HIGH-VISIBILITY PAINTING DESIGN FOR AIRCRAFT

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San Diego, California

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A BUREAU OF SHIPS LABORATORY

THE PROBLEM

Make a general study of the problem of aircraft painting for maximum visibility, and of the role of color, as well as luminance contrast, in the detection and recognition of aircraft. Specifically, this report describes an application of some of the findings of this general study to a privately owned Grumman Widgeon seaplane.

RESULTS

1. A high-visibility paint design for the Grumman Widgeon was produced and evaluated in flight tests.

2. The basic principles of high visibility or anti-concealment were developed for general application to aircraft. Briefly these are:

a. Maximize luminance contrasts relative to normal backgrounds through the use of black paint on areas normally dark and the use of white paint on surfaces normally bright. This means that the underside of wings and fuselage, and also the areas normally shadowed by the wings, must be painted black, whereas the tops of wings and fuselage should be painted white.

b. Use "unnatural" color (fluorescent red or orange) in one or two fairly large simple areas that normally receive sunlight (since fluorescent paint gives little or no added conspicuity when not in sunlight).

RECOMMENDATION

Give consideration to the above principles in establishing paint schemes designed to contribute to collision avoidance and aid in rescue.

ADMINISTRATIVE INFORMATION

Work was performed under SR 07401, NS 714-100 (NEL N6-3) at intermittent times during the period September 1958 to March 1959. The report was approved for publication 25 May 1959.

Special thanks are extended to Dr. Gifford Ewing of the Scripps Institution of Oceanography for cooperating in this study by donating the use of his aircraft and piloting it during the air-to-air photographic phases of the study; and to the personnel of the Fleet Air Photographic Branch, North Island Naval Air Station, for their considerable assistance in furnishing aircraft and photographic services.

