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DEVELOPMENT OF LOW-COST COCKPIT/OUTSIDE TIME SHARING TRAINING EQUIPMENT

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16. Abstract

Ten certificated pilots were given time-sharing training using a low-cost visual in-cockpit device. Training sessions in a ground trainer with subsequent flight checks in an airplane showed marked improvement in cockpit/outside visual scanning and piloting proficiency. Pilots expressed favorable comments regarding use of the concept for student pilot training. Three pilot training schools also evaluated an in-cockpit aural signal device designed to prompt pilots to scan outside for other aircraft. The device received unfavorable comments from student pilots and flight instructors due to excessive amounts of annoyance and distraction, and was not recommended as a training aid.

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PREFACE

My sincere appreciation is expressed to James Thomas, NA-241, who, given the task of designing the necessary circuitry of the test units, responded with noteworthy ingenuity and commendable professionalism; to Albert Schwartz and Ray Orcutt, NA-440, who expertly assembled the components into functional hardware, and to Arthur Madge, NA-440, who ably assisted in collecting the subjective data in a resourceful and accurate manner.

The author also wishes to acknowledge the personal interest and contribution of the many other NAFEC personnel who supported this effort.

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INTRODUCTION

Purpose.

As a continuing effort, this experiment is directed toward the development and evaluation of a low-cost cockpit outside scan time-sharing training equipment concept for the purpose of detecting airspace intruders and avoiding midair collisions, to determine if in-cockpit signal devices do or do not provide meaningful training to aid pilots in improving their cockpit/outside visual scan.

Background.

As VFR traffic increases in volume, more and more aircraft become candidates for potential midair collisions or near-miss situations. Statistics point out the apparent laxity of pilots in evaluating their responsibilities to better time-share their attention between inside-the-cockpit (instrument) and outside-the-cockpit information. One has but to recall the number of actual midair collisions and near misses to realize that a pilot's scanning is somewhat statistically marginal at best. Previous studies have been conducted to develop and evaluate a means of enhancing the time-sharing ability of a pilot during his visual scan, both inside and outside the cockpit (see references). Some have tried to establish a scanning habit pattern by means of a relatively short training period in a ground trainer, hopeful that the pilots would thereafter perform their visual scan more efficiently and more often. Although generally favorable comments were received regarding acceptance of this training into a pilot training curriculum, how effective such training received on the ground will be over a long period of time in the air has yet to be determined and is very difficult to measure. The need for looking out is paramount, but is usually compounded by student/instructor absorption in flight tasks, pilot attention to navigation and communication demands, or just the general laxity that quite often pervades the cockpit during long, boring flights. Any or all of the aforementioned situations is conducive to a possible midair collision due to periods of inattention.

DISCUSSION

Device Description.

The project evaluated two low-cost devices, one employing a visual presentation, Device A, and the other, an aural presentation, Device B.

Device A (Figure 1). This device consisted of a series of 6 small, 12-volt lamps individually wired and strategically located within the confines of the airplane and ground trainer windshield area. The lights were mounted so as not to constitute a hazard or obstruction to the safe conduct of the flight. Each light was lit automatically in a programmed random sequence by a sequence/scoring unit (Figure 2). This unit could be operated from an internal 12-volt battery or externally from the 12-volt cigarette lighter of the airplane. A light was lit every two minutes and flashed for a period of ten seconds. A small push-button switch located adjacent to each light served to extinguish the light and simultaneously enter a score in the scoring unit. The brightness of the lights was such that direct heads-up visual attention was required to detect them. The scoring unit automatically totalled the number of lights presented and how many lights were extinguished.

Device B (Figure 3). This device was a self-contained aural signal transmitting unit which activated automatically once every sixty seconds, and had an on-time of about one second. Two frequencies were available, 400Hz (LO) and 4500Hz (HI). A "beep" or "steady" signal mode could also be selected with either frequency. The device was placed in the cockpit and served as a prompter to the pilots to remind them to conduct a full outside visual search for other aircraft. The unit did not employ a scoring function.

METHOD OF APPROACH

Pilot Subjects.

A group of 12 pilots was selected who had varied amounts of flight time and had recent experience in the Piper Cherokee-PA-28-180 aircraft being used in the project. This significantly reduced the cost and time of familiarizing pilots in a potentially unfamiliar airplane. This group of pilots evaluated the test lights (Device A), only.

