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PRELIMINARY EVALUATION OF VISUAL LANDING AIDS FOR AV-8A AIRCRAF--ETC(U)
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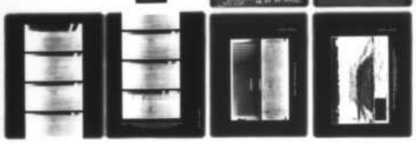

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DEPARTMENT OF THE NAVY
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NAVAL AIR STATION
LAKEHURST, N. J. 08733

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(9) NAVAIRTESTFAC LETTER REPORT. 22 Apr-5 Sep 74. (14) NO. NATF-A77 (11) 13 JAN 1975

FROM: Commanding Officer, Naval Air Test Facility (12) 16p.

TO: Commander, Naval Air Systems Command (AIR-537)
Commanding Officer, Naval Air Engineering Center

SUBJ: (6) Preliminary evaluation of visual landing aids for AV-8A aircraft operations at VSTOL Forward Operating Facilities.

AIRTASK	WORK UNIT	EFFORT LEVEL
A537-5374 0715 5537-000040	NA	Normal

TEST DATES	INSTALLATION DATES (IF APPLICABLE)
22 Apr to 5 Sep 1974	

NATF PROJECT ENGINEER	LOCATION OF NATF TEST/INSTALLATION
Stephen Zukowski, LT Saraniero	VSTOL Site

ENCL: 5 PHOTOGRAPH(S) ___ TABLE(S) ___ APPENDIX(ES)
___ DRAWING(S) ___ CURVE(S) 1 Sketch

Ref: (a) NAVAIRENGCEN Test Directive No. V/STOL 73-1 of 14 Aug 1973: Preliminary Flight Test Evaluation of the Visual Landing Aids provided on the NATF, Lakehurst V/STOL Site
(b) NAVAIRENGCEN Drawing No. 617546: VSTOL Forward Operating Facility
(c) SATS Visual Landing Aids Service Bulletin No. 20 of 15 Mar 1974: Visual Landing Aids Equipment, Marking and Lighting Systems for Flight Operations on VTOL, VSTOL, SATS, and Expeditionary Airfields; general requirements for
(d) AV-8A NATOPS Flight Manual NAVAIR 01-AV8A-1 of 1 Jan 1973
(e) NAVAIRTESTFAC Letter Report of Test Results No. NATF-A33 of 15 Apr 1970: Evaluation of SATS low-profile taxiway-edge lights
(f) NAVAIRTESTFAC Letter Report of Test Results No. NATF-A46 of 14 Jun 1971: Evaluation of Crouse-Hinds Company SATS taxiway-edge lights

INTRODUCTION

1. The NAVAIRTESTFAC *(Naval Air Test Facility)* was tasked by the NAVAIRENGCEN *(Naval Air Engineering Center)*, by reference (a), to evaluate visual landing aids installed at the VSTOL *(vertical and short take-off and landing)* Forward Operating Facility to support Harrier aircraft (AV-8A)

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED operations from this type of airfield. The NAVAIRTESTFAC set up the following test objectives:

a. Establish that the pilot has sufficient cues to enable him to approach the runway and transition to a stable hover over the desired landing area.

b. Determine the ease of identifying the runway envelope and the degree of difficulty in maintaining the aircraft heading on the runway centerline throughout the approach.

c. Optimize the glide slope indicator location.

d. Determine the minimum acceptable lighting package.

This report describes the test site, test equipment, and test procedure. Also, it presents the results of tests, and conclusions and recommendations based on the results.

TEST SITE AND EQUIPMENT CONFIGURATION

2. VSTOL Forward Operating Facility: This Facility, constructed of AM-2 extruded aluminum matting, was installed in accordance with reference (b). It consists of a 600-foot-long by 78-foot-wide runway connected to a parking area by way of a 72-foot-wide taxiway. The clearing in which the runway is installed is 2,600 feet long and 178 feet wide, with trees up to 50 feet high allowable at the edges of the clearing (reference (b)). The cleared area extends approximately 1,000 feet from each end of the runway and 50 feet from each side of the runway to the tree line. This site is representative of the second stage in the build-up of Marine Corps expeditionary airfields.

3. Lighting

a. The VLA (visual landing aids) "package" for this site was installed in accordance with reference (c) and includes the following lights (see Figures 1 and 2):

(1) Approach lights, NAEC PN 505954-1
(2) Strobe lights, NAEC PN 506208-1
(3) Threshold lights, NAEC PN 505954-3
(4) Rotation lights, NAEC PN 505954-2
(5) Runway edge lights, NAEC PN 615911-1
(6) Runway centerline lights, NAEC PN 613593-1
(7) Obstruction lights, NAEC PN 505956-1
(8) Taxiway lights, NAEC PN 615910-1
(9) GSI (glide slope indicator),MISC 09246
(10) Lighted wind sock, NAEC PN 506054-1

b. "Over-the-nose" visibility from the AV-8A cockpit is very restricted. When the aircraft is in a hover of 50 feet or greater over the first third of the runway, it is physically impossible for the pilot to see the majority of the runway centerline and edge lights. Based on a decision made by NAVAIRTESTFAC pilots and engineers, additional lights were added to the VSTOL site to overcome this problem (see Figure 1):

(1) The runway centerline was extended by installing an additional lamp, MS 24348-1, on the third, fourth, and fifth sets of approach lights.

