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16. Abstract An investigation was conducted to rank the conspicuity of three paint schemes for airplane propellers and two schemes for tail rotor blades previously recommended by the U.S. military and British Civil Aviation Authority. Thirty volunteer subjects with normal vision viewed rotating propellers at 6.1 m (20 ft) and tail rotor blades at 9.1 m (30 ft) under bright sunlight conditions. Observations of the grouped airplanes and helicopters were made from three angles that included (i) viewing upward from a crouched position, (ii) at eye level while standing, and (iii) downward from an elevated platform. At all viewing angles, the propeller design consisting of black and white stripes asymmetrically placed on opposing blades was judged "most conspicuous" by a wide margin. The red and white stripe design (symmetrically placed) was considered slightly more effective than the yellow tip design. Of two designs for tail rotors, the black and white asymmetrical stripe scheme was chosen "more conspicuous" (9 to 1 ratio) than a red, white, and black stripe design.					
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CONSPICUITY ASSESSMENT OF SELECTED
PROPELLER AND TAIL ROTOR PAINT SCHEMES

I. Introduction.

The U.S. National Transportation Safety Board (NTSB) has reported that accidents from propeller and tail rotor blades have resulted in 82 fatalities and 158 serious injuries from 1965 to 1974 (3). Furthermore, NTSB data indicate that propeller/rotor contact injuries have steadily increased from 17 in 1965 to 30 in 1974. Causative factors associated with helicopter rotor accidents involving 17 fatalities are discussed in an article by Kiel (2).

Federal Aviation Regulations (FAR) Parts 27 and 29 (par. 1565) for Normal Category Rotorcraft and Transport Category Rotorcraft, respectively, state that, "Each tail rotor must be marked so that its disc is conspicuous under normal daylight ground conditions." However, FAR Parts 23 and 25 (par. 905) for Normal, Utility, and Acrobatic Category Airplanes and Transport Category Airplanes, respectively, do not specify requirements to enhance conspicuity of airplane propellers. In addition, no conspicuity requirements were found in FAR Part 35 pertaining to airworthiness standards for aircraft propellers.

In 1975, the FAA initiated a study designed to evaluate the effectiveness of several paint schemes. However, the investigations were halted prematurely when the DC-3 test aircraft was damaged during takeoff in March 1975. The present requested study was conducted to rank the visual effectiveness (see and avoid) of three paint schemes for airplane propellers and two schemes for helicopter tail rotor blades currently used by the U.S. military services.

II. Methods.

Paint scheme specifications for each of three airplane propellers (Figures 1-3) were taken from: (i) U.S. Army, TB-746-93-2, (ii) U.S. Air Force, T.O. 1-1-4, and (iii) U.S. Navy, MIL-M-25047-C, (ASG). Specifications for two helicopter tail rotor blades (Figure 4) include U.S. Navy, MIL-M-25047-C, (ASG) and U.S. Army, TB-746-93-2. Propeller/tail rotor specifications recommended by the British Civil Aviation Authority

