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INSTRUCTOR AND STUDENT PILOTS' SUBJECTIVE EVALUATION OF A GENERAL AVIATION SIMULATOR WITH A TERRAIN VISUAL SYSTEM

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SUMMARY

Airplane simulators previously tests for use as trainers for General Aviation pilots have been fairly simple devices. Few of these simulators have provided motion, and none have displayed terrain that would be visible through the windscreen. The NASA General Aviation Simulator located at Langley Research Center with its visual display, motion base, and landing aid display was considered to be a useful tool to investigate the applicability of such a sophisticated device to the private pilot training curriculum. Each of ten student pilots flew a 1-hour session simulating a training session that they might receive in an airplane and, subsequently, gave a qualitative evaluation of the value of the session to their training program. The students' instructors (3) were also allowed to evaluate the simulator in a somewhat similar fashion. The instructors then commented on any noticed improvement of the students after their next regular flight. The students and instructors generally felt that the maneuvers best suited for the simulator were: landing approaches, level flight, climbs, dives, turns, instrument work, and radio navigation. They recommended that the simulator would be very useful in introducing the student to new maneuvers before doing them in flight. They recommended that about 8 hours of simulator time could be used profitably in a private pilot course. The follow-up flight evaluation of the student by the instructors generally indicated a positive effect of the simulator session.

INTRODUCTION

In terms of the number of fatal accidents per aircraft hours flown, General Aviation has the poorest record of any transportation mode. According to the National Transportation Safety Board statistics for 1975, General Aviation had approximately one fatal accident for every 100,000 aircraft hours flown. This is approximately 20 times that of the certified air carriers. Therefore, government and industry alike are continually seeking methods to reduce the general aviation accident rate. One method of current interest for reducing the accident rate is the use of ground based trainers (synonymously called simulators, flight trainers, flight duplicators, or synthetic trainers) in the training and certification of private pilots.

Most of the general aviation pilot training research conducted thus far has been directed toward the use of these devices for either instrument or radio navigation procedural training. Many of these studies involved a study of the possible transfer ratio when the ground trainer was substituted maneuver for maneuver with the airplane for certain phases of the flight (refs. 1-4). Other studies explored the use of such devices for pilot certification checks (refs. 5-7). There have been very few studies which analyzed the possible use and effectiveness of a more sophisticated simulator incorporating such features as visual display, motion, and a complicated mathematical model of the aircraft dynamics.

There are several questions which should be raised concerning the suitability of sophisticated trainers to general aviation pilot training, such as (1) Can they be used effectively in general aviation pilot training? (2) What tasks or maneuvers are better suited for the simulator and which are not? (3) How important is high fidelity of simulation in relation to teaching effectiveness at the private pilot training level? (4) What degree of transfer exists for selected pilot tasks between the simulator and corresponding aircraft? (5) Of what value and application are such special devices as visual display, motion base, and landing-aid displays in private pilot training simulators? (6) Finally, will the particular ground trainer being considered be cost-effective as a training device? The recently developed NASA General Aviation Simulator offered an appropriate research platform for studies that could address some of these questions.

This paper presents the results of a preliminary study which used a total of four FAA certified instructors and ten of their currently active student pilots. The students were given a 1-hour instructional period in the simulator by one of the authors and a follow-up lesson in the airplane by their own instructor. The instructors were given a 1-hour session similar to the instructional period given to their students. The instructional material covered in the simulator corresponded to that material which would be covered in their next training session. The results of these tests are entirely subjective consisting of student and instructor comments concerning the simulator training session and instructor comments concerning their following airplane session. Although this study could not be expected to find answers to the above listed questions, it was expected to provide some insight into some of these areas of ground based general aviation training.

METHODS AND EVALUATION PROCEDURE

The method of approach used in this study consisted of the selection of ten students currently enrolled in a course of pilot training leading to the private pilot certificate. Each subject selected received approximately 1 hour of dual instruction in the NASA simulator based on the maneuvers listed in Appendix A. This maneuver checklist was modified for each subject to correspond to the material that the student would receive in his next regular lesson. The maneuvers usually involved taxiing, takeoff, approaches and landings, climbs, descents, level cruise, various turning maneuvers, slow speed (high angle of attack) including stalls, and flight by reference to instruments.

Prior to the simulator session, each pilot was briefed as to the purpose of the instruction period and given a description of the simulator, how it operated, and the maneuvers that he would execute. One of the special features incorporated in this simulator was a head-up landing aid display referred to as LASI. Since these pilots had never used such a display, the LASI was described to the student as to the information that could be derived from it and how normal piloting techniques could be used with it.

Subsequent to each simulator session, the Student/Pilot Evaluation Form (Appendix B) was filled out by each test subject to record his or her reactions to the simulator, its special devices, and other related factors appropriate to objectives of the study.

Each flight instructor whose students participated as subjects in the study also flew the simulator performing all maneuvers and tasks given to the students. The instructors also filled out the evaluation form. Following the simulator session, the student's flight instructor conducted the next regular lesson in sequence and the instructor was interviewed on any observed changes in students' performance which, presumably, resulted from the instruction in the simulator.

The simulator characteristics were subjectively evaluated by the student and instructor pilots in each of three major categories: simulator realism, flying characteristics, and special devices. This evaluation involved rating the various simulator components and characteristics with a four point rating scale consisting of, in adjective form: "excellent," "good," "fair," and "poor." An "excellent" qualitative rating corresponded to a numerical value of one and a "poor" rating corresponded to a numerical value of four (see Appendix B for a full description). In most cases the ratings were plotted in histogram format for each item rated. However, for the flying characteristics group the 14 maneuvers (Appendix B, item B) were divided into seven groups based upon the similarity of the maneuvers. This breakdown is indicated by the letters A through G in the appendix. The histograms for these seven maneuver groups were the average of one or more maneuvers. Therefore, fractional numbers of responses will be obtained.

Simulation Facility and Equipment

The simulation facility incorporated four separate pieces of equipment; a digital computer, a simulated general aviation aircraft cockpit, a visual landing display system (VLDS), and a special graphics computer. The graphics computer was used to simulate the special head-up display referred to as LASI.

Computer.- A CDC 6600 computer was used in this study. The equations of motion required 7 milliseconds of computer time and were updated 32 times a second. Analog signals associated with the cockpit and VLDS were interfaced with the computer by means of analog-digital conversion units. Digital signals were transmitted directly to the graphics computer from the 6600 computer.

The simulation program was broken down into subprograms. The main program controlled the flow of the calculations and the real-time sequencing with subprograms used for aerodynamic, power plant, landing gear, navigation, VLDS drive signals, and motion base computations. The simulated airplane typified a single engine, high wing airplane that is used in private pilot training.

Cockpit.- The simulator typified a general aviation cockpit and was mounted on a two-degrees-of-freedom motion base. Figure 1 is a photograph showing the layout of the cockpit. The cockpit was arranged so that it could be operated either as a single or twin engine airplane but for this study only the single engine configuration was employed. The display instruments were representative of those found in general aviation airplanes equipped for instrument flight. The flight controls used by the subjects consisted of control wheel, rudder pedals, throttle, and a switch for electrically operated flaps. Trim controls were provided for pitch, roll, and yaw. Audio cues were provided for engine and airstream noises and stall-onset warning.

The motion base on the cockpit (fig. 2) provided motion in pitch (-7 to 13 degrees) and roll (±12 degrees). The computer program scaled the drive signals for dynamically positioning the cockpit. The motions (ref. 10) were of the type that wash out any steady attitudes and provide only onset cues of pitch and roll rate; however, steady accelerations (longitudinal or lateral) cues were provided by slowly tilting the cockpit until the appropriate component of earth's gravity vector was obtained.

The control feel system and the motion system had a few problems associated with them, due to the newness of the simulator. The control feel system had a force hysteresis of about 1 newton. Thus, the control forces felt like those of a twin engine aircraft. The motion system had a slight bump every time a motion reversal occurred. However, it was assumed that these problems would not seriously affect the results of the tests.

The visual scene through the windshield was presented to the pilot on a color TV monitor that was viewed through a beam splitter and spherical mirror arrangement which produced a virtual image focused at infinity. This system provided a visual scene of unit magnification to the pilot with a total field of view of 36 degrees vertically and 48 degrees laterally. This field of view provided a fairly reasonable forward view for normal level flight and limited maneuvering but was inadequate in accommodating peripheral vision, particularly for abrupt maneuvers. There was no provision for a side window scene which would be very useful for most traffic pattern and ground reference maneuvers.

VLDS.- The terrain model (fig. 3) of the VLDS was used at a scale of 1:750 which provided a visual scene of 13.8 by 4.5 kilometers and a maximum altitude of 0.9 kilometers. The airport (fig. 4) used for the takeoff and landing practices had two runways each 45 meters wide and 1500 meters long.

A color TV camera was positioned over the terrain model by a cart drive system (see fig. 3) in response to computer signals that placed the camera's optical head-lens system at the scaled position of the aircraft. The optical head also rotated in pitch, roll, and yaw to present the changing angular relationships that the pilot would see out the front window.

