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Small Target Identification

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by

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INTRODUCTION

The identification, observation, and counting of raptor (hawks, owls, ospreys, eagles, etc.) nests, fledglings, and eggs are accomplished by Forest Service wildlife biologists as part of the eagle recovery effort, the protection of endangered species, and widlife management in general. The traditional way of obtaining such counts is by flying over the nest trees at a low (less than 500 ft above ground level [AGL]) altitude in small fixed-wing aircraft. However, this operation is in violation of Forest Service policy that requires fixed-wing, single-engine aircraft to maintain an altitude of at least 500 ft AGL for all operations. From an altitude of 500 ft, the naked eye has been shown through experience not to have the acuity necessary for performing the required raptor observations.

Alternatives to direct observation, i.e., infrared detectors, various varieties of cameras, time-lapse photography, etc., have also been considered. These alternatives are not examined in this Project Record for several reasons.

All of the biologists contacted agree that the current preference is for real-time visual observation. This is because the parameters which the biologists are inspecting, including counting of the young, looking for eggs and chicks, etc., sometimes take as many as seven passes of the nest to put the biologists into position to make the observations needed.

Of course, the method which could reduce the number of passes required would also reduce disturbance to the nest, and this feature the biologists liked. The observer simply needs real-time feedback to assure that accurate counts of eggs and chicks, which are quite difficult to see against the nest background, have been made.

Although an infrared detection scheme has been tried with some success for large animals, no information exists on its being applied to raptors. The opinion of wildlife biologists is that even though such a system may have some application, it would need an extensive period of development before it could replace direct observation. Also, such systems are very expensive, costing in the tens if not hundreds of thousands of dollars, depending on the configuration and platforms used.

One alternative to real-time direct observation would be some sort of a stabilized television platform, equipped with a television camera which has a remotely zoomable lens, and a real-time monitor. Some observers have hypothesized that a stabilized television camera with a remotely zoomable lens could be passed once or twice over the nesting site. The observer, sitting in the cabin of the aircraft, could see what is being recorded on video tape via the monitor. A decision could be made whether or not coverage is adequate. Once it was determined that a satisfactory tape of the nesting site was made, counts, measurements, etc., could be made from the tape, played back on the ground where it could be stopped for easy measurements, etc. A great deal of interest was shown by the biologists in such a system. They were particularly interested in the ability to "zoom" from "wide-angle" to high magnification, as this would make the counting and observation task much easier. The biologist would spot the nest and instruct the pilot to maneuver the aircraft to an advantageous position with the lens at "wide-angle." The lens could then be zoomed in to obtain necessary detail. If a system could provide adequate stabilization for 12X magnification, without loss of resolution, the observation task could be accomplished from altitudes of roughly 1,000 ft, provided air speeds could be held low enough to allow for target acquisition in zooming while range was at its minimum. Such a system will be tested early in FY 84.

Also, all of the biologists have shown a great interest in stabilized real-time optical systems as the most acceptable, currently available, alternative to low-altitude fixed-winged flights.

The objective of the tests here described is to determine if a stabilized, real-time optical system (hereinafter called simply "sight") is available to do the raptor observation job.

SIGHTS

Eight stabilized systems are, or have been, available. Of these eight, only four appeared to have any promise at all for our mission. These four are:

British Aerospace Corporation (BAC) Steadyscope

The Steadyscope is a monocular instrument, although its body resembles conventional binoculars. It has two eye-pieces; one is blanked off. The example tested has a magnification of 10X with a field-of-view of 6°. Stabilization is accomplished by a gimbal-mounted mirror, which is controlled by a battery-driven gyroscope. The Steadyscope may be held in any attitude while in use. Power is provided by a single "D" manganese alkaline 1.5-V cell that provides 8 to 10 hr of running time. The Steadyscope weighs 4.4 lb, including the battery. Inspection of the unit supports BAC's claim that the unit is a simple, rugged, and dependable device. It is in use by the military services of over 30 countries, including the United States.

