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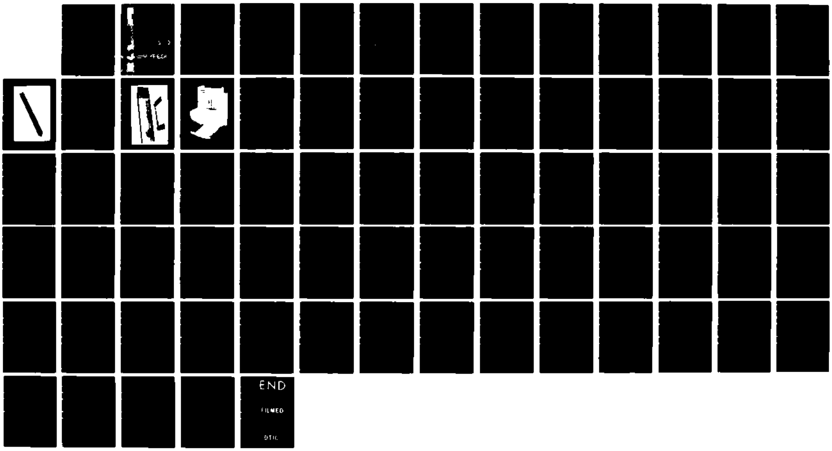

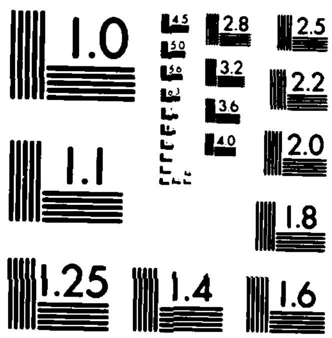
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ESL-TR-84-19

Evaluation of Arctic Test of Improved Tritium Radioluminescent Lighting

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The arctic test of radioluminescent (RL) lighting was conducted to respond to the Alaskan Air Command (AAC) mission requirement for a self-sustaining airfield lighting system suitable for arctic deployment. The test showed durability and dependability of tritium lights. It also showed that the system, as now designed, can support the operations of most aircraft. Additional improvements in the Visual Approach Slope Indicator (VASI) system are desirable.

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EXECUTIVE SUMMARY

This test was conducted by the Air Force Engineering and Services Laboratory, the Alaskan Air Command, and the Department of Energy's Oak Ridge National Laboratory to determine if the improved generation of tritium radioluminescent runway lighting could effectively support aircraft operations in the Alaskan winter environment.

The lighting system was unidirectional and consisted of threshold and touchdown zone lights (each end), edge lights, and Visual Approach Slope Indicator (VASI) lights. The primary lighting layout tested was similar to that required by Military Airlift Command (MAC) regulations for C-130 operations.

Nearly all pilots rated the runway lights satisfactory for use at tactical operating locations. Visual acquisition range was 3 to 5 miles under dark conditions. This distance was decreased by ambient lighting conditions. Pilots landing into the twilight of a setting sun reported as little as 1 mile acquisition range.

The VASI system did not fare as well and was rated marginal by pilots. Increasing the number of radioluminescent (RL) panels used and the distance between the panels significantly improved acquisition and usable ranges.

The tritium lights were extremely durable throughout the test. They required no maintenance except an occasional "wipe off," and there were no failures or security violations.

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PREFACE

The work described in this report was performed by the Radioisotope Department, Operations Division, Oak Ridge National Laboratory, Post Office Box X, Oak Ridge, Tennessee, under Interagency Agreement 40-1127-80 for the Air Force Engineering and Services Center, Engineering and Services Laboratory (AFESC/RDCS), Tyndall AFB, Florida, between 17 November 1983 and 15 December 1983. The AFESC/RDCS project officer was Thomas C. Hardy.

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This report has been reviewed by the Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication.

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LIST OF DEFINITIONS, TERMS, AND ABBREVIATIONS

AAAF	Allen Army Airfield
AAC	Alaskan Air Command
AFESC	Air Force Engineering and Services Center
AK ANG	Alaska Air National Guard
ATP	Arctic Test Plan
ATS	Arctic Test Site
COMPW	Composite Wing
DLZ	Donnelly Landing Zone
DOE	Department of Energy
MAC	Military Airlift Command
ORNL	Oak Ridge National Laboratory
RL	Radioluminescent
TFW	Tactical Fighter Wing
TOL	Tactical Operating Location
VASI	Visual Approach Slope Indicator

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SECTION I

INTRODUCTION

Radioluminescent (RL) lighting is light produced by impingement of radiation, generally a beta particle, into a phosphor. The light may be visible or infrared (IR), depending on the phosphor selected. Radioluminescent lighting has been used in industry for clock dials, exit signs, and light standards in the photographic industry. Military applications include light-emitting paints for aircraft dial illumination, minefield markers, and gunsight illumination.

The Air Force is investigating alternate airfield lighting systems. In addition to electric power costs, current airfield lights use incandescent bulbs which require frequent maintenance and replacement and wiring systems which are expensive to install and also require maintenance. The use of tritium RL lighting should greatly reduce maintenance costs. Mission planners desire a self-contained, lightweight system for tactical bare-base employment which can be readily adapted to permanent airfields during periods of contingency. Remote Arctic air operations demand energy self-sufficient airfield lighting capable of enduring severe environmental extremes.

In 1979 an Air Force suggestion was submitted by the 1776th Civil Engineering Squadron, Andrews Air Force Base, Maryland, to construct runway distance and taxiway marker signs using the radioisotope tritium as a power source. The proposal advocated the use of tritium-filled, phosphor-lined glass tubes instead of incandescent bulbs and electric power for savings in airfield operation and maintenance costs.

A joint Department of Defense/Department of Energy (DOD/DOE) study group was formed to develop applications for defense nuclear waste radioisotopes as "alternate energy" lighting systems. This group, now known as DOD/DOE RL Light Technical Working Group (TWG), has identified many military applications. ORNL has designed, built, and demonstrated the lights for many of these applications.

Tritium light fixtures were first demonstrated to the U.S. Air Force (USAF) by DOE's Oak Ridge National Laboratory during a July 15-17, 1980, demonstration at Andrews Air Force Base, Maryland. The demonstration was during night conditions, and some observers reported visual sighting of up to 1 mile. However, more research was needed to improve brightness, color quality, light distribution, and safety.

Subsequently, joint Department of Energy/Engineering and Services Laboratory (DOE/ESL)-sponsored research at ORNL produced a report entitled Testing of Tritium-Powered Runway Distance and Taxiway Markers.(1)

ORNL performed the initial evaluation tests on these RL signs, which included the evaluation of illumination intensity, discoloration, temperature, thermal shock, pressure, impact, vibration, immersion, rough-handling, blowing-sand, and service-life tests.