Experimental Procedure (Device A).

Each pilot was required to fly two VFR local cross-country flights in the airplane, then scheduled for a series of training sessions in the ground trainer, after which they returned to the airplane and completed two flight checks. Throughout every session of the experiment, both in the airplane and the ground trainer, the prime data was collected by the experimenter sitting in the rear seat where he graded the pilots in two major areas. First, on his flight proficiency; that is, how well he maintained his heading, altitude and airspeed, and navigation/communication performance. Secondly, how well he conducted his total outside/inside visual scanning. A grade was entered every three minutes.

In order to introduce a modest workload, the first leg of the actual airborne cross-country flights was flown by means of pilotage, that is, without the use of any navigational radio aids, just an aeronautical chart. The

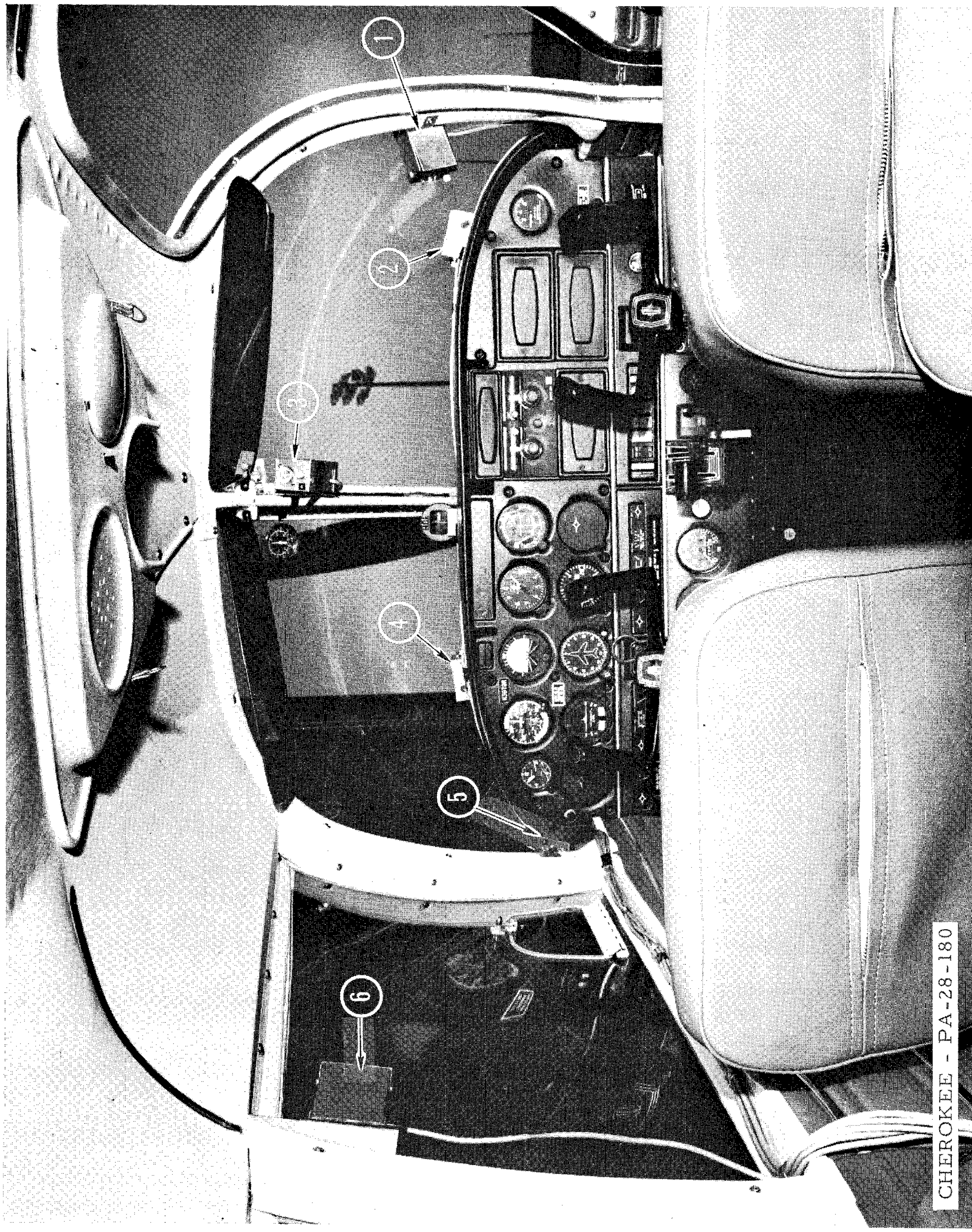

FIGURE 1 IN-COCKPIT LOCATIONS OF TEST LIGHTS

FIGURE 2 TEST LIGHT SEQUENCING/SCORING UNIT

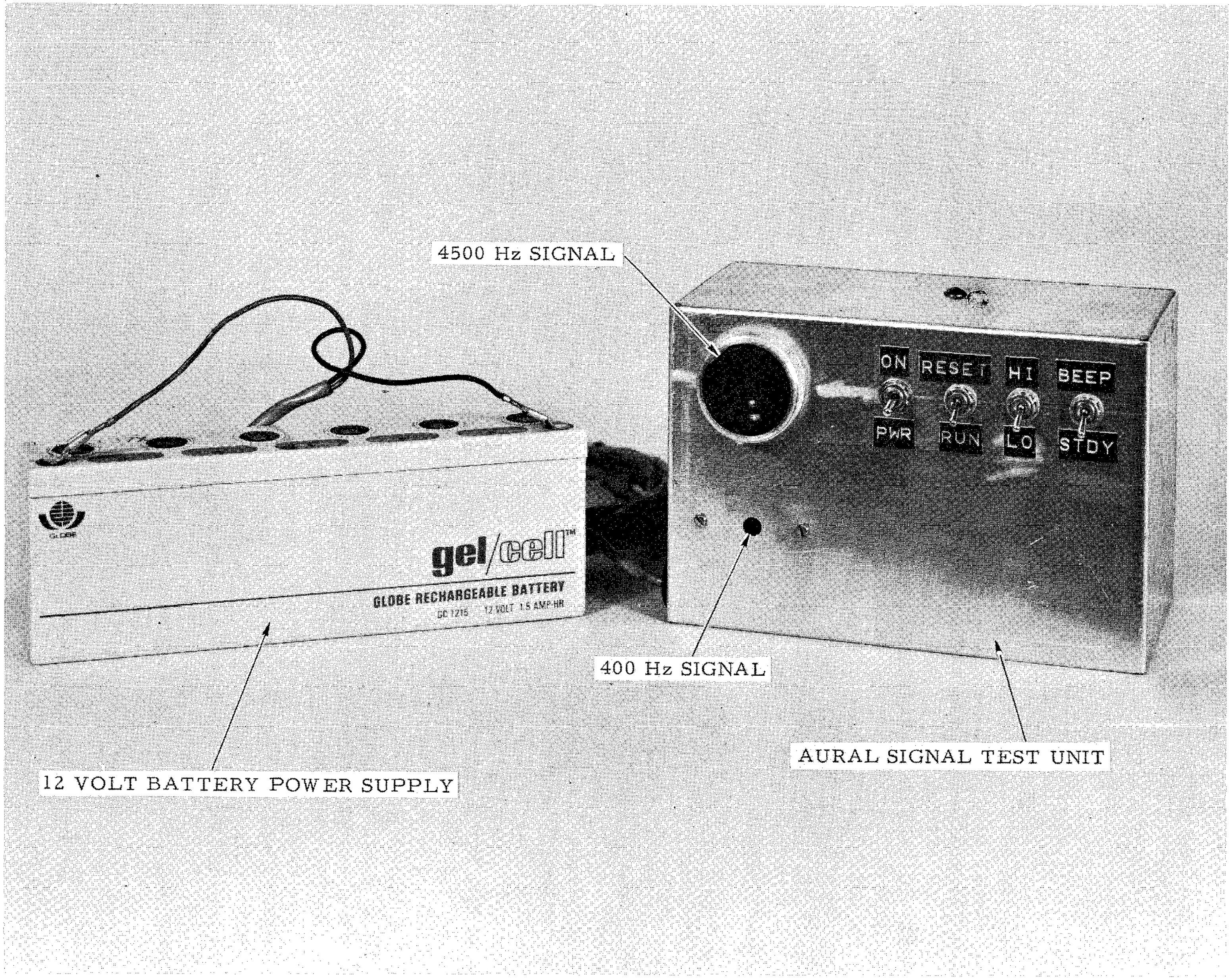

FIGURE 3 AURAL SIGNAL TEST UNIT

last portion of the flight was flown using Visual Omni Range (VOR) navigation. The subject pilot was responsible for all in-flight communications. An FAA pilot from the Flight Operations Branch was assigned as safety pilot on all flights.

Initial Flight Evaluation.

The first two flights in the airplane were set up primarily as the basis for comparison of subsequent flights. In reality these two flights gave an accurate account of how each pilot flew his airplane without seemingly being under the stress of project demands. On the first flight, the subjects were merely told that this flight was to familiarize them with the routing they would be flying. The second flight, using the test lights, was quite similar in nature. The subjects were not told why the lights were there, only that they were to put out a light if they saw it lit while performing their normal visual scanning. Test light detection scores were documented and served as a broad measurement of how well a pilot was normally conducting his individual visual scanning.