The test unit (fig. 1) sells for approximately $4,900. BAC has established a sales outlet in the United States at Dulles International Airport near Washington, D.C.

Fujinon Stabiscope

The Stabiscope is available in two magnifications; both were tested. They are similar in appearance to the Steadyscope—see figures 2 (10X) and 3 (14X). The Stabiscopes also appear to be rugged, well-built, precision units developed mainly for the military market. There is a basic difference in the operating principle, however. The Stabiscopes are true binoculars; i.e., each has two complete optical paths, necessitating a rather greater mass in the gyroscope gimbal system. This results in a somewhat longer time for the gyroscopic mass to stabilize after the binocular has received any angular input than in the case of the Steadyscope. A small, external, rechargable battery pack powers each unit. It is not a standard battery as is the BAC battery. Fujinon also has a U.S. outlet (in Virginia). The price of the 10X is $3,850; the 14X sells for $4,250.

Kenlab Invisible Tripod

This unit is not a stabilized binocular, but is a gyro that is attached externally to a binocular and stabilizes the entire case. It uses an external rechargable power pack; the stabilizing unit weighs 34 oz. The system is shown in figure 4, attached to the binocular supplied by the manufacturer. The KS 4 model tested, complete with charger and power pack, sells for $2,117. Kenlab is located in Connecticut.

THEORETICAL CONSIDERATIONS

In the evaluation of any stabilized optical system, two facets must be considered: The resolving power of the optics and the stabilizing properties of the gyro.

Optical Consideration

To be just detectable by a 20-20 eye with no astigmatism, a target, with a 100 percent contrast against its background, must subtend an angle of approximately 380 microradians (μrads). At a distance of 707 ft (the distance between the

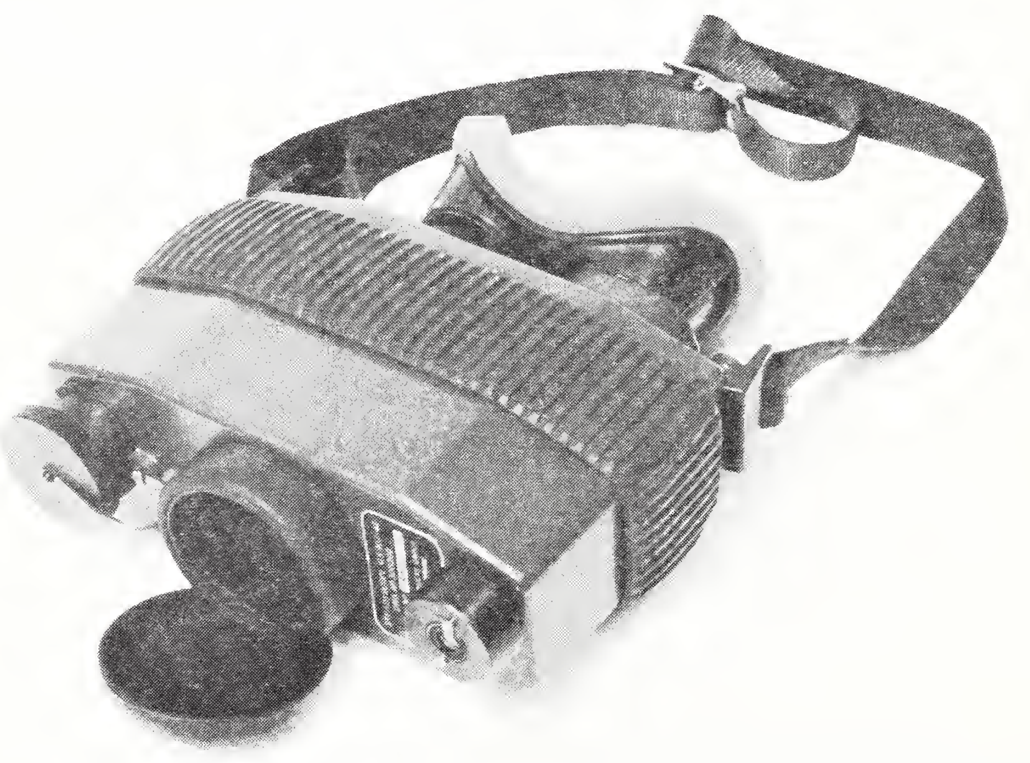

Figure 1. BAC Steadyscope test unit.