The current program became known as PROJECT FIREFLY when tests of an improved RL fixture were conducted by ORNL at Bogue Marine Corps Auxiliary Landing Field (MCALF), North Carolina, on September 14-18, 1981. These tests evaluated the product of joint DOE/ESL-sponsored RL developments (2,3) and showed that the new fixture was at least twice (228 percent as bright as the original prototypes. During August 9-12, 1982, operational tests (OT&E) were performed at Bogue MCALF by ORNL to evaluate a new tritium light fixture geometry redesigned to provide a significantly greater area of light emission. These lights were tested in the Arctic environment during January and February 1983.[4] While improved, further improvement was required. The current tests described in this report are of an improved lighting system. The improved lights are observable at greater than twice the distance of the previously tested lights.

The AAC has a continuing requirement for portable runway lighting to support exercise and operational commitments. TOLs for A-10, C-130, and other aircraft must be capable of 24-hour-a-day operations. Permanent airfields require a portable runway lighting system to back up installed lighting if failure should occur.

The arctic and subarctic environments of Alaska place special demands on runway lighting systems. Adverse weather conditions of precipitation, wind, and extremely low temperatures occur year round and cause conventional lighting equipment breakdowns and frequent maintenance. During the winter, there are few hours of daylight in which to make repairs; and the cold weather hampers these efforts, or even makes them unsafe. Additionally, replacement parts for currently used runway lighting systems are often difficult to procure and have long delivery times.

The requirement for improved portable runway lighting has been formally identified in AAC Statement of Operational Need (SON) 1-84.

The primary goal of the Arctic Operational Test was to evaluate the ability of RL lighting technology to satisfy the Alaskan Air Command (HQ AAC) operational requirements. The secondary role of this test is to evaluate the feasibility of this lighting to reduce installation, operation, and maintenance costs of airfield lighting systems. A complete list of evaluation objectives is described in Appendix A.

SECTION II

TEST PLAN, TEST PROCEDURE, AND EVALUATION PLAN

TEST PLAN

The Tritium Radioluminescent Lighting Arctic Test Plan was prepared and distributed by HQ, Air Force Engineering and Services Center (AFESC), Tyndall Air Force Base, Florida. This plan should be consulted for a detailed description of the tests, participants, test requirements, methodology, and responsibilities of participating organizations.

TEST PROCEDURE

The Test Procedure is taken from the Test Plan and is presented in Appendix B.

EVALUATION PLAN

The Arctic Test Evaluation Plan is taken from the Test Plan and is presented in Appendix C.

SECTION III

TRITIUM RADIOLUMINESCENT LIGHT PANEL DESCRIPTION

The tritium RL light panels consist of seven individual Pyrex® glass light tubes, each containing approximately 50 curies of tritium. The glass tube (Figure 1) is convex-shaped for strength and is pressurized with tritium to approximately 1.5 atmospheres absolute pressure. The tubes are coated on the inside surfaces with GTE-1260 phosphor, which is a zinc-sulfide-based phosphor doped with copper.

The tubes are packaged in an aluminum box, 12 3/4 inches by 12 3/4 inches by 2 3/4 inches, with foam shock mounting and a clear polycarbonate face. The tubes are held in place by silicone cement on a clear polycarbonate bracket (Figure 2).

The RL light panel has been tested and withstood all the American National Standard N540 Performance Level 4 tests for self-luminous light sources.(5)

The RL lights were mounted in racks (Figure 3), each containing five panels for the threshold, touchdown zone, end of runway, and downwind lights. Runway edge markers (Figure 4) were a single-panel rack. The racks were held in place by sandbags. Generally, the sandbags were adequate, except in areas where the C-130 aircraft made a turn. These light fixtures required staking to hold them in place in the intense propeller wash from the C-130.

The airfield layouts for the different runways are shown in Figures 5 through 12. The standard VASI configuration is shown in Figure 13.