(2) Portable red and white lights were positioned off to the side of the runway as touchdown zone marker lights. These portable lights can be positioned anywhere along the runway to signal the pilot where his intended point of landing should be.

4. Test Vehicles

a. The primary test vehicle used for the evaluation was the NAVAIRTESTFAC NHH-2D helicopter, BUNO 147981. In order to simulate the field of view available from the AV-8A (Harrier) aircraft, masking of the NHH-2D cockpit was necessary. With the assistance of McDonnell-Douglas Aircraft Corp. and Second Marine Air Wing personnel, an accurate cockpit masking was developed and installed in the NHH-2D helicopter (Figure 3).

b. The Second Marine Air Wing provided an AV-8A aircraft, BUNO 158943, and a pilot to assist during the final evaluation.

TEST PROCEDURE

5. It was necessary to establish a minimum aircraft-to-treetop clearance for safe operations at the VSTOL test site. NAVAIRTESTFAC pilots and engineers discussed the minimum obstruction clearances required in a tactical environment with pilots from various helicopter and Harrier field activities whose opinions varied between 25 and 100 feet. Taking these opinions into consideration, the NAVAIRTESTFAC pilots and engineers judged a 60-foot treetop-to-wheel clearance to be the minimum for safe operations at the VSTOL test site.

6. All approaches and landings with both the helicopter and the Harrier were flown in accordance with the AV-8A NATOPS Flight Manual (reference (d)). Two helicopter pilots and one Harrier pilot participated in the evaluation. Approaches were flown bidirectionally to the VSTOL site, but because of the site restrictions imposed by reference (b), no cross-field landings were attempted: the minimum glide-slope angle needed to provide a 60-foot wheel-to-treetop clearance for a cross-field approach is 13.6 degrees without elevating the GSI more than six feet above the ground. Also, no taxi tests, rolling takeoffs, or rolling landings were attempted: the natural process of erosion had undermined certain areas of the matting (installed in fall of 1972) and made it unsafe to conduct

these operations. The restrictions imposed by the erosion limited the evaluation of only the rotation lights and the taxiway lights, both of which require the aircraft to be rolling on the matting; however, the taxiway lights did not have to be evaluated because they had performed satisfactorily during prior evaluations reported in references (e) and (f).

7. Day and night familiarization flights were flown in the NHH-2D helicopter before the cockpit was masked. During all flights with the masking installed, the co-pilot's field of view remained unobstructed as a safeguard.

8. A major concern was the GSI location. The GSI must be placed where it can provide adequate obstacle clearances without forcing the pilot to set up an excessive sink rate while making his approach. If possible, the GSI should be placed where it can provide an altitude cue to the pilot when the aircraft is in the hover position.

9. The pilots flew approaches to evaluate the complete VLA package, including the extended centerline lights and touchdown zone marker lights added by the NAVAIRTESTFAC. To determine the effectiveness of each light or group of lights, each was removed, one at a time; upon each removal, the pilot made approaches against the rest of the lights.

10. All tests were conducted in VFR conditions, with night conditions ranging from overcast to clear with 3/4 moon.

TEST RESULTS AND DISCUSSION

11. <u>Tests With NHH-2D Helicopter (Cockpit Masked to Simulate Field-of-View Available From the AV-8A Aircraft)</u>

a. <u>Complete VLA Package, Extended Runway Centerline Lights, and Touchdown Zone Marker Lights</u>

(1) Field acquisition was easily attained when the helicopter was within 30 degrees of the approach corridor. Once the helicopter was established on final approach, the strobe lights were no longer required in VFR conditions. However, downwind positioning of the aircraft through the 90-degree position in the approach was difficult to accomplish due to a lack of visual cues outside of the approach corridor.

(2) Field boundary identification was greatly enhanced by the placement of the red obstruction lights at the tree line at both ends of the runway corridor and in line with the runway edge lights. Although not tested, placement of the obstruction lights at treetop level would ensure aircraft clearance and provide a downwind positioning cue to the pilot. These lights also aided in center lineup and closure rate. Once the helicopter is clear of the tree line, centering information and altitude cues are obtained from all runway environment lights and the GSI (Figure 4).

(3) Once the helicopter was established in a hover over the runway, approximately 150 to 200 feet from the approach end, the extended centerline lights and upwind red obstruction lights provided satisfactory lateral and centerline cues. The lighted wind sock at approximately the 45-degree position aided the pilot in determining his position relative to the runway.

(4) GSI

(a) The optimum angular size of the amber *COMMAND PATH* was investigated. Both 1-degree and 1/2-degree *COMMAND PATHS* were tested. All of the pilots preferred the 1/2-degree *COMMAND PATH* because it provided more rapid trend information. The resultant display consisted of a 4-1/2-degree red *LOW* signal, a 1/2-degree amber *COMMAND PATH*, and a 4-1/2-degree green *HIGH* signal. The total spread was 9-1/2 degrees in elevation and 40 degrees in azimuth (Figure 5).