Simulation Training.

At the completion of the second flight, the pilots were scheduled for two training sessions in the GAT II ground trainer. This trainer is representative of a light twin-engine aircraft similar to a Beech Baron in performance, and provides limited motion in the pitch and bank axis. It is situated in the center of a partial sphere of 10 foot radius, extending 240° around the trainer. The test lights were removed from the airplane and installed in the ground trainer and the subjects required to fly duplicate cross-country flights as in the first two flights except that due to the lack of a visual terrain scene, the simulation flights were all flown using VOR radio navigation throughout. Full emphasis was placed on maintaining maximum outside visual search while adhering to accurate flight performance in an endeavor to develop and/or improve pilot time-sharing to a higher level of competency. During the simulation training sessions, ten small shadow-like aircraft silhouettes were projected in a programmed fashion on the dome surface surrounding the trainer so as to provide a somewhat real-life flight environment. Each silhouette was on for 30 seconds. In addition, three engine instrument malfunctions were introduced throughout each session to observe in-cockpit scan proficiency. Each malfunction was on for 60 seconds. Upon completing the two training sessions, the simulation effort was terminated and the pilots rescheduled for two final flight checks in the airplane.

Final Flight Checks.

The pilots were required to fly the same flight routings as in the first two flights. During the first flight check, the test lights were installed in the plane and test light detection scores were documented. The test lights were then removed and the second flight was flown without using the lights. Overall flight proficiency and visual scanning proficiency were graded by the experimenter on both flights and compared with the first two flights.