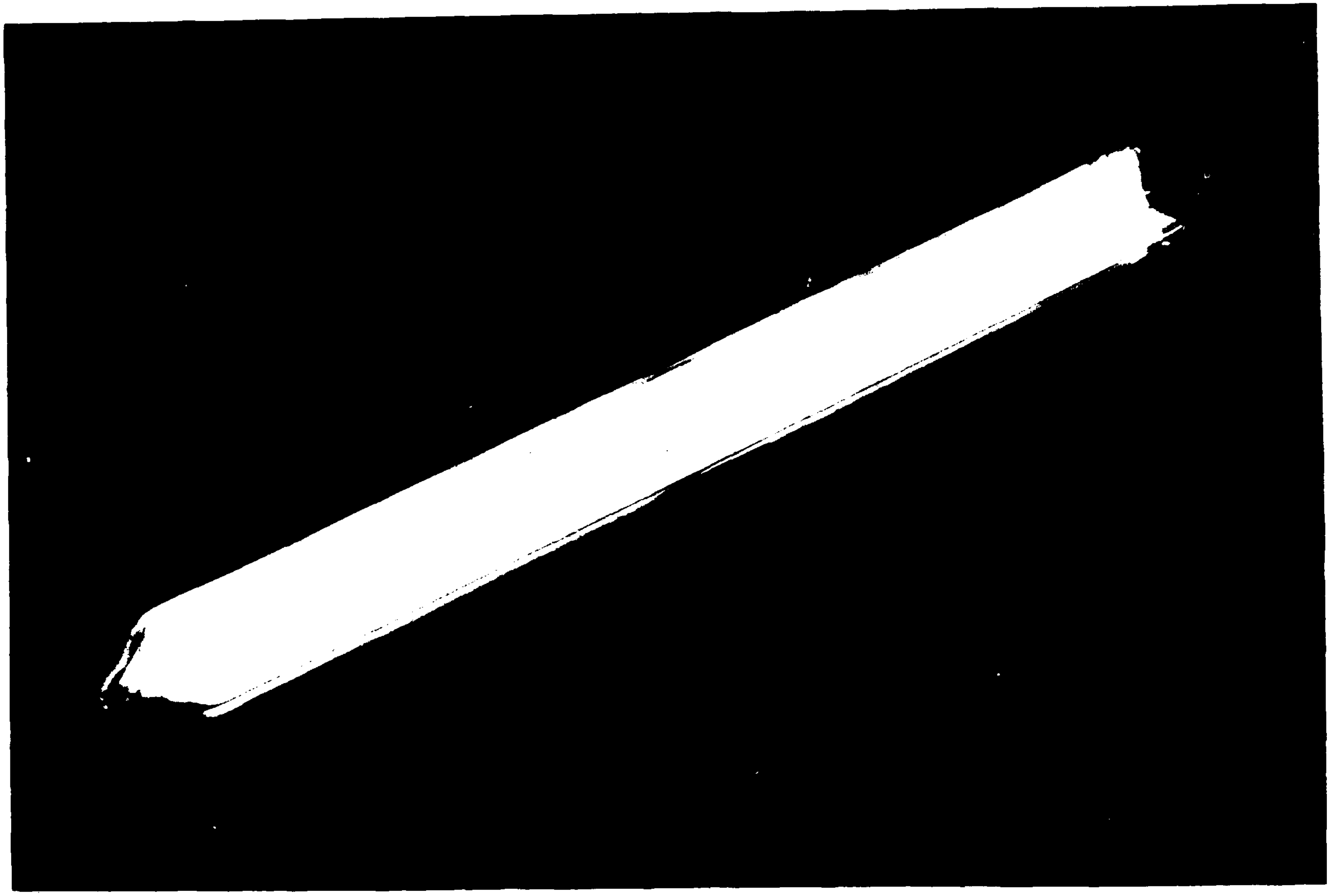


Figure 1. Radioluminescent Light Tube

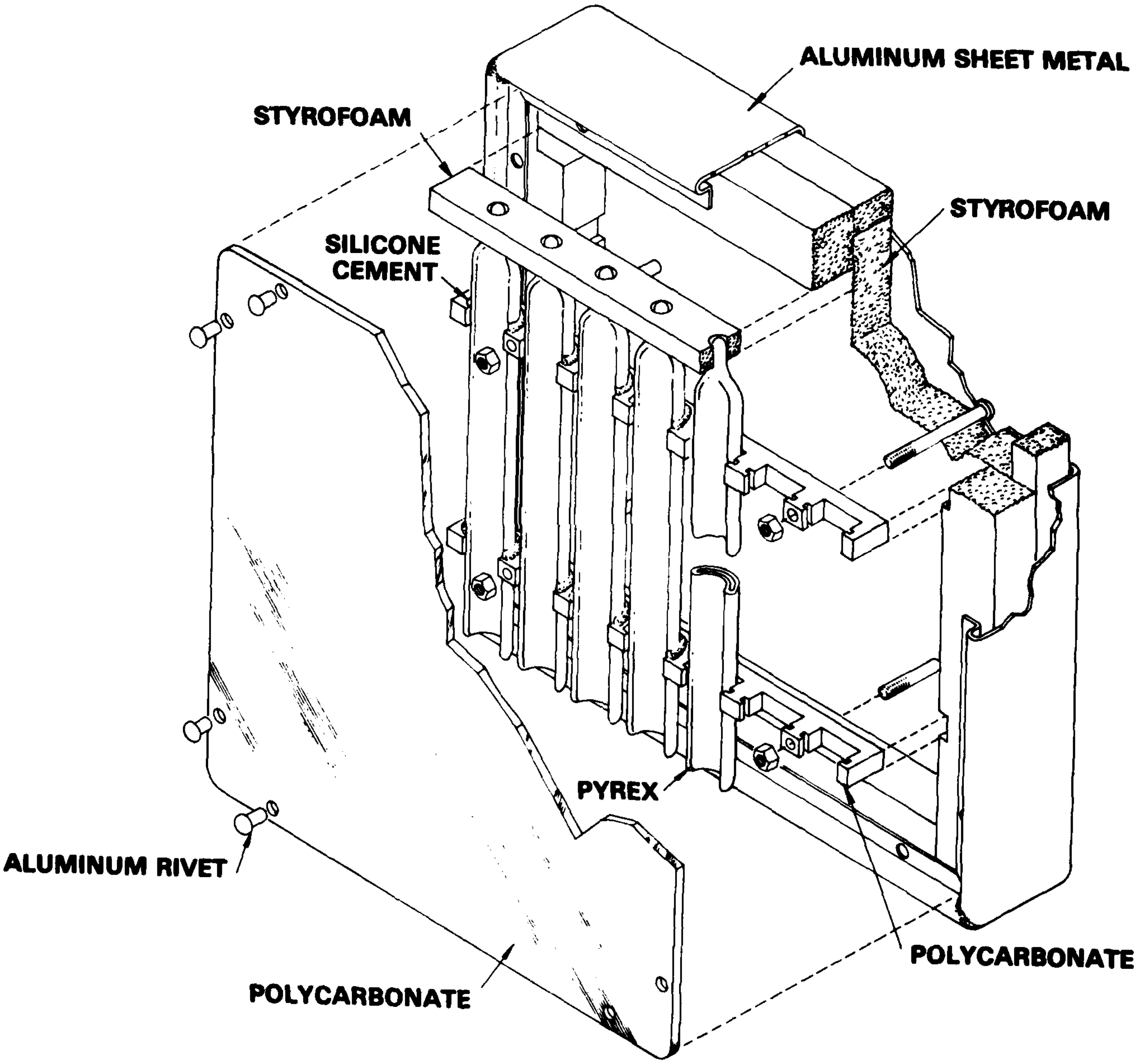


Figure 2. Seven-Tube RL Light Panel

