Simulation Tests of a Horizontal Display for the Control of High-Altitude Traffic

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SIMULATION TESTS OF A HORIZONTAL DISPLAY FOR THE CONTROL OF HIGH-ALTITUDE TRAFFIC*

SUMMARY

Simulation tests were conducted to determine the practicability of using a horizontal plotting display instead of a flight progress board for the procedural control of high-altitude aircraft in an Air Route Traffic Control Center Movable target markers carried the pertinent flight data for each aircraft on a horizontal plotting board which was scaled 8 miles to the inch The use of projected course lines, plotted with grease pencil and calibrated in time, also was tried

Tests, based on recent actual traffic samples of the Indianapolis Air Route Traffic Control area for all aircraft flying at 24,000 feet mean sea level and above, indicated that the use of this display was practicable for handling present traffic loads The use of projected course lines was found to be unnecessary except for aircraft with unusual flight paths.

INTRODUCTION

For the past three years, controllers at the CAA Technical Development Center (TDC) have experimented with pictorial horizontal displays, primarily in connection with radar-derived position information. Some tests were conducted without radar to determine if this type of display still could function in the event of radar failure. Successful results of these tests indicated that horizontal displays might be used in procedural control in place of flight progress boards. Although subsequent tests indicated that the horizontal display used without radar was not superior to the present flight progress display, experience obtained during these tests indicated the following

1. An aircraft flying a direct off-airway routing is displayed better on a pictorial presentation than on a tabular display.
2. The pictorial display requires much less paper work, and it provides access to the displayed information by a working team of controller personnel
3. The most undesirable feature of a pictorial display is its lack of tabulated estimated arrival times over various points along the route of flight.
4. The optimum placement of control equipment, such as interphones and radio control panels, to suit the average controller is more difficult with a pictorial display.
5. The scale of the display is important from the standpoint of controller fatigue as well as from that of posting and observation of adequate information on the control display itself.
6. The aircraft target markers must be large enough to contain adequate information for the control of aircraft and for the transfer of pertinent data to other sectors and centers

The Office of Federal Airways requested this Center to use a pictorial display in simulation tests of the control of aircraft flying at and above 24,000 feet Two controllers from the Cleveland Air Route Traffic Control (ARTC) Center participated in these tests because they had conducted simulation tests previously on a pictorial display early in 1955.

TEST PROCEDURES

General Considerations.

All tests were based on the following assumptions

1 Pilots were expected to file and fly routes between specified radio facilities, each of which would become a designated reporting point for the flight.

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*Reprinted for general distribution from a limited distribution report dated May 1956.

Fig 1 The Basic Horizontal Display

2 These navigation aids were to be approximately 200 miles apart, plus or minus 100 miles It was considered practical to comply with procedure, at least in the area east of the Rocky Mountains where there is an ample number of radio navigation aids In the western areas of the United States, the distances between suitable navigation aids seldom exceed 400 miles

3 Navigation was assumed to be in a straight line between successive navigation aids with a course accuracy within 10 miles of the specified route

4 Except for air carrier aircraft, no direct communications were used between controllers and pilots because it is expected to be several years before air route traffic controllers will have radio channels adequate for direct contact with all categories of aircraft flying in the system

5 Standard ANC separation minimums would be used at all times

Display

Figure 1 shows the basic display used in these tests A board 6 feet by 3 feet was placed horizontally as a table top Sectional maps then were placed on this board In order to reduce the brightness of the map colors, thereby making the colored grease-pencil lines more readable against the map background, three layers of translucent paper were placed on top of the maps A plotting surface was obtained using a clear plastic sheet placed on top of these layers of paper

It was decided that the primary items needed on the display were the locations of all radio aids, airports, restricted areas, and unusual terrain These areas were marked on the under surface of the plastic top, and no reference was made to the sectional maps

The "shrimp boat" target markers used are shown in Fig 2 These provided sufficient room for pertinent control information The altitude was very readable at the front end of the marker, but it also was carried on the strip as a double check against possible errors Arrows painted on small arms at the sides of the markers were used to indicate aircraft in a state of climb or descent

