NASA Technical Memorandum 73292

Development and Evaluation of a Prototype In-Flight Instrument Flight Rules (IFR) Procedures Trainer

J. B. Aaron, Jr.

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National Aeronautics and Space Administration

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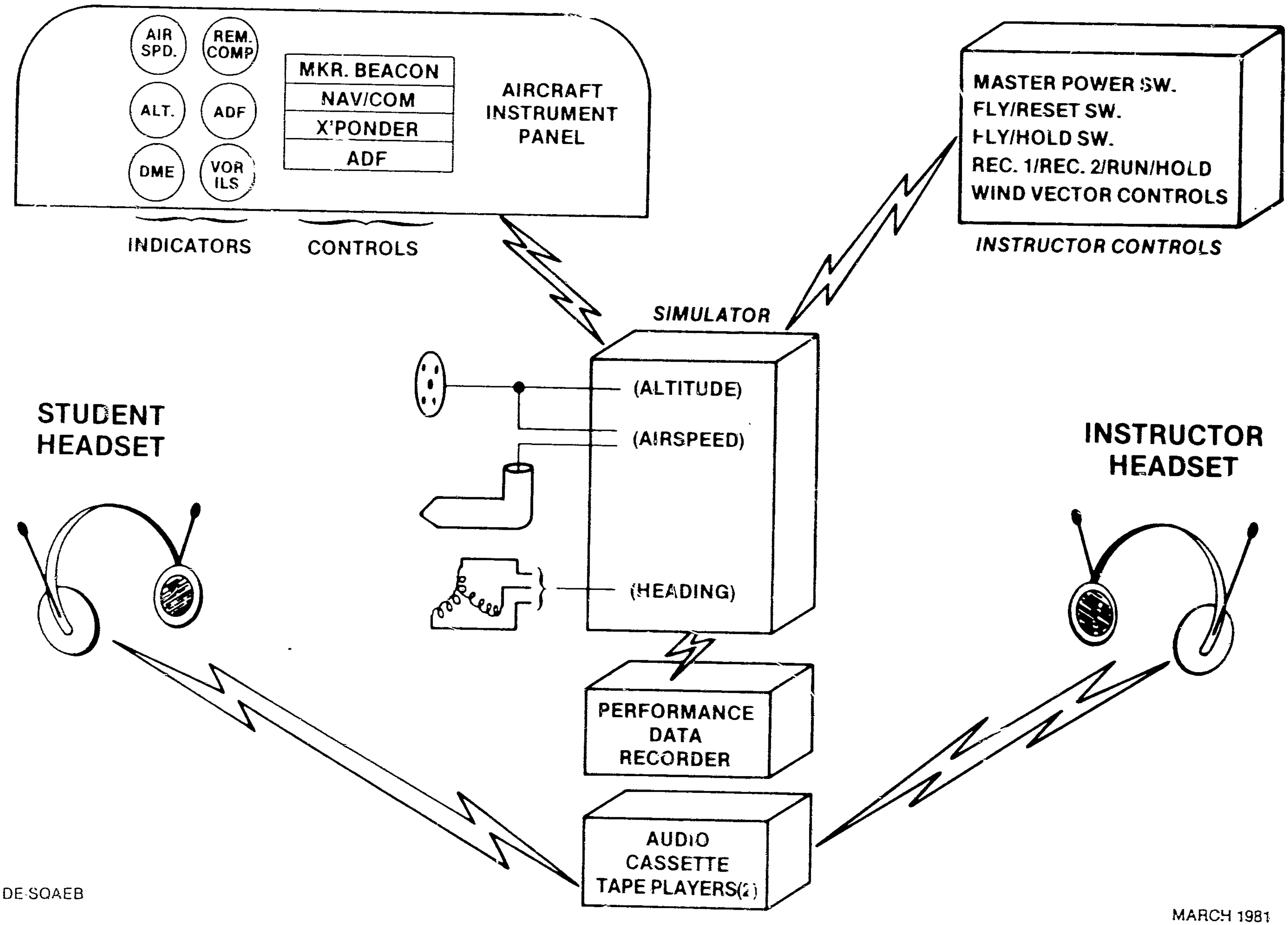
NASA

WALLOPS FLIGHT CENTER
WALLOPS ISLAND, VIRGINIA

IN-FLIGHT IFR PROCEDURES SIMULATOR



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CONTENTS

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DEVELOPMENT AND EVALUATION OF A PROTOTYPE IN-FLIGHT INSTRUMENT FLIGHT RULES (IFR) PROCEDURES TRAINER

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SUMMARY

The National Aeronautics and Space Administration (NASA), Wallops Flight Center (WFC), Virginia, has developed an In-Flight Instrument Flight Rules (IFR) Procedures Trainer capable of providing simulated indications of instrument flight in a typical general aviation aircraft independent of ground based navigation aids. The IFR navaid related instruments and circuits from an ATC 610J table top simulator were installed in a Cessna 172 aircraft and connected to its electrical power and pitot-static systems. The benefits expected from this hybridization concept include increased safety by reducing the number of general aviation aircraft conducting IFR training flights in congested terminal areas, and reduced fuel use and instruction costs by lessening the need to fly to and from navaid equipped airports and by increased efficiency of the required in-flight training. The technical feasibility of this concept was successfully demonstrated by NASA in test flights at WFC. Embry-Riddle Aeronautical University (ERAU) of Florida, under contract with WFC, evaluated the operational feasibility of this concept by flying IFR procedures training flights in this aircraft at their Daytona Beach facility. Results of their preliminary study indicate the in-flight simulator to be an effective training device for teaching IFR procedural skills and one well received by a representative sample of general aviation student and instructor pilots.

INTRODUCTION

General aviation pilots have traditionally received training leading to their instrument flight certification by using ground based table top simulators to learn basic attitude and instrument navigation procedures, followed by flight with an instructor pilot for exposure to actual cross-country and terminal area conditions. Both of these methods of training have proved less than totally satisfactory.

The table top simulators are both economical and safe and have the additional advantage of permitting the instructor to autonomously control the selection, sequence, and repetition of the training exposure unconstrained by either weather or traffic.