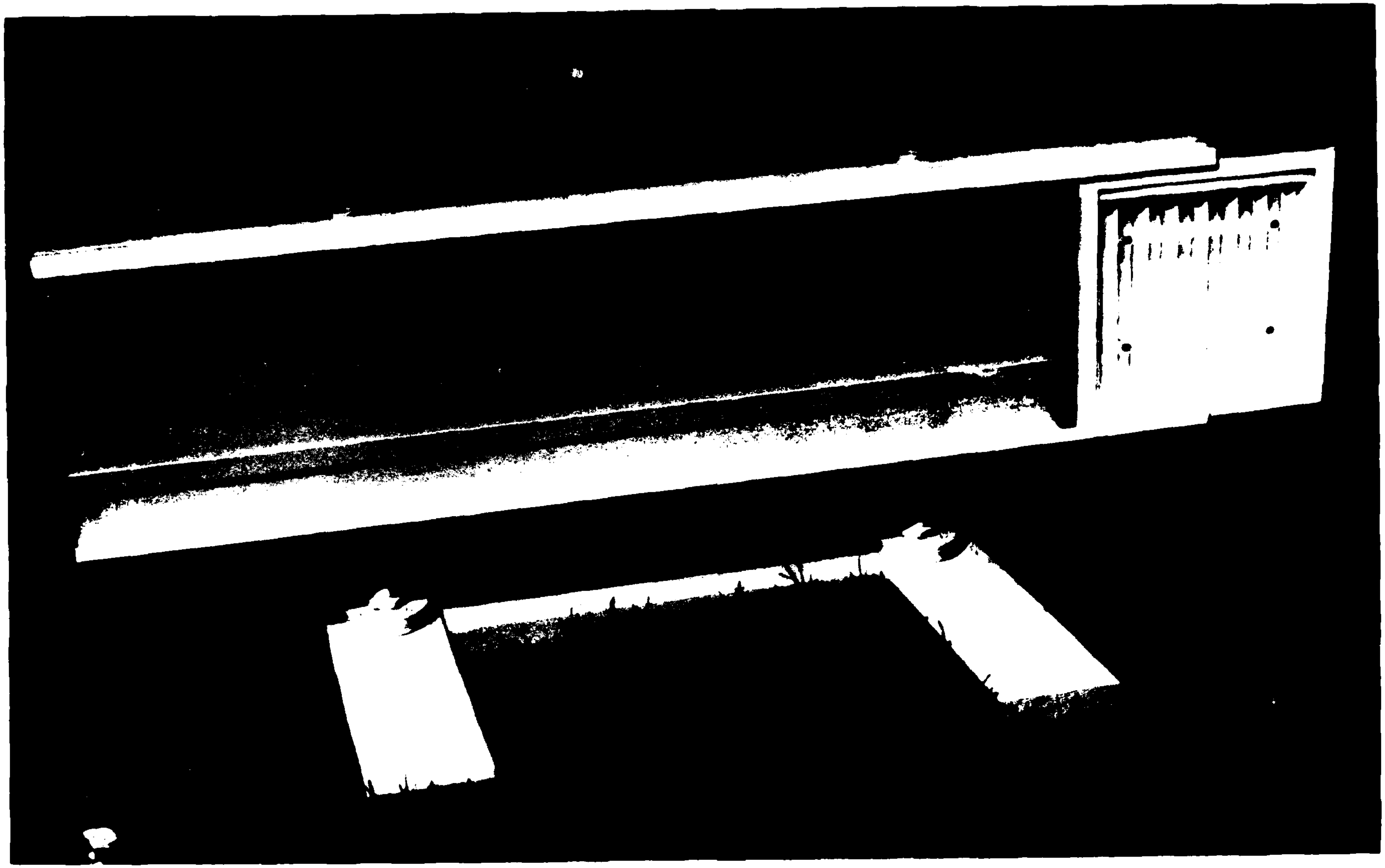


Figure 3. Rack for Holding RL Light Panels

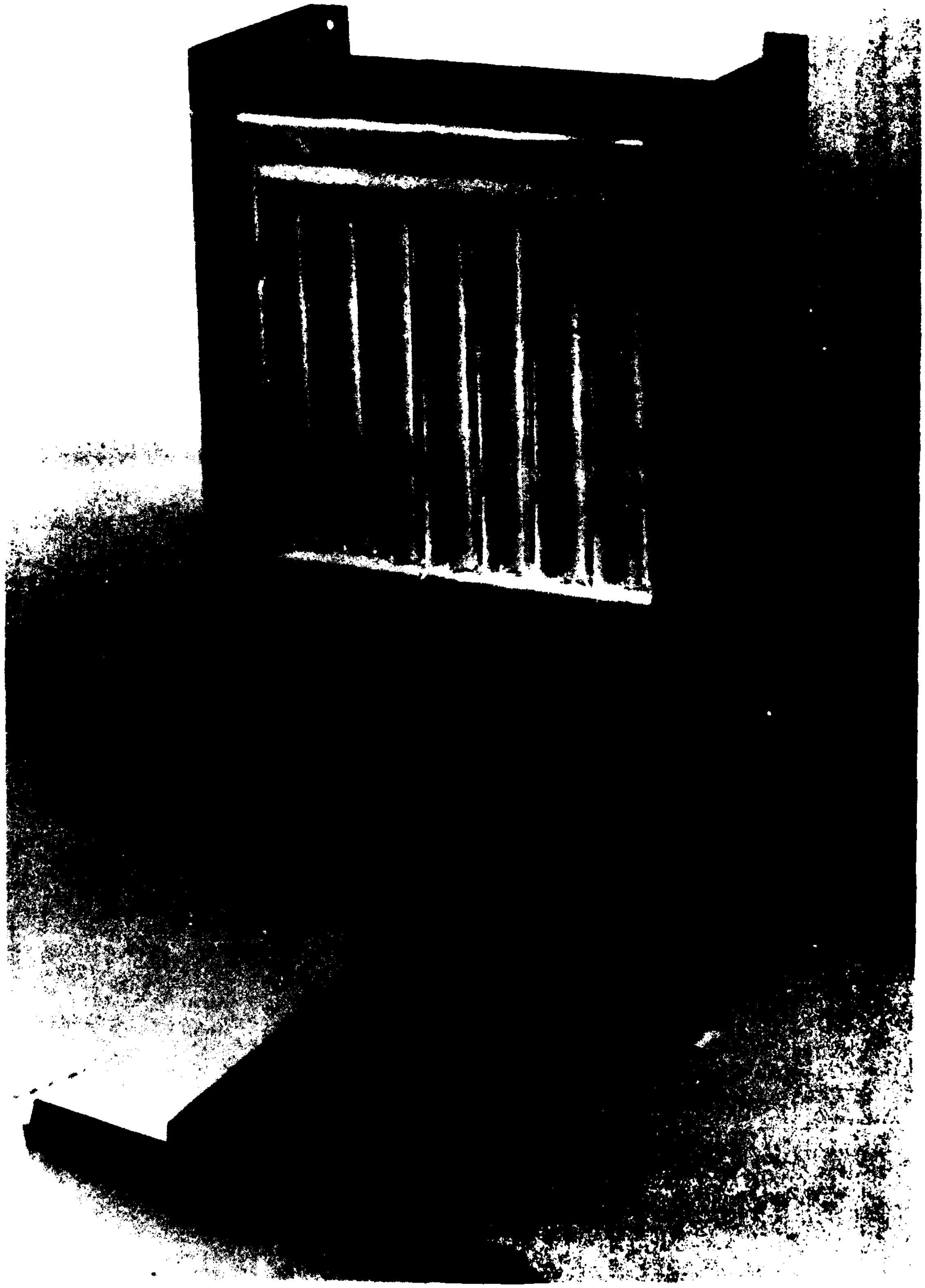


Figure 4. Radioluminescent