These markers were two-sided On one side, the body of the marker was painted red to indicate a range of altitudes of 20,000 through 29,000 feet The other side was painted yellow to indicate the altitude range above 30,000 feet Thus, the body colors quickly indicated the amount of traffic above or below 30,000 feet In addition to this use of color, each altitude shown on the dial had a significant background color such as green for 35,000 and 45,000 feet, yellow for 33,000 and 43,000 feet, and so forth

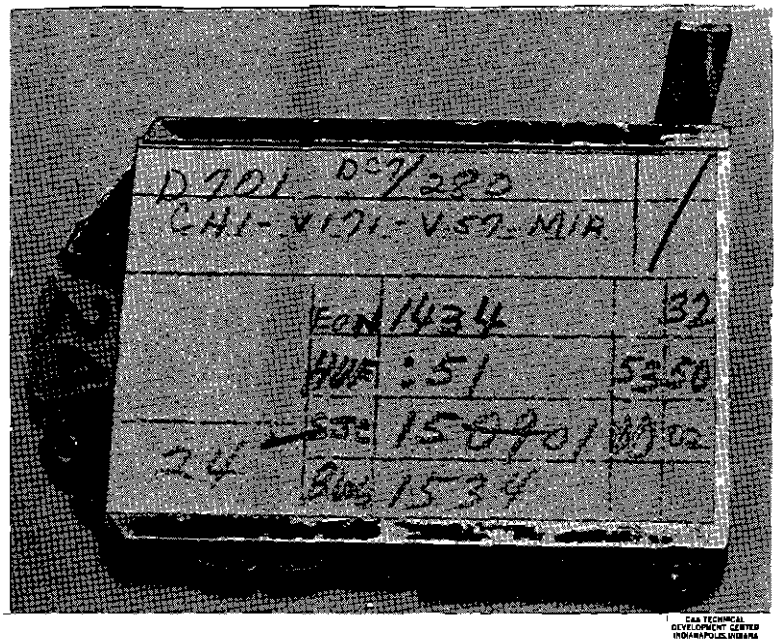

Fig 2 A Typical Target Marker

Traffic Samples

Three 4-hour traffic samples were constructed, based on actual traffic operations in the Indianapolis ARTC area The samples included all aircraft which were assigned definite cruising altitudes of 24,000 feet and above, as well as all aircraft cleared at "1000-on-top" but of types which could be expected to cruise at altitudes of 24,000 feet and above.

Two of these samples duplicated exactly the altitude information posted on the actual flight progress strips. The peak hour of these samples included 11 aircraft flying at definitely assigned altitudes and 17 aircraft flying with 1000-on-top clearances. The third sample contained the same total number of aircraft, but the number of flights at definitely assigned altitudes was increased from 26 to 35 for the 4-hour period. This was done to determine if the display still could be used under weather conditions when the cloud tops were unusually high The peak hour of this sample had 16 aircraft flying at assigned altitudes and 16 with 1000-on-top clearances

Position of Operation

A flight-data position was used to receive and transfer aircraft flight plans To provide a realistic controller environment, two positions were arranged in another room and provided with interphone lines to the "Indianapolis Controller." These two positions represented the activity of surrounding centers for this area.

Two additional positions were arranged in this room and equipped with interphone lines to the controller These positions represented the INSACS for the entire area It is expected that personnel requirements for actual operating displays will vary from area to area, depending on the number of bases which have considerable jet activity

RESULTS AND OBSERVATIONS

Test No 1

The first test was made using techniques as employed by the Cleveland ARTC Center during its tests on a similar display. Figure 3 shows the display at a peak period Figure 4 is a close-up view of the course-line and time projections.