Another advantage of ground simulators is the capability to interrupt or "freeze" the training so as to allow the instructor to provide critical feedback information to the student in a timely, safe, and relaxed manner.

Despite these and other advantages, a number of limitations have been reported in the use of ground training devices. One of the more serious for general aviation pilot training is attitudinal and concerns the inability or unwillingness of students to take seriously the capabilities of the device to condition critical skills which will transfer to the aircraft. This tendency to treat the device as a toy can seriously degrade training because poor piloting techniques and procedures acquired in the use of the device will almost certainly transfer to the aircraft. There also has been much resistance within general aviation to the replacement of flying time with ground trainer time. Many students trained by fixed based operators (FBO's) feel that their training dollars should be applied to training in the "real thing" even if it means that such training is ultimately more expensive. Finally, ground training devices have acquired some disrepute on the basis of their lack of physical fidelity to the aircraft. The feeling persists among many training personnel that use of a device that does not produce kinesthetic, vestibular, tactual, visual, aural, and control cues exactly like those experienced in the aircraft will result in inferior training.

The advantages of instruction in a real aircraft after the student pilot has mastered the preliminaries of instrument flying by means of a ground simulator are obvious. It is generally agreed that for general aviation (normally low hour) pilots, actual exposure to real world conditions is essential. However, with escalation of fuel and instruction costs, terminal area congestion, and air traffic control complexity, the use of traditional in-aircraft training with actual ground-based navigation aids is accompanied by increasingly severe economic penalties and safety risks, while at the same time constraining the flexibility and control by the instructor of the training activity.

Attention to the problems inherent in the use of terminal area navigation aids for training was heightened by the collision involving a Cessna 172 on such a training flight and a Boeing 727 air carrier at San Diego in 1978. This event provided stark emphasis to the risks associated with the mix of general aviation aircraft performing training and commercial aircraft at busy terminal areas. The Federal Aviation Administration (FAA) subsequently proposed the creation of navaid equipped reliever airports to ameliorate the problem. Such facilities will be costly to build and maintain and will not be available to general aviation pilots in many areas of the country.

CONCEPT

It was thought by engineers at NASA WFC that for instrument navigation training the apparent advantages of ground based simulators (i.e., more flexible and efficient use of training time and safety of operations), and the generally accepted advantages of in-flight training (i.e., real physical cues and actual flight) could be advantageously combined by a hybridization of the two traditional methods.

This concept involved taking the IFR navaid-related instruments and circuitry from a table top simulator and installing them in a typical general aviation trainer aircraft. They were to be interconnected such that actual flight air speed, altitude, and heading information would control the operation of the simulator and the resulting IFR navigation instrument indications presented to the student pilot.

The instructor/safety pilot was to occupy the right seat with the student, wearing a vision restricting visor, occupying the left seat as in normal IFR training. Also considered was the possible use of such an aircraft by an IFR rated pilot flying alone to perform refresher training. An aircraft equipped with such an in-flight simulator could thus be used to conduct IFR procedures training independent of any ground-based navigation aids.

TECHNICAL FEASIBILITY

Hardware Adaptation

Preliminary examination of the concept indicated it to be potentially feasible. To verify this conclusion, hardware was procured from which an operational prototype system could be configured. A popular and relatively inexpensive general aviation table top simulator, an ATC 610J, manufactured by Analog Training Computers of West Long Branch, New Jersey, was obtained.

To accomplish the original intent of having the simulator respond to actual flight parameters, two pressure transducers were added to the simulator with their inputs connected to the aircraft pitot-static lines. From these transducers analog voltages proportional to the altitude and air speed of the aircraft were connected to the appropriate circuits of the simulator. An electrical slaved directional gyro having a synchro output was similarly connected through a servo repeater to the simulator circuitry to provide inputs analogous to actual aircraft heading. Numerous other electrical and mechanical modifications were made to the hybridized configuration, including the necessary power supplies to make the unit compatible with the electrical buss of the aircraft. Thus, the circuitry and components of the ATC 610J required to produce IFR flight information on the simulator panel instruments were extracted, modified, and repackaged on a shock-mounted platform for eventual installation in a test-bed aircraft.

The ATC 610J panel instruments and controls required to perform and produce instrument indications of simulated IFR flight were removed from the table top unit, modified as necessary, and prepared for installation in the aircraft instrument panel. In addition, an instructor's control box containing appropriate switches and lights to permit the desired operation of the in-flight simulation equipment was designed and built. At this time it was decided to plan for the installation of this equipment in a Cessna 172 aircraft, a popular and typical general aviation trainer.

Bench Testing

The extracted and modified equipment described above, including the added slaved directional gyro, was first assembled for operational checks in a laboratory at WFC. A field type pitot-static calibration set was used to provide simulated air speed and altitude inputs to the system, thus allowing initial operation, trouble shooting, and design improvements to be accomplished.

Since the original simulator was intended to represent an arbitrary general aviation aircraft, it was necessary to edit the original training scenario air traffic control voice tapes to make them time compatible with the different flight performance of the Cessna 172. Repeated flights with the hybridized simulator in the laboratory through each of the four standard ATC flight training scenarios verified the accuracy of the edited tapes. It was further demonstrated that, significantly, the new system was fully capable of successfully performing all of the IFR procedures inherent in the original ATC 610J.

Installation in the Aircraft

During this time period a contract was awarded to ERAU to perform a study of the in-flight IFR Procedures Trainer to evaluate student training effectiveness, pilot acceptance, and potential benefits of using the Wallops in-flight simulator compared with training as previously conducted by ERAU. After the successful completion of the bench tests at Wallops, the in-flight simulator equipment was shipped to the contractor's facility at Daytona Beach, Florida, for installation by them in one of their Cessna 172 trainers. A plan for the general placement of the in-flight simulator equipment in the aircraft had been worked out earlier.