(b) The GSI was placed 10 feet inboard from the runway edge and 15 feet forward of the runway. Its placement here is paramount because if placed farther outboard, the GSI is lost in the red runway-end markers and amber rotation lights. At this location, a 4-1/2-degree glide slope (*COMMAND-PATH* coverage from 4-1/4 to 4-3/4 degrees elevation) provides the pilot with a 60-foot treetop-to-wheel clearance when crossing the tree line approximately 1,000 feet from the runway threshold. This clearance is based on a wheel-to-eye height of 10 feet and on the red-amber interface of the GSI. This GSI location also provides the pilot with the green *HIGH* indication as an altitude cue to better establish a hover while over the runway. The disadvantage of this GSI location as opposed to midfield is the loss of immediate bidirectional capability for the runway. However, the GSI is portable, weighs approximately 50 pounds, and can be moved quickly. Location of the GSI at midfield is undesirable because the minimum glide-slope angle becomes excessive in order to provide a 60-foot treetop-to-wheel clearance, and an altitude cue at the hover position is lost.

b. <u>VLA Package (No GSI), Extended Runway Centerline Lights, and Touchdown Zone Marker Lights</u>: Numerous helicopter approaches to touchdown were flown without the GSI. The pilots noted a considerable increase in their work load and scan because the only accurate altitude information must be obtained from the cockpit on the radar altimeter. However, a pilot familiar with the site and the approach path, if given a minimum descent altitude and a UFH radio call "clear of trees", can accomplish a safe approach. This procedure increases pilot work load because the pilot must spend more time in the cockpit on the radar altimeter and also makes the final transition to a hover more difficult without the altitude hover cue provided by the GSI. It was concluded that in any tactical situation, a GSI would be required for safe night approaches.

c. Minimum VLA

(1) A series of tests was conducted to determine the minimum lighting package for safe operations. This lighting package consisted of the GSI, the extended centerline lights, the obstruction lights at both ends of the runway corridor, the touchdown zone marker lights, and the lighted wind sock (Figure 6). These lights provided sufficient cues for the following:

(a) Field identification, that is the cleared area, was easily accomplished with the red obstruction lights.

(b) Sufficient centerline information could be obtained from the extended centerline lights with the upwind red obstruction lights providing lateral drift information.

(c) Accurate altitude information was obtained from the GSI.

(d) The touchdown zone was well defined by the touchdown zone markers and the lighted wind sock; however, throughout the approach, from approximately one mile out to final landing, the pilot had to plan his approach to an unseen, unlit runway. He knew the lights present would enable him to safely position the aircraft in the desired zone, but he could not see it.

(2) One other minimum lighting configuration was tested. This lighting package consisted of the GSI, the runway edge lights, the runway centerline lights, and the touchdown zone marker lights. The pilots made the following comments:

(a) Field identification, that is the cleared area, was not discernible; without the obstruction lights, it became increasingly difficult to position the aircraft on the downwind leg, at the 180-degree position, and also with a sufficient final approach leg to decelerate to 30 knots comfortably.

(b) Centerline information from one mile out was adequate but as the aircraft approached the runway, centerline cues were lost under the nose of the aircraft, making final transition to a hover and landing extremely difficult.

(c) Altitude cues from the GSI were adequate.

(d) Without the obstruction lights to define the field boundary, closure rate throughout the approach to hover was difficult to judge due to a lack of depth perception.

12. <u>Tests With AV-8A (Harrier) Aircraft; Complete VLA Package, Extended Runway Centerline Lights, and Touchdown Zone Marker Lights</u>

a. Day and night test flights with an AV-8A aircraft flying approaches to landing were conducted in order to confirm the test results that were achieved with the NHH-2D helicopter. The pilot felt that this lighting package provided excellent lineup information and closure rate on approach. The package was adequate for information in the hover position but could be improved by moving the GSI farther downfield to provide the amber *COMMAND PATH* altitude cue at the hover position. The pilot found that a hover height of 70 to 80 feet was more comfortable than the 50-to-60-foot hover height stated in the AV-8A NATOPS Manual (reference (d)); although the touchdown zone marker lights could not be seen from that hover height (70 to 80 feet), the extended centerline lights and the lighted wind sock provide sufficient position information while establishing a hover to allow safe operation without touchdown zone marker lights. The marker lights would have to be moved farther away from the runway in order to be visible. This would require placement of the marker lights beyond the tree line where the trees would obscure them from view. To make use of the marker lights advantageous, the site clearances specified in reference (b) would have to be expanded.

b. A glide slope of 5 degrees was used for the AV-8A test sequence and was found to be acceptable. On a hot day or at a high-altitude site, however, an excessive sink rate could easily develop with insufficient power available to overcome the sink speed on a 5-degree glide slope. Depending upon obstacle clearance, a glide slope of between 4 and 4-1/2 degrees would be safer and more comfortable to fly. This could be accomplished by locating the GSI at the fifth set of approach lights, 500 feet downfield from the end of the runway, approximately 1,000 feet from the touchdown zone, where it would provide both a more shallow glide slope and sufficient clearance when crossing the tree line on approach. One other benefit of moving the GSI farther downfield is that it could then provide the amber *COMMAND-PATH* cue at the hover position which is a more accurate altitude cue than the green *HIGH* now visible at the hover position with the GSI at its current location.