Runway Edge Light Fixture

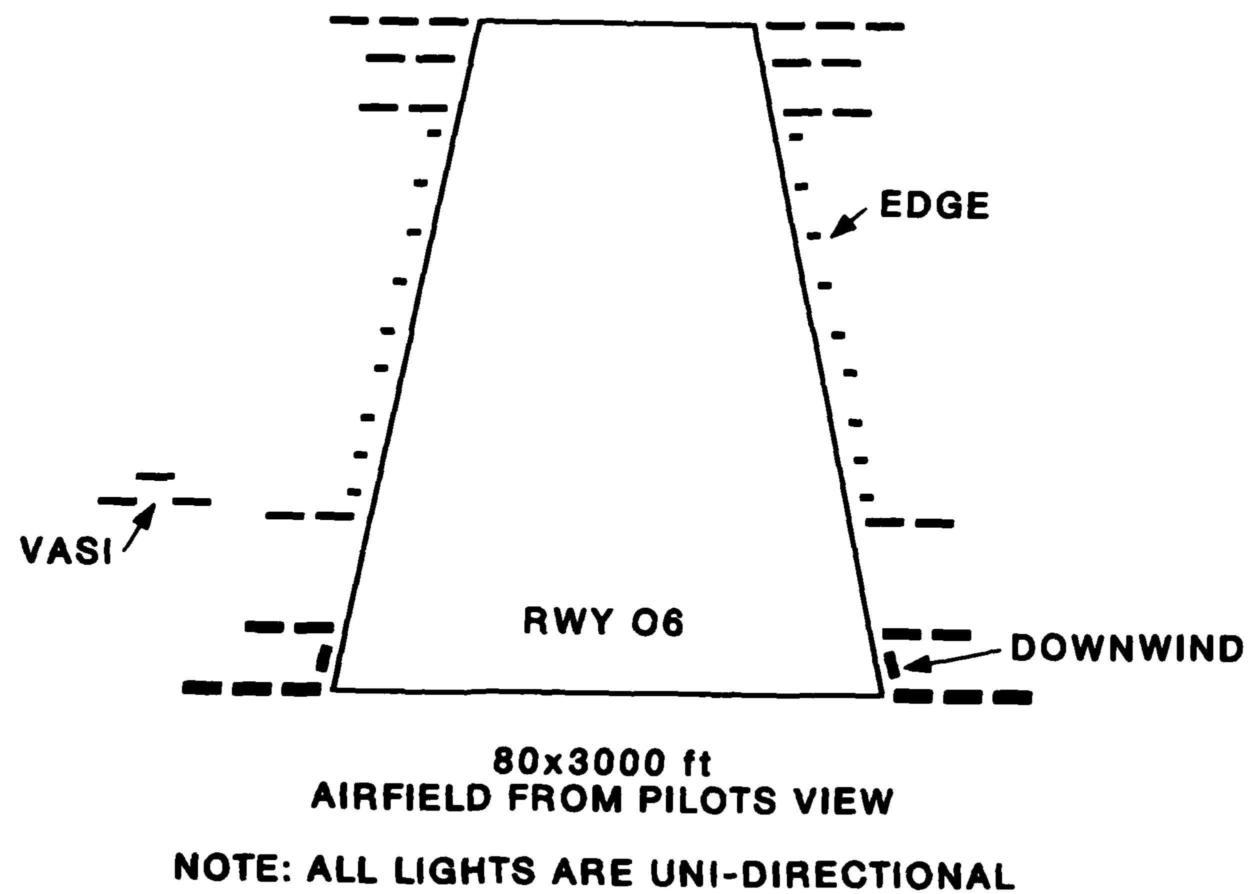


Figure 5. Allen AAF - 21 Nov 83

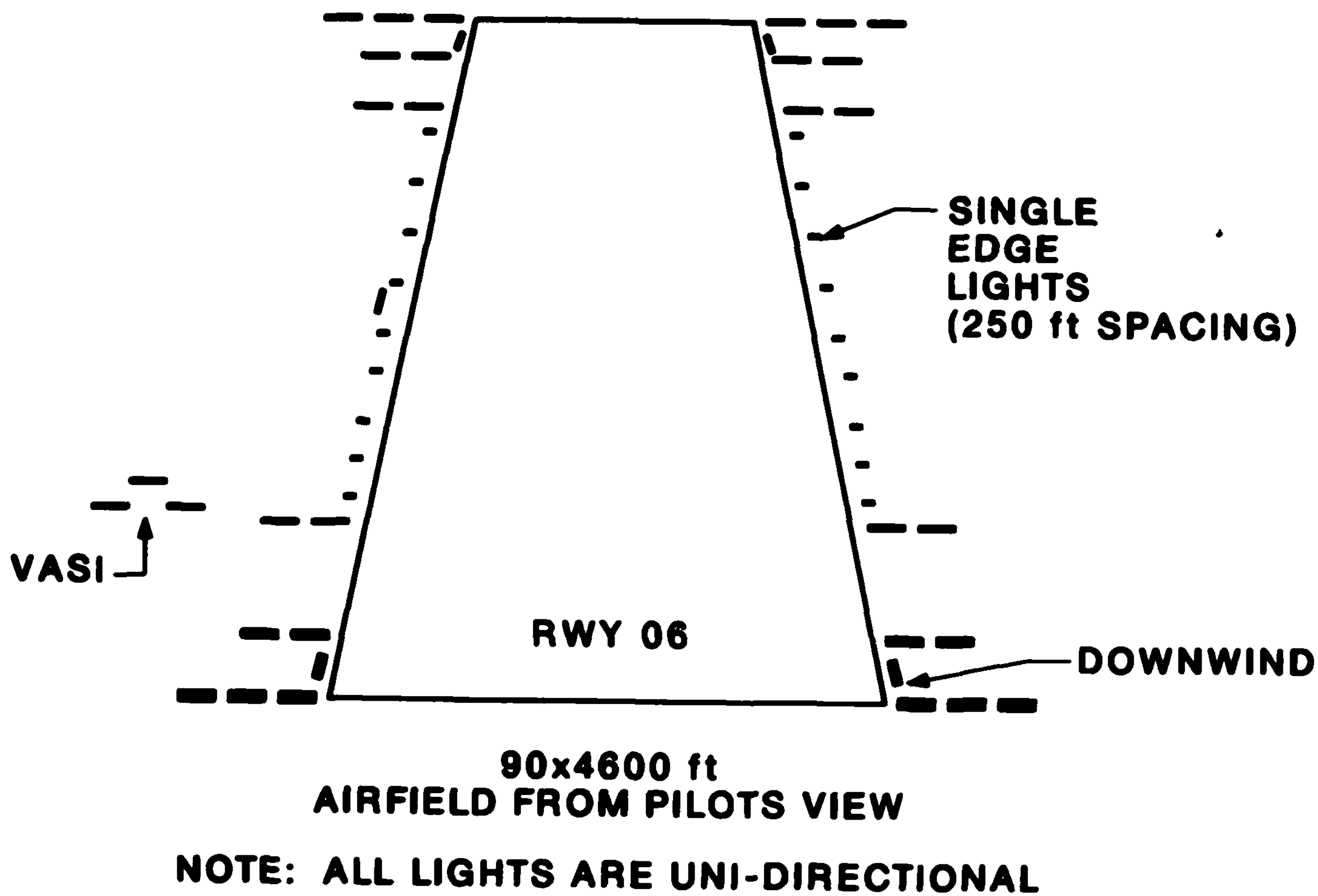