To remain within budget and schedules the IFR related panel instruments and controls were installed by ERAU in available, though in some cases non-standard, locations in the instrument panel of the selected aircraft. The instructor's control box was mounted in the right side of the panel. The slaved directional gyro and its flux valve transmitter were installed in the normal fashion. The basic simulator circuitry and related components plus two audio cassette tape recorders and a digital data recorder were installed in place of the removed rear passenger seat.

The input connections of the air speed and altitude transducers were made to the pitot-static tubing, the two audio cassette tape recorders were connected to the aircraft intercom, and the simulator was connected to the aircraft electrical power buss. As installed, the prototype equipment package occupied four cubic feet, weighed 140 pounds, and fully operational consumed 130 watts of electrical power. After completion of this installation, the aircraft was flown to WFC for operational readiness checks and flight verification.

Operational Verification

After arrival of the aircraft at WFC, preliminary operation checks and calibrations of the system were successfully completed on the ground. Using a NASA pilot and an engineer from the design team, initial in-flight testing was begun. It was intended that each of the four original ATC training scenarios, which together involve the full scope of normal IFR flight procedures, would be flown successfully and repeatedly before the system would be considered ready for return to the contractor for their evaluation. During these initial flight tests minor modifications were made to improve system capabilities, and final calibrations such as altitudes over outer and middle marker beacons during the ILS approaches were completed. Following this, each of the four training scenarios was flown successfully on repeated occasions, and the system was considered to be fully operational.

During this period of flight testing several innovations planned in the design of the in-flight system were operationally verified. One of these involved the capability to begin a training scenario at any selected altitude so as to perform all subsequent IFR procedures, such as ILS approaches, at a safe height above the ground. This was accomplished by connecting the reference side of the differential pressure transducer controlling the simulator altitude circuits through an instructor actuated solenoid valve to the aircraft static port. The active side of this transducer was connected directly to the same port. This permitted the aircraft to be flown to the training area with the valve open, and upon reaching the selected altitude closing the valve, causing the static pressure at that altitude to be "clamped" as the reference pressure for the transducer. Thus, the training could begin at any chosen altitude, which to the simulator would appear as the field elevation of the airport runway specified for the start of the scenario. For safety reasons the aircraft altimeter remained directly connected to the static port in the normal manner and always read height above sea level. The changes necessitated as a result of this feature were notations on the training approach plates to adjust them for the altitude selected for reference, and similar changes to the appropriate scenario voice tape call-outs. For the evaluation to be conducted by ERAU at Daytona Beach, an altitude of 1,000 feet for this "runway in the sky" was agreed upon for all scenarios. Approach plates and voice tapes were modified to reflect this agreement.

A second idea was addressed to the possibility of conflict between the orientation of the desired training area and that of the selected scenario. In such a case the instructor has the option of rotating the slaved directional gyro so as to in effect rotate the scenario orientation to coincide with the training area. This can also be done during the scenario as different legs are flown. While the gyro will slave back towards its original alignment, the rate is slow enough so as to not significantly affect the training lesson.

Finally, the simulated winds capability of the ATC 610J was included with the extracted circuitry installed in the aircraft. The controls for this function were mounted in the instructor's control box. The reasons for including this capability were two-fold. The instructor can use the simulated winds input to have the student fly a realistic ground track if desired (though this is not necessary), or he can use it to offset the effects of real winds to keep the aircraft within the training area. Each of the ideas discussed above was verified as practical in flight tests.

Also at this time, the functioning of the two audio cassette tape recorders and the digital data recorder were operationally tested successfully. One of the audio cassette recorders was used to play the scenario tape over the aircraft intercom during the lesson. The second audio recorder was used to record the instructor-student conversations and the scenario being played for post-flight evaluation. The instructor's control box contains switches to permit the starting and stopping of either audio recorder during the flight, which together with the "fly/hold" switch on the control box, can be used to either stop the scenario tape, or "freeze" the simulator at the existing position in the flight, so as to permit correction if the student's flight progress has not kept pace with the scenario events.

The digital data recorder was provided to record parameters of interest for post-flight analysis. As configured in the prototype system, sixteen parameters, including air speed, altitude, heading, ADF bearing, DME indication, selected settings of the instructor's control box switches, outer and middle marker beacon lights, localizer and glide slope needle deviations, simulated wind direction and velocity, "to/from" flag on the VOR, the X and Y coordinates of the aircraft in the scenario, and a timing channel were scaled, calibrated, and recorded at a choice of scan rates, usually every two or five seconds. The data recorder in the aircraft, the separate data cassette reader unit, and the associated software were operationally verified after reducing the data resulting from several flights involving different scenarios.

Prior to returning the aircraft to the contractor, invitations were extended to several organizations concerned with general aviation to examine the in-flight simulator at WFC. Representatives of GAMA, AOPA, FAA, and NASA Langley Research Center responded and were given flight demonstrations following which their comments on the prototype system were solicited. The reactions to the concept and its potential advantages were unanimously favorable. Representatives of the ATC 610J manufacturer also examined the in-flight system and expressed much interest in the hybridization concept.

Having demonstrated the capability of the in-flight simulator to perform all IFR functions inherent in the original ground-based unit, the technical feasibility phase of the project was complete. The aircraft was then flown back to Daytona Beach for the contractor's evaluation phase.

OPERATIONAL FEASIBILITY

Purpose

The two major thrusts of the ERAU evaluation effort were concerned with the effectiveness of the in-flight simulator as a training device to teach IFR procedure flying, and its acceptance by a representative sample of general aviation student and instructor pilots.

Approach

To evaluate the system, ERAU employed three groups of subjects from their university consisting of ten beginning students, ten advanced students, and five certified instrument flight instructors. Of the twenty students, five from each group were trained on an ATC 610J table top simulator and five from each group were trained with the in-flight simulator. The five instructors flew only the in-flight simulator. The beginning students had completed no more than ten, and the advanced students had completed at least thirty hours of dual IFR flight instruction. Beginning students flew one scenario four times, and advanced students flew each of the four scenarios once. Both groups of students were scored by means of the same scoring forms, according to the same criteria as were all other test subjects, and completed subjective questionnaires.