13. The extended centerline lights are necessary because they provide lineup information throughout the approach and are the only lineup cue during the hover mode. The extended centerline also provides some guidance during takeoff in helping the pilot stay in the runway corridor. The VSTOL runway centerline lights, PN 613593-1, are not required because sufficient lineup information is provided by the approach lights, extended centerline lights, and runway-edge lights while the aircraft approaches the site and because the runway centerline lights cannot be seen while the aircraft is hovering over the site. The extended centerline lights should also be installed on the first and second sets of approach lights to even out the display. The red obstruction lights should be placed at treetop level so as not to mislead any pilots into thinking they are clear of obstructions when they are not.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

14. The complete VLA package and the extended centerline lights (Figures 1 and 2) provide all the visual lighting cues necessary for safe bidirectional operations at a VSTOL Forward Operating Facility. *(Paragraphs 11a and 12)*

15. The red obstruction lights should be used to demarcate the cleared area by placing them at treetop level, in line with the runway-edge lights where they will also assist in the downwind positioning of the aircraft. *(Paragraphs 11a(2) and 13)*

16. The extended centerline lights are a requirement for safe operation of the VSTOL Forward Operating Facility. *(Paragraphs 11a(3), 11c, 12a, and 13)*

17. The 1/2-degree *COMMAND PATH* on the GSI is superior to a 1-degree or greater *COMMAND PATH* in that it provides more rapid trend information. *(Paragraph 11a(4))*

18. The optimum GSI location would be at the fifth set of approach lights, 500 feet downfield from the end of the runway, approximately 1,000 feet from the touchdown zone. *(Paragraph 12b)*

19. The GSI is required for safe night operations. *(Paragraph 11b)*

20. The VSTOL runway centerline lights are not required for operation and can be removed from the VSTOL VLA package. *(Paragraphs 11c, 12a, and 13)*

21. The touchdown zone marker lights are not required for use on the VSTOL Forward Operating Facility. *(Paragraph 12a)*

RECOMMENDATIONS

22. Establish the GSI location to be 500 feet downfield from the end of the runway at the fifth bank of approach lights.

23. Include the extended centerline lights in the VLA package for VSTOL lighting, making them an addition to the approach-light system (PN 505954).

24. Delete the runway centerline lights, PN 613593-1, from the VSTOL Forward Operating Facility VLA package.

B. F. Kolacz

B. F. KOLACZ
By direction

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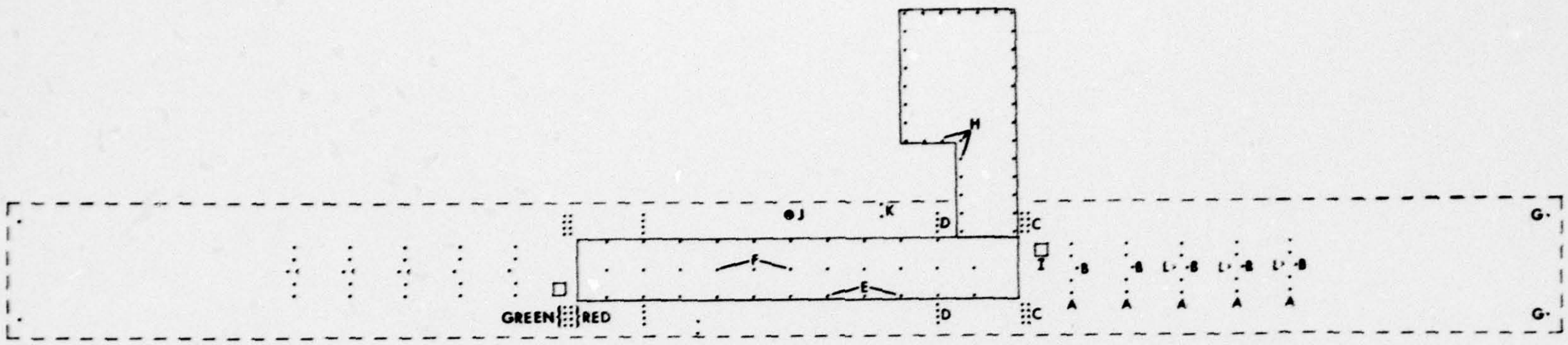


A = APPROACH LIGHTS
B = STROBE LIGHTS
C = THRESHOLD LIGHTS (GREEN AND RED)
D = ROTATION LIGHTS (AMBER)
E = RUNWAY EDGE LIGHTS
F = RUNWAY CENTERLINE LIGHTS
G = OBSTRUCTION LIGHTS (RED)
H = TAXIWAY LIGHTS (BLUE)
I = GLIDE SLOPE INDICATOR (1 UNIT, 2 LOCATIONS)
J = LIGHTED WIND SOCK
K = TOUCHDOWN ZONE MARKER LIGHTS
L = EXTENDED CENTERLINE LIGHTS