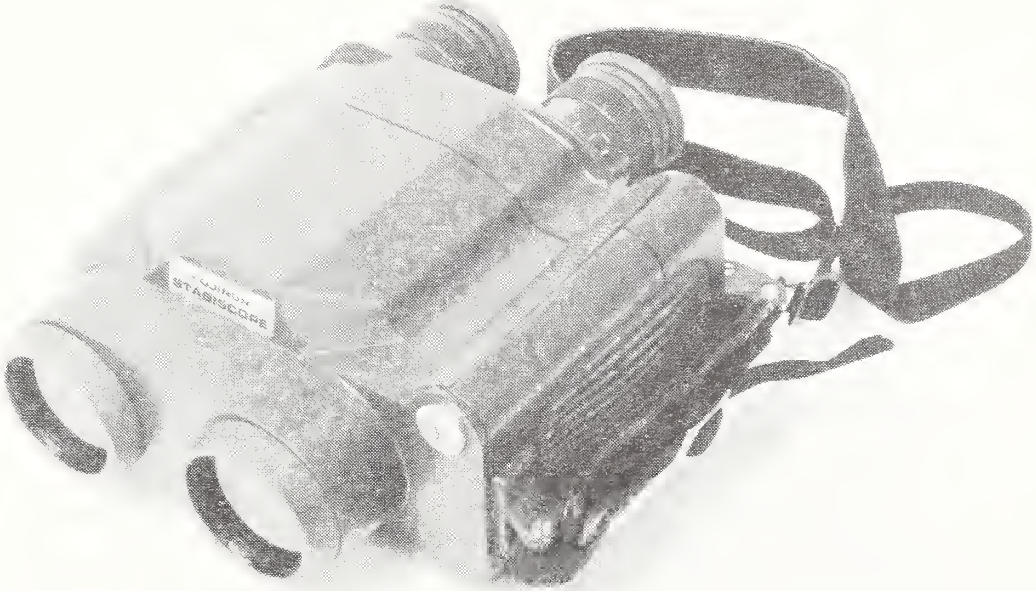

Figure 2. Fujinon Stabiscope, 10X magnification model.