The instructors were asked only to supply subjective answers to questionnaires and were not scored on their abilities to fly particular maneuvers, but rather to observe the capabilities of the in-flight simulator. Each instructor flew two of the four scenarios and also practiced simulated IFR approaches to one of the six programmed airports of the in-flight simulator. The instructors also flew the aircraft as instructors, practice teaching the project flight instructor as they would their own students using that equipment.

Training effectiveness was evaluated through student pilot performance as rated on the standardized scoring forms. The results from these forms, taking in account the specific conditions of the testing, were statistically analyzed and reduced. The acceptability of the in-flight simulator concept and system hardware was determined by examination of the responses by the student and instructor pilots to the standardized questionnaire.

Results of ERAU Evaluation

The analysis by ERAU of the results of the scoring forms for both the beginning and advanced student pilot groups indicates that the prototype in-flight simulator is as effective a trainer as an ATC 610J, the results indicating a slight superiority in favor of those trained with the in-flight unit.

The analysis of the responses to the questionnaires indicated a generally very favorable acceptance of the concept and equipment by both the student and instructor pilots. While there were some specific comments regarding the disadvantages of the in-flight simulator as viewed by the test subjects, these disadvantages were recognized by the Wallops design team early on and accepted in light of budget and schedule constraints. The majority of these comments concerned the ATC voice tapes, non-standard location of the panel instruments, and the inability of the training aircraft to fly actual IFR conditions. It is believed by the design team that most of the mentioned problem areas can be rather easily remedied. Both student and instructor pilots agreed that the in-flight simulator would be valuable in a pilot training program.

The summarized results of the student scoring forms and questionnaire responses from all test subjects are presented in the Appendices.

CONCLUSION

As a result of the foregoing effort is has been demonstrated successfully that the concept of simulating IFR indications on panel instruments in a general aviation aircraft, independent of any ground-based navigation aids, is technically feasible. The operational feasibility of the in-flight simulator, that is its training effectiveness and acceptance by expected users, has also been verified.

It should be borne in mind that the in-flight IFR simulator concept was intended to supplement, not supplant, the traditional ground-based and flight training in IFR procedures. The potential of the concept to save fuel, time, and instruction costs, as well as to increase the flexibility and efficiency of the training experience make the idea very attractive.

Perhaps the greatest benefit inherent in this concept, however, is its potential to significantly reduce the risks associated with traditional IFR flight instruction conducted at congested terminal areas. With the ability to conduct such training in any conveniently located low traffic area the danger of mid-air collisions is minimized. With the ability to select any training scenario the "I own the airport" idea is realized with attendant benefits in both improved safety and flexibility of training.

While the prototype system used in this study had technical and asthetic limitations because of cost and time constraints, these are in most cases easily correctable. Other recommendations from the ERAU study, such as the ability to use the aircraft for either simulated or real IFR flight, were early considered for inclusion in a possible state of the art follow-on system. Second generation equipment incorporating digital rather than the current analog circuitry and programmable microprocessor technology would not only overcome the more significant limitations raised, but would provide the opportunity for substantial improvements as well.

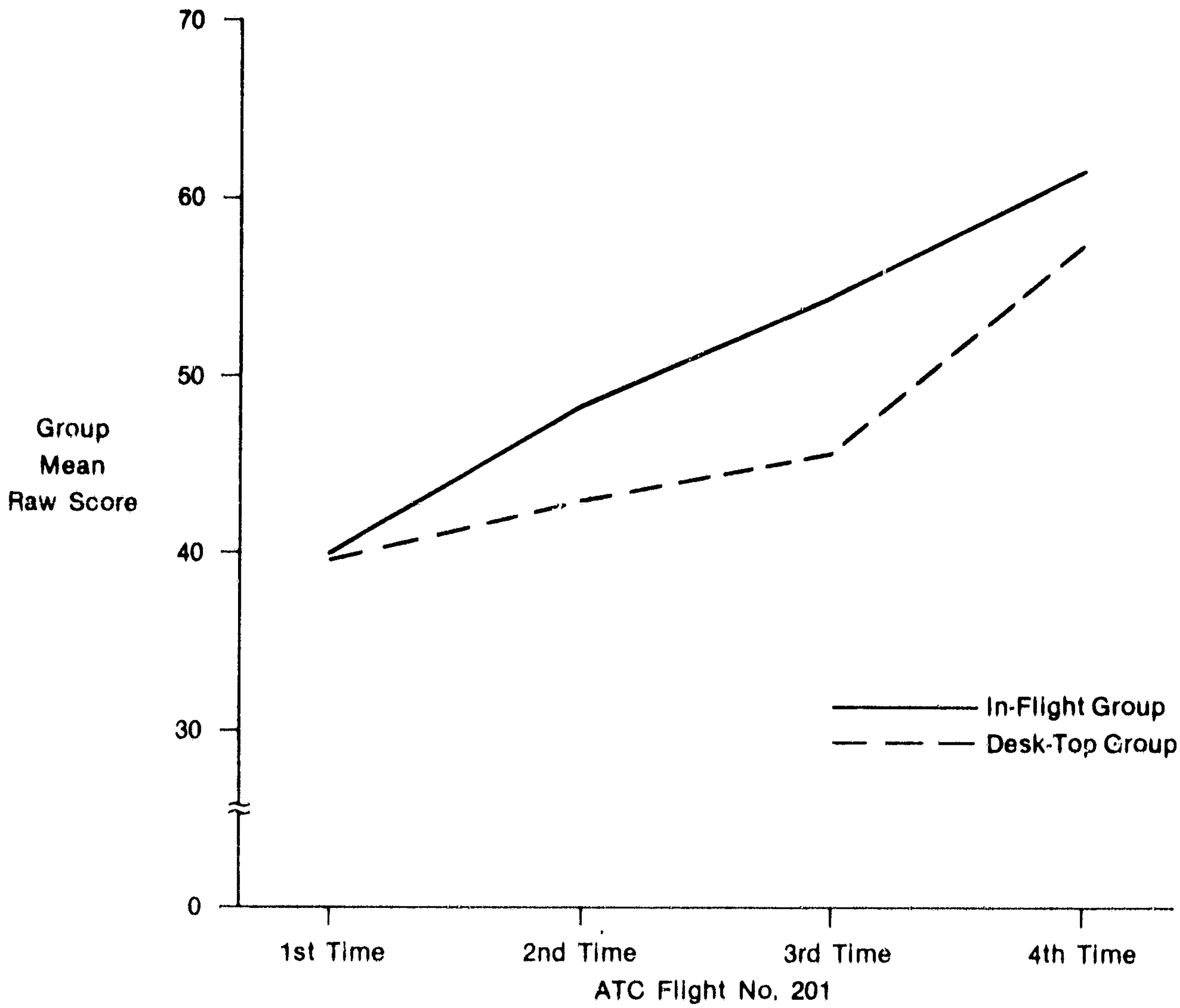
With the digital microprocessor approach, the ability to use standard IFR panel instruments in their standard locations for both real or simulated IFR flight becomes possible. The "plug in, plug out" suitcase sized equipment would not require dedicated aircraft for such training. With a programmable processor, a library of pre-recorded cassettes or manually entered programs would permit an unlimited selection of scenarios involving either real or designed terminal area and cross-country situations. Synchronization of air traffic control voice tapes with actual flight progress could be achieved with the X-Y coordinate position of the aircraft in the scenario triggering appropriate voice tape instructions at predetermined threshold distances. With such a system the flexibility and efficiency of use would be essentially limited only by the ingenuity of the user. For training operations larger than the typical FBO, formally developed curricula would appear desirable. Benefits additionally expected from using the newer technology would include smaller size, lighter weight, reduced energy demands, and lower costs.

