AUTOMATED PILOT ADVISORY SYSTEM TEST AND EVALUATION

AT

MANASSAS MUNICIPAL AIRPORT

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INTRODUCTION

It is anticipated that the growth of aviation in the next decade will occur primarily in general aviation thereby placing greater traffic demands on the uncontrolled airport system. Since Air Traffic Control (ATC) services are not normally provided at these airports, automated systems are being evaluated as a means of ensuring safe and orderly air traffic flow at high density uncontrolled airports.

The National Aeronautics and Space Administration (NASA), in cooperation with the Federal Aviation Administration (FAA), has developed an experimental Automated Pilot Advisory System (APAS) (reference 1) to provide airport and air traffic advisories at high density uncontrolled airports. The APAS concept is to utilize low cost automated systems to provide the necessary information for pilots to more safely plan and execute approach and landing at uncontrolled high density airports. The system is designed to be a natural extension of the procedural Visual Flight Rules (VFR) system used at uncontrolled airports and, as an advisory system, will enhance the "see-and-be-seen" rule.

The current system used at uncontrolled airports is for pilots to "self-announce" (traffic advisory) over a UNICOM radio channel and request the active runway (airport advisory) from the Fixed Base Operator (FBO). The UNICOM radio channel is also used for general information and requests, and can be shared by several different airports. For example, the UNICOM at Manassas airport is shared by Manassas, Montgomery County, Warrenton, and Freeport. The problems with this type of system are (1) not all pilots self-announce; (2) the active runway information may not be available (FBO may be absent from the radio performing other jobs, etc.); (3) there may be radio interference due to multiple transmissions; and (4) self-announcement at one airport may be interpreted by pilots at another airport.

The experimental APAS was designed to be a test instrument in which its concept could be evaluated and experiments could be performed to determine the specifications for an operational system. Testing of the experimental system was initially performed at NASA's Wallops Flight Center (WFC) using NASA test pilots, but in late May 1980, the APAS was moved to Manassas Municipal Airport, Manassas, Virginia. This airport was selected because it is a high density uncontrolled airport with an estimated 200,000 operations per year. From June 23, to August 16, 1980, the experimental APAS was operated daily between 9 a.m. and 5 p.m. (9 a.m. to 10 p.m. the week of August 11), and an evaluation of the APAS concept was obtained from pilots who used the system. These evaluations and the system performance are presented.

APAS DESIGN AND CONFIGURATION

In order to implement the APAS concept, the APAS was required to have the following design features:

(1) Low Cost - The system must be affordable to most of the county, municipal, or privately-owned airports in the nation. (A cost limit of $50,000 in 1975 dollars was imposed for the APAS.)

(2) Airport Advisory System - This system should be capable of:

- (a) Issuing a report at least once every two minutes which would include an airport identifier, time of day, favored runway, wind speed, direction and gust, altimeter setting, and ambient and dew point temperatures.
- (b) Automatically selecting the runway and having self-checking features.
- (c) Manual control over runway select and sensor fault via an operator control panel.
- (d) Handling at least five additional sensors.

(3) Traffic Advisory System - This system should be capable of:

- (a) Issuing a report every 20 seconds to identify the number of aircraft on each pattern leg and the position, bearing, and heading of non-pattern aircraft.
- (b) Radar surveillance of a non-cooperative aircraft via a skin tracking radar.
- (c) Radar coverage to five nautical miles.
- (d) Height detection.
- (e) Reporting at least ten (10) aircraft and tracking at least twenty (20) aircraft.

(4) Interface - The APAS should require only a standard Very High Frequency (VHF) radio.

To meet these requirements, the experimental APAS configuration (Figure 1) used at the Manassas airport included a radar set, mini- and micro-computers, weather sensors, a VHF transmitter, and an operator control panel.