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ILLUSTRATIONS

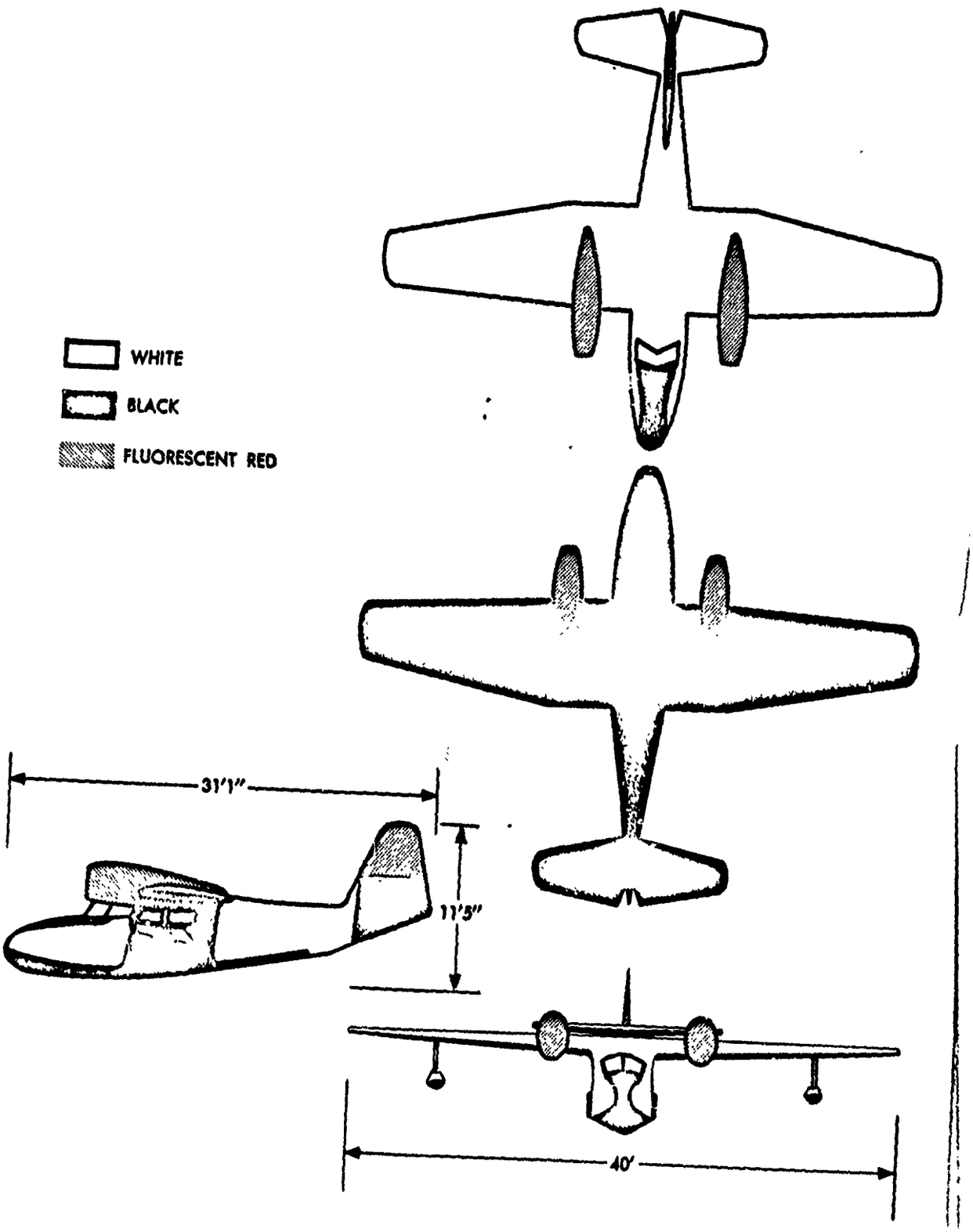


Figure 1. The Grumman Widgeon with original paint design.

greatest contrast for distant air-to-air detectability. Black was also used forward of the cockpit to reduce glare to the pilot. Its application here as a high-visibility marking was of secondary importance. However, under certain conditions at bow aspect it will become distinctive as a high-visibility marking.

Viewed at steep downward angles, land and water backgrounds are generally dark, the sea reflecting as little as 3 per cent of the incident light back to the observer and the land reflecting from 5 to 20 per cent. For this reason white was used for the upward facing surfaces of the fuselage, horizontal stabilizer, and wing. The white as shown on the sides of the craft presents the necessary contrast to darker backgrounds while the black shadowed areas are effective against the lighter background situations from horizontal or shallow upward angles of view.

The application of fluorescent paint to the upper portions of the vertical stabilizer and engine nacelles not only provides brightness contrast to dark backgrounds but presents a color contrast which is foreign in nature and therefore conspicuous. It is in this "unnatural" color that the fluorescent paints contribute greatly to high-visibility painting design. It has been observed, however, that they give no particular advantage when applied in shadow areas and tests have shown that they do not generate significantly higher positive contrasts against dark backgrounds than does white paint.

FIELD TEST AND EVALUATION

The design was tested photographically and visually. An R4D plane flew formation with the Widgeon in a flight pattern designed to present all available angles of view, lighting, and backgrounds to the accompanying Beechcraft photo plane.

A square flight pattern, 10 miles on a side, and located off the west side of Point Loma, San Diego, was monitored by radar from the Laboratory.

Ground observers were stationed about 2 miles from the radar and had a clear view of the complete pattern. Since all aircraft were visual targets during the tests, dimensions and paint designs of the other two craft were determined and are shown in figures 2 and 3. The R4D presented a target three to four times the projected area of the other two aircraft which were approximately matched in size. The photo plane, being nearly the size of the Widgeon, was used for comparison by the observers. Observations were made with the naked eye and with 7X50 binoculars. Comments of observers were entered in a log, including notations regarding time, relative headings, positions in formation, apparent brightnesses in relation to each other, and contrasts to the background.