Figure 1 - Sketch of VSTOL Site and Approach Corridor

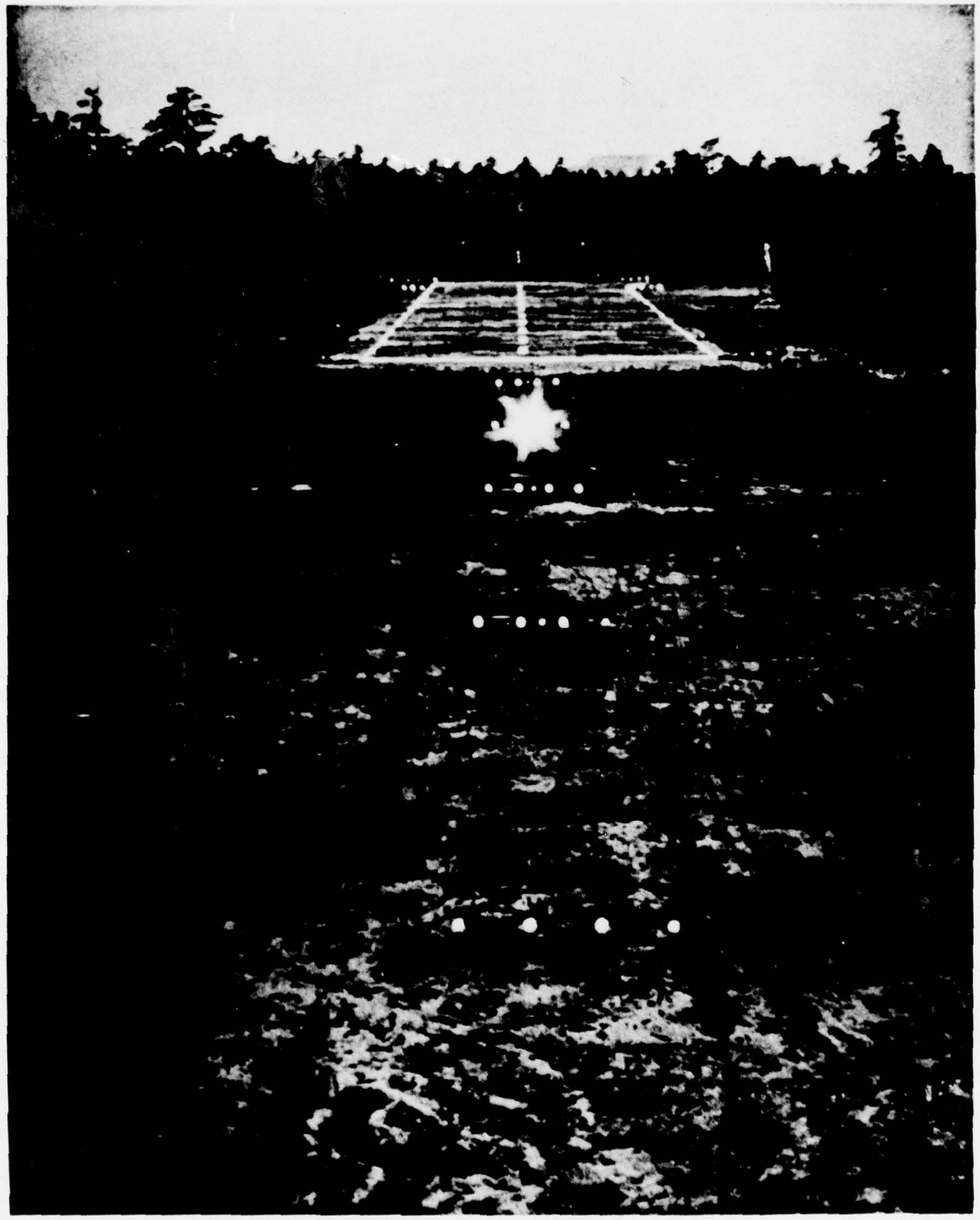


Figure 2 - Lighted Visual Landing Aids Package on NAVAIRTESTFAC VSTOL Forward Operating Facility (View Also Shows Extended Runway Centerline Lights and Touchdown Zone Marker Lights Added by NAVAIRTESTFAC)