Ideally, an APAS radar system should have the following features: solid-state electronics, a Moving Target Indicator (MTI) or Doppler processor for ground clutter elimination, capable of detecting a 0.5 m^2 target at three nautical miles with a 300 meter range resolution, and costing $30,000 in production runs. Studies performed (reference 2) to select the APAS radar indicated that MTI and Doppler type radars were either cost prohibitive (>$250,000) or had insufficient range capability (<1.8 nautical miles). From these studies, it was concluded that the most suitable radar for APAS was the Marine Pathfinder surveillance radar. This non-coherent radar is solid-state, except for a magnetron and modulator switch tube, and requires targets to be detected and tracked in a ground clutter environment. To accomplish this, the APAS used clutter suppression techniques (narrow beam width antennas, Sensitivity Time Control (STC) for each antenna, and a clutter screen set to attenuate Radio Frequency (RF) signals below two degrees elevation), and software target detection algorithms (clutter mapping, thresholding, and mean level).

A single transmit and multiple receive antenna were selected for the APAS to enable the system to determine whether aircraft were at pattern altitude, above pattern altitude, or so high that they were of no interest. For the Manassas configuration, three receive antennas were used and set at 5, 10, and 20 degrees elevation with beam widths of 4, 6, and 13 degrees, respectively. One antenna was scanned 360 degrees every two seconds resulting in a six second target update rate. (Under certain conditions, the signal returned from a target was received in two of the three antennas.)

The mini- and micro-computers were used to provide target detection and tracking, pattern classification, evaluation of weather sensory data, and generation of audio voice messages for transmission to aircraft. The operator control panel provided manual control over runway selection and weather sensory status.

SYSTEM PERFORMANCE EVALUATION

An evaluation of the APAS performance in a high density uncontrolled environment was one of the primary objectives of the Manassas testing. The purpose of this evaluation was to determine the adequacy of system specifications and to ascertain whether any system degradation would occur due to high traffic density or other factors. The primary areas of concern were system cycle time, target detection, tracking, and message rates.

The methods used to evaluate APAS performance included a continual verification of advisory reports and the maintenance of a system anomalies and pertinent data log. Additionally, during two 90-minute periods each day, all traffic advisory reports were recorded and a count was obtained of those reports verified or unverified by radar or visual spotters. Throughout the six-week test period, 95 percent of the APAS reports were verified during the 90-minute counts. The breakdown on the five percent incorrect reports showed that one percent was loss of track on the final leg, one percent were late reports on departing aircraft, two percent were false tracks caused by large earth-moving equipment being used to construct a parallel runway, and one percent was for various other causes. The occurrences of the incorrect final and departure reports were enhanced by earth-moving equipment and site location problems unique to the experimental APAS. These two factors caused a higher-than-normal radar signal to be required for target detection, therefore, decreasing the probability of detection. It should be noted that the APAS software contains a computer code to eliminate problems produced by roadways, but it could not be utilized because the "roadway" for the earth-moving equipment was one-half mile wide.

During the test period, the maximum traffic density occurred on Sunday, July 13, 1980. The total track rate, operation rate, and traffic report histogram data for this day are presented in Figures 2, 3, and 4, respectively. (Total track rate is the number of APAS validated tracks per hour; the operation rate is the sum of take-offs and landings per hour; the traffic report histogram depicts the number of traffic reports containing "N" number of aircraft). This data indicates that the APAS operated for five hours at an operational rate exceeding 50 operations per hour with a peak rate of 70 operations during a one-hour period. Additionally, the system reported its design limit of 10 aircraft on several occasions. System performance measurements during this period indicated: (1) the two-second system cycle time was maintained; (2) no degradation occurred in traffic report accuracy rates (the highest accuracy rate achieved during the six-week test occurred during the five-hour high density period on July 13); and (3) the time for a traffic advisory message exceeded the 20-second period several times, but system software handled this situation by delaying the next advisory by the time overrun.