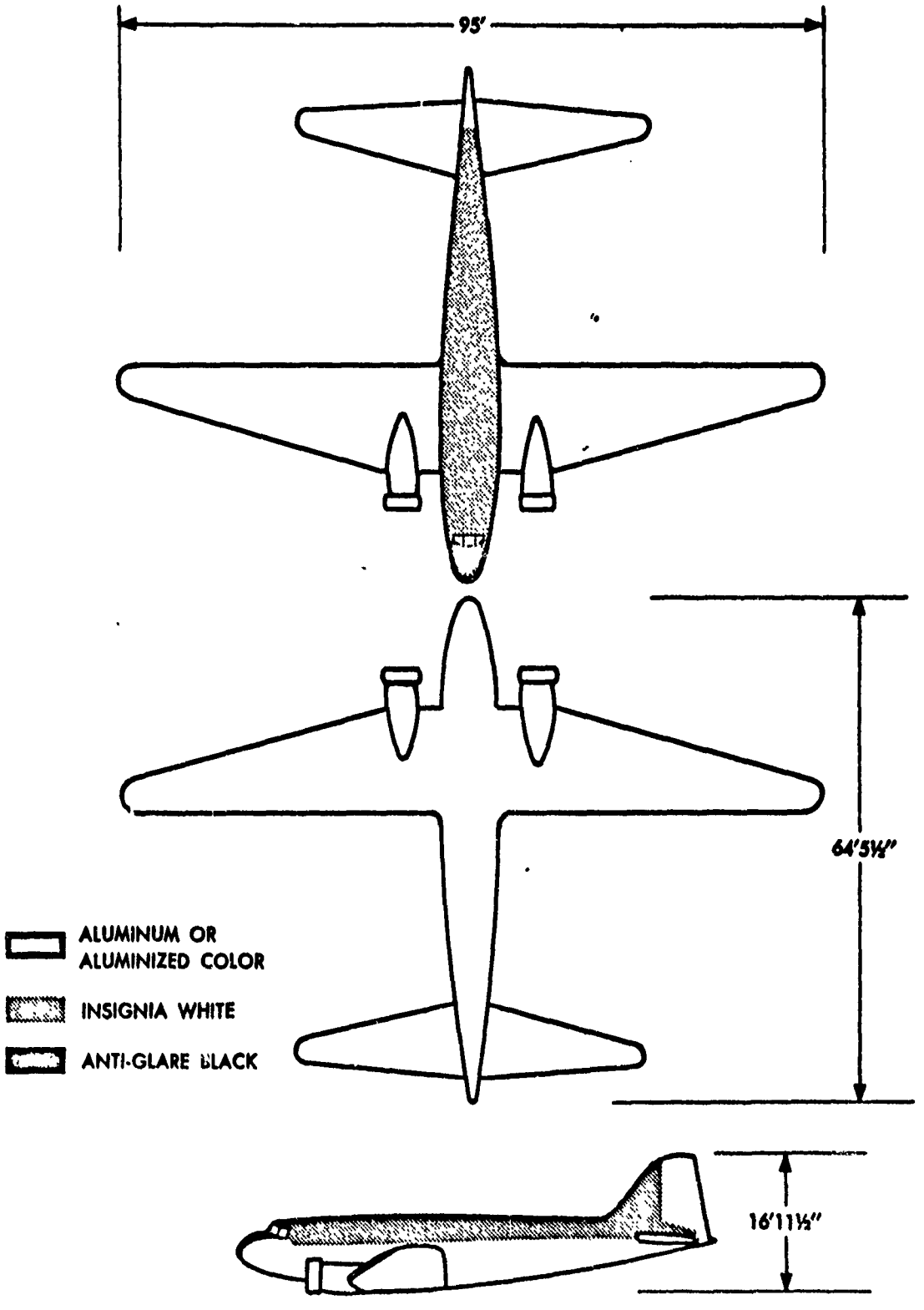


Figure 2. Target aircraft, R4D.