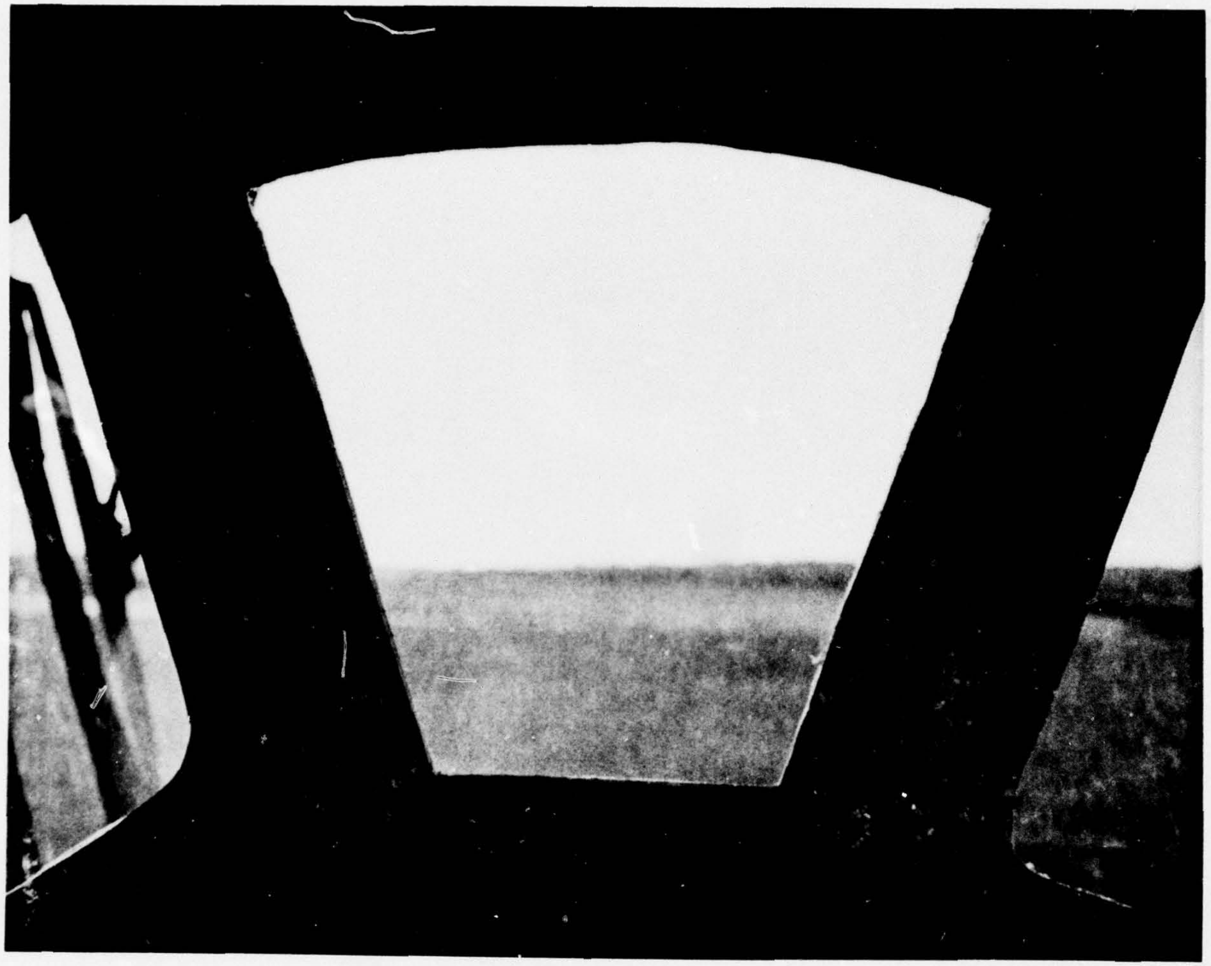
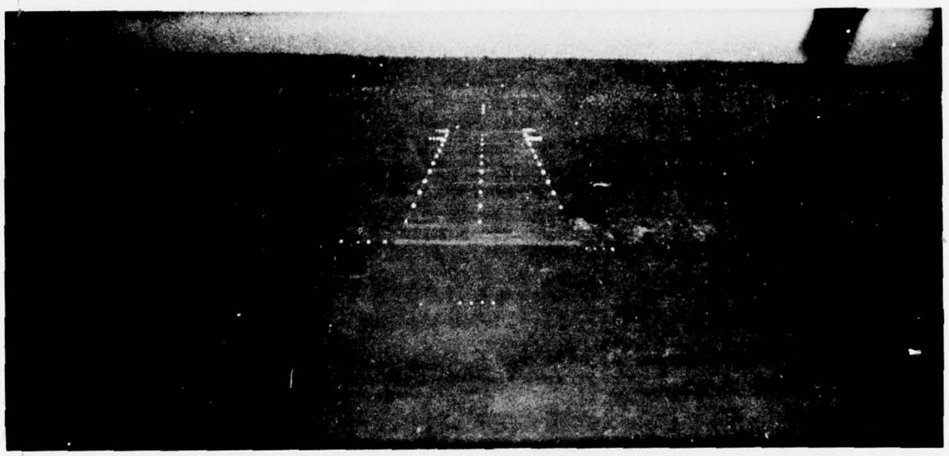
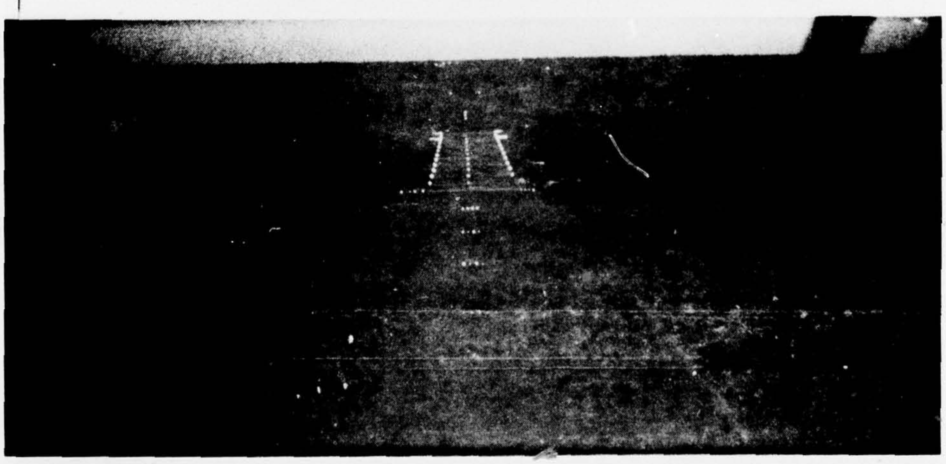
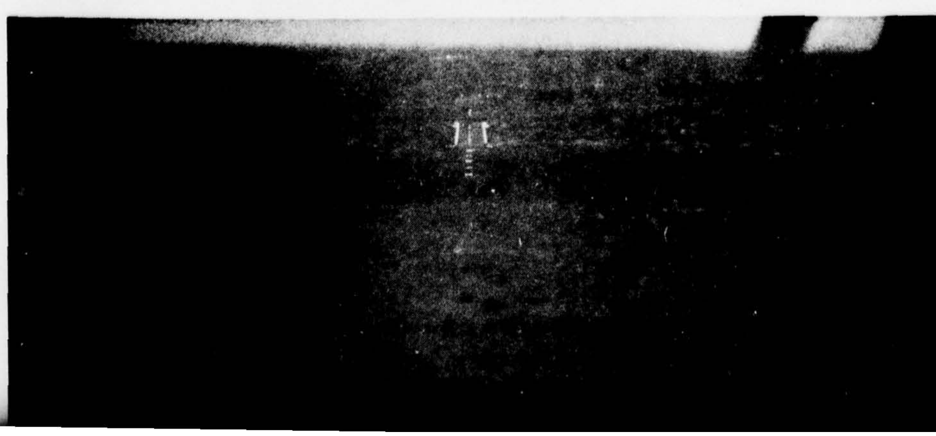