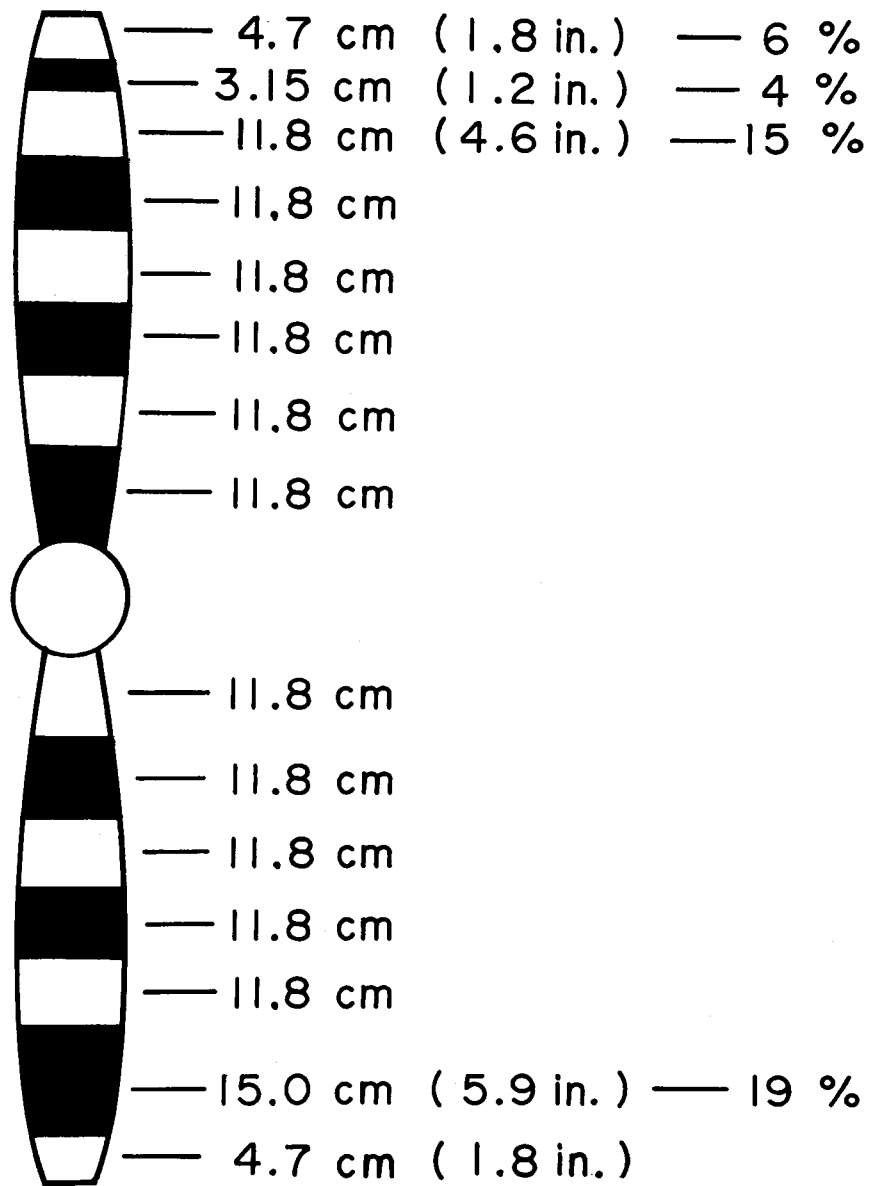


FIGURE 1. Propeller with black and white paint scheme and asymmetrical stripes taken from U.S. Army, TB-746-93-2.