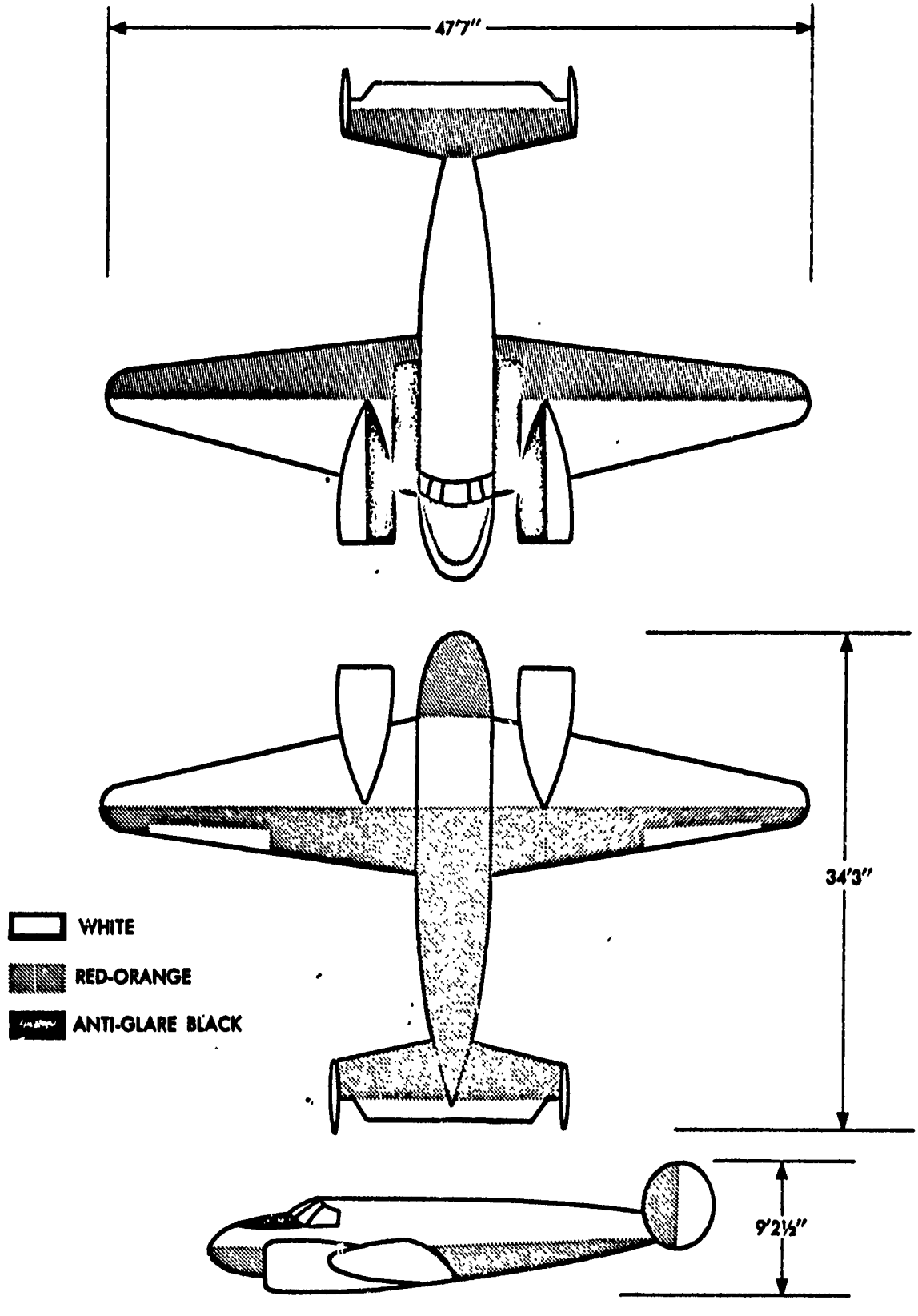


Figure 3. Beechcraft photographic reconnaissance plane.

The weather conditions on the day scheduled for the flight operations were most favorable; there was a wide variety of sky and cloud conditions. The previous weekend had been stormy, leaving the air clear. Visibility below 2000 feet was unlimited. The sky above this level consisted of scattered clouds furnishing a large variety of sky backgrounds and lighting conditions.

Standard air-to-air communications were maintained between the three aircraft. A radio telephone link was provided through the cooperation of Scripps Radio to the NEL radar site.

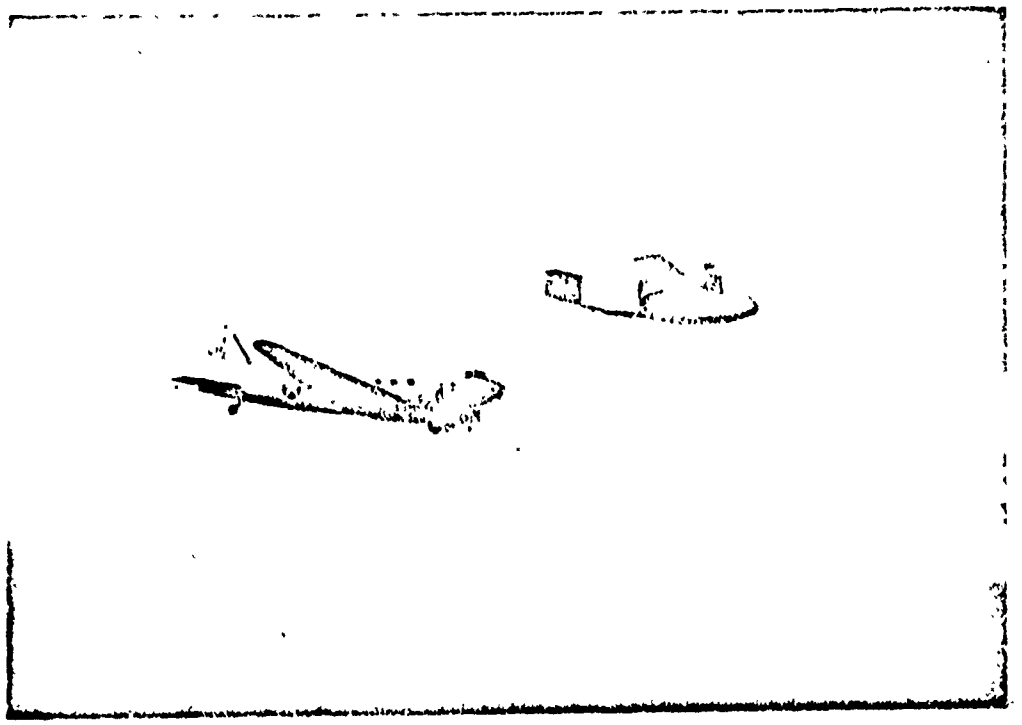
Time logs were used in correlating the comments made by the visual observers with the photographs and the radar plots.