Controller personnel consisted of one controller and two plotter-estimators In a live situation, it is believed that two controllers would be required to control an entire ARTC area, particularly in areas where there is an airport which generates heavy high-altitude traffic during certain periods

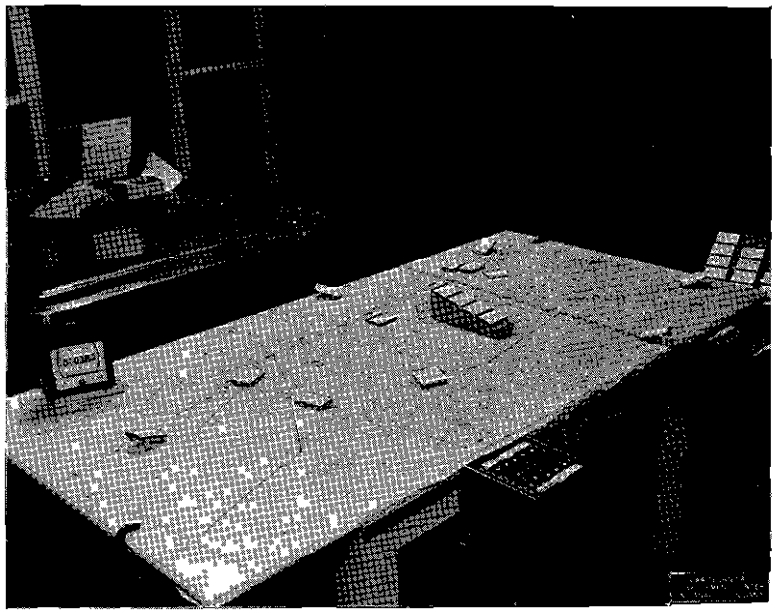

Fig 3 The Display in Use with Course-Line and Time Projections

The duties of the plotter-estimators consisted of plotting the path of flight for each aircraft and placing estimates along this path of flight in 10-minute increments. When necessary, these controllers also were required to revise not only the route of flight but the estimates along the routes of flight as well. If a potential conflict was noticed during the process of plotting the flight, it was called to the attention of the control personnel

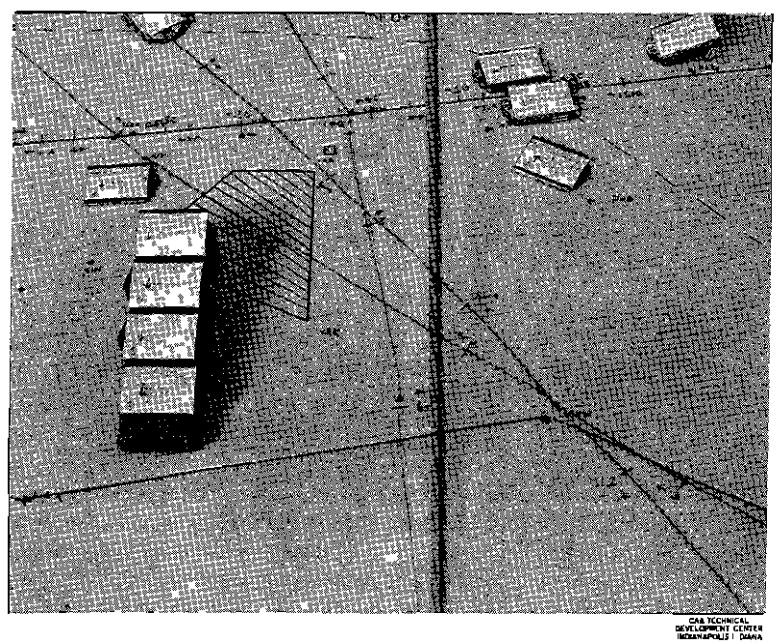

Fig 4 Close-Up View of Course-Line and Time Projections

An alarm was employed to ring at 10-minute intervals. At these times the estimators moved all markers forward to the next 10-minute marker on the course line and erased the line in the area used previously by the aircraft Course lines for each flight were drawn with colored grease pencils. In this test, colors were assigned at random to different flights. The color in which the course-line plot was made also was marked on the strip in the target marker to indicate the color associated with that flight

The results of this test indicated that

1 It was possible at this traffic density to plot the flights adequately

2. The use of the different colors to indicate different flights was of little value

3 The course lines and estimates were usable for eight or nine aircraft plots Beyond that point, the controller rarely used this information. Instead, he scanned the display for aircraft at the same altitude, then checked estimates off the marker rather than the board As a result, it was decided to run the next test using the colored course-projection lines to show altitude. When two lines of the same color crossed on the display, it indicated possible conflict at the same altitude.