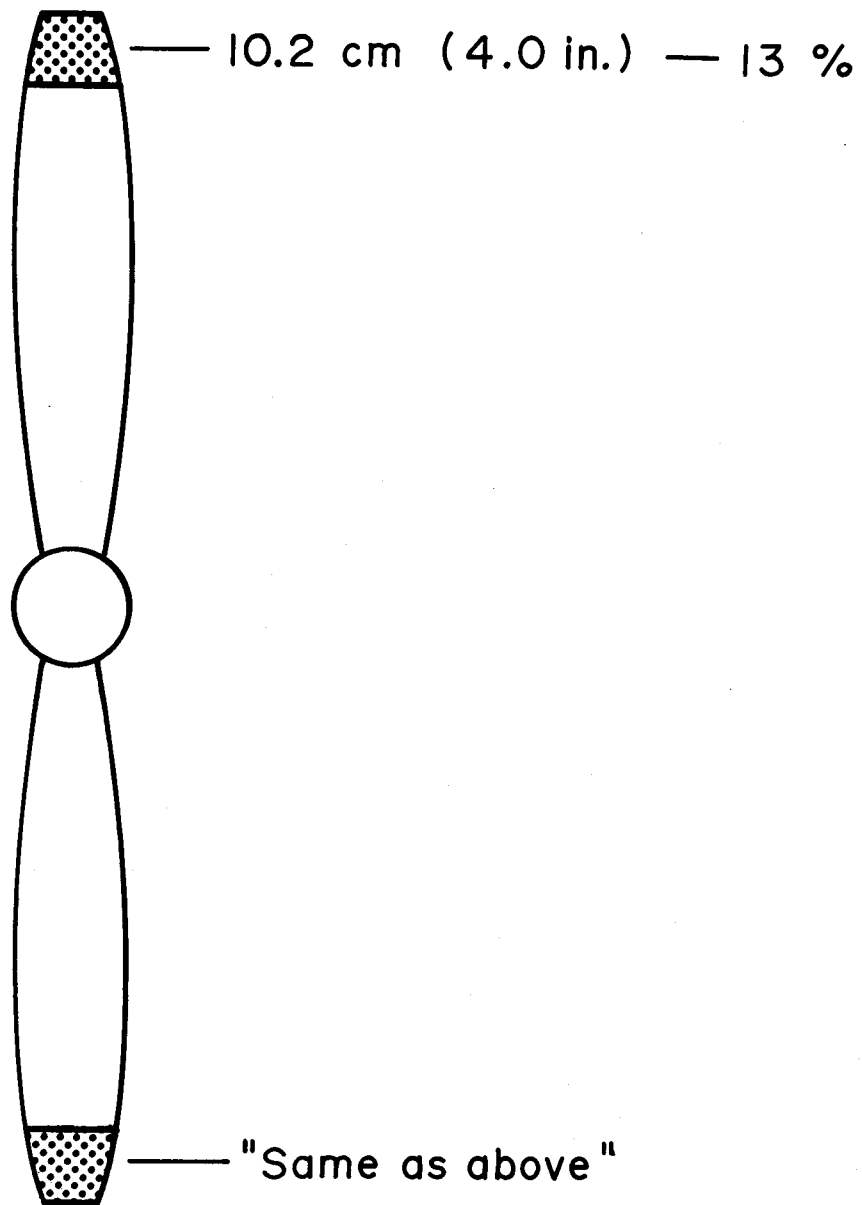


FIGURE 2. Propeller with yellow tip paint scheme (stippled area) taken from U.S. Air Force, T.O. 1-1-4.

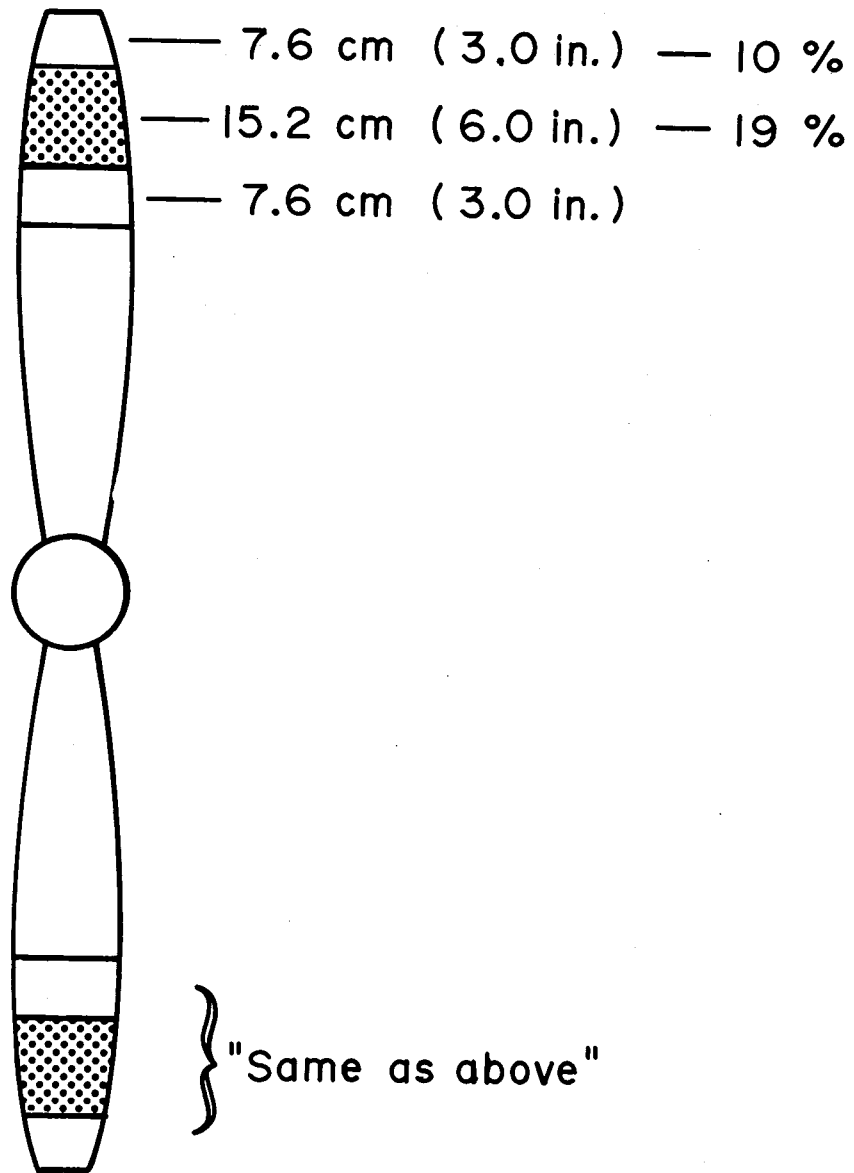


FIGURE 3. Propeller with red (stippled area) and white paint scheme taken from U.S. Navy MIL-M-25047-C (ASG).