RESULTS

No attempt will be made to quantify the ground observations. However, by comparing the descriptions with radar range data, it is possible to summarize as follows: The R4D (because of its greater size) was generally more visible than either of the two smaller planes. The Widgeon and the Beechcraft photo plane (being of approximately the same size) were both detected at or tracked to about the same distance. The red fluorescent paint markings on the Widgeon were consistently distinguished by the observers as colored areas at greater range (around 12 miles) than the red painted areas of the photo plane. This observation is quite remarkable since, as shown in figures 1 and 3, there is considerably less area painted fluorescent red on the Widgeon than is painted standard red on the photo plane.

An inspection of the 60 black and white and 60 colored aerial photographs disclosed that practically every point of view and lighting condition had been obtained. Figures 4A - D are illustrative of the black and white photographic data obtained. In these pictures the fluorescent paint appears washed out and of about the same brightness as the white areas. However, the colored photos were much more valuable from the standpoint of giving information concerning the color recognition factors and seemed to impart more of the correct impression concerning the brightness factor of the fluorescent red paint.

The special design effectively produced high visibility from above and from below because of the higher contrast-to-background generated. From the horizontal aspect it was found that the flat sides of the Widgeon when painted white provided too little contrast and therefore were less effective than the rounded sides of the R4D which naturally produced a considerable undershadow.