During this test period, the APAS performance in marginal VFR conditions was mixed. On two occasions, during very hazy conditions, the APAS experienced no performance degradation; on other occasions, in light to moderate rain, the traffic advisory system was turned off because of numerous false target reports. The APAS contains computer software which detects the existence of rain and attempts to maintain pattern reports while deleting traffic reports outside the pattern in the area where the rain occurs. This software was used with favorable results on several occasions during isolated thunderstorms. Although the computer software in the experimental APAS did not contain the proper messages, it appears that the rain detection software could be expanded to handle the moderate rain problems.

The experimental APAS had a seven-to-eighteen second system delay which resulted in aircraft completing a pattern leg turn being reported on the previous pattern leg. This time delay was caused by a combination of the traffic advisory reporting time, the six-second target update rate, and target coast mode following a missed detection. Initial users of APAS expressed concern about the delay, but pilots who continually used the system indicated that, if they didn't locate the traffic reported in a pattern leg, they would instinctively look for traffic on the next pattern leg and, therefore, the delay wasn't a problem.

During the APAS operational period, the Manassas UNICOM voice traffic was significantly reduced. This condition was illustrated by a comparison between the voice traffic which occurred immediately before to that which occurred during short periods in which APAS messages were terminated to store tracking data. During these periods pilots used the self-announcement system. Although measurements were not made to quantize it, the reduction was significant enough to make it obvious to those who monitored the UNICOM frequency.

The only APAS anomaly occurred in the runway selection algorithm, which caused a runway change three times over a five minute period in light and variable winds. An analysis of the problem indicated that the number of runways impacted several input numbers in unforeseen ways. An immediate fix to the problem was implemented by changing the value of an input number, but this fix would negate the universality of the algorithm. A solution to this problem has been proposed but has not been tested.

PILOT EVALUATION

The second objective of the Manassas testing was to obtain pilot evaluations of the APAS concept in the uncontrolled high density environment. To accomplish this, the experimental APAS was operated for an eight-hour period each day for six weeks. An informational package, including a questionnaire was distributed to pilots who used the system and one hundred pilots responded to the questions (Q). Their responses (R) and an authors comment (C) are presented:

Q: Date and time of experience?

R: Not applicable.

Q: Pilot Hours?

R:
50 - 5%
100 - 6%
200 - 12%
500 - 18%
1000 - 17%
>1000 - 42%

Q: a. Function?

R:
Pilot - 99%
Co-Pilot - 1%

b. Rating?

Private	- 7%
Commercial	- 2%
Instrument	- 12%
SEL	- 28%
Multiple	- 51%

Q: Type of aircraft?

R:

SEL	- 81%
MEL	- 16%
Other	- 3%

Q: APAS Voice Quality?

R:

Unusable	- 0%
Confusing	- 1%
Satisfactory	- 39%
Excellent	- 53%
Other	- 7% (4% favorable and 3% unfavorable)

Q: Was the airport advisory two minute rate satisfactory?

R: Yes - 89%
No - 11%

C: Most of the no reponses occurred on hazy days when pilots indicated they needed favored runway information more often. The two-minute rate was insufficient because pilots were released from a controlled condition to VFR and tuned to the APAS broadcast after they had the airport in sight. Invariably, some pilots had to fly around the airport for almost two minutes to learn the favored runway from the next airport advisory.

Q: Was the airport advisory message format acceptable?

R: Yes - 92%
No - 8%

Q: Any improvements in airport advisory?

R:

No improvement	- 38%
Repeat runway more often	- 12%
Runway change confusing	- 10%
Temperature and dew point information not necessary	- 6%
Other	- 34%

Q: a. Did you experience a change in active runway?

R: Yes - 18%
No - 82%

C: The APAS selects the favored runway by a technique which is a function of the prevailing winds. When conditions occur which produce a change in the favored runway, the APAS initiates the change by announcing it on the next airport advisory message. On each of the next six traffic advisory reports, which occur between airport advisories, the runway change is announced following the traffic report. The process is completed on the next airport advisory when the favored runway is announced to be the new one.