The scaled maximum drive cart velocities of 148 knots were well within the flight speeds of general aviation airplanes being simulated. The optical head of the camera had a travel of 75 degrees in pitch (50 degrees down and 25 degrees up), and 360 degrees in roll and yaw. The maximum attitude rates of the optical head were also in excess of the rates needed for the simulation of general aviation airplanes (better than 220 degrees per second). The color TV camera produced a standard picture with 510 scan lines at a frame rate of 30 per second.

Graphics Computer.- The graphic computer was used to generate a TV compatible image of the LASI head-up display and also generate a cloud scene that was intended to give the pilot a visual reference when flying at high pitch attitudes when ground reference was lost.

Vector plotting was performed by the graphics computer on a CRT display with a repetition rate of 40 times per second. The CRT display was viewed by a TV camera and the resulting TV signal was electronically mixed with the VLDS TV signal and displayed to the pilot.

Landing Site Indicator.- The LASI was used in this program because results of reference 8 and an unpublished NASA report suggested that the LASI might be applicable to the training of pilots from the standpoint of helping both the students and instructor evaluate the landing performance.

The LASI consisted of five elements (fig. 5): the α, β-index, the normal visual scene out of the windshield. The α, β-index was movable and responded to angles of attack and sideslip. In effect, it graphically presented to the pilot the airplane's velocity vector which, when compared with the visual scene of the landing area, indicated the aimpoint used for controlling the landing approach. The α, β-index was used to tell the pilot if he was going to be short of the runway (index below the runway, fig. 5c), overshoot the runway (index above the runway, fig. 5a), or if he were on a flight path that would place him at the beginning of the runway (index superimposed on the beginning of the runway, (fig. 5b). The approach reference represented the angle of attack that should be used during approach. If the α, β-index coincided with the approach reference, the airspeed would correspond to the recommended approach speed. The digital airspeed display provided a direct head-up presentation of the velocity in knots. The airspeed readout always moved with and stayed inside the index. The long reference line at the bottom of this display corresponded to the angle of atack where stall began.

The pilot's task was to establish the appropriate flight path by placing the α, β-index over the beginning of the runway and to maintain the proper airspeed by also placing the α, β-index on the approach reference line. This task did not require the students to develop any new flying techniques but was an aid to give them some anticipation in determiming when to make control inputs.

Student Subjects

Subjects for this study were selected from students and instructional staff of a nearby commercial flight school.

The student subjects in the study were selected on the following criteria: (1) they must be enrolled in a course of instruction leading to the private pilot certificate; (2) they must be actively receiving instruction as indicated by having received an instructional period within the preceding 30 days; and (3) they must consent to the specific requirements of the study and complete a questionnaire, a sample of which is included as part of Appendix B.

Ten student subjects participated in this study and comprised a broad cross section of age and experience level in flight training as evidenced by the following ranges: (1) There were two female and eight male subjects; (2) prior flight experience ranged from 0 to 86 flight hours; (3) there was a fairly even distribution of students in each phase of the private pilot course; (4) two of the subjects had prior simulator experience, but none had flown a simulator comparable to the NASA simulator; and (5) the students generally represented a broad cross section of age, educational, and professional backgrounds, although no exact statistical information was collected on these aspects.

Flight Instructors

The instructional staff utilized in this study consisted of one of the authors who served as the simulator instructor along with three flight instructors. The FAA qualifications and general experience of all the instructors are included in table I.

Each flight instructor was given a thorough briefing on the purpose and procedures of the study and continuous liaison was maintained throughout the study in order to maintain efficient and effective coordination in scheduling and planning of the subjects' instructional periods. The flight instructors also flew the simulator and responded to the same questionnaire utilized for the students. Each instructor was interviewed at the conclusion of the simulator session and subsequent to the next flight lesson given each student.

RESULTS

Simulator Characteristics

Simulator Realism.- The students and instructor pilots evaluated the realism of the simulator for nine specific characteristics. Figure 6 is a summary of the realism ratings for each characteristic. In general, the ratings of the students and instructors were fairly high and very close to each other, with the students' ratings about one quarter rating level higher than the instructors. The biggest disparities in this trend between the student and instructor ratings were associated with the three items rated the lowest: control feel, motion, and visual.

The control feel was rated the lowest of all the realism factors. The pilots stated that the controls felt too heavy for a single engine airplane. This comment was expected and we do not think that it had much of an influence on the other ratings. The pilots also mentioned that the control sensitivity and/or responsiveness was too great resulting in an overcontrolling of the simulator. This overcontrol could be due to the lack of acceleration cues. The special features of motion and visual system will be discussed in the section on special devices.

Flying Characteristics.- The pilots evaluated the flying characteristics for 14 types of maneuvers (Appendix B) that are used in the private pilot course. The night flying response was dropped because of the lack of opportunities to use it. For presentation (fig. 7), the 14 maneuvers have been combined into seven groups; therefore, some fractional responses will be noted due to the averaging of those closely related maneuvers. On the average, the pilots rated the simulator between excellent and good. As in the case of simulator realism, the students and instructor ratings were very close to each other with the students rating the flying characteristics slightly higher than the instructors by less than one quarter of a rating point.

The largest disagreement between student and instructor ratings was concerning the high angle of attack flying characteristic. Comments of the pilots indicated that the instructors were relying more on visual references for these maneuvers, whereas the students were using instruments more. The limited visual references at high pitch attitude and the lack of peripheral vision appeared to be more significant to the instructors; consequently, they gave lower ratings to these maneuvers than did the students.

The one characteristic that the instructors rated higher than the students was in instrument flight. This could possibly be due to the students' confusion with the roll attitude indicator and possibly the lack of an adequate scan pattern by the students; see comments under follow-up flight evaluation. In the simulator the roll attitude scale was fixed on the outer edge of the instrument and the pointer moved beneath it. In the airplane that the students had been flying, the pointer was fixed on the outer edge of the instrument and the scale tick marks moved beneath it.

Special Devices.- Separate evaluations were made by the pilots for the three special devices of the simulator; the virtual image display, the motion base, and the LASI. Each device was rated for various flight maneuvers since it was assumed that different maneuvers would cause the special device to be used to a different extent.

The evaluation ratings for the visual display are summarized in figure 8 for four phases of flight. Basically the students and instructors rated the visual scene very consistently between excellent and good with the students rating it slightly higher than the instructor by less than one-third of a rating point.

A significant portion of the comments dealt with the quality of the display, especially at altitudes of about 400 meters or at distances of over 4 kilometers. Under these conditions the picture sharpness had decreased to a point that it was noticeable and to some degree bothersome. This lack of sharpness was not a problem of focus, but apparently due to a lack of detail or resolution which may be a result of the raster line width.

Another pilot comment was the desire for an expanded field of vision to include at least the left window. This would help for traffic pattern work at the airport, ground reference operations, and high pitch attitudes where forward visual scenes are lost over the airplane's nose. In addition, it would give the instructor at least a partial view of the outside world. In the present simulator only the pilot can view the visual scene due to the infinity optics.

The pilots evaluated the simulator's motion for six phases of aircraft operation (fig. 9). In general, the overall evaluation of the motion system was rated as good with the students slightly higher than the instructors by almost half of a rating point. This represents the greatest difference between the students and instructors. Most of the down rating of the motion system was due to a jerkiness in the roll motion which was caused by hardware problems which could not be fixed for these tests. In addition, the pilots considered that the "G" forces for turns, stalls, and landings should also be included in the motion cues.

The closest agreement between the students and instructor pilots was obtained in their evaluation of the LASI head-up display (fig. 10). The LASI was flown by only seven students and two instructor pilots. Their average evaluation was halfway between excellent and good with a difference of less than one-tenth of a rating point between the students and instructors. On crosswind landings, it was noted that sometimes the crab angle required during the approach displaced the LASI symbology off to one side of the runway making the sighting more difficult. The pilots recommended that the approach reference lines be extended to alleviate this problem. The instructors thought that the display would be a good training aid to use in some phases of the students' training.

Training Applications

The pilots also subjectively gave opinions as to which maneuvers they considered to offer the greatest benefit and least benefit to them as students. In addition, they were asked which maneuvers they considered to be important and included in a simulation training syllabus of a simulator. This question was asked because all of the pilots did not have the opportunity to fly all of the maneuver groups in their session.

Figure 11 presents the number of student responses of these maneuver groups. Half or more of the students considered that approaches and landings, instrument work, and the in-flight maneuvers should be included in any ground trainer syllabus. Student comments generally recommended that a ground trainer be used for learning the basics and to introduce new material to the student before they perform it in actual flights. The students recommended that about 8 hours of ground simulator time could be used profitably in a private pilot course.