A. DOWN-SUN, CLEAR SKY BACKGROUND

B. DOWN-SUN, DARK SEA BACKGROUND, CLEAR SKY

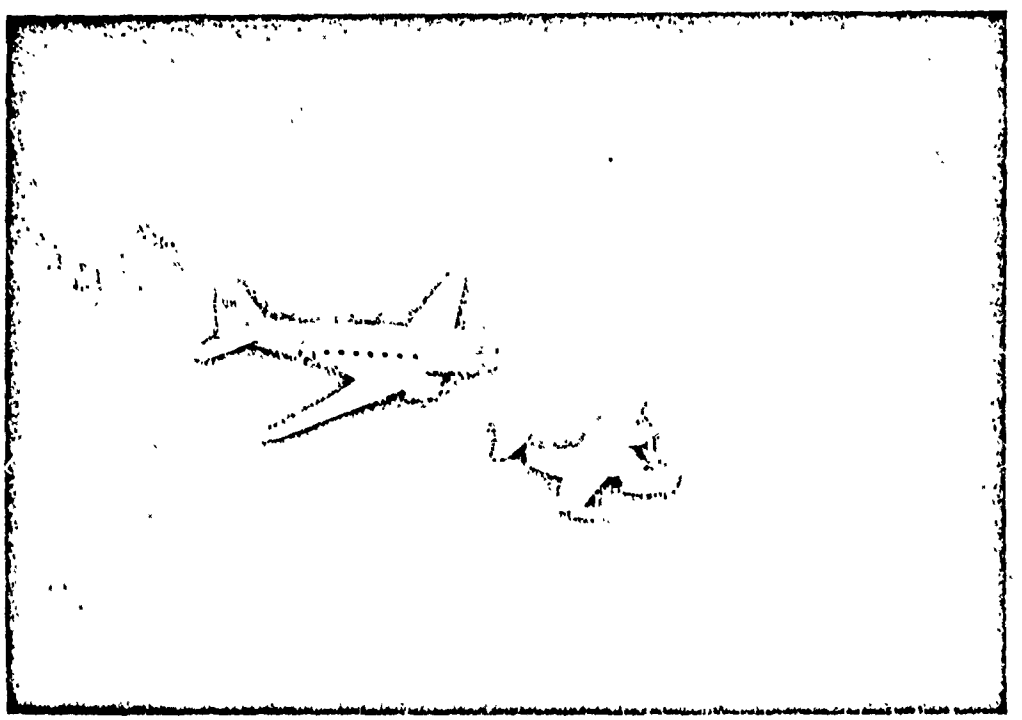
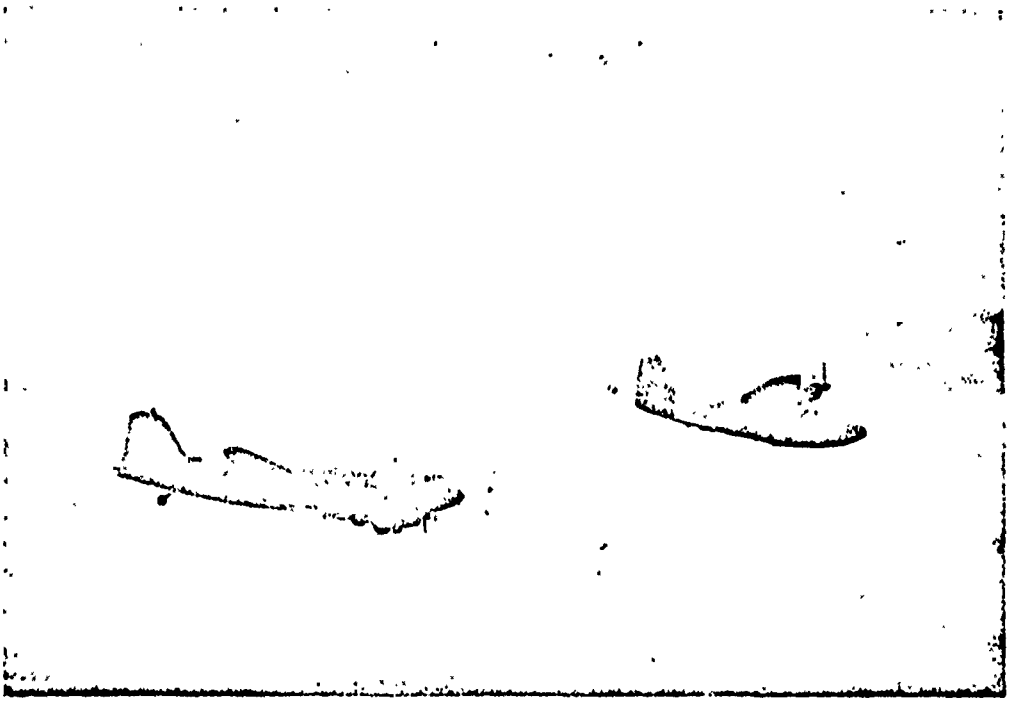


Figure 4. R4D and Widgeon against various visual backgrounds.