Figure 3 - Masking Installed in NHH-2D Helicopter to Simulate Field of View Available From Cockpit of AV-8A Aircraft

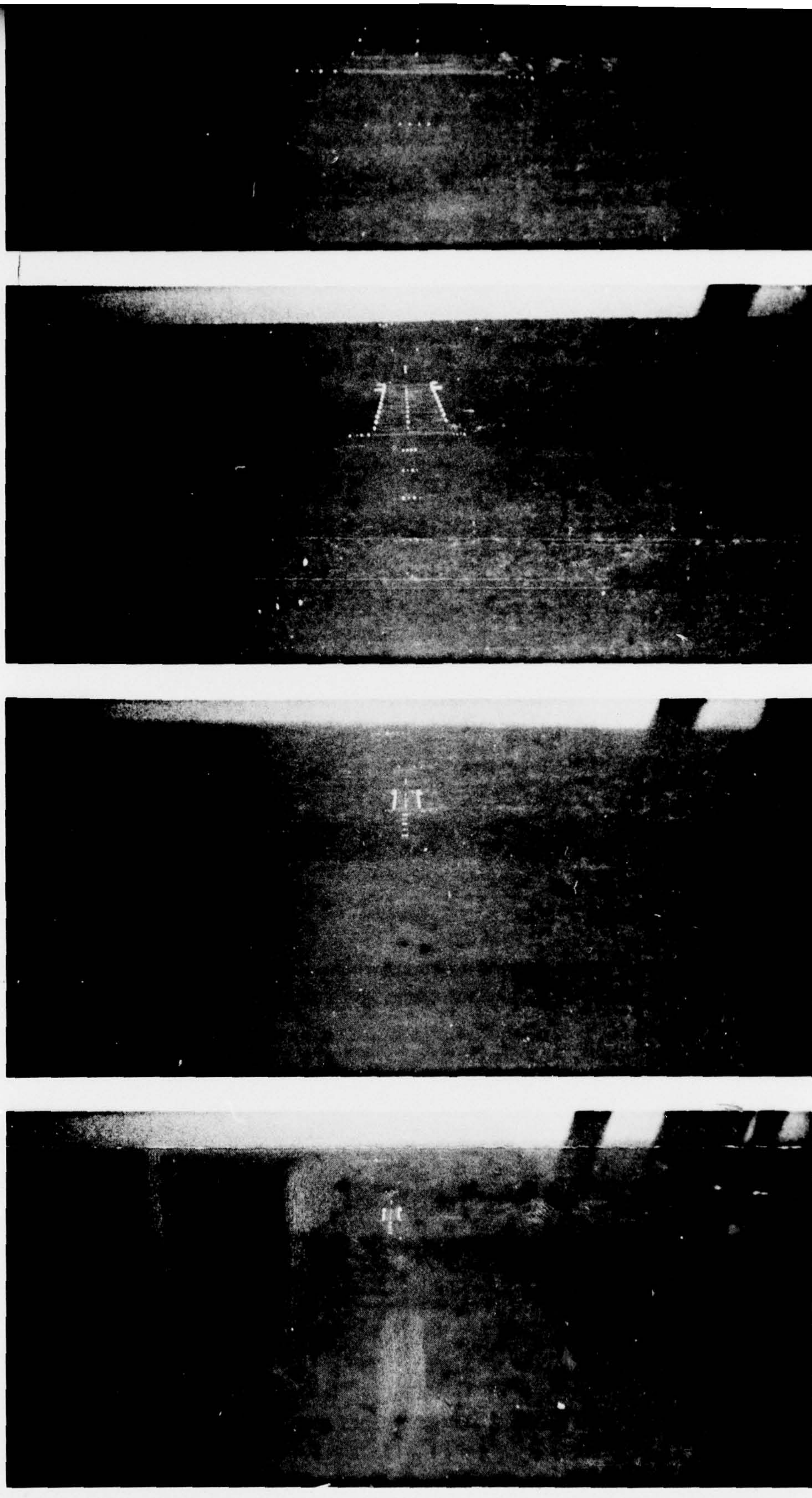


Figure 4 - **Approach** by Helicopter From Approximately 1-1/2 **Miles Out** to Transition to