Due to the low number of flight instructors involved the data were not graphed. The instructors' recommendations were very similar to the students' comments. In addition to the student recommended maneuvers, they recommended that stalls and radio navigation should be included in a ground trainer syllabus. They also considered the trainer to be important in introducing new material at the start of each learning block or maneuver group and important for teaching the procedure related to these maneuvers. Two instructors recommended that 4 to 7 hours; and one over 12 hours of ground trainer time, could be devoted to pilot training. No opinions were obtained as to whether these ground trainer hours should reduce the number of flight hours needed to qualify as a private pilot.

Follow-Up Flight Evaluation

Following all of the simulator sessions the instructors were given time to conduct the next lesson with their students and then the instructors were questioned about the students' performances in light of the simulator session.

One instructor considered that his two students showed a significant improvement in cross-check of the instruments.

Another instructor considered that his student showed improvement in his instrument scan, was smoother with the controls, and had a better awareness of the airplane as a result of the simulator session.

The last instructor observed that one of his students showed improved confidence in aircraft control, more smoothness with the controls, and an increased accuracy in all operations. Two students showed no apparent improvement as a result of the simulation session. One of these two students had a variety of flight experience while in the military service and was considered by his instructor to be an above average student before the simulator session. However, the student did comment that he thought that he did learn a significant amount from the simulator session. The other student was judged by both the flight and simulator instructors to have a negative attitude about the simulator instruction.

A fourth student was an interesting subject because he had not received any formal flight instruction in an airplane prior to the simulator session. His flight instructor commented that he thought that the student learned as effectively in the simulator as in the airplane with the exception of learning about corrections of torque and "P" factor during climbs and descents. As a result the student was able to proceed into the next lesson's material with a minimum of repeat instruction.

SUMMARY OF RESULTS

The results of these preliminary tests can be summarized as follows:

(1) The simulator was generally rated the same by the student and instructor pilots, generally with a "good" rating.

(2) The follow-up instructor evaluation generally indicated a positive effect of the simulator session. Improvements were noted in their instrument scan, smoother use of the controls, and a general improved familiarity with the airplane.

(3) All of the pilots stated that motion of the simulator was important in the training.

(4) In some areas fidelity was considered important, such as details in the instruments, functioning engine instruments, proper representation of control stick forces and even using the same cockpit complexity of the aircraft being represented. However, some areas such as using a simpler math model to represent the airplane were not addressed. Further work in this area should be pursued.

(5) The students and instructors estimated that about 8 hours of simulator time could profitably be used in a private pilot course. Subjectively, from the experimenter's point of view, the teaching benefits of the simulator were directly proportional to the student's enthusiasm toward the simulator and although only one simulator instructor was used, the effectiveness could also depend upon the instructor's attitude toward the simulator.

(6) The maneuvers which were recommended by the students and instructors as best suited for the simulator were: landing approaches, level flight, climbs, dives, turns, instrument work, and radio navigation. Operations involving high angle of attack such as minimum controlled airspeed, stalls, and landing flare would require an expanded peripheral field of view to be satisfactory. Both the students and instructors thought that the simulator would be an efficient means of introducing the student to new maneuvers before doing them in flight.

(7) Most of the students and instructors stated that the LASI head-up landing aid was a definite help during landing and that it would be a good aid in teaching students the dynamics of the landing approach.

In conclusion, it should be stated that we did not make a cost to benefit analysis of this sophisticated simulator in this limited study. However, this will be a strong influence on a final recommendation of the type of simulator (if any) that could be profitably (financially and learning) utilized in private pilot training.

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TABLE I

INSTRUCTIONAL STAFF

SIMULATOR INSTRUCTOR:

- FAA Certificated Flight Instructor: Airplane single and multi-engine land, instrument airplane

  FAA Designated Pilot Examiner

  2500 hours flight instruction

FLIGHT INSTRUCTORS:

- FAA Certificated Flight Instructor: Airplane single

  2220 hours flight instruction

- FAA Certificated Flight Instructor: Airplane single and multi-engine land, instrument airplane

  2000 hours flight instruction

- FAA Certificated Flight Instructor: Airplane single and multi-engine land, instrument airplane

  500 hours flight instruction

APPENDIX A

SIMULATOR FLIGHT MANEUVERS

CHECK LIST

Date ______________

Pilot ______________

A. Ground Operations

___ 1. Taxi straight

___ 2. Taxi turns

___ 3. Use of brakes

☐ With visual

☐ With LASI

☐ With motion

B. Takeoffs

___ 1. Normal no flaps

___ 2. Short field

___ 3. Soft field

___ 4. Cross wind

C. Normal Maneuvers

___ 1. Straight and level - cruise

___ 2. Climb - V_X 65 MPH

___ Climb - V_Y 82 MPH

___ 3. Descents - clean

Descents - flaps @ 40°

4. Turns

___ Straight rate - 3°/sec $90/180^{\circ}$

___ Medium bank - 30° bank $90/180^{\circ}$

___ Steep - 60° bank 360°

___ Coordination - 30° bank 45° duration

5. Climbing and descending turns

___ Climbing

___ Descending

D. Slow Speed/High Angle of Attack

1. Minimum control airspeed

___ Straight and level - clean

___ Straight and level - full flaps

___ Straight and level - climb V_Y

___ Straight and level - descent 500 ft/min

___ Turns 15° bank

2. Stalls*

a. Approach

___ Power off flap up

___ Full flaps 1500 RPM

b. Takeoff

___ Full power

c. Accelerated

___ Straight @ 1700 RPM

___ Turn @ 45° bank and 2000 RPM

d. Cross controlled entries

___ Slip - 15^{o} bank 1700 RPM

___ Skid - 15^{o} bank 1700 RPM

*Recoveries will be executed at (1) first physical indication; (2) after "break"; (3) after nose falls through level flight attitude.

3. Spins

___ Enter with 1700 RPM reduce power after 1/2 turn

E. Ground Reference

___ 1. 720^{o} turns about a point

20 knot wind component

___ 2. Figure 8's across a road

20 knot wind component perpendicular to road

F. Approaches and Landings

___ 1. Normal @ 75 MPH

___ 2. Short field @ 65 MPH

Full flaps

___ 3. Cross-wind

15 knot wind @ 45^{o} to runway

Crab method

Slip method

G. Instrument Flight

___ 1. Straight and level

___ 2. Turns

___ 3. Climbs and descents

___ 4. Unusual attitude recoveries

H. Special Maneuvers

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________

Code for special devices

A ______________________________

B ______________________________

C ______________________________

D ______________________________

APPENDIX B

GENERAL AVIATION SIMULATOR

PILOT TRAINING STUDY

Student/Pilot Evaluation Form

Please respond to the following questions on the basis of your flight in the simulator as compared to a corresponding instructional flight in the airplane.

Use the following rating scale in responding to the first group of questions. Space is provided for comments.

Rating	Adjective	Description
1	Excellent	Virtually no discrepancies. Simulator reproduces actual airplane characteristics to the best of my memory.
2	Good	Very minor discrepancies. The simulator comes close to duplicating actual airplane characteristics.
3	Fair	Simulator has many minor discrepancies which are annoying but is overall representative of airplane.
4	Poor	Simulator is not representative due to discrepancies which prevent airplane characteristics from being recognized or has characteristics which are contrary to airplane.

APPENDIX B

A. Basic Simulator Realism

1. Cockpit Layout . . . . ☐
2. Flight Instrumentation . . . . ☐
3. Control Feel . . . . ☐
4. Ground Effects . . . . ☐
5. Visual Scene . . . . ☐
6. Motion Cues . . . . ☐
7. Physical Arrangement of Cockpit . . . . ☐
8. Power Effects and Response . . . . ☐
9. Effect of Flaps . . . . ☐

B. Simulator Flying Characteristics

C 1. Straight and Level . . . . ☐
C 2. Climbs . . . . ☐
C 3. Descents . . . . ☐
C 4. Turns . . . . ☐
D 5. Minimum Control Airspeed Operations . . . . ☐
D 6. Stalls . . . . ☐
C 7. Steep Turns . . . . ☐
F 8. Basic Instrument Operations . . . . ☐
G 9. Radio Navigation . . . . ☐
E 10. Approaches . . . . ☐
E 11. Flare out and Touchdown . . . . ☐
B 12. Takeoff . . . . ☐
A 13. Taxiing . . . . ☐
14. Night Operations . . . . ☐

C. Evaluation of Special Devices

Indicate the value of the following special devices for the following tasks or maneuvers:

1. Visual Display

Basic maneuvers straight and level, turns, climbs, descents . . ☐

Stalls, minimum control airspeed operations . . . . ☐

Approaches, takeoffs, landings . . . . ☐

Ground operations . . . . ☐

Night operations . . . . ☐

2. Head-Up Display IAS1

Stalls, minimum control airspeed operations . . . . ☐

Normal approaches . . . . ☐

Short field approaches . . . . ☐

Night approaches . . . . ☐

Flare out and landing . . . . ☐

3. Motion Base

Climbs and descents . . . . ☐

Turns . . . . ☐

Stalls . . . . ☐

Approaches . . . . ☐

Flare out and touchdown . . . . ☐

Ground operations . . . . ☐

D. General Comments

1. Indicate in order of value those maneuvers or operations from which you derived the greatest benefit during the simulator flight and why

____

____

____

____

____

____

____

2. Indicate as in above those maneuvers or operations from which you derived the least benefit - please comment

____

____

____

____

3. Overall, how would you rate the simulator flight in terms of its value in your training?

Extremely valuable . . . . ☐

Somewhat valuable depending on operations . . . . ☐

Of limited value . . . . ☐

Of no value . . . . ☐

APPENDIX B

4. In the course in which you are enrolled, how much time would you think could be flown in a simulator:

   0-3 hours . . . . ☐

   4-7 hours . . . . ☐

   8-12 hours . . . . ☐

   12 plus hours . . . . ☐

5. What maneuvers or tasks should be performed in a simulator?

   ____

   ____

   ____

   ____

   ____

6. What recommendations do you have for improvements to the simulator that would render it more useful for general aviation pilot training at your level?