Q: b. If so, describe your reaction.

R: Dangerous - 22%
Confusing - 28%
Satisfactory - 28%
Orderly - 22%

C: Two occurrences contributed negative responses to this question. The first was the runway change anomoly described in the system performance evaluation where several aircraft were forced to taxi back-and-forth on the taxiway, while the APAS kept changing the favored runway. This occurrence caused several responses that the runway change method was confusing.

The second occurrence resulted from a breakdown in control over the favored runway. Since controlling the runway would be part of any APAS evaluation, an agreement was made with the Manassas airport authorities, whereby the Manassas FBO would direct anyone requesting the favored runway to obtain the information from APAS broadcast. On two occasions this procedure failed and a favored runway, different than the one selected by APAS, was announced on the UNICOM frequency. On both occasions, the result produced was two aircraft simultaneously attempting to land on opposite runways. Announcements were made to divert the aircraft, but several "dangerous" responses were received from pilots.

Q: Was the traffic advisory rate satisfactory?

R: Yes - 89%
No - 11%

C: A non-limiting method was chosen to announce traffic information for the APAS. Non-pattern reports were ordered by azimuth so that pilots could differentiate potential conflicting and non-conflicting aircraft. This method would produce numerous target reports in high traffic densities so the next several questions were designed to evaluate the method.

Q: a. Were you able to identify yourself in the traffic advisory?

R: Yes - 95%
No - 5%

b. How many other aircraft were being reported?

1 - 9%
2 - 13%
3 - 24%
4 - 19%
5 - 19%
6 - 10%
7 - 4%
8 - 1%

Q: Were you able to locate all other traffic in the advisory?

R: Yes - 46%
No - 54%

If no, were you able to locate all traffic presenting a potential conflict?

Yes - 86%
No - 14%

Q: What is your opinion of the traffic advisory?

R: Disastrous - 3%
Confusing - 8%
Satisfactory - 34%
Wonderful - 30%
Other - 25% (19% favorable and 6% unfavorable)

Q: Did you experience any false target reports?

R: Yes - 14%
No - 86%

If yes, was it a problem?

Yes - 45%
No - 55%

Q: Did you site any traffic that was not reported by the system?

R: Yes - 20%
No - 80%

Q: Was the traffic advisory information in a format that you fully understood?

R: Yes - 95%
No - 5%

Q: What is your opinion of the APAS messages vs. self-announcement?

R: Favored APAS - 87.5%
Favored self-announcement - 12.5%

Q: Comments:

R: Favorable - 86.5%
Unfavorable - 13.5%

C: The favorable comments indicated that pilots thought that APAS was a safer system than the self-announcement procedure. The unfavorable comments were in two general areas: system delay and lack of knowledge about pilot intentions.

CONCLUDING REMARKS

The testing at Manassas was the first attempt to evaluate an APAS in a high density uncontrolled environment. As a minimum, this test proved that low-cost automated systems can provide airport and air traffic advisory information at high density uncontrolled airports, and a large majority of the users preferred the APAS over a self-announcement procedure.

The operational performance of the APAS indicated that additional investigations should be conducted in the following areas:

Clutter Suppression.- - Enhancements in clutter suppression will decrease the false target report rate and could solve the final and departing aircraft reporting problem. The enhancements could be made in several ways, such as increasing the height of the antenna platform and optimizing the transmit and receive antennna elevation beam width. It is recognized that an MTI type of radar would solve the clutter problem, and this type radar may be required at some "trouble" airports, but the cost of this solution should be analyzed vs. system affordability.

System Delay.- - Decreasing the system time delay appears feasible without significantly increasing system cost by using a dual receiver radar system and concurrently processing two receive antennas. It is suggested that the lowest elevation antenna be processed every cycle and the two upper elevation antennas be alternately processed. This method should result in a three-to-seven second system delay and have additional benefits such as to increase the range of initial target reporting and decrease the false target report frequency.