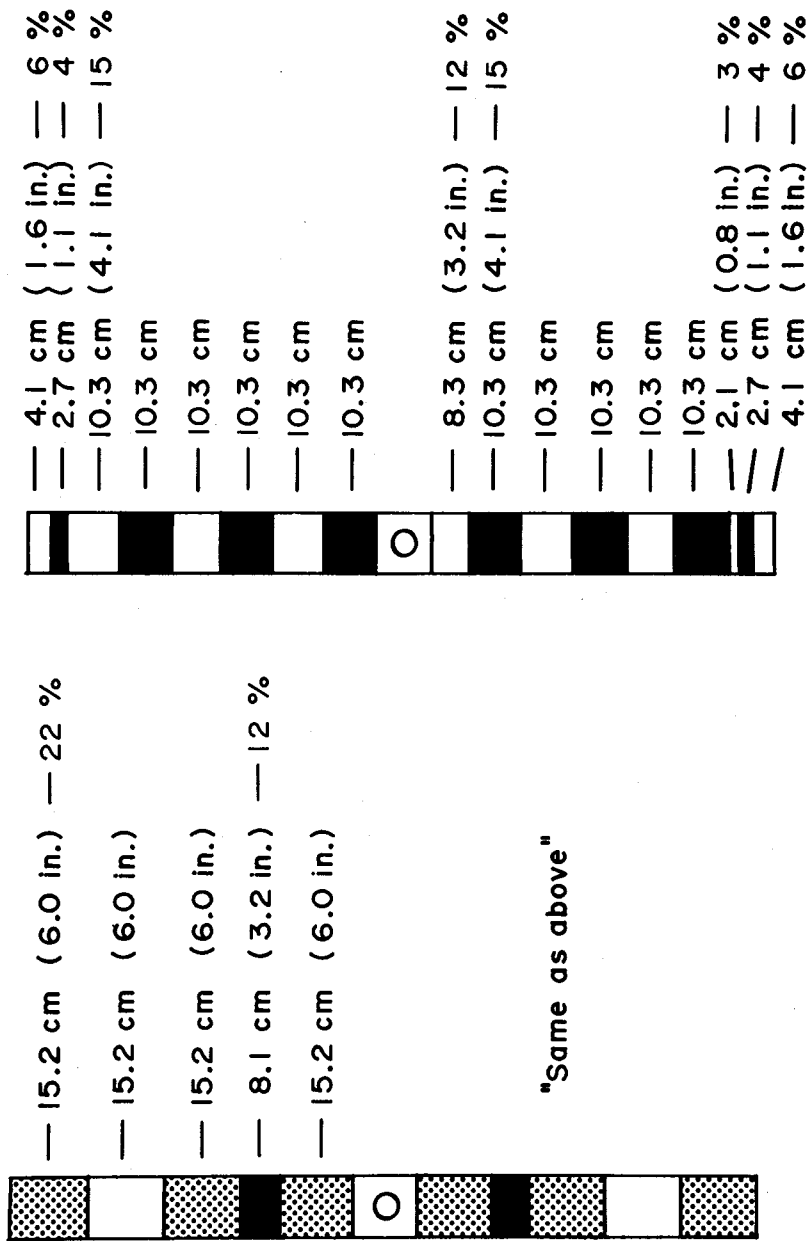


FIGURE 4. Two helicopter rotor paint schemes. (Left) U.S. Navy scheme taken from MIL-M-25047-C (ASG) with stippled area in red. (Right) U.S. Army scheme with black and white asymmetrical stripes taken from TB-746-93-2.

(Info. Circular 104/1973) approximate those used by the U.S. Army. Stripe width dimensions are specified in fixed values for all sizes of propeller/rotor blades in U.S. Navy and Air Force documents. U.S. Army specifications require painting of the entire blade and therefore give stripe widths in percentage values. The Federal Standard Color numbers for the acrylic lacquer paints used in the evaluation were 17875, 37038, 31136, and 33538 for colors white, black, red, and yellow, respectively.

Three Piper Cherokee airplanes (Model 140) were positioned wing-to-wing in a semicircular fashion facing a central viewing area. Two Bell helicopters (Series B47G, open tail) were positioned nose-to-tail at a distance of approximately 90 m (300 ft) from the airplanes. The viewing areas, sectioned off by pylon-type markers, were located 6.1 m (20 ft) from the airplanes and 9.1 m (30 ft) from the helicopters. A photograph of the airplane viewing area is shown in Figure 5.