   ____

   ____

   ____

   ____

   ____

   ____

   ____

____
Name Date

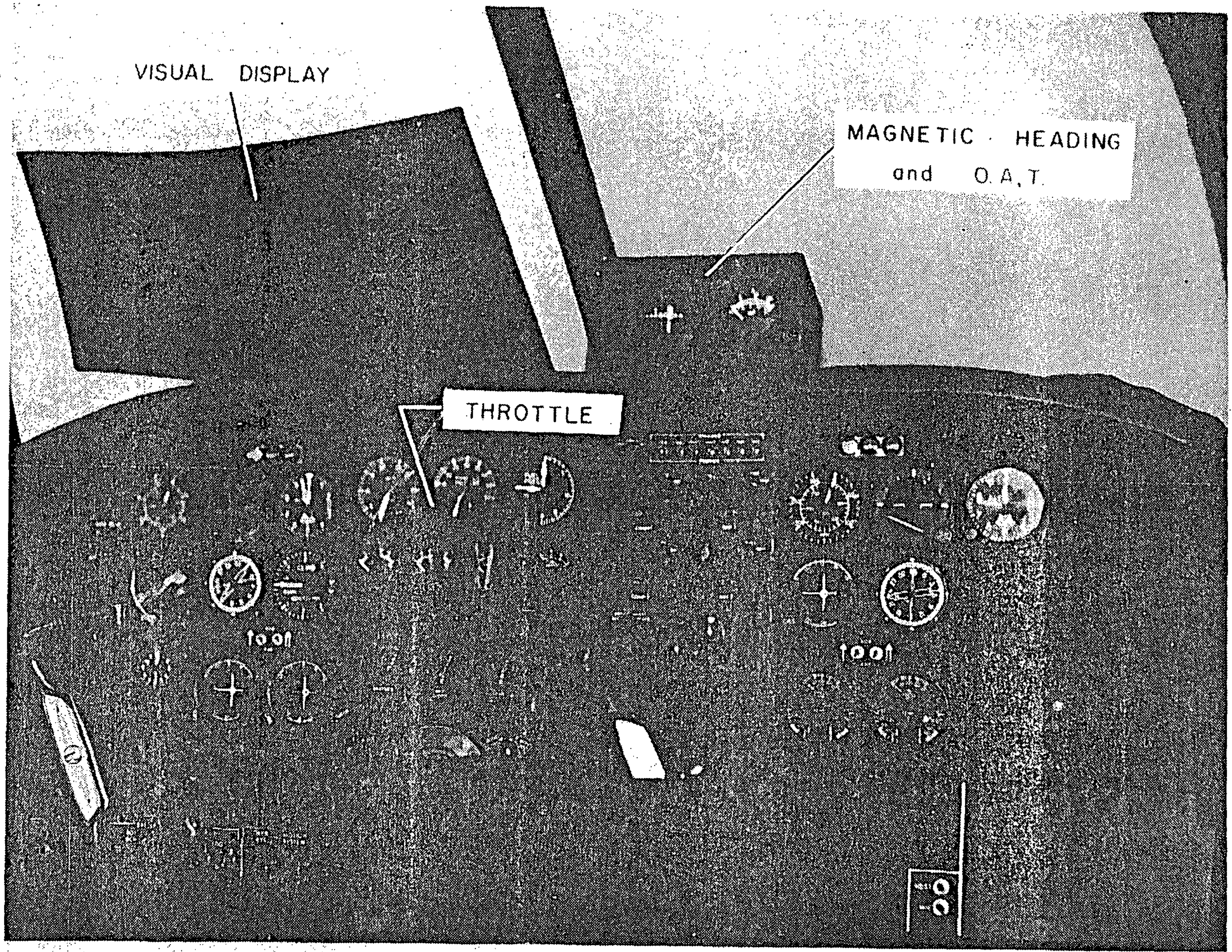


Figure 1.- Simulator cockpit.

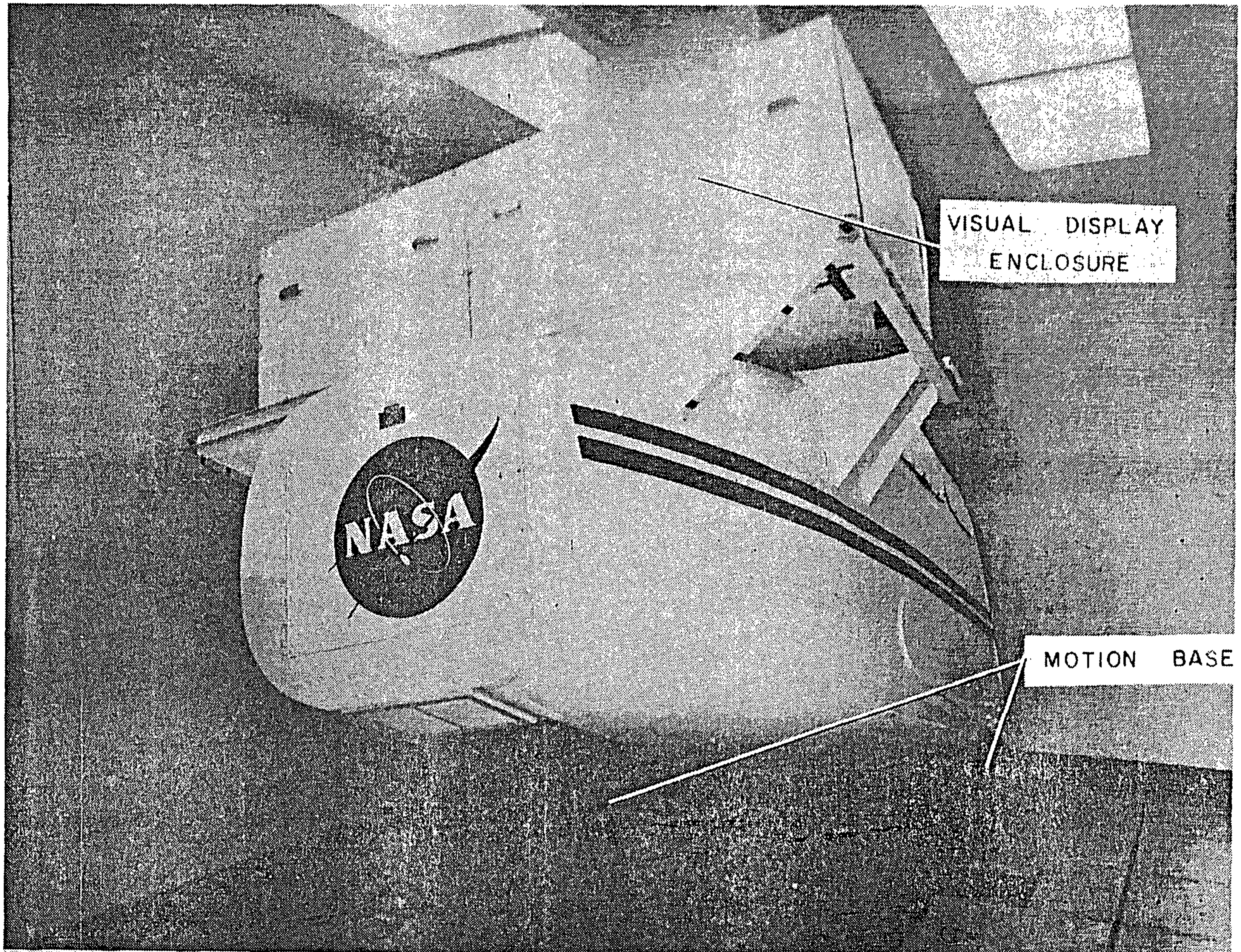


Figure 2.- Simulator exterior showing location of some special features.