Channel Assignments. - - The decrease in UNICOM voice traffic during APAS operations and the APAS requirement of only a 10- to 20-nautical mile broadcast coverage area are significant factors in accessing frequency channel assignments for an operational system. Additional channels for the APAS broadcast may be obtained by assigning more uncontrolled airports the same UNICOM frequency.

The initial objectives of the APAS program have been accomplished in that concept feasibility has been demonstrated and a system description can be defined. It is recommended that a Phase II program be initiated to incorporate the results of the Manassas testing into a follow-on system.

REFERENCES

1. Parker, L. C., et al.: "An Automated Pilot Advisory System," (A paper presented at the 1978 IEEE Region 3 Conference and Exhibit in Atlanta GA, April 10-12, 1978).

2. Haidt, J. G., et al.: "Pilot Advisory System Feasibility Definition Study," Research Triangle Institute, February 1977.

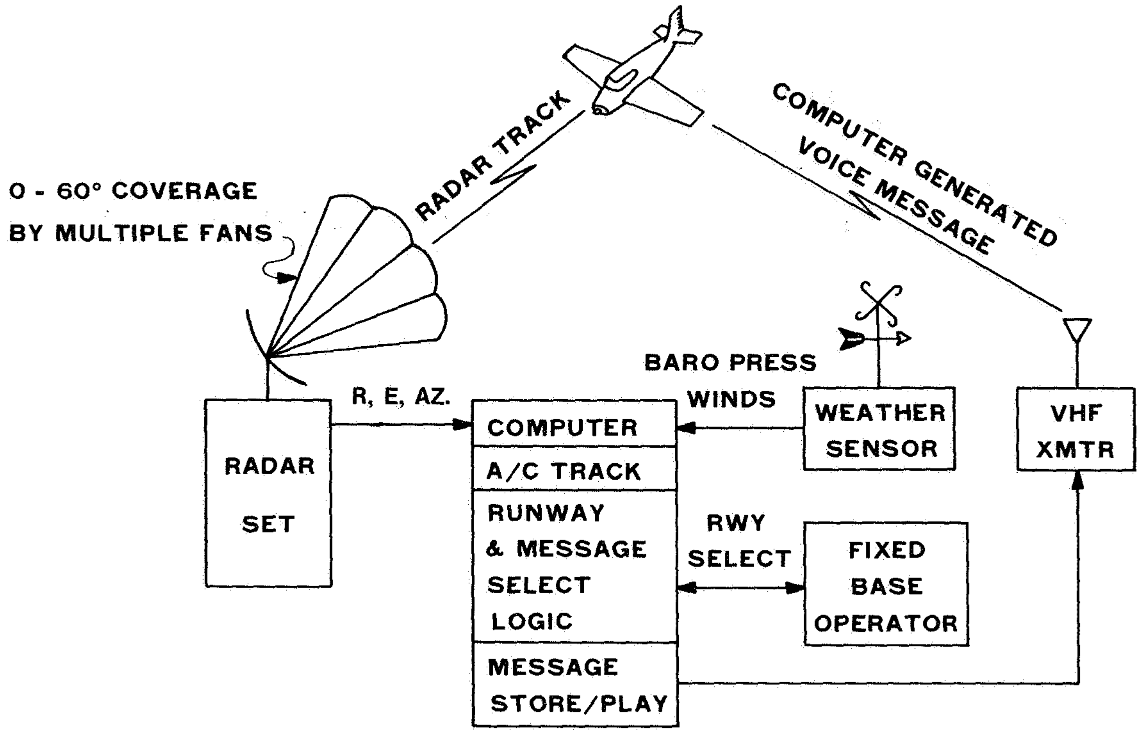

Figure 1.- Automated pilot advisory system.