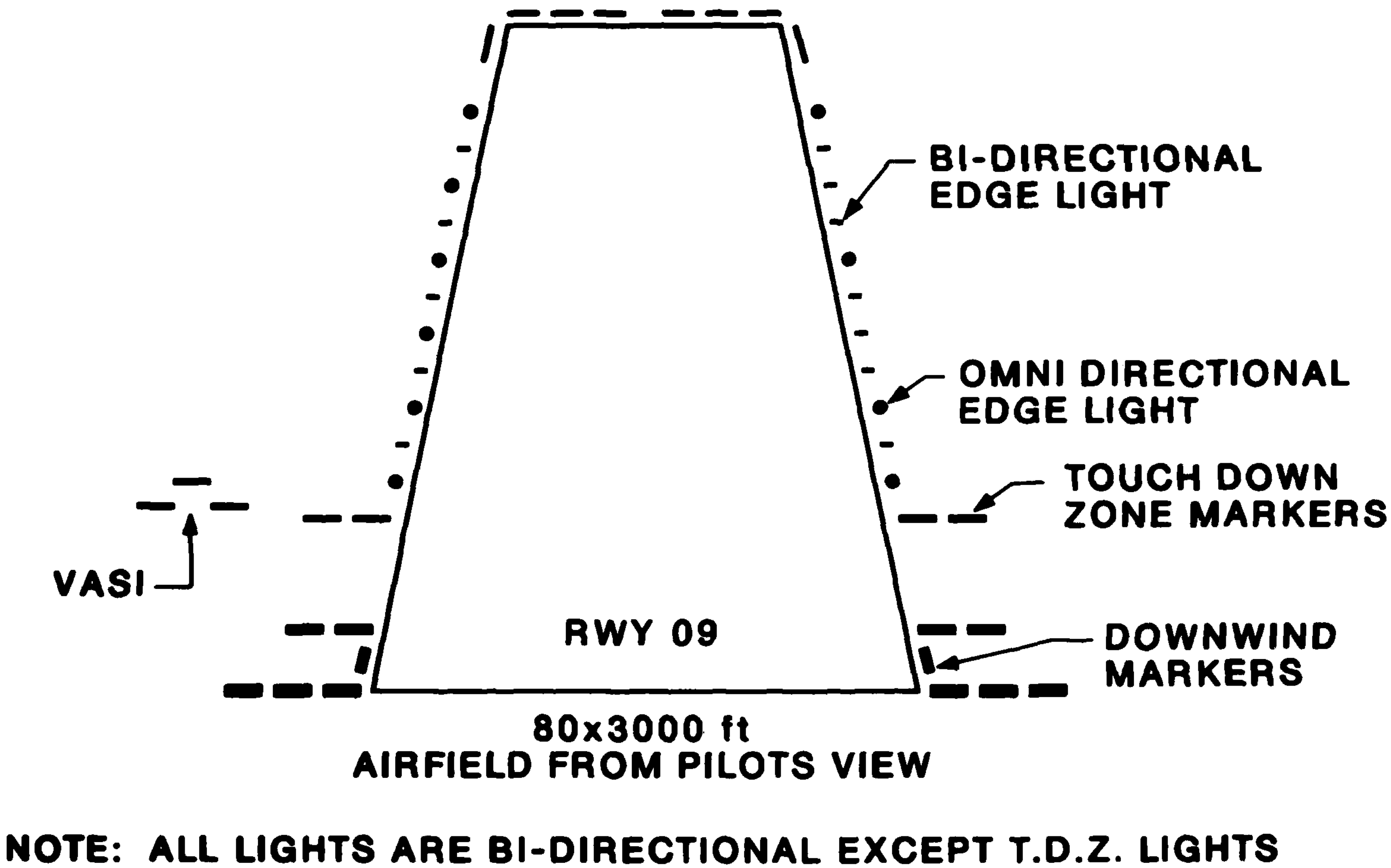


Figure 6. Allen AAF - 22 Nov 83



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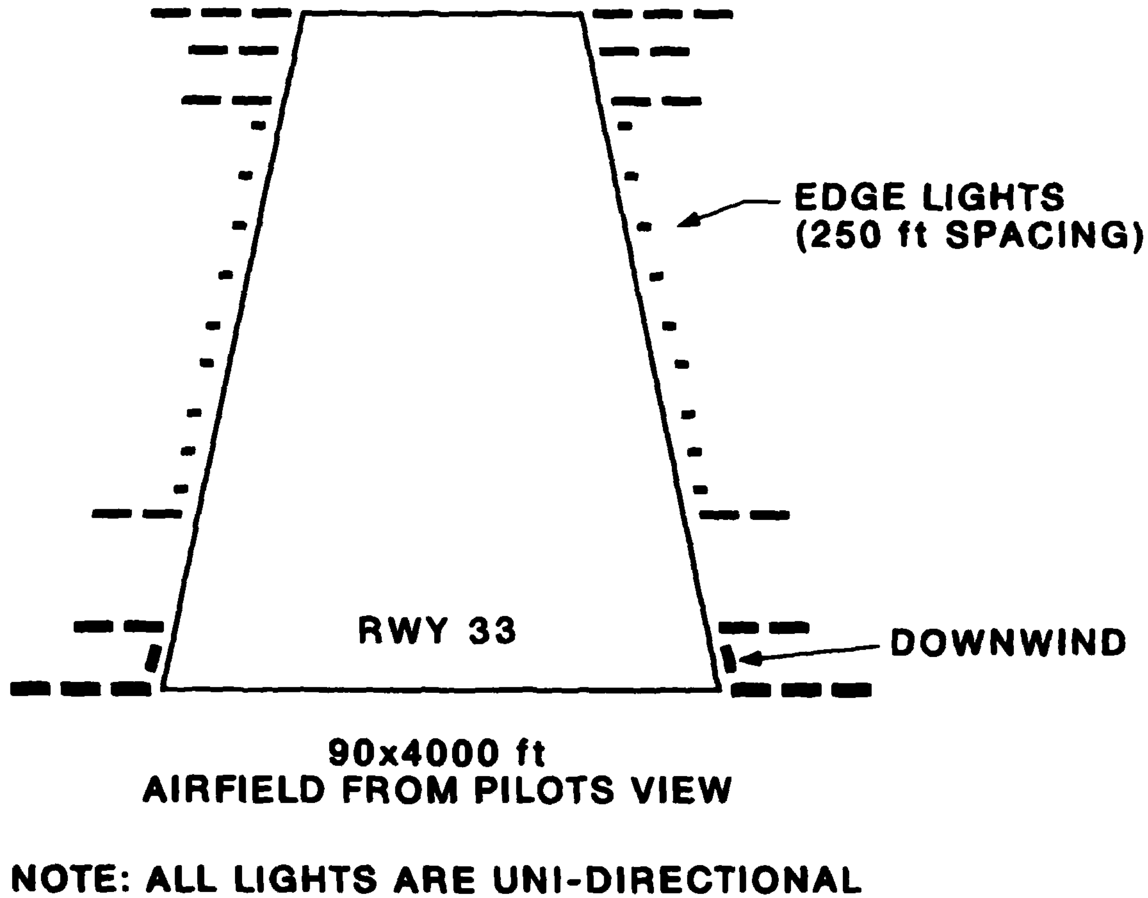