C. UP-SUN, CLOUD BACKGROUND, PARTIAL OVERCAST

D. UP-SUN, BRIGHT SEA BACKGROUND, PARTIAL OVERCAST

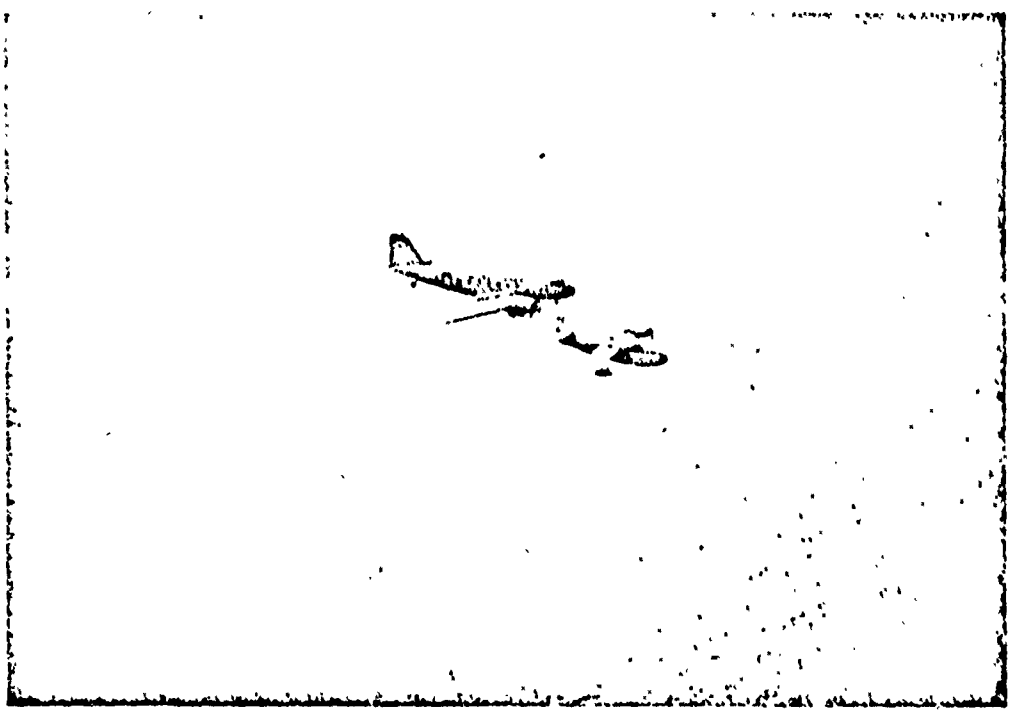


Figure 4. R4D and Widgeon against various visual backgrounds.

THE MODIFIED DESIGN

On the basis of the photographic and ground observer data, the following modifications were made in the basic paint design.

1. Black on the sides of craft was increased to include more of the shifting shadow forward of the wing (fig. 5). The shadow which is also cast aft of the wing had to be disregarded to avoid conflict with the registration numbers. For the same reason the shadow cast forward by the horizontal stabilizer was left as originally designed.

2. The black along the hull was carried up approximately 2 feet to compensate for the lack of undershadow created by the flat sides of this particular aircraft as shown in figure 5.

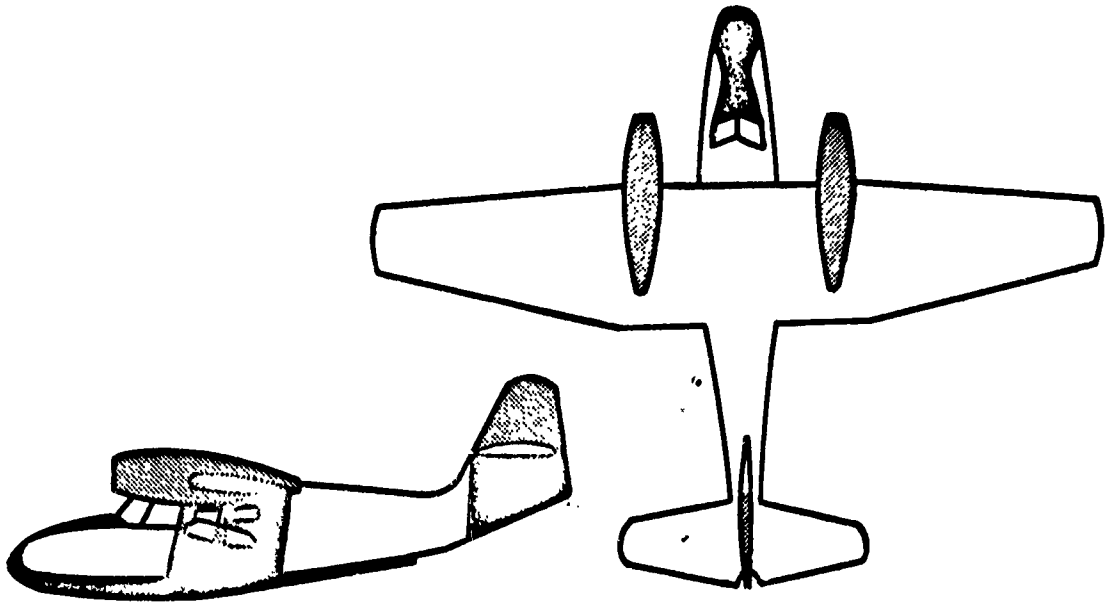
3. Fluorescent red was added to the upper portion of the wing between the engine nacelles to visually tie the nacelles together into an integrated compact mass of color. This will enhance the recognizability for the downward looking situations and would be a distinct advantage for search in case the aircraft were forced down or had crashed.