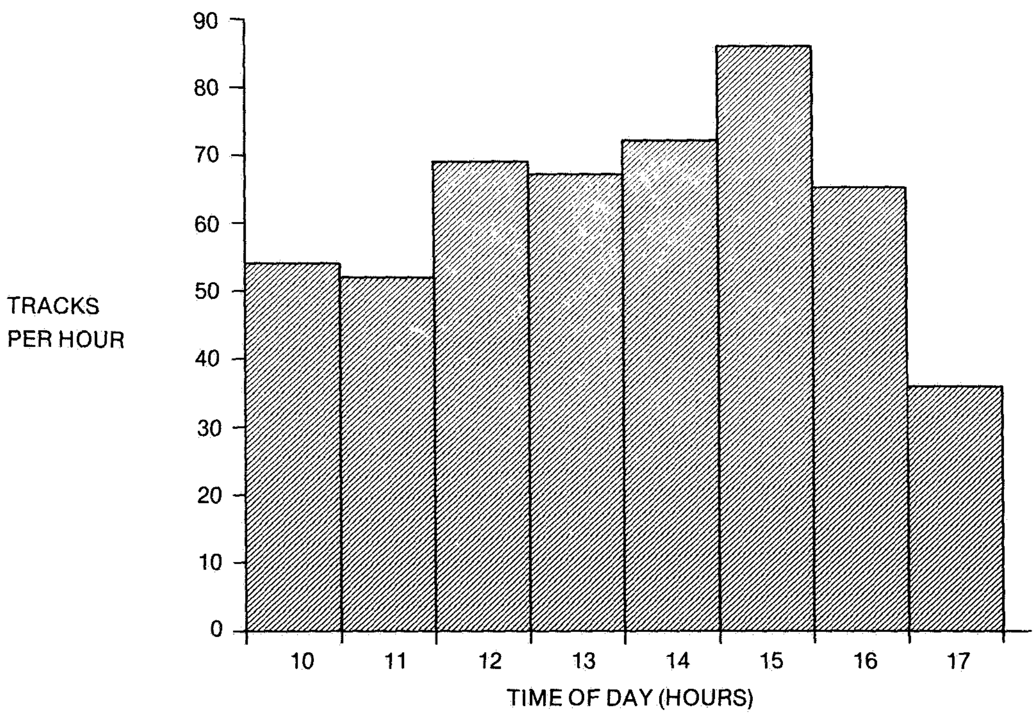

Figure 2.- Track rate - July 13, 1980.