As a result of this study it was found that the innovative nature of the concept, the uniqueness of the prototype hardware configuration, and the many ramifications of its possible applications and potential benefits have created much interest in the various segments of the general aviation community which have been exposed to it.

APPENDIX A

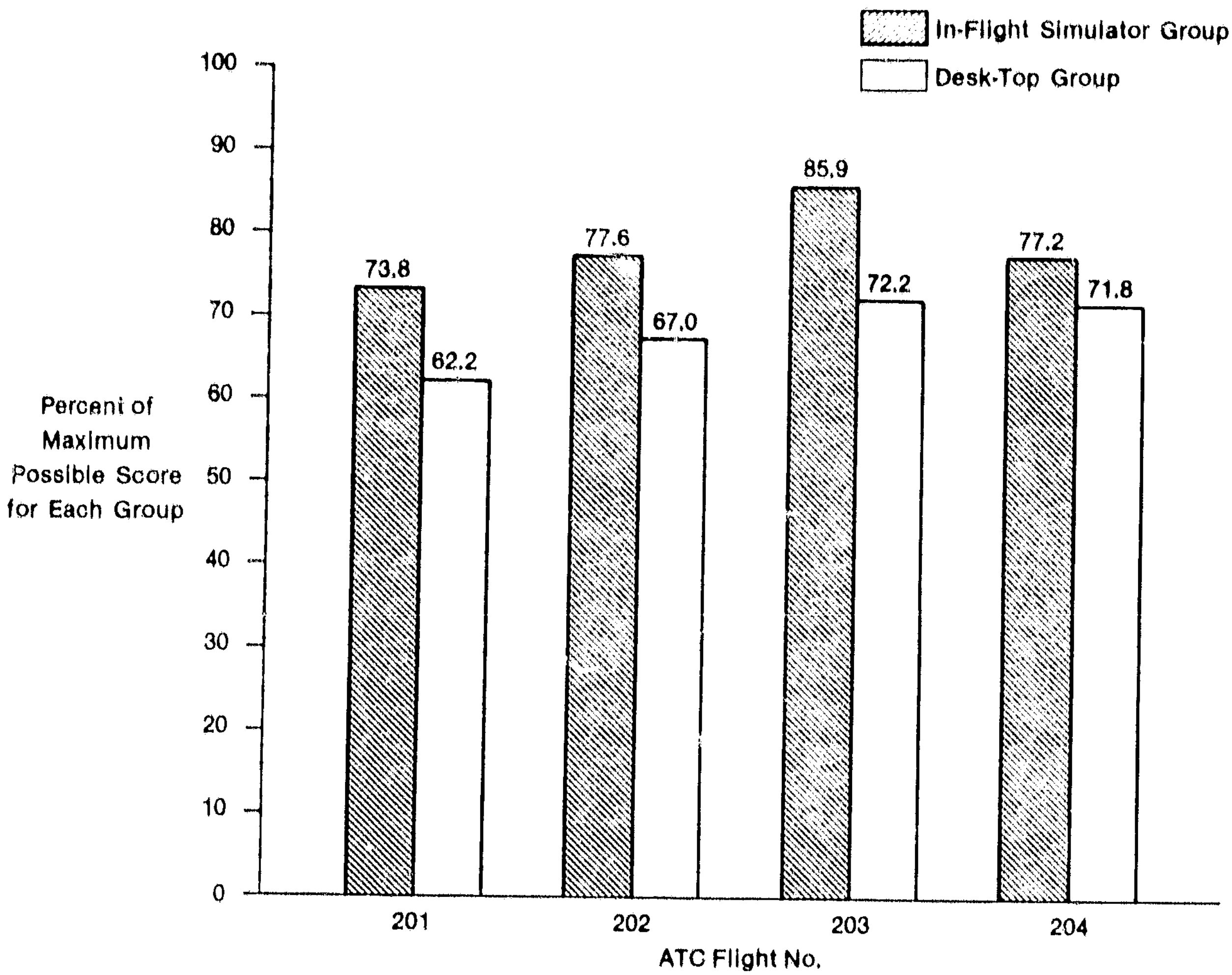
SUMMARIZED RESULTS OF SCORING FORMS
AND
RESPONSES TO MULTIPLE CHOICE QUESTIONS

BEGINNING STUDENTS



(Each Beginning Student Flew Flight 201 Four Times)

ADVANCED STUDENTS



(Each Advanced Student Flew Each ATC Flight One Time)