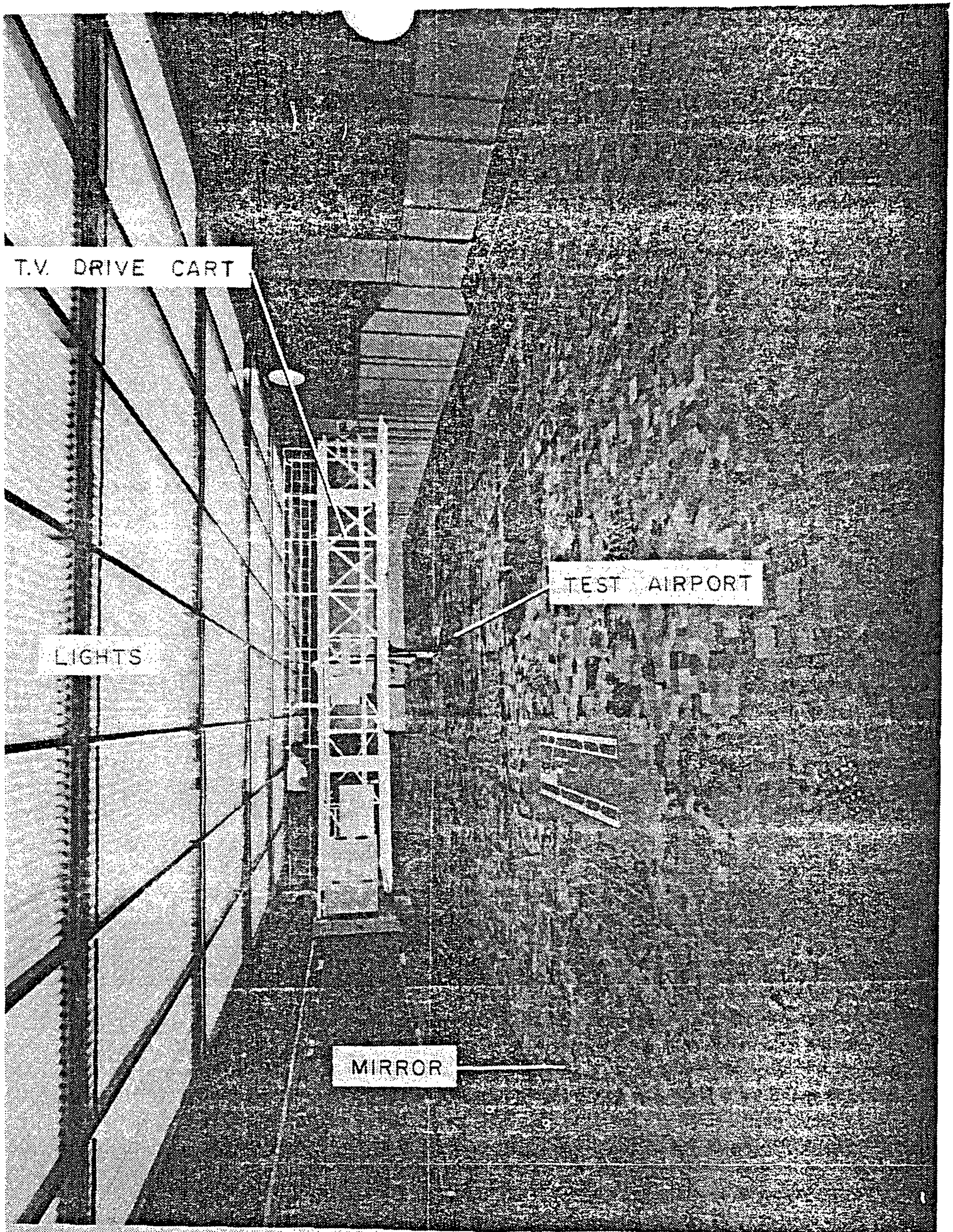


Figure 3.- Visual Landing Display System (VLDS).

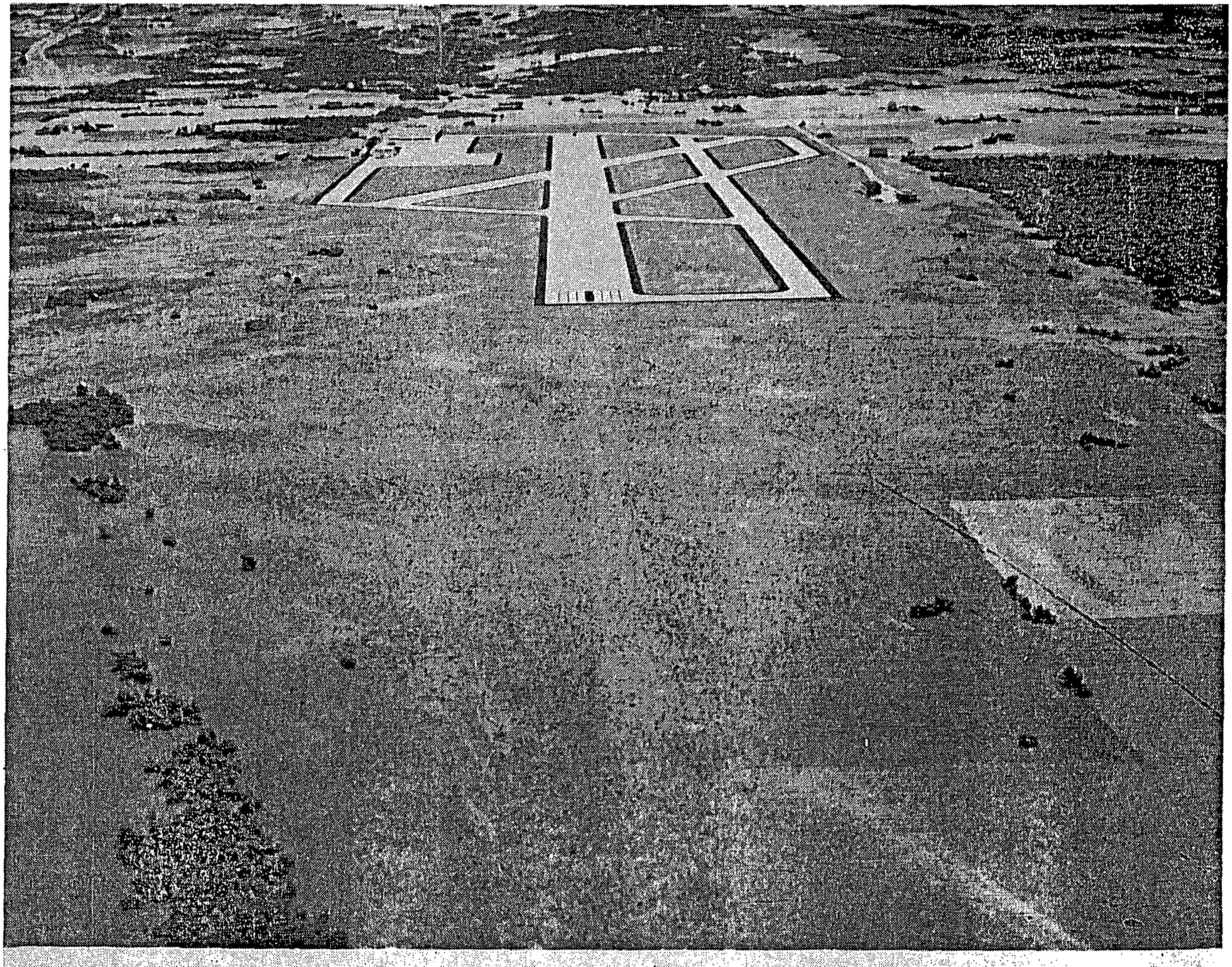
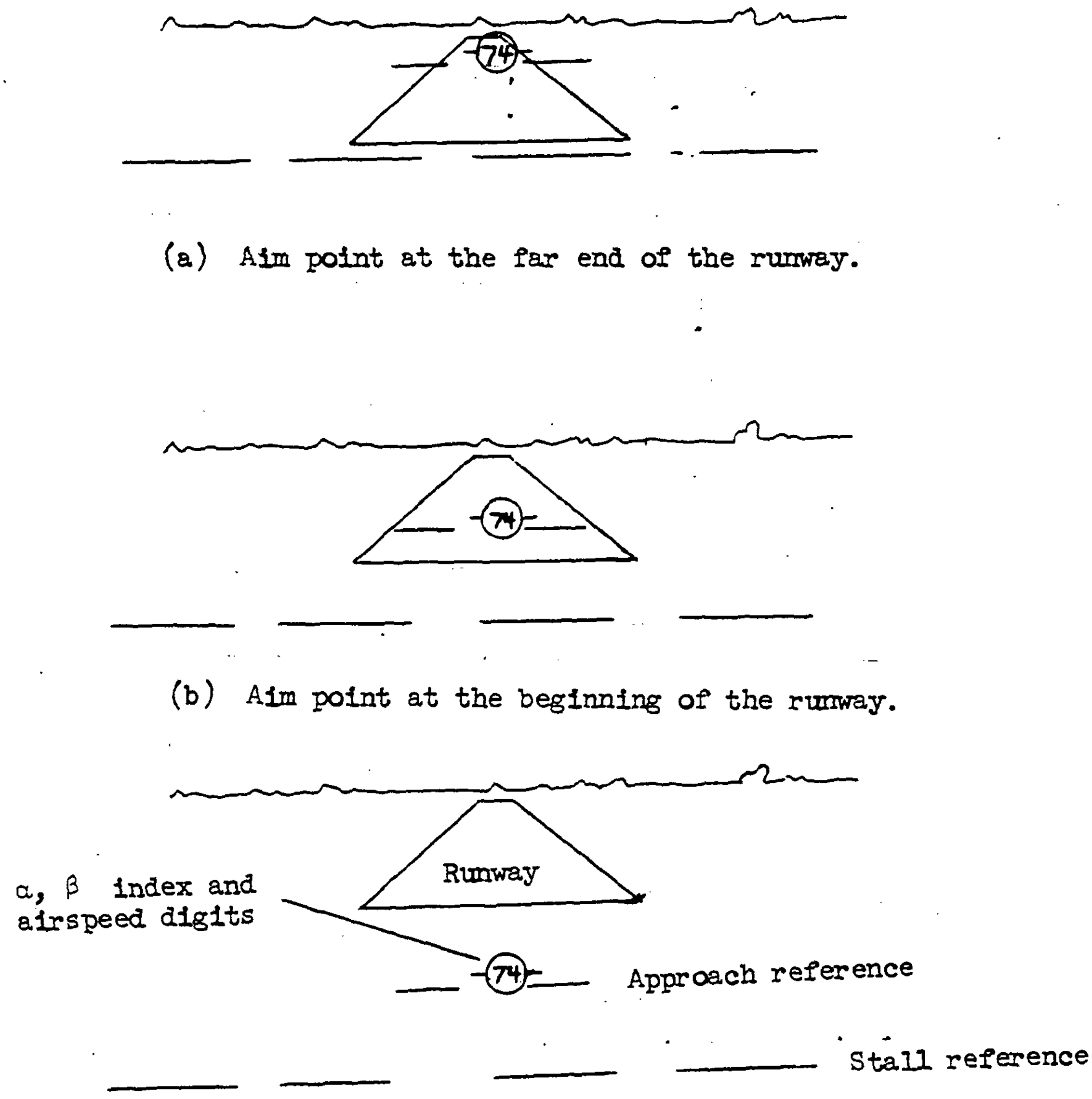