Hover Over the Runway Threshold (VSTOL Forward Operating Facility)

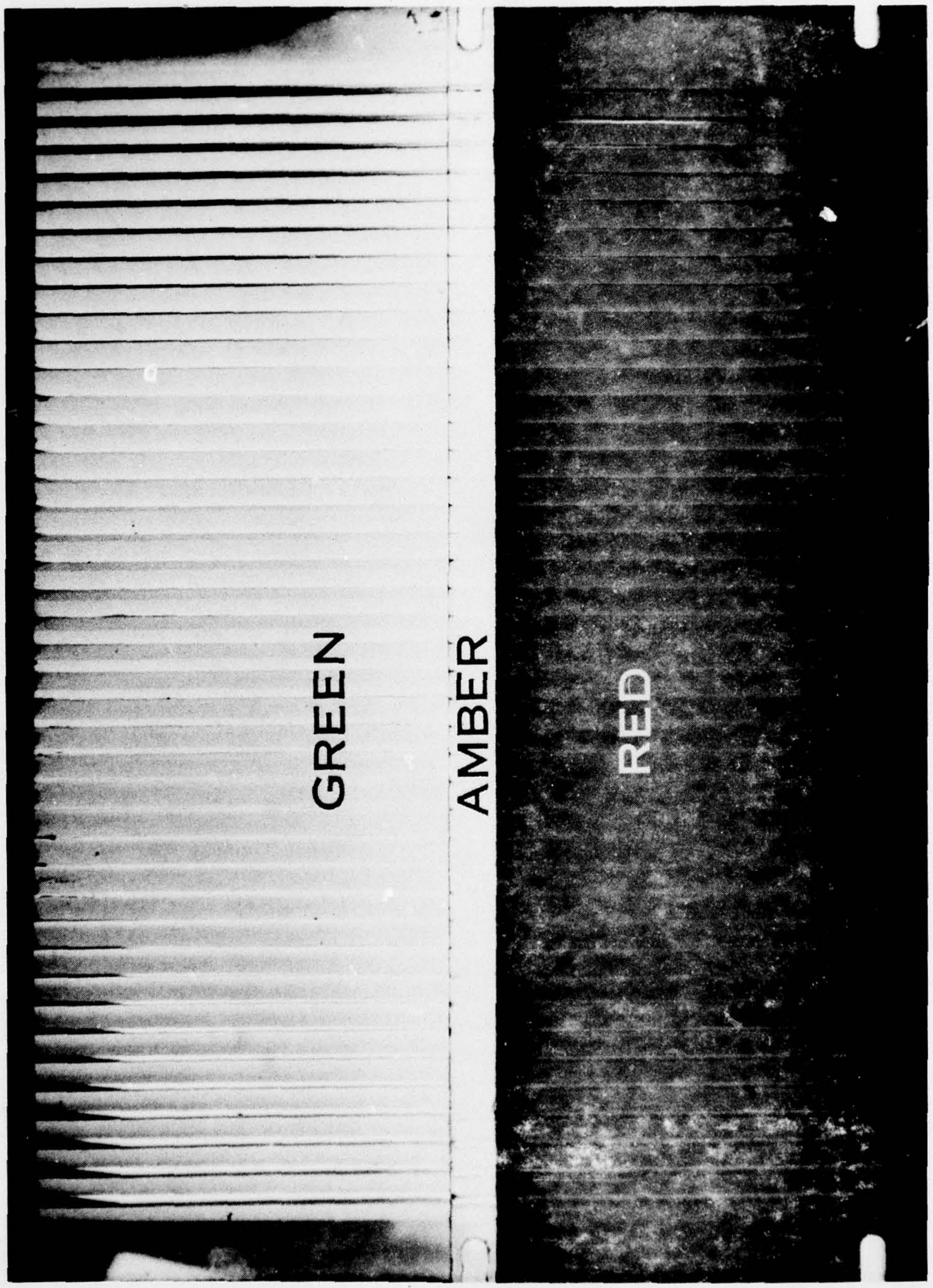


Figure 5 - Glide Slope Indicator Lens

Figure 6 - Minimum Lighting Package Acceptable for Safe Operations
at a VSTOL Forward Operating Facility