4. Modifications were also made to the wing floats which are in themselves small areas. The original paint design served only to break up this relatively small area into three parts. The design changes were made as shown in figure 6. The under portions were left black for the previously cited reasons as well as for the practical reason that the fluorescent paints are not as durable as other types in contact with water. The principal advantage to the present design is that the float, if detached in an accident, would present a single compact target of high contrast and unusual color floating in the sea.

DISCUSSION AND RECOMMENDATIONS

Application of the information contained in this report should serve to minimize the air collision problem and increase the probability of rescue by emphasizing the more basic controlled-design principles which should be considered before applying paint to any aircraft shape.

A large number of commercial aircraft and the majority of private aircraft paint designs are of a purely aesthetic nature. The use of fluorescent paint as applied in narrow bands, arrowheads, or small stripes on large areas serves very little useful purpose from the standpoint of safety.

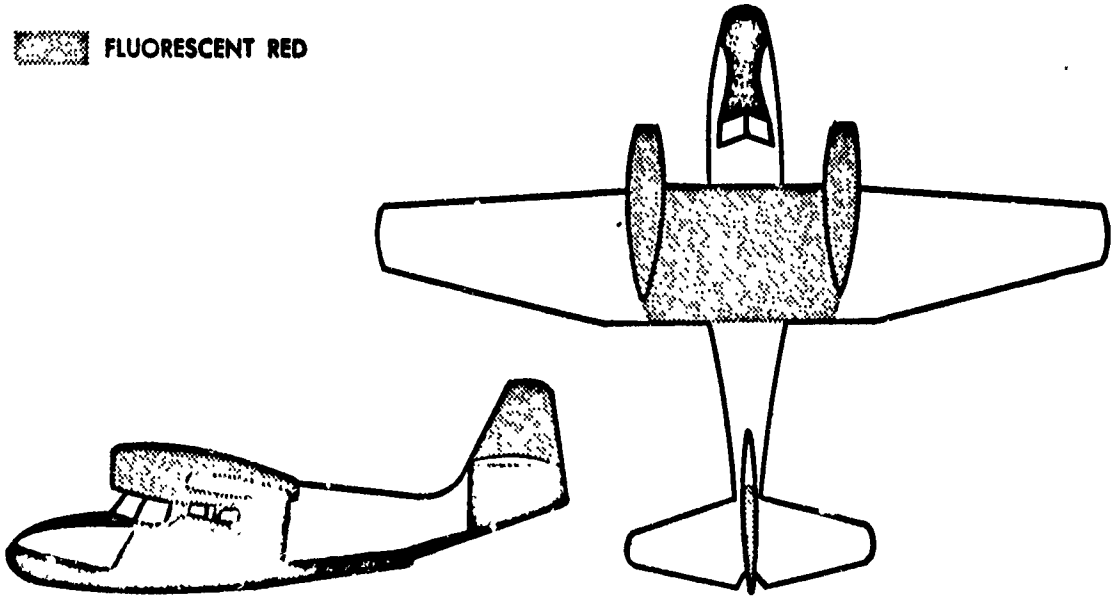


BASIC DESIGN

WHITE

BLACK

FLUORESCENT RED



RECOMMENDED MODIFIED DESIGN

Figure 5. Grumman Widgeon, before and after modification of paint design.

Paint designs should be carefully thought out, resulting in a sound reason for each and every color or reflectance on the various surfaces. Full consideration should be given to the common backgrounds against which the aircraft types will be seen when operating normally, and to the lighting to which they will be subjected.

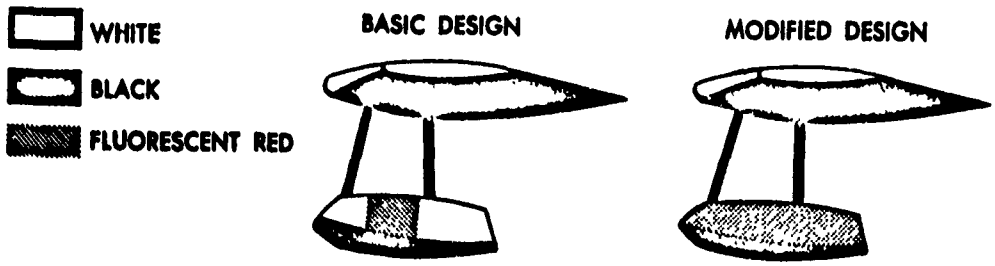


Figure 6. Paint design of wing float, before and after modification.

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