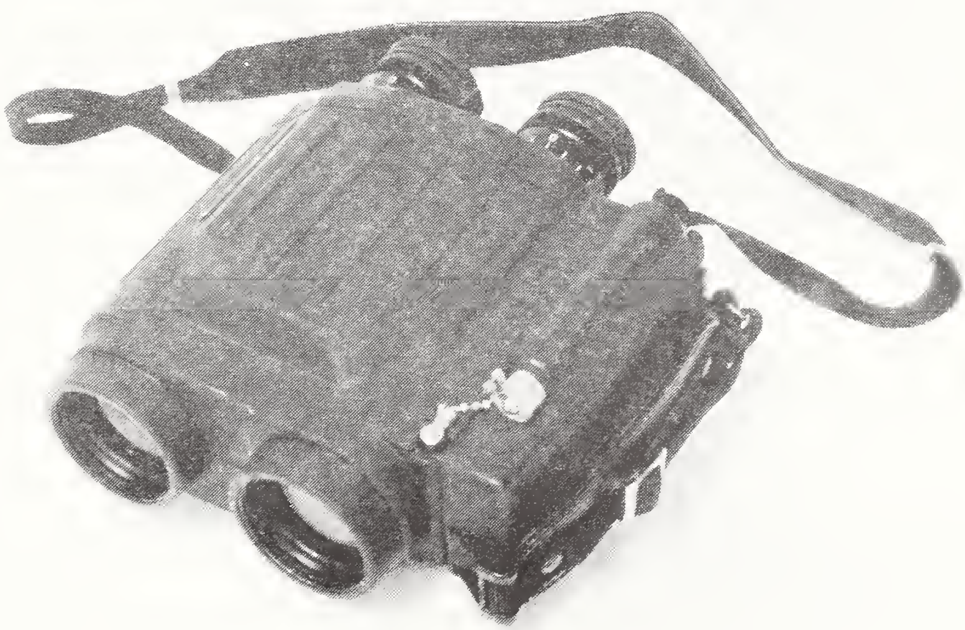

Figure 3. Fujinon Stabiscope, 14X magnification model.

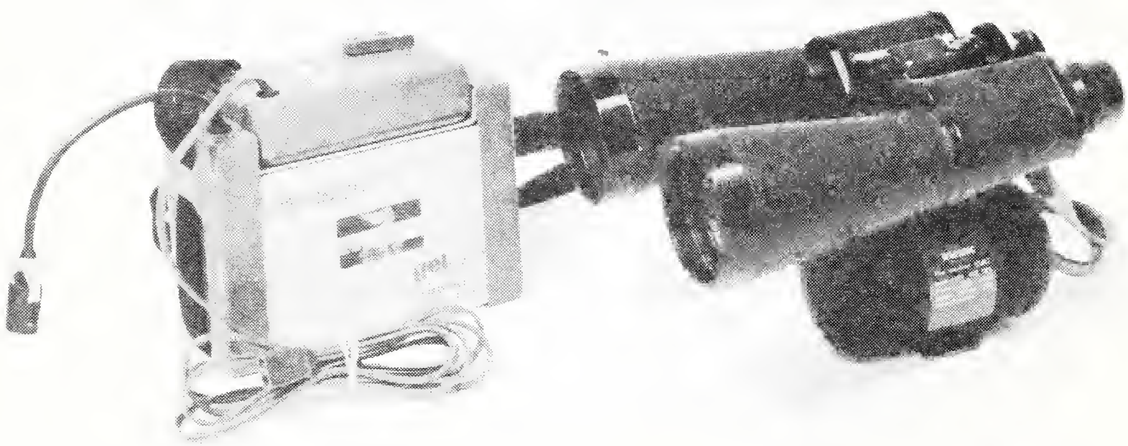

Figure 4. Kenlab "invisible tripod" attached to binocular.

observer and the target in an airplane flying 500 ft above and 500 ft to the side of the target), the target, to subtend this angle, would have to have a "smallest dimension" of approximately 3.2 in. ("Smallest dimension" for the Landolt C targets, used in our tests and below, is the gap in the C, *not the diameter of the targets.*) Thus, with a 10X sight, a target of roughly 1/3 of an inch should be detectable from 707 ft.

In practice, many factors conspire to degrade this detectability. Imperfect optics, turbulence in the air, visibility-reducing haze and dust, hand tremor, target movement, contrast between target and background of less than 100 percent, target shape ambiguities, etc., all make the ideal unachievable. In a moving vehicle situation, by far the greatest limiting factor is the ability of the observer to train the binoculars steadily on the target. For this reason, increases in optical resolution (i.e., greater power) do not improve the situation. In fact, they have just the opposite effect as the higher the power, the greater effect of binocular movement on resolution. Thus, one should select a system that has the lowest optical magnification that will provide for the necessary detection.

In our case, we simply do not have enough data about the contrast between the intended ultimate targets (birds against their nests) to make a precise calculation of the needed resolving power. However, based on an analysis of a photography of a typical raptor in the nest, and on reports of military users whose task has been to observe targets from aircraft and other moving vehicles, it appears that a magnification of 10 would be optimum for our use. This estimate is supported by the opinion of engineers from both BAC and Fuji.