Experimental Procedure (Device B).

Three aural signal devices were constructed and loaned to three local flight schools to evaluate their effectiveness under actual pilot training conditions. A supply of pilot questionnaires was provided to each school to be filled out by all pilots and instructors using the device.

SUMMARY OF RESULTS

Device A.

Ten of the twelve subjects were able to complete the project and the data shown herein is the results of their effort only. To answer the question of how effective the practice in time sharing using the test lights proved to be, the test light detection scores and the subjective evaluations by the experimenter of overall pilot flight proficiency and scanning proficiency should be compared between the beginning sessions and the two final flight checks. If both these scores showed an upward trend with no marked deterioration of piloting proficiency, it would be reasonable to decide that the practice sessions had been effective.

Pooling the scores of all subjects, the percent of overall pilot proficiency and test-light detection scores by session is shown in Table 1. Comparison scores of similar sessions before and after the training sessions in the ground trainer, shows about a 45 percent improvement in flight and scanning proficiency between Session 1 and Session 6 (without the test lights), and a 17 percent improvement between Session 2 and Session 5 (using the test lights). Session 3, which was the first training session in the ground trainer, does show a slight decrease in both the flight and scanning proficiencies. Although all subjects were given familiarization sessions in the ground trainer prior to data collection, the fact remains that some pilots still experienced a little difficulty in flying the trainer and performing the additional project tasks at the same time. Significant improvement, however, is noted in the second training session and can largely be attributed to emphasis on task performance by the experimenter and increased familiarity with the trainer.