4 The need for the course lines and estimates was questionable because ten plots at one time seemed to be the maximum that could be plotted and deciphered adequately

Test No. 2

The control positions used in this test were the same as those described previously Course-line plots were color-coded as follows

Color	Altitude (in thousands of feet)
Green	24, 25, 35, 45
Purple	26
Blue	27, 37, 47
Brown	28
Black	29, 39
Red	31, 41

When two or more aircraft were following along the same flight path at the same altitude or at another altitude for which the same color was used, it was necessary to place alphabetical letters on the target-marker strips in order to distinguish between flights.

The results of this test indicated that.

1. In the first sample, the use of color for altitude was more advantageous than the use made of color in the first test. No difficulty was experienced in light traffic conditions.

2. When there were as many as 12 course lines plotted on the display at one time, the controllers again began to consult the target markers for control information instead of referring to the plotted information

3. When an aircraft altitude was changed to avoid a conflict, it became necessary to either erase the original color and replot the flight on the display or use a symbol of some type to indicate a change. The most rapid method was to make a wavy line in the new color over the original course line. If a third change was made, a replot of the flight was necessary.

4. The course-line plots and estimates were not required at the lighter density and were undesirable at the heavier density because of their cluttered appearance.

Test No 3.

Control positions were the same as in tests Nos 1 and 2 In this test, no course lines or estimates were plotted on the board. Instead, all information was placed in appropriate spaces on the target-marker strip Figure 5 shows the display at a peak period of a run.

The results of this test indicated that

1 At normal density, the course lines and estimates were not required.

2 The timer alert signal still was required as a reminder to place the markers in a position along the path of flight relative to the fix estimates shown on the strip.

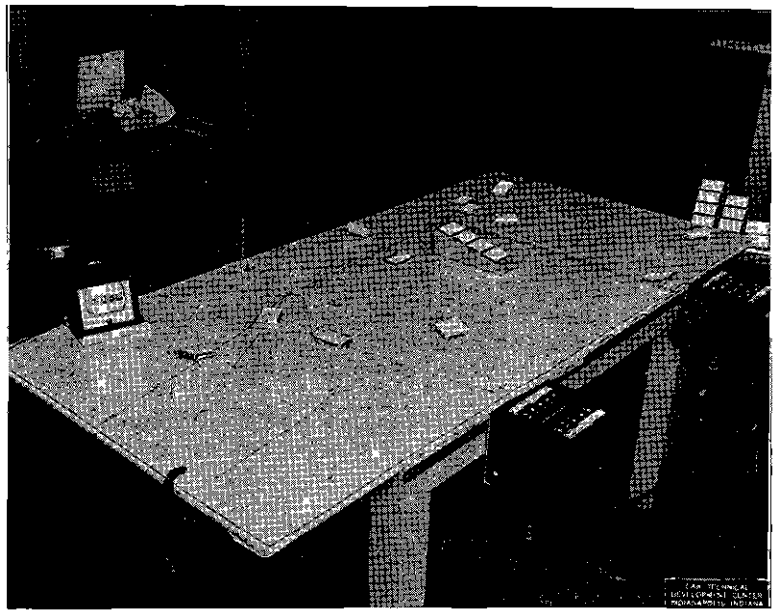

Fig 5 The Display in Use Without Course-Line and Time Projections

3 During periods of heavier densities, a course plot would be advantageous for those aircraft which were flying dogleg routes through the area Therefore, this was carried out for the remainder of the tests on this display, and no time-estimate marks were placed on this course line

4 No difficulty was experienced with the heavier traffic densities.

5 The team of plotters had ample time to run accurate estimates, forward data, and help to position the markers, as well as to study the display for potential conflicts

Procedure for 1000-on-Top Clearances.