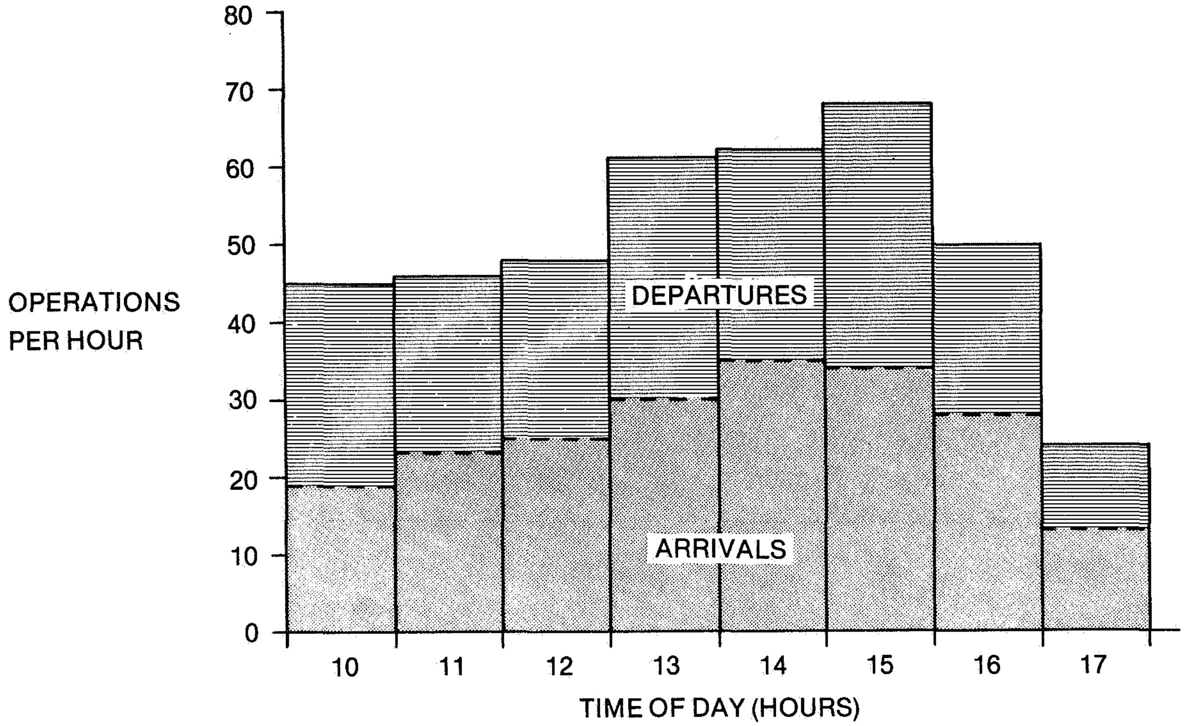

Figure 3.- Operational rate - July 13, 1980.

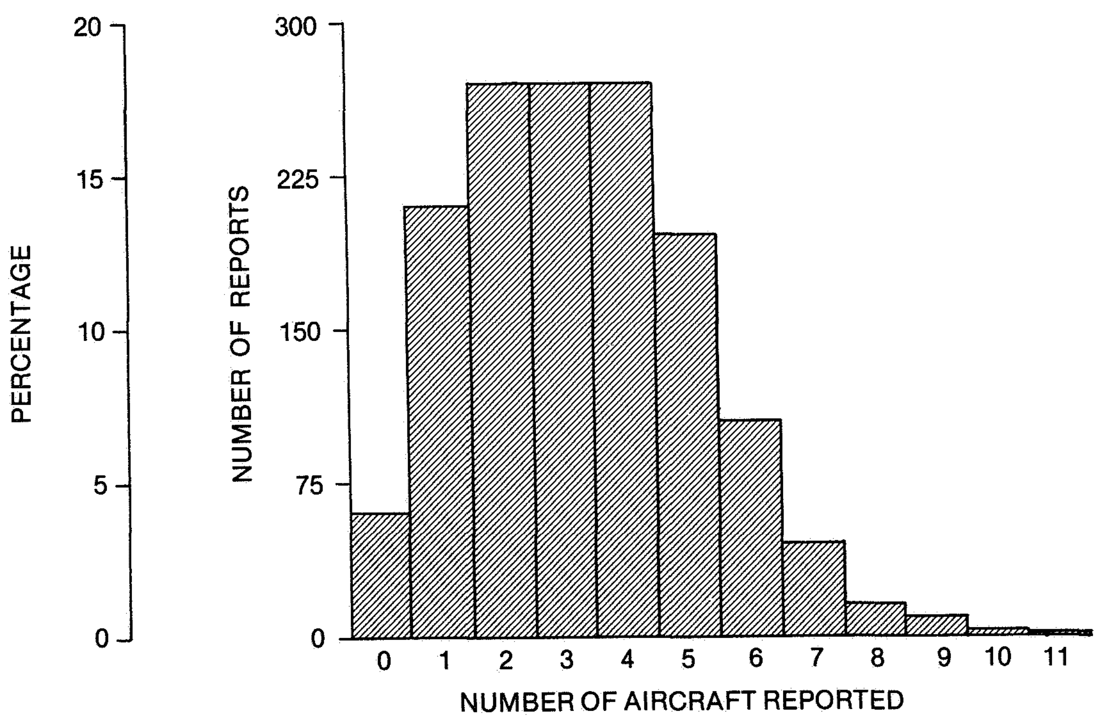

Figure 4.- Traffic report histogram - July 13, 1980.