Figure 8. Donnelly LZ Layout - 29 Nov-3 Dec 83

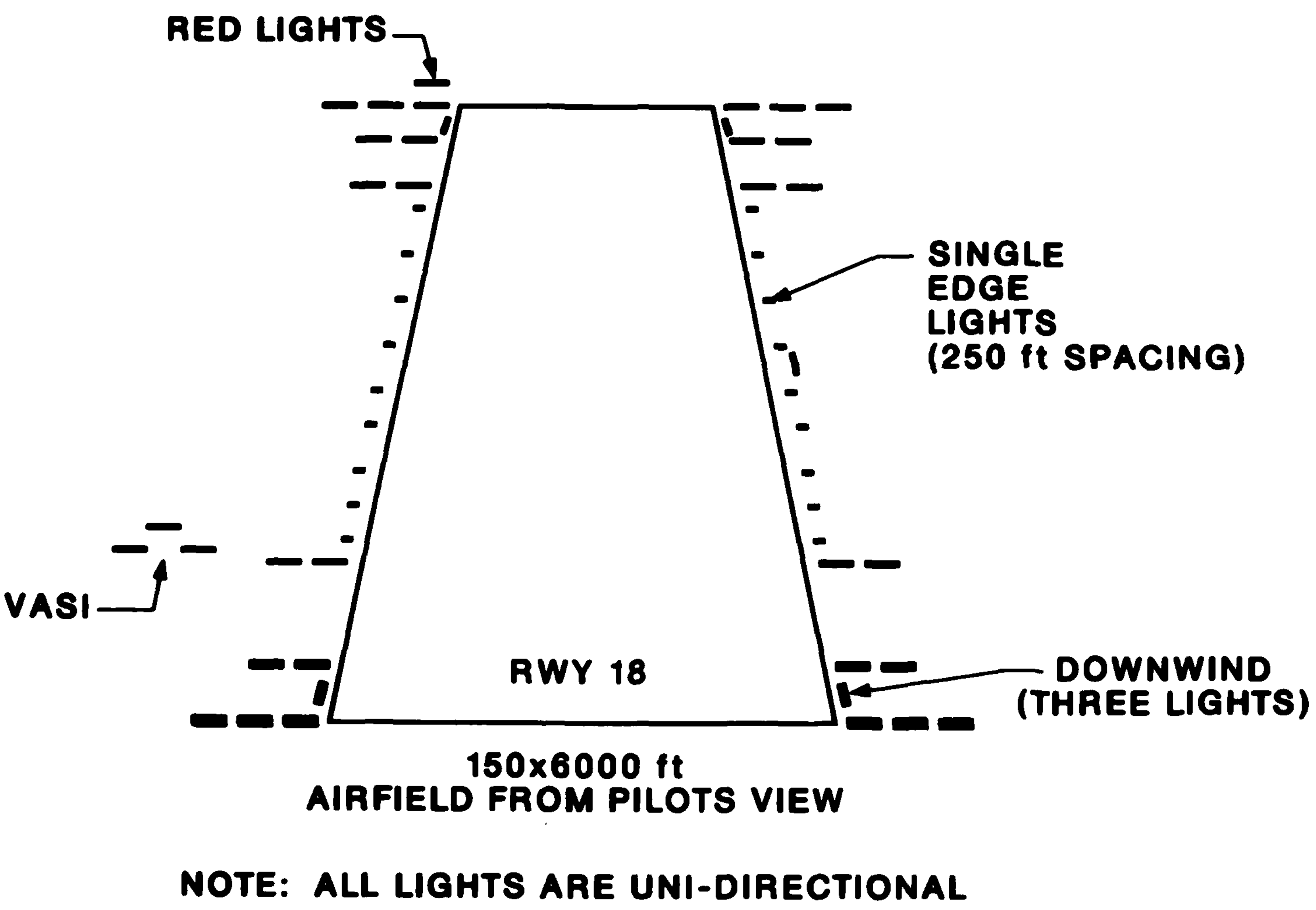


Figure 9. Allen AAF - 5-6 Dec 83

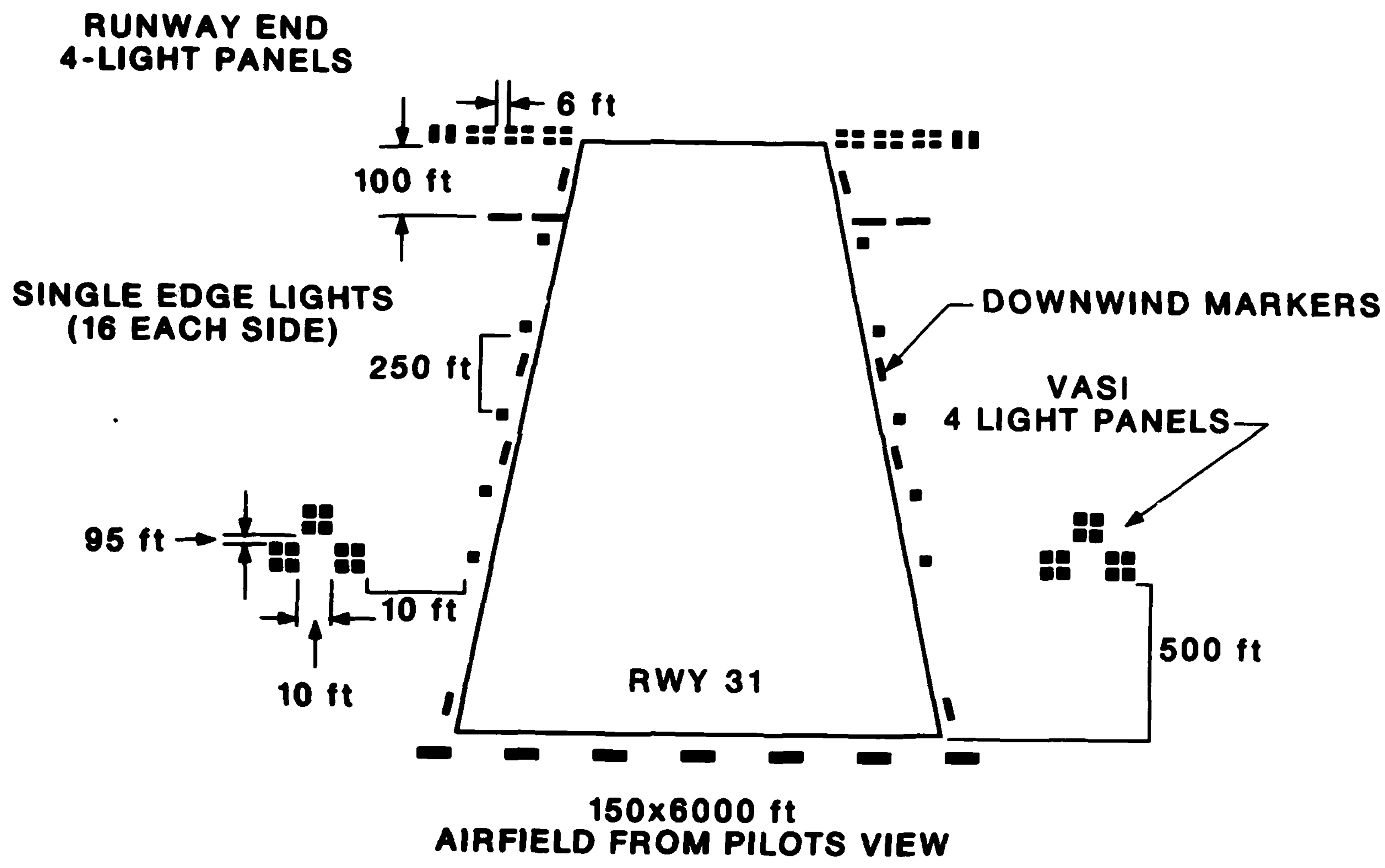