Stabilization Systems

Since any good optical quality 10-power sight will detect a target as small as 1/3-in at distances of interest in 100-percent contrast backgrounds, and probably will allow for positive identification of a 4- or 5-in minimum dimension fledgling, even under contrast conditions of as low as 5 or 10 percent, the limiting factor, in any stabilized binocular, will be the stabilization system and not the optical system.

A basic consideration in a design of gyrostabilized systems is that the lighter the stabilized mass, the more quickly it "settles down;" i.e., when the stabilized mass is subjected to a rotational input, it takes a certain period of time to come to a steady state. In a stabilized optical system, this time period shows up as target instability. While this instability persists, target detection and recognition are impossible. The design of the BAC Steadyscope features a very light stabilized mass. This is possible because, among other considerations, a single optical path is used. In the Fuji designs, parallel optical paths are employed. Rather than a mirror, prisms are used as the stabilizing element. These are necessarily heavier. Also, because interpath alignment and rigidity are extremely important, the stabilized mass, must of necessity, be heavier than in a single-path system.

In the third system tested, the Kenlab, the stabilized mass is much greater, including not just the binocular prisms, but the entire binocular itself. Thus, the "settle-down time" is much longer for the Kenlab than for either of the other systems.

Brief evaluation of the "settle-down" time substantiates the theoretical considerations, and indeed proved to be the most important factor in the performance of the various sights. This is dealt with below under "ground tests."

TESTS

A preliminary flight test was run from a Hughes 500 helicopter. Three observers, all experienced aviation personnel, used the BAC 10X and the Fujinon 14X and attempted to observe ducks walking around on the ground from 500 ft AGL. No quantitative test procedure was followed; however, it was the unanimous opinion of the three testers that neither system was optimum but that the BAC system might perform our job. These tests were conducted at speeds varying from a hover to 120 knots. In addition to observing ducks, various features on the ground from 500 ft AGL were also observed. While the opinion of the testers was uniform that the Fujinon 14X optics were desirable, all agreed that the long stabilization time made successful observation difficult, even from a hover. However, it was felt that a test more closely simulating the actual raptor observation task should be conducted before any sight should be eliminated. Based on these observations, ground tests and flight tests were planned and conducted.

Test Subjects

The same test subjects were used for ground and flight tests. Six subjects were used, three "naive," and three "trained." The "naive" observers were selected from a pool of volunteers; all are employees of the San Dimas Equipment Development Center (SDEDC). Their vision was tested at a local optometrist. All six eyes had 20-20 vision uncorrected, five had no astigmatism; one had about ½ diopter.

The three "trained" subjects were not all blessed with such good vision. J, an SDEDC employee, does have 20-20 vision with no astigmatism. R, Project Leader, is 20-30 with 1½ diopter in one eye and ¾ in the other. G, who proved to be the most successful observer, has worse vision yet; roughly 20-40 uncorrected, but with only slight astigmatism. As it turned out, the skill of the observers was much more important than their visual acuity.

Test subjects R and J has considerable experience with binoculars and other optical systems, although no previous experience using stabilized binocular systems. Test subject G was a trained Air Force navigator/bombardier who flew in B-47's and B-52's. His observation technique was to look for line discontinuity, not for the opening in the Landolt C. He indicated that training was very important in the use of any optical system and his performance in the test showed this to be true.

Ground Tests

The objectives of the ground tests were to determine if the optics of the sights functioned properly and to determine what the "steady-down" time was for each of the sights.

