbs
Useful Load:	974 lbs

Cruise Performance

Pressure Altitude Ft	RPM	20°C Below Standard Temperature %BHP	KTAS	GPH	Standard Temperature %BHP	KTAS	GPH	20°C Above Standard Temperature %BHP	KTAS	GPH
2000	2500	-----	-----	-----	76	114	8.5	72	114	8.1
	2400	72	110	8.1	69	109	7.7	65	108	7.3
	2300	65	104	7.3	62	103	6.9	59	102	6.6
	2200	58	99	6.6	55	97	6.3	53	96	6.1
	2100	52	92	6.0	50	91	5.8	48	89	5.7
4000	2550	-----	-----	-----	76	117	8.5	72	116	8.1
	2500	77	115	8.6	73	114	8.1	69	113	7.7
	2400	69	109	7.8	65	108	7.3	62	107	7.0
	2300	62	104	7.0	59	102	6.6	57	101	6.4
	2200	56	98	6.3	54	96	6.1	51	94	5.9
	2100	51	91	5.8	48	89	5.7	47	88	5.5

Source: *1985 Cessna 172P Skyhawk Information Manual*