MEANS AND STANDARD DEVIATIONS OF RESPONSES TO MULTIPLE CHOICE QUESTIONS: STUDENT AND FLIGHT INSTRUCTORS

STUDENTS

Please rate each of the following aspects of the in-flight simulator on a scale of 1 to 4, where:

1 = not at all
2 = a little bit
3 = moderately so
4 = very much so

The in-flight simulator's:

	$\overline{X}$ +	SD	N
1) Ease of use	3.5	0.50	10
2) Usefulness in teaching you IFR skills	3.8	0.40	10
3) Usefulness in practicing IFR skills	4.0	0.00	10
4) Scenario realism	3.5	0.50	10

INSTRUCTORS

Please rate each of the following aspects of the in-flight simulator on a scale of 1 to 4, where:

1 = not at all
2 = a little bit
3 = moderately so
4 = very much so

The in-flight simulator's:

	$\overline{X}$	SD	N
1) Ease of use	3.6	0.49	5
2) Usefulness in teaching IFR skills	3.6	0.80	5
3) Usefulness in maintaining IFR skills	3.6	0.80	5
4) Ability to transfer IFR skills to an aircraft	3.2	0.75	5
5) Potential for large-scale future use	3.2	1.17	5
6) Potential to compliment desk top simulation training	3.2	0.98	5
7) Potential to compliment in-flight training	3.4	0.80	5

\+ $\overline{X}$ = Mean

SD = Standard Deviation

APPENDIX B

RESPONSES TO INSTRUCTOR QUESTIONNAIRE
(OPEN-END QUESTIONS)

RESPONSES TO INSTRUCTOR QUESTIONNAIRE: OPEN-ENDED QUESTIONS

Please answer each of the following questions as completely as you can. (Use the other side of the page if you need more room).

Question 8) How would you use the in-flight training program?

Response No. 1) The in-flight simulator is very useful in coordination with a ground trainer program. The instrument procedures should first be established in some type of ground trainer. Once these habit patterns are set the student should be transitioned into the in-flight. This method would probably benefit the student and reinforce the learning process.

No. 2) Only in areas where instrument facilities were not available or in congested areas where wait times were excessive.

No. 3) First of all, I would of course, be certain that the student understood the basics of instrument flight in order for him to benefit the most from the in-flight trainer. After reaching an acceptable level of performance during basic attitude maneuvers and knowledge of IFR procedures, I would introduce him to an actual flight using the in-flight simulator. Basic VOR and ADF Tracking should also be accomplished in this simulator since it would preclude the need for a high altitude flight when the stations are a great distance away. The in-flight simulator could be used continuously at this point or at least until the student is ready for the actual cross-country.

No. 4) I would use this to supplement or, in some cases, replace, a large part of current simulator work. The in-flight is the ideal way to convert from the simulator to the real environment, and could handle the transition from basic instrument flying, (best done on the ground), to full IFR operation. (See no. 10).

No. 5) There are of course a good number of ways the simulator could be employed effectively in any kind of instrument training program. It might be best, however, to identify specifically the training objectives of each individual course and/or program before attempting to identify how the simulator is going to be employed. However, a few comments could be made keeping in mind our standard or traditional objectives; i.e., introduction to instrument techniques and procedures, instrument pilot certification, advanced instrument course, instrument instructor course and instrument refresher for rated pilots. I believe that the in-flight simulator could be an effective tool in each one of the courses just identified.

9) How would you maximize student learning in the in-flight simulator?

1) By creating a realistic IFR environment with communication tapes and variety of approaches in different terminal areas. A training program should not consist of only a few local approaches that a student can memorize. More cross-country IFR flights should be implemented into the actual in-flight training program, including delays, holding, terminal approaches, missed approaches, and continuation to alternate.

2) Simplified to complex IFR routings with realistic ATC tapes. The routings would be over long distances for flight planning purposes, but shortened through the use of the computer.

3) As previously stated in question 8, be sure he has a knowledge of the instrument flight system along with the skills to control the aircraft by instruments. The student should be thoroughly briefed as to the operation of the simulator. This should include the differences between a simulator flight and an actual flight in an aircraft other than the in-flight trainer. Also, he should be briefed as usual prior to the flight on the route, approaches, and runways, etc., of destination airport.

4) By using the device exactly as a real aircraft, operating in the IFR environment. In other words, treating the in-flight as an integral part of route and approach training, without differentiating the simulated radio aids from the real thing. For this to be achieved, some of the criticisms below must be corrected.

5) It would appear to me that the in-flight simulator provides a unique opportunity to apply the laws of exercise, intensity, and effect to the instrument training program in a way which has heretofore been unavailable to the instructor. The simulator makes it possible to expose the student to a wider variety of approaches and procedures than would otherwise be possible. It allows the instructor to make efficient utilization of the time by repeating approaches or immediately transitioning from one approach to another approach, and it allows the student of course the opportunity to be successful in a variety of situations. However, all three of these laws would only be applicable if specific lesson plans were provided that would allow the instructor to know in advance which approaches to use and how to use the approaches and/or the instrument procedures in a given lesson plan. I do not believe that the tape lessons are of particular value on any of the basic flight courses that were identified in answer to question number 8. However, the tapes might have some enrichment value to the advanced student or even to the student who is completing the instrument flight course. Even then I am really not sure that the tapes as they presently stand are particularly valuable. My suggestions for the most effective utilization of the devices would be to introduce the student to the procedure and/or technique in the ATC 610 on the ground, allow the student to fly the procedure and/or technique there and then, once

Answer #5 Cont.

the student has demonstrated satisfactory performance, allow him to transition and repeat the same procedure in the in-flight simulator. The number of procedures flown and/or techniques could be gradually expanded so that more and more activities are included in any one given flight.

10) In what sequence would you use the in-flight simulator in a flight training program?

1) Procedures should be introduced and executed in a ground trainer including basic attitude flying. Once the student has developed these IFR habit patterns, he or she should apply what was learned in-flight. This will decrease cost and increase the learning process in-flight. First teaching the terminal procedures, then enroute, and finally, a complete cross-country would probably be the most effective method.