Figure 4.- Simulated airport on the VLDS (1:750 scale).



(a) Aim point at the far end of the runway.

(b) Aim point at the beginning of the runway.

(c) Aim point short of the runway.

Figure 5.- Sketch illustrating the IASI display as viewed by the pilot during the landing approach with different aim points. The display consists of the α, β index, airspeed digits, the approach reference, and the stall reference.

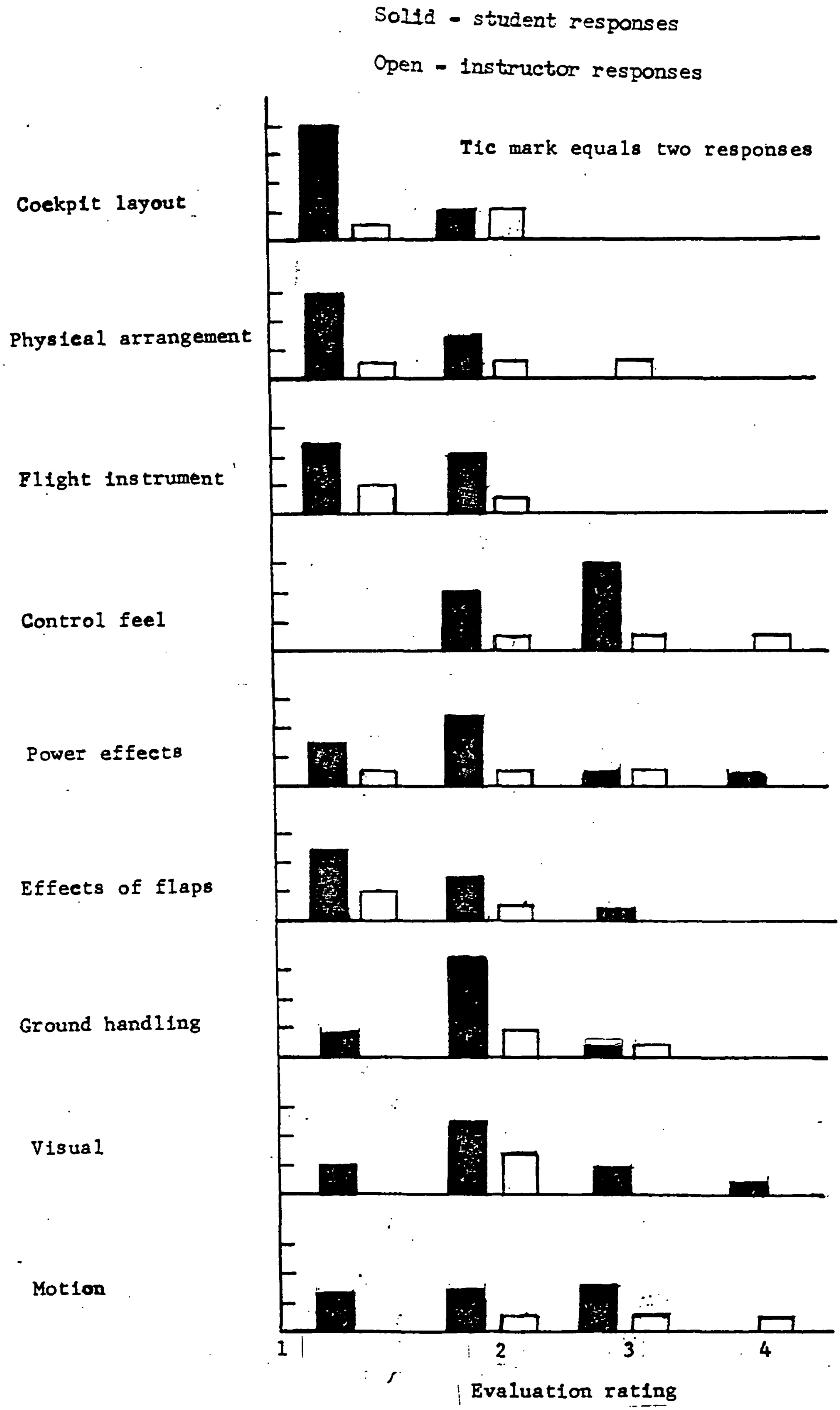


Figure 6.- Summary of the student and instructor rating of the simulator realism.