Optics

We determined that the optical performance of all of the sights was adequate; i.e., the optics did not limit the detection job. At 500-ft sight distance, the position of a 0.45-in gap Landolt C target, 100 percent contrast, was properly identified by all of the "naive" (20-20) observers with near 100-percent consistency. Such a target subtends an angle of approximately 75 μrads so, through a 10X system, the subtended angle would be 750 μrads. This is approximately two times as large as the theoretical detection limit of 380 μrads. At the limit, one would expect approximately 50 percent of the "detections" to be accurate. Thus, we concluded that the optical system would not limit the performance of any of the sights.

Evaluation of Sweep Stabilization Time. This test was done by sweeping the sights rapidly from left to right and from right to left, and from down to up and up to down, and stabilizing on a distant target. Results were obtained from the BAC and both Fujinon units: The BAC stabilized in less than ½ sec in all tests. Both Fujinon units were much slower; stabilizing in roughly 3 to 5 sec. It should be noted that Fujinon states that their binoculars should not be swept more than 5 degrees-per-second. This is quite a slow rate of sweep and it proved to be impossible to maintain while attempting to acquire the target during the flight tests described below. This rate was exceeded during these sweep stabilizing time tests. A rotational rate of roughly 90 degrees-per-second was maintained during the tests. This is approximately the rate of head rotation one experiences while watching a tennis match.

The Kenlab unit proved to be impossible to test. The concept of "settle-down time" had very little meaning because the unit was so hard to train on the target. The gyroscope is heavy enough to cause considerable procession; i.e., when rotation is attempted in one direction, a gyroscopic moment forces the sight in another. Several hours of experience with the sight did not alleviate the problem. Even after a distant target was acquired, small, slow panning movements to inspect areas around the target center resulted in unsatisfactory jitter and jump.

Flight Tests

The purpose of the flight test was to evaluate the stabilization system of the path of the sights by simulating as closely as possible in a controlled manner the actual conditions encountered during observation of raptors from fixed-wing aircraft.

Test Procedure. The test was a controlled observation of a Landolt C target by three "naive" observers and the three "trained" observers, using the stabilized sights while flying in a Cessna 182. The flight pattern was 500 ft above and 500 ft to the side of the target. The C, shown in figure 5, was designed to have a contrast of 100 percent. Three sizes of C targets were used. It should be noted that the significant dimension in the target is the gap. The gap was adjusted to one of eight positions so that the observers could report the position to a technician on the ground. Radio communication was maintained between the aircraft and the ground crew. The test site is as shown in figure 6.

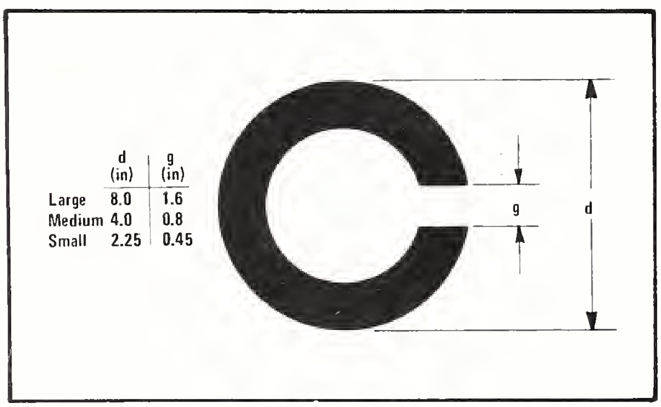

Figure 5. Landolt C target.

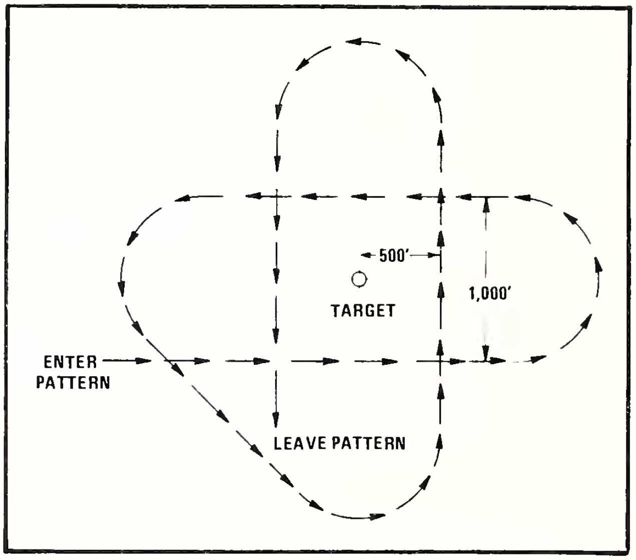

Figure 6. Flight path.