2) After basic attitude training and during procedure training.

3) I would introduce it after the student has shown the ability to control the aircraft with reference to instruments. The in-flight simulator could be used for this, but another aircraft would seem more appropriate due to management reasons. VOR and ADF tracking and all navigation should be done next, using the simulator. From this point the student could be introduced to the glide-slope as if it were merely another nav. aid. The student could follow the glide-slope and practice using the correct attitude to maintain a centered needle. Next I would have the student track to a nav. aid and execute an approach without the use of the cassette tape. Finally he should be ready to use the tape and fly an entire cross-country.

4) a. Basic Instrument flying and aids work on ground.
   b. In-flight simulator work until competent IFR Standard achieved in the air.
   c. Real IFR operation up to check ride.
   The in-flight would replace the last half of ground simulator work and the first half of air work.

5) I believe my answer to number 9 already suggests the answer to question number 10. My feeling is that the most effective sequence would be one that provided for a flight lab experience with a mock up from there to a desk to trainer/simulator such as the ATC-610 from there to the in-flight simulator and from there to the real world exposure of an airplane operating within the air traffic control system.

11) In your opinion, what are the in-flight simulator's advantages?

1) Its ability to introduce the student to a variety of terminal and cross-country environments with programmable software. Safety is a very large asset to this program because training can be conducted away from high volume traffic areas. It is important to still simulate the terminal area and comply with ATC procedures in a high density traffic area.

2) Aircraft flight feel used during rapid turnover approaches.

3) Its greatest advantage is its ability to save the student money. You are never very far from a navigation facility which cuts down on flight time. The approaches and other navigation practice can be conducted in an uncongested environment. Busy airports and ground nav. facilities can be avoided. If a cloud or an approaching aircraft require you to turn, you do not have to completely abandon the approach, just cage the directional gyro and turn as desired. The in-flight idea gives the student the feel of an actual aircraft.

4) Versatility; ease of operation, realism. Being able to shoot approaches in unused airspace away from traffic, and in a carefully controllable manner.

5) Seems to me the in-flight simulator has a number of rather obvious advantages, some being in the operational area and some being in the training area. In the operational area the major advantages are the simple ability to expose the student to a variety of instrument procedures and techniques while actually operating outside the uncontrolled air space. The training considerations are extensive. One, I can expose a student to a wider variety of situations within the IFR environment that would otherwise be impossible, two the instructor can make more effective use of the time in the airplane.

12) In your opinion, what are the in-flight simulator's major disadvantages?

1) There are really no major disadvantage in this type of training as long as the student gets an opportunity to fly an actual cross-country with approaches. The introduction of the actual or real environment is important in this type of training. This in-flight simulator is a tremendous teaching aid and requires a person that understands how to utilize it properly.

2) a. Having to use an airplane for simulator work that ties up aircraft panel space for instrumentation.
b. Bulk.
c. Cost.

3) a. If the system is not thoroughly explained to the student, he may be confused with some of the procedures differentiating it from an actual IFR flight.
b. I think the instruments, especially the comms. should be arranged so as not to confuse the student as to what is real and what is simulator.
c. The tapes should be developed with a little more activity to provide a more realistic flight.

4) The non-standard presentation of control heads and displays. These are difficult to use and unrepresentative. The DME display is almost useless for accurate flying. In addition, the simulators avionics preclude a standard IFR set. Thus, operation is limited to VFR. This is a shame because a great benefit would be realized if a student could "dry run" a trip immediately, before flying it for real. For this to be possible, the software must be adaptable to the local environment of the user. It is not clear if this is presently possible.

Of a more specific nature:
a. The ILS glide-slope is far more sensitive than real life.
b. The wind control is useless, with unrepresentative drift which often works in an incorrect sense.

The ideal general solution is where the simulator output is directly hooked into the real instrument displays on the aircraft (ILS, ADF, DME). Also, as no transmissions are actually made on the com., there is no reason why a real com. head cannot be used to simulate frequency management more realistically. The other com. box would be used for VHF monitoring.

c. I would dispense with the tapes. In this way, the student and instructors could concentrate on the flying. High radio workload can be introduced, if required, by the instructor. Anyway, the real environment will provide this later in the training.

d. The lack of a chart display, which is a major advantage of ground simulators; a flight log would really help for analysis of a flight.

5) The major disadvantage of the simulator as it presently stands is, I think, the limitations that it puts on the utilization or the flexibility of the airframe itself. The considerable investment that would be required to outfit the airplane with the simulator as it presently stands would, I believe, not be cost effective to the average airplane operator, in that the airplane would be limited in the way it could be used. However the development of the microprocessor just may have a positive effect on this disadvantage. A second disadvantage of the simulator I felt was the unrealistic aspect of the tapes themselves. Again, in order to take maximum advantage of the tapes you would need a very closely controlled situation whereby the student would have the opportunity to listen to himself in the presence of the instructor and whereby the instructor gave immediate feedback and debrief the student on his performance. This of course would be very effective but I am not sure it would be a very efficient way to teach a student how to fly the airplane in instrument conditions. There are a couple of changes that would make the simulator more widely accepted in the training community.

- Development of a smaller computer, one smaller light weight.

- The development of more realistic tapes for in-flight simulator situations for the advanced pilot or the refresher course or for simply enrichment of the beginning instrument pilot.

- The development of a specific lesson plan that would provide for skill or task orientated activities with each lesson.

13) What changes would you make to improve the in-flight simulator as an instructional aid and an aid to IFR pilot skill maintainance?

1) The in-flight simulator has to be designed in a realistic aspect. It must have identifiers for all navigation facilities. Communication tapes for ATIS, TWEB, Sigmets, Airmets should be received by the nav. radios. The radios should be up to date equipment and all displays legible. The student should be able to get feedback on performance by viewing a plot of the approaches or cross-country flight.

   Overall, this project is very useful in solving the problem of training flights in very high density traffic areas and also expands the knowledge of instrument students by not concentrating on one local environment.