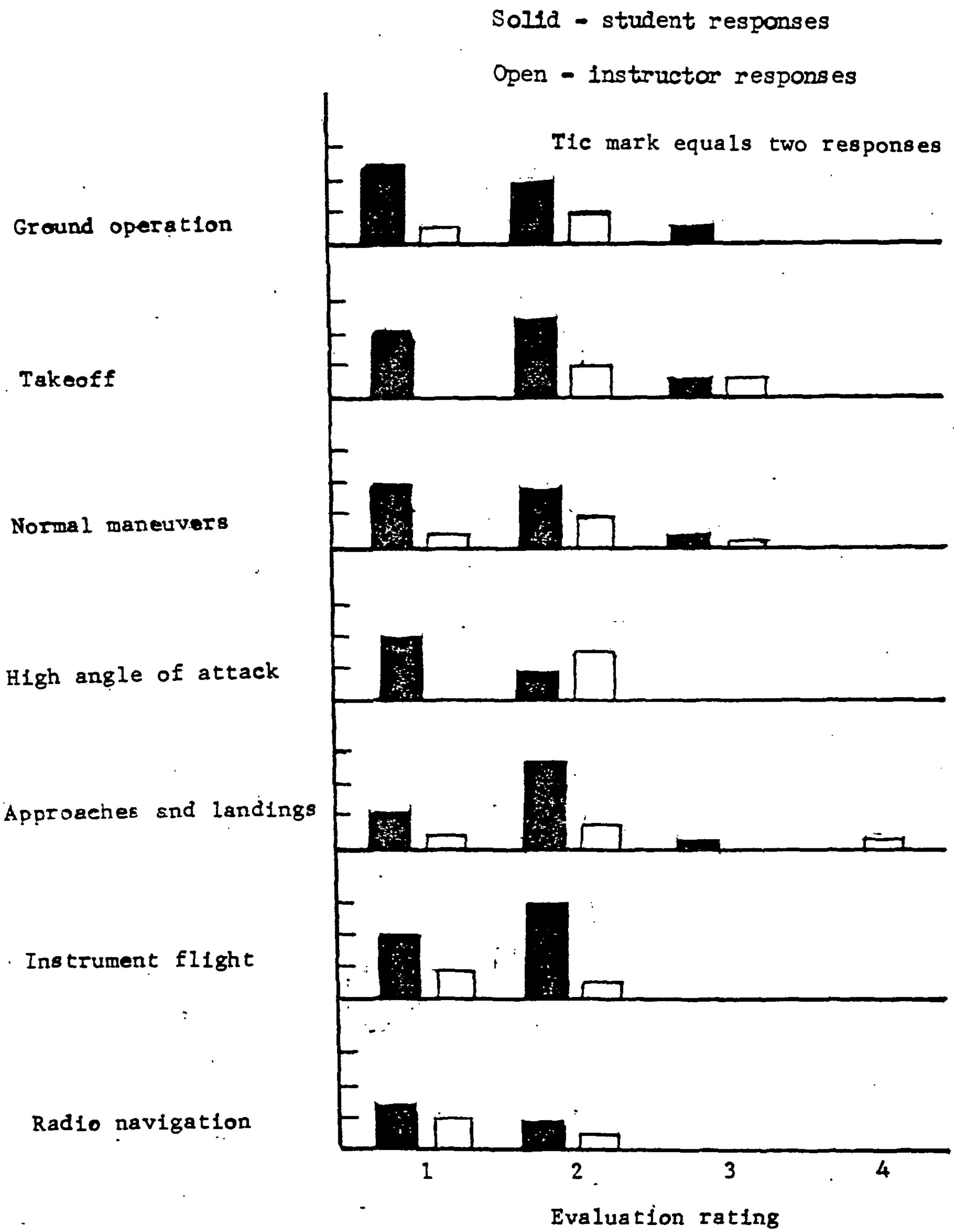


Figure 7.- Summary of the student and instructor rating of the simulator flying characteristics for various flight maneuvers.

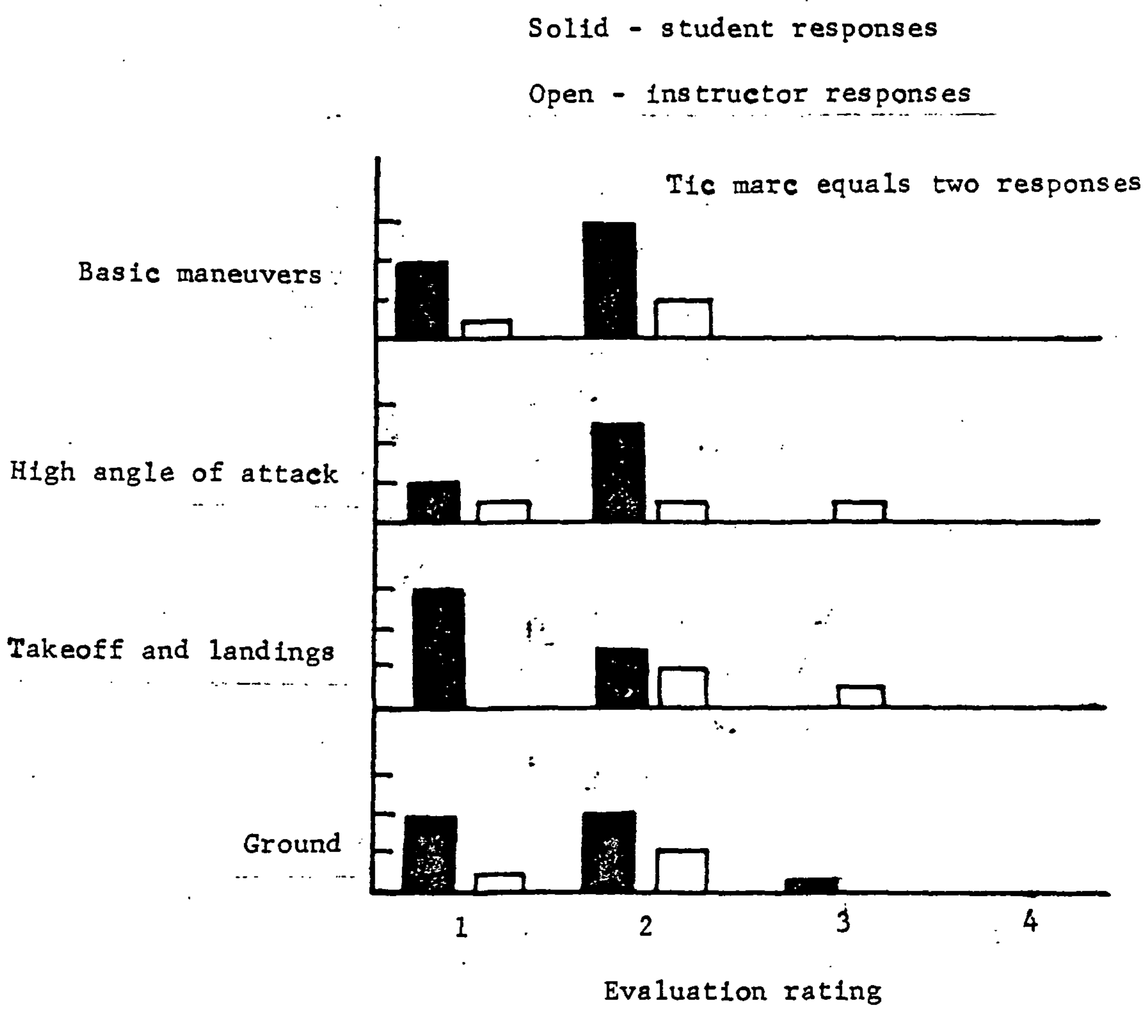


Figure 8.- Summary of the student and instructor rating of the visual display for various flight maneuvers.

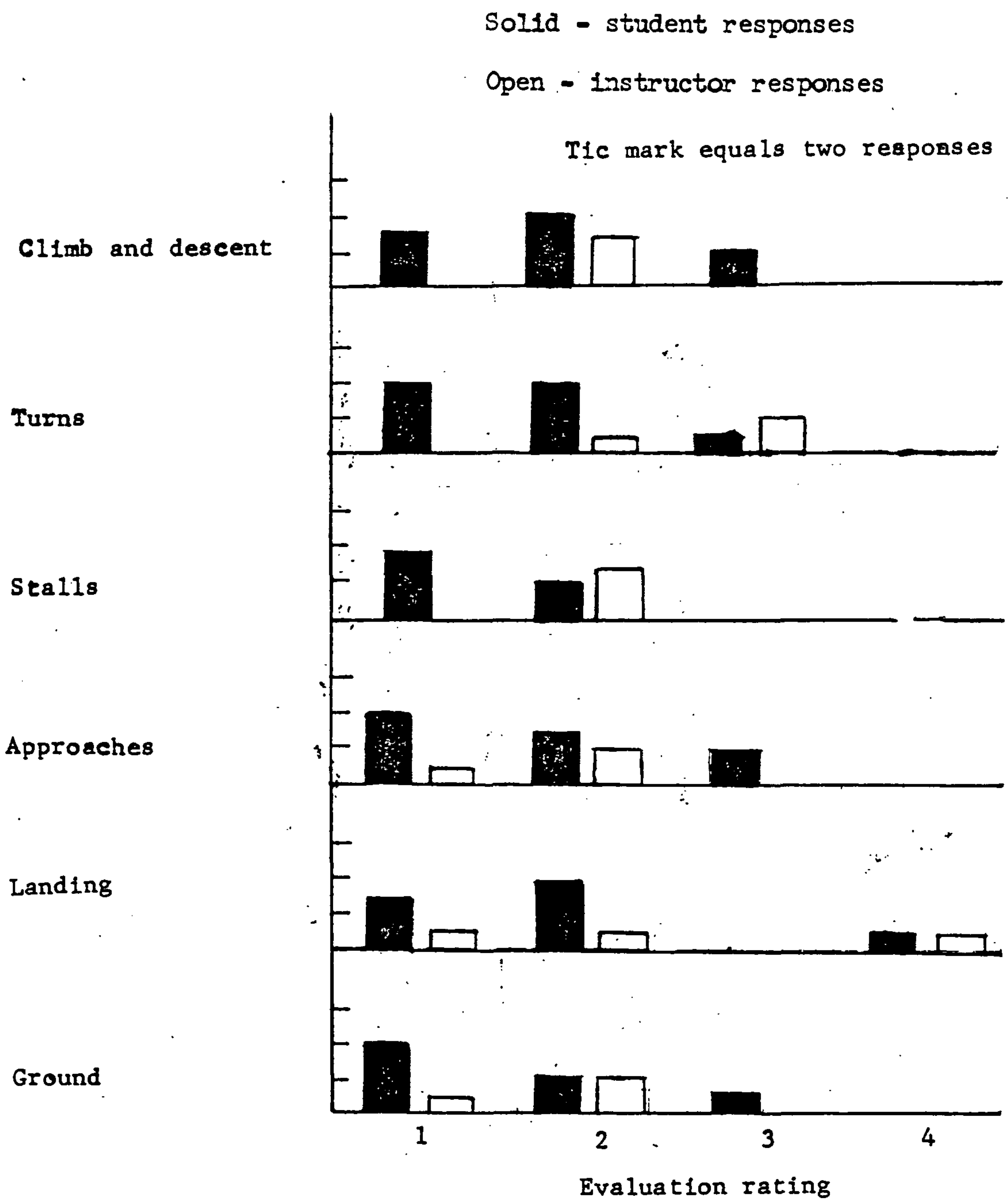


Figure 9.- Summary of the student and instructor rating of simulator motion for various flight maneuvers.