It is very probable that pilots filing flight plans with compulsory check points spaced about 200 miles apart will report more often than is customary under present high-altitude flight operations. During the simulation tests, the controller spent a high percentage of his time receiving position reports on flights which were cruising 1000-on-top, but which were neither taking off nor landing in the Center's area Because this procedure contributed nothing to the actual control of the aircraft, a new procedure was suggested to relieve the controller of this time-consuming workload This procedure functioned very well in subsequent tests, and it appears practical for immediate adoption The procedure was

1 When the pilot of an aircraft filed a flight plan requesting 1000-on-top or received this type of clearance on departure, the flight plan would be forwarded via Teletype or long lines to the ARTC area of destination only

2 After reaching 1000-on-top, the pilot of the aircraft would make normal position reports to INSAC stations during flight

3 INSAC personnel would keep this record but would not forward the information to the center

4 When the aircraft was within 100 to 150 miles of destination, the pilot would advise an INSAC station of his position and destination and request further IFR clearance from ARTC.

5. Upon receipt of this position report, INSAC personnel would contact the proper ARTC and further clearance would be issued for the final stages of the flight.

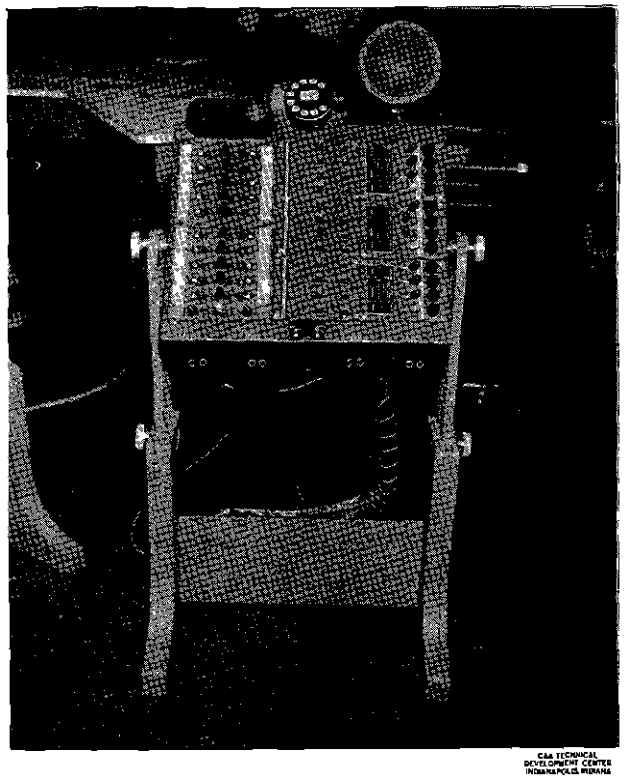

Fig 6 Movable Communications Rack

CONCLUSIONS

1. It appears practical to control the present densities of high-altitude aircraft (those desiring to fly at assigned altitudes) using a horizontal display

2 The projected course lines, as used with the Cleveland display, were of little value when the total number of plots on the display exceeded ten

3 In areas where heavy concentrations of military traffic are common, an additional controller may be required to coordinate that traffic with approach control and other sectors. In these tests, the controllers were forced to work this traffic via indirect communications, however, the volume was such that it would have taken one controller's time to do the work even if direct communications had been assumed

4 The use of a timing device was helpful in reminding all of the personnel to check the current status of all aircraft As experience is gained with the display, it is believed that this aid may not be required, because checking is as much a duty on this display as is current marking of the flight progress board.

5 A sectional map scale (8 miles to the inch) was adequate for the display of the Indianapolis area. Another scale may be desirable in other areas, depending on the size of the area

6 At present traffic densities, the training time in the use of this display should be short for new personnel.

7. It is difficult to arrive at a satisfactory arrangement of equipment around such a display for all controllers Figure 6 shows one type of movable communications rack used in the Indianapolis Airways Operations Evaluation Center

8. The size and arrangement of the target marker and posting strip used in these tests were satisfactory for use with a display at the scale factor used Although the body color of the marker proved very useful, the use of different background colors for the altitude markings was of doubtful value

9. Because of many factors, such as the desire of jet pilots to use cruising climb procedures and the necessity for controllers to use 2,000-foot altitude separation between aircraft above 29,000 feet due to altimeter errors, it is impractical to assign cruising altitudes to all aircraft desiring to fly at or above 24,000 feet mean sea level It is anticipated that the 1000-on-top clearance will continue to be used for a large percentage of flights at these altitudes.

ACKNOWLEDGMENT

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