TABLE 1. PERCENT OF OVERALL PILOT PROFICIENCY BY SESSION

SESSION	FLIGHT PROFICIENCY	SCANNING PROFICIENCY	TEST LIGHT DETECTION
1	74.7	70.0	-
2*	86.5	84.9	21.3
3**	74.8	64.5	24.4
4**	95.0	97.2	34.2
5*	89.2	99.1	52.1
6	94.8	95.8	-

*Airplane flights using test lights.
**Simulator training sessions using test lights.

During the two training sessions in the ground trainer, a score was kept by the experimenter on the number of aircraft silhouettes and engine malfunctions detected by the pilots. Individual scores varied considerably, but in every case, all detections increased during the second training session - from an average of 19 percent in the first training session, to 42 percent in the second session. These scores may appear to be lower than one might expect, but the aircraft silhouettes were purposely displayed with minimal but adequate contrasting brightness with the ambient lighting and were difficult to detect.

Test-light detection scores show rather significant improvements. A 10 percent increase between the first and second training session in the ground trainer, while the final flight check in the aircraft (Session 5) shows a 31 percent increase over the first flight using the test lights (Session 2). At the completion of the project, each pilot was asked to fill out a questionnaire on numerous aspects of the test lights. Summarizing the pilot responses to the questionnaire, the majority of the pilots stated that the brightness of the test lights were such that it made their detection moderately difficult. Test-light brightness was deliberately reduced to a point that required direct visual sighting. It was extremely difficult to detect the light with peripheral vision. The pilots were divided in their opinion regarding a possible eye-focusing problem caused by looking inside for the lights and then outside the cockpit to scan for other aircraft. However, those few pilots experiencing the eye-focusing problem stated it was tolerable. To alleviate the problem, these pilots were told to maintain their focus outside the cockpit and visually sweep through each test light as they searched outside. Although the light may have been slightly out of focus, it was easily detected when lit. This procedure met with a good degree of success. All the pilots stated that the two training sessions in the ground trainer were quite beneficial in helping to achieve better time sharing of their scanning, but a few stated that on occasion, while trying to detect the test lights, they had a slight tendency to fly the airplane and ground trainer a little less efficiently than they normally do. Nevertheless, all the pilots agreed that their participation in the project made them aware of how poorly they did scan and all felt that they had improved their time-sharing technique substantially. Use of the test-light concept in the early stages of student pilot training was highly endorsed by all the pilots.

Experimenter Comments.

It should be noted that the test-light detection scores, that is, how many times a pilot detected a light and extinguished it to register a score, only constituted a broad measurement of how well he was conducting his outside visual scanning. Invariably, the pilots scanned very diligently but did not detect too many lights due to their short on-time of 10 seconds, and the fact that on countless occasions his scan was elsewhere at the particular moment that a light was on. Thus, while possibly receiving a relatively low "detection score," he was graded higher by the experimenter for displaying initiative and thoroughness in his overall scanning.

The very first flight in the airplane without the lights, revealed that almost all of the pilots scanned a rather limited sky area, roughly, about 45° either side of the nose of the airplane. Side scanning and "over-the-shoulder" scanning were notoriously inadequate. The two training sessions in the ground trainer were very instrumental in correcting that deficiency as shown by the higher gradings in the two final flight checks. The test lights appeared to serve their purpose quite well; they were not bright enough to detect easily and by virtue of their physical positions in the cockpit, they forced the pilots to scan more of the sky area. As stated earlier, the project was a rather short-term evaluation of a concept and employed certificated pilots who had total flight times ranging from a low of about 75 hours to a high of about 1000 hours. The results of this effort showed a significant improvement in the overall performance of the pilots, but to determine the long-range benefits to the pilots is very difficult to predict or measure. Perhaps another authorized flight check in 3 or 6 months would give some insight to pilot retention. In addition, a voluntary evaluation of the test-light concept was conducted at a pilot training school to determine its benefits during student pilot training. The appendix contains a brief summary of results and indicates possible concept acceptance if minor modifications are made and an in-depth evaluation conducted under more controlled conditions. In view of the fact that to date, there is no formal time-sharing training being conducted at flight schools, it warrants further investigation to determine whether the time, money, personnel and equipment expended enhances a pilot's visual search technique and/or further validates it as a potential formal part of pilot training. The cost of the complete visual test-light unit was approximately $425.00. The three aural signal units cost about $100.00 each.