Thirty naive volunteer FAA employees with normal distant visual acuity and color vision were transported in groups of five to the viewing areas. Subjects viewed the propellers and rotors from three positions that included: (i) looking upward from a crouched position, (ii) while standing, and (iii) viewing downward from a maintenance stand. The background for each aircraft varied somewhat and consisted of shadows cast by the aircraft, the surrounding landscape including hangars, and other aircraft on the ramp. Observations were made looking generally northward between 1300 and 1530 (CST) on November 17, 1977, under clear sky conditions. During the observation periods, contract pilots maintained propeller and rotor speeds at 1,000 and 2,300 rpm, respectively. Motion picture sequences and still photographs were taken while propeller/rotor blades were stationary and while rotating (Figures 6-15). Viewing areas for the helicopters can be inferred from Figures 12-15.

III. Results.

The distribution of the relative conspicuity rankings of the three propeller paint schemes is shown in Table 1, and the frequencies with which each scheme was ranked "most conspicuous" at each viewing angle are expressed as percentage values in Figure 16.

The black and white asymmetrically striped scheme was judged "most conspicuous" more frequently at all three viewing

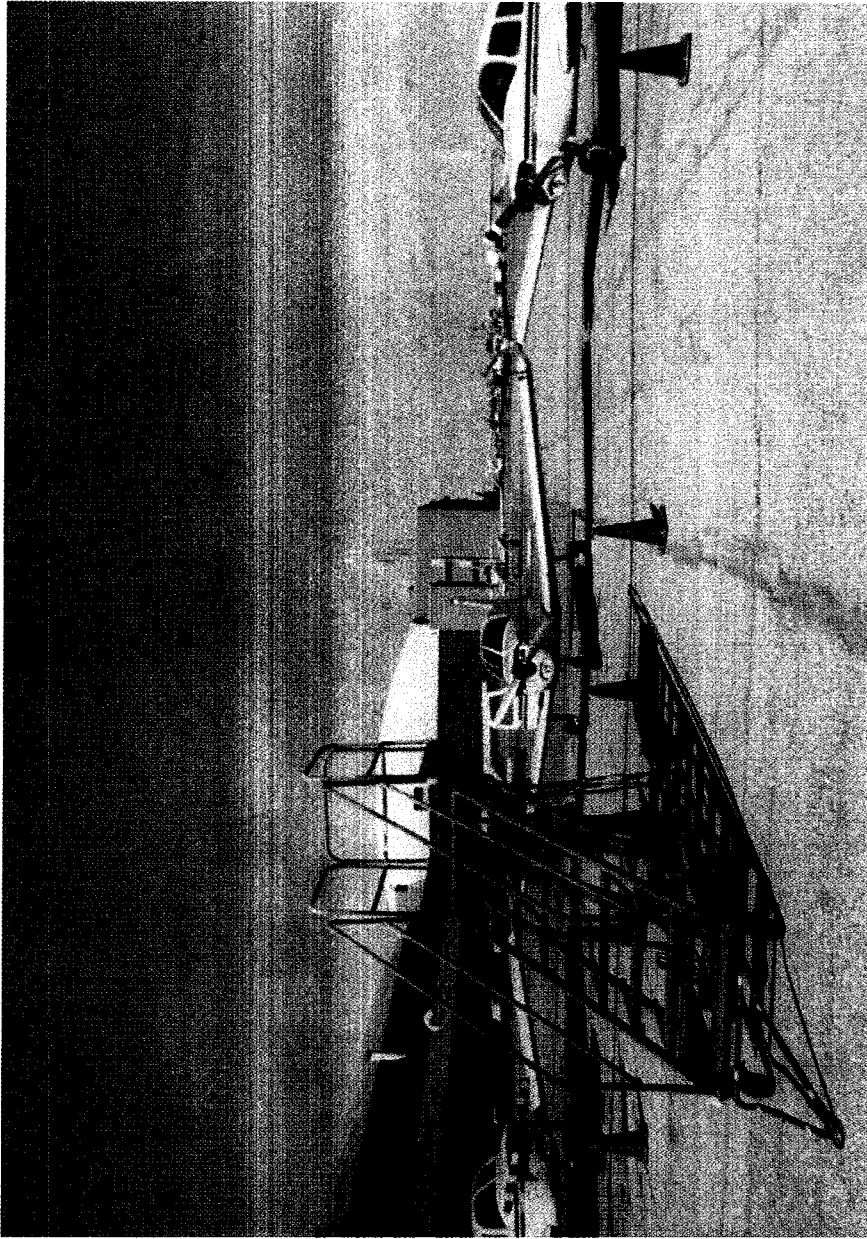


FIGURE 5. Three Piper Cherokee, Model 140, airplanes positioned in the viewing area with an elevated viewing platform.