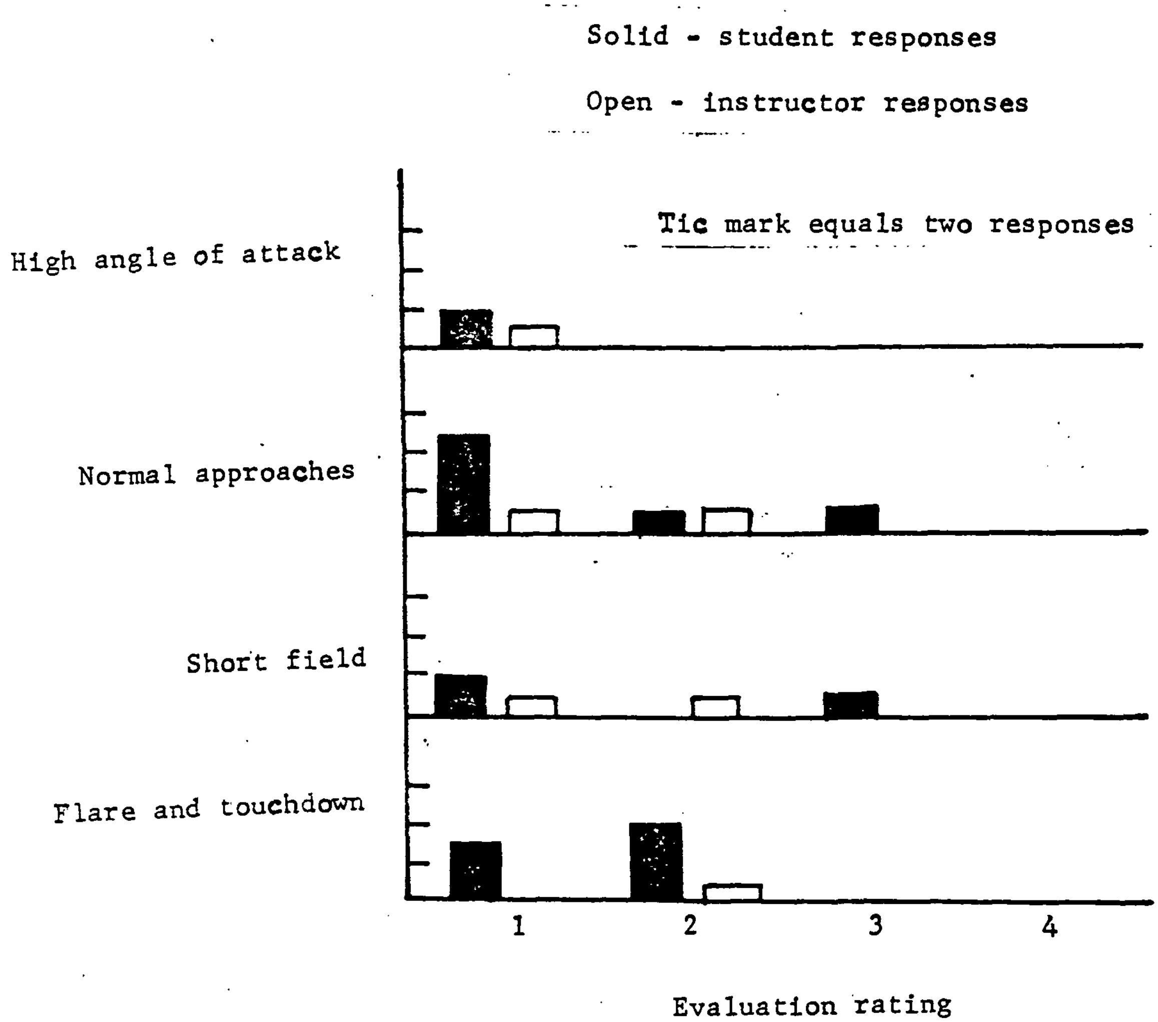


Figure 10.- Summary of the student and instructor rating of the LASI as a training aid.

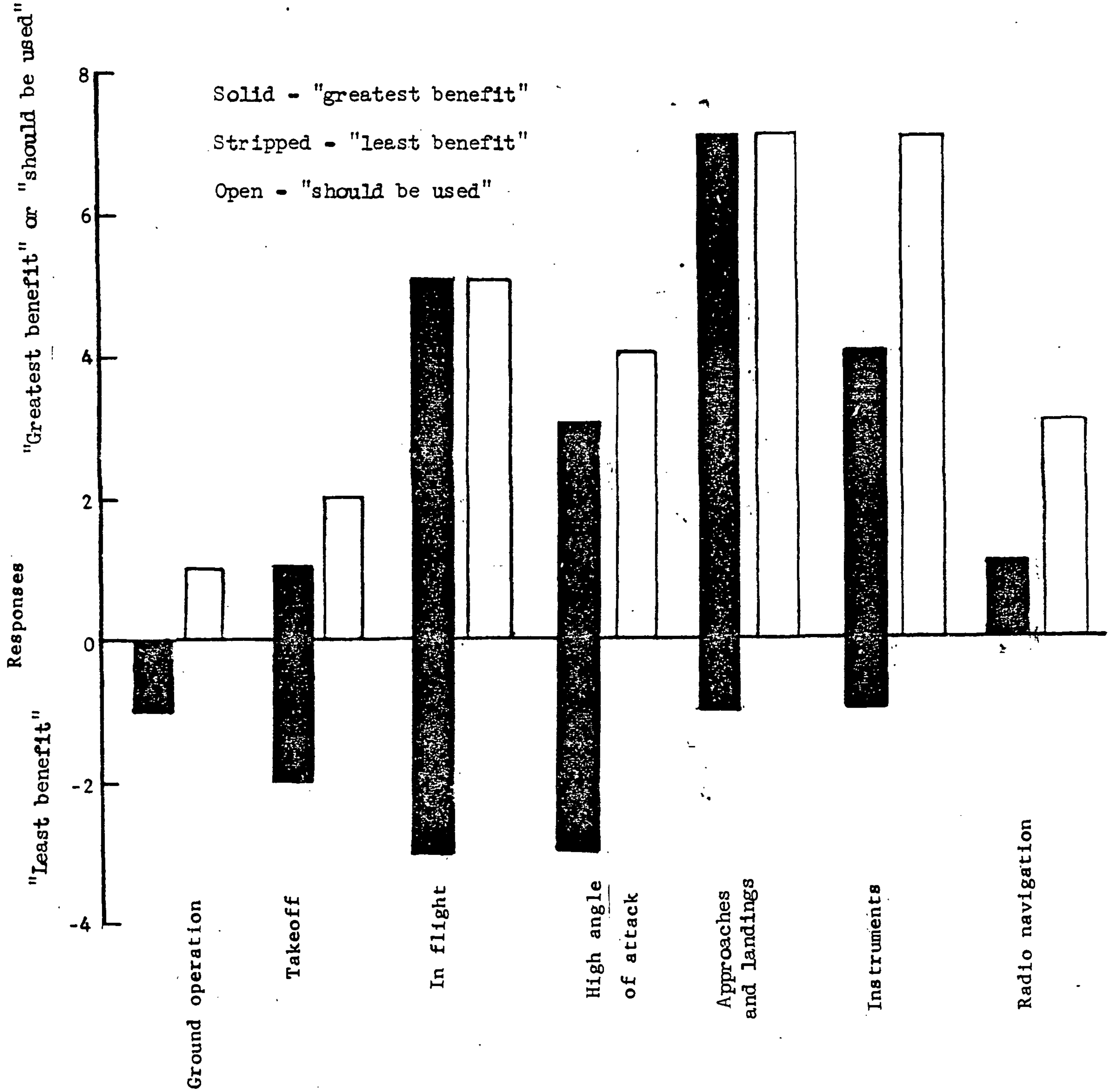


Figure 11.- Plot of the number of student responses to three questions concerning the application of the simulator to various flight maneuvers. (1. Which maneuver(s) did you derive the greatest benefit from? 2. Which maneuver(s) did you derive the least benefit from? 3. Which maneuver(s) should be used in a training program?)

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15. Supplementary Notes

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16. Abstract

Ten student pilots were given a 1-hour training session in the NASA Langley Research Center's General Aviation Simulator by a certified flight instructor and a follow-up flight evaluation was performed by the student's own flight instructor, who had also flown the simulator. The students and instructors generally felt that the simulator session had a positive effect on the students. They recommended that a simulator with a visual scene and a motion base would be useful in performing such maneuvers as: landing approaches, level flight, climbs, dives, turns, instrument work, and radio navigation, recommending that the simulator would be an efficient means of introducing the student to new maneuvers before doing them in flight. The students and instructors estimated that about 8 hours of simulator time could be profitably devoted to the private pilot training.

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