Initially, a ground speed of 120 mph was tried, however, this was determined to be too fast for acceptable target acquisition and so ground speeds of 75 to 80 mph were used for the data gathering passes.

At all times the wind was less than 10 mph, turbulence was never greater than occasional light. Visibility was better than 60 mi, and there was no cloud cover.

RESULTS

"Naive" Observers

None of the "naive" observers could acquire the target consistently. Even when they could acquire the target through what turned out to be the best of the systems, the BAC, all three had zero percent correct answers for the position of the target.

"Trained" Observers

BAC Steadyscope. The "trained" observers had no trouble acquiring either the large or the medium Landolt C while using the BAC system. The gap in the Landolt C on the large target subtends an angle of 1,330 μrads in the 10X scope, while the medium target gap subtends an angle of 670 μrads and the small target gap subtends an angle of 370 μrads.

None of the observers were able to correctly identify the position of the small target, indeed none could state with certainty that the small target was even seen. Since the significant dimensions of the Landolt C are the width of the limb (the black portion) and the width of the gap in the C, this is not surprising (370 μrads is less than the detection threshold of 380).

For the large target, observer G was 88 percent correct in his positionings, observer R was 75 percent, and observer J was 50 percent. This gives a clear indication of the stabilization performance of this sight, especially when compared with the results for the other sights given below. For the medium-sized target, only observers G and J made tests. While observer G achieved a 58 percent (highly significant) correct identification rate, observer J achieved only an 8 percent correct identification rate, which is insignificantly greater than would expected by chance. This indicates the overwhelming importance of training and technique, especially remembering that observer J has 20-20, no astigmatism vision, while observer G's vision is much less than perfect. It is apparent from this last result that a trained observer, even with less than perfect vision, can detect a 0.8-in target with these binoculars under the environmental conditions presented by this test.

It is the impression of all three of the experienced observers that even in the limited time that they flew with these binoculars, their performance improved towards the end of their test session. Time and budget unfortunately did not permit further exploration of this point.

Fuji 10X. This sight came out a distant second best. Neither observer G nor R were able to make any correct identifications on even the large target. Observer J achieved a 23 percent correct identification rate, which is greater than would be expected by random luck. J was unable to successfully acquire the target when the medium target was substituted.

Other Systems. With the Fuji 14X, only observer G was able to acquire the target and he returned a zero percent correct identification rate. With the Kenlab system because of the difficulties mentioned above, none of the observers were able to even acquire the target area.

CONCLUSIONS

Of all of the stabilized sights tested, only the BAC Steadyscope should be considered for further testing. This sight will apparently meet the performance criteria necessary to do our raptor observation job.

Training of the observers is absolutely necessary. Even observers familiar with the job (i.e., observation of raptors) need additional training, not just with the stabilized binoculars, but with the stabilized binoculars used in the environment in which the actual observation will be carried out. Field experience as well as formalized training will probably be required.

RECOMMENDATIONS

Since the BAC Steadyscope will apparently meet the objectives of the project as set forth in the Project Plan, further testing and development to lead to the implementation of this sight should be carried out. This should include:

- Field tests using the BAC device to determine the optimum techniques and field acceptability of these systems

- The development of a training program and training plan for the use of this sight in the raptor observation job

- Publication of an Equip Tips describing the BAC Steadyscope and its proper use, and the training program necessary to effectively use it.