2) a. Have similar ATC tapes in ground simulators.
   b. Reduce Bulk.
   c. Enable aircraft instruments to be used as actual or simulated.

3) First of all, I would arrange the instruments so as to differentiate between the instructors real instruments and the simulator instruments. By this I mean a clear division such as a divider.

   The head sets are very impoitant also. If they are not used, then the radio hand-held microphone should be usable in the system. Maybe a switch to put it into the simulator comm.

   I would like to see the tapes set up in order to provide an increase in difficulty. For example, demanding more reports to be made by the student as he progresses. They might alter his course, enter him into an unexpected holding pattern or make various estimates as to arrival, etc.

   The instructor should have he ability to cause an instrument malfunction. This could sharpen the student as to an erratic glide-slope needle, for example.
   It might be advantageous to program the simulator to use local approaches and navigation facilities in this area along with a variety of other areas.

4) a. Standardize displays to real aircraft specifications.
   b. Make the simulator compatible with a full IFR fit in the aircraft.
   c. Increase versatility of radio area coverage by having different software for individual uses.
   d. Incorporate a flight log display. Miniature logs already on the market could easily fit on the back seat of an aircraft. The flight path could then be discussed on the ground during debriefing.
   e. Incorporate failure modes for the instructor's use.

Answer #4 Cont.

Most of these items could be achieved by using some of the more sophisticated table top simulators on the market as the basis for the in-flight.

APPENDIX C

RESPONSES TO STUDENT QUESTIONNAIRE
(OPEN-ENDED QUESTIONS)

RESPONSES TO STUDENT QUESTIONNAIRE: OPEN-ENDED QUESTIONS

Please answer each of the following questions as completely as you can. (Use the other side of the page if you need more room).

Question 5) What aspects of the in-flight simulator, if any, were distracting and/or unrealistic?

Response No. 1) The ATC clearances.

2) a. ATC request/responses (understandable).
   b. Some instrument arrangements (position in cockpit) sometimes made a scan difficult.

3) The mechanics of the simulator are very good, but using a background tape is unrealistic. Timing was off in a few instances, which was confusing.

4) Sometimes it is hard to keep VFR when flying the cross-countries (clouds).

5) None.

6) On the ILS I found it easy as it is not possible to simulate the low level turbulence associated with the final stages of the approach.

7) The only unrealistic aspects that I found were the ATC tapes. At times, when the tape didn't work right the scenario realism was lost a little. Perhaps better tapes or recorders might provide a better effect.

8) The tapes needed to be sped up a bit. The ideas and incidents in the tape seem actual, except the people are talking too slow. It's like they are making a tape instead of actual conditions. With practice, I think this problem can be eliminated.

9) No parts of the in-flight simulator were unrealistic. In fact, it provided an environment in which IFR flight could be handled on a professional basis.

10) The tape recordings could have been a little more realistic.

6) What did you like most about the in-flight simulator?

1) It gave me the extra time I needed to fully understand instrument approaches.

2) a. The variety of instrument work that could be done and its ability to nearly fit into reality.
   b. Practical for practice.

3) Sensitivity was strong, which, I feel teaches one to be gentle with the aircraft. Also it seemed very realistic in all phases of the flights.

4) One can set up an instrument approach anywhere. It saves time, and the approach can be stopped at anytime and restarted in case an explanation is needed during the approach. The tape helps to make one listen for call numbers.

5) Saves time, fuel, and delays; it also gives perfect simulation of instrument flying.

6) The ability to freeze the approach and receive instruction, and then complete the approach with proper technique.

7) The fact that it worked just like you would find in a real IFR environment. The approaches and enroute flying all seemed real enough to cause me anxiety if something was going wrong.

   The idea behind the in-flight simulator is very sound. Proper instrument training requires not only knowledge of what is going on, but also practice. With the simulator in a flying environment, the student will really get the chance to practice instruments as well as his flying skills. The performance of the student can be measured directly as he is in an actual flying situation.

8) Time and money saved. The whole concept. The fact of being able to fly on actual aircraft to imaginary aerodromes only minutes from your home base. The instruments performed perfectly. If I would not have known I was flying a simulator I would have expected to see a runway at my DH or MDA.

9) Mostly its ease of use, and being able to use it anywhere without the aid of ground and/or airport facilities. A perfect instructing tool for student instrument pilots in large metropolitan areas.

10) No pressure from Controllers, or having to copy clearances quickly. Trish Westover is a big help, because she took her time in explaining things and when to do certain things at different times. She is a very good instructor.

7) What did you dislike most about the in-flight simulator?

1) Nothing. Overall I thought it was pretty good.

2) The set-up of the panel was sometimes difficult to scan, and I was sometimes distracted by the delays on the tape.

3) Background tapes.

4) Sometimes the tape would be off from the flight.

5) Nothing.

6) As I am working for my instrument rating presently, I could not possible state any dislikes. I don't have enough instrument time to derive good or bad points, only accept them.

7) The instruments and markings on the front instrument panel should be cleaned up. A better installation would help out visually, and with the acceptability of the simulator.

8) When it was actual IFR you could only do localizer approaches, thus not getting full usage of the aircraft. You could use the simulator in VFR only.

9) I have no dislikes.

10) Nothing!

8) What changes would you make to the in-flight simulator to improve it?

1) It should be programmed for more airports.

2) No major changes, or minor changes either, really need to be made. It just takes getting used to.

3) None.

4) More ATC radar vectors on tape less cross-country and more approaches and holding patterns.

5) None.

6) If the simulator was to be deployed on a scale the size of ERAU's, I don't feel it would be satisfactory as you would have aircraft "shooting" approaches at random; which might pose more of a safety hazard than a busy terminal airport.

7) The only change I would make would be to dress up the front instrument panel for easier use. The mechanics of the simulator seemed to work fine and I was very pleased with its function.

8) Install a functional ILS head (so it could be used more even in actual). Make tapes more realistic.

9) Increase the workload on the pilot so that every flight minute will be more of a stress related operation-such as certain situations in actual IFR.

10) I think the course worked out pretty good; I wouldn't change anything!