Device B.

At the completion of each flight all pilots were asked to fill out a questionnaire on various aspects of the device. A modest response was received from the three flight schools regarding the use of the aural signal device as a prompter to remind the pilots to scan. The device was evaluated by flight instructors, student pilots and private pilots under dual instruction and solo conditions.

Summarizing the total responses to the questionnaire, the pilots stated that they made every effort to look up when the signal came on, but on many occasions they chose to ignore it due to more pressing in-cockpit duties. They felt that the signal duration of about one second was satisfactory, as was the interval of one minute between each signal. The main objection appeared on the longer cross-country flights where a somewhat significant annoyance and distraction factor began to form after about 15 to 20 minutes into the flight. On several occasions some pilots turned the device off as it interferred with voice communications. Although, while in operation, preference was stated for the high frequency (4500Hz) in the "beep" mode.

The vast majority of the students and instructors felt that using the device in the early stages of pilot training would produce very marginal benefits. It therefore appears that to add another aural sound in the cockpit to the existing aural alarms such as stall warning and landing gear warning, even for a relatively short instructional period of time, would not enhance or develop a pilot's outside visual scanning to any significant degree and might possibly add an additional amount of annoyance and distraction that is certainly unwanted at this stage of the training.

CONCLUSIONS

Based on the piloting and visual scanning performance of 10 certificated pilots who were given training with low cost visual time-sharing training equipment, it is concluded that:

1. Time-sharing practice, using a low-cost visual in-cockpit device, is effective in improving a pilots cockpit/outside visual search.

2. Two intensive training sessions in a ground trainer appeared sufficient to achieve significant visual scan improvement.

3. This pilot time-sharing training concept appears to be the most effective to date with the least amount of equipment required.

4. The use of an in-cockpit aural signal device in the early stages of pilot training produced objectionable amounts of annoyance and distractions to be of any significant benefit in aiding pilots to develop or enhance outside visual scanning.

REFERENCES

1. Collins, R.L., "A New Flight Skill: The Fine Art of Collision Avoidance," Air Facts, June 1968, pp. 48-54.

2. Crook, W. G., "Evaluation of Low-Cost Collision Avoidance Ground Training Equipment," Federal Aviation Administration, NAFEC, Atlantic City, N. J., Report No. NA-68-37, November 1968.

3. Gabriel, R. F., Burrows, A. A. and Abbott, P. E., "Using A Generalized Contact Flight Simulator to Improve Visual Time Sharing," Douglas Aircraft Co., Inc., April 1965, NAVTRADEVCEN 1428-1, AD 619-047.

APPENDIX

Voluntary Evaluation of the Test Light Unit,
Device A, By a Pilot Training School

BURNSIDE-OTT
AVIATION TRAINING CENTER
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MIAMI, FLORIDA

PHONE: 685-5111
AREA CODE: 305

Burnside-Ott Aviation Training Center is constantly striving to further safety in aviation, and welcomed the opportunity to evaluate the effectiveness of the low-cost cockpit/outside time sharing training device developed by the FAA to aid pilots in establishing a more efficient visual scan technique so as to avoid other aircraft and prevent potential midair collisions.

The test light unit was installed in a Cessna 150 airplane and evaluated throughout a 60 day period. Instructor opinion was quite favorable toward the basic concept, but felt that they had possibly used the test unit. to extensively. After numerous flights, it became a game of "scores" between instructor and student. Occasionally, flight proficiency was noted to deteriorate slightly due to concentration on detecting the lights. However, they saw no real harm in using the test lights in the pre-solo phase of flight training where instructor/student workload is probably the greatest.

The following suggestions are offered for consideration:

1. Fewer lights (perhaps four) could be just as effective if placed properly.

2. Have only one switch to push to "score" a detection instead of one switch for each light.

3. Consider alternating flights with and without the test lights throughout the training period.

We feel that the concept has merit and the test unit possibly be modified and evaluated even further to determine optimum cockpit layout and instructional criteria compatable with current flight instruction techniques.

Sincerely,

Donald L. Burnside
President