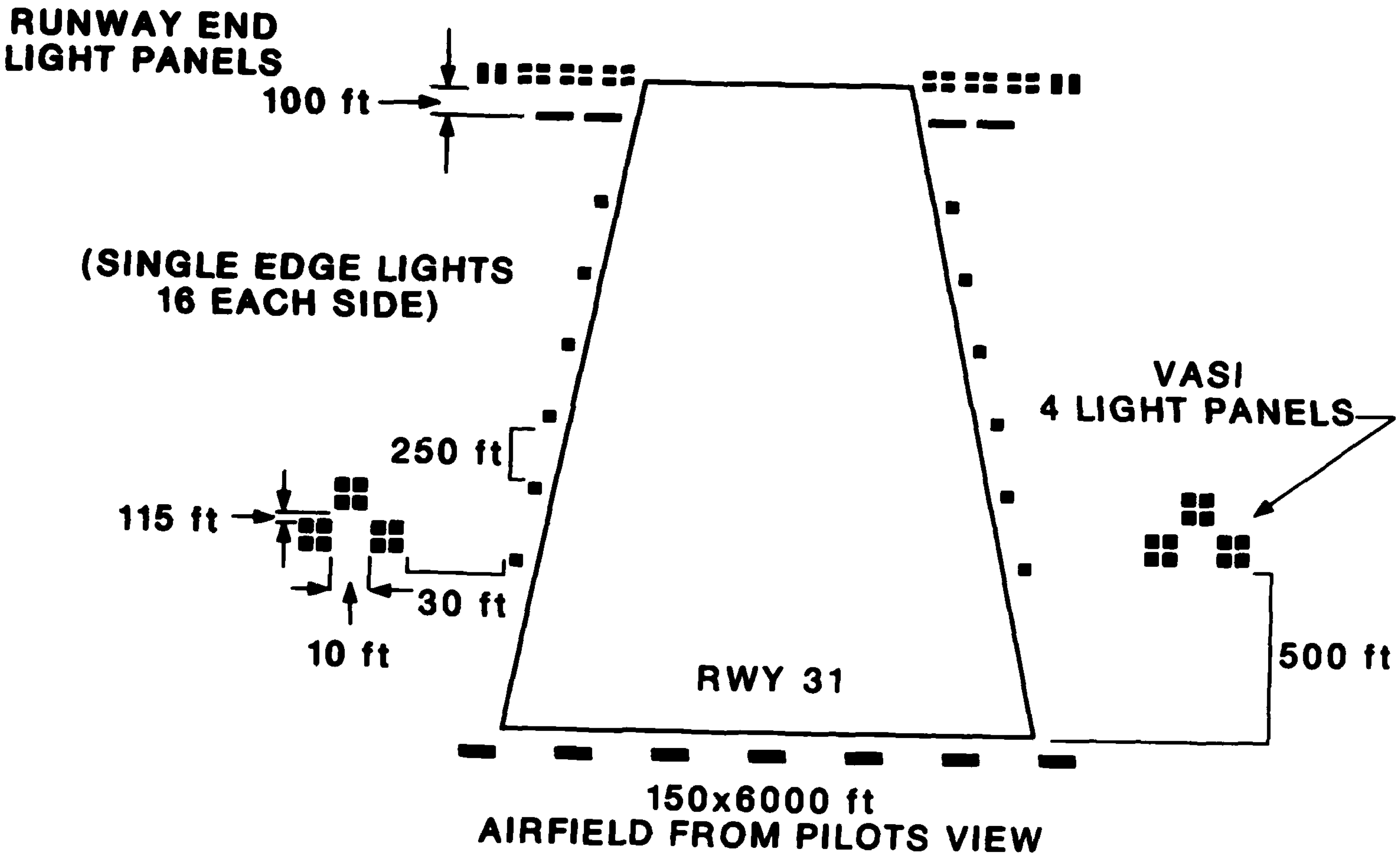


Figure 10. Eielson AFB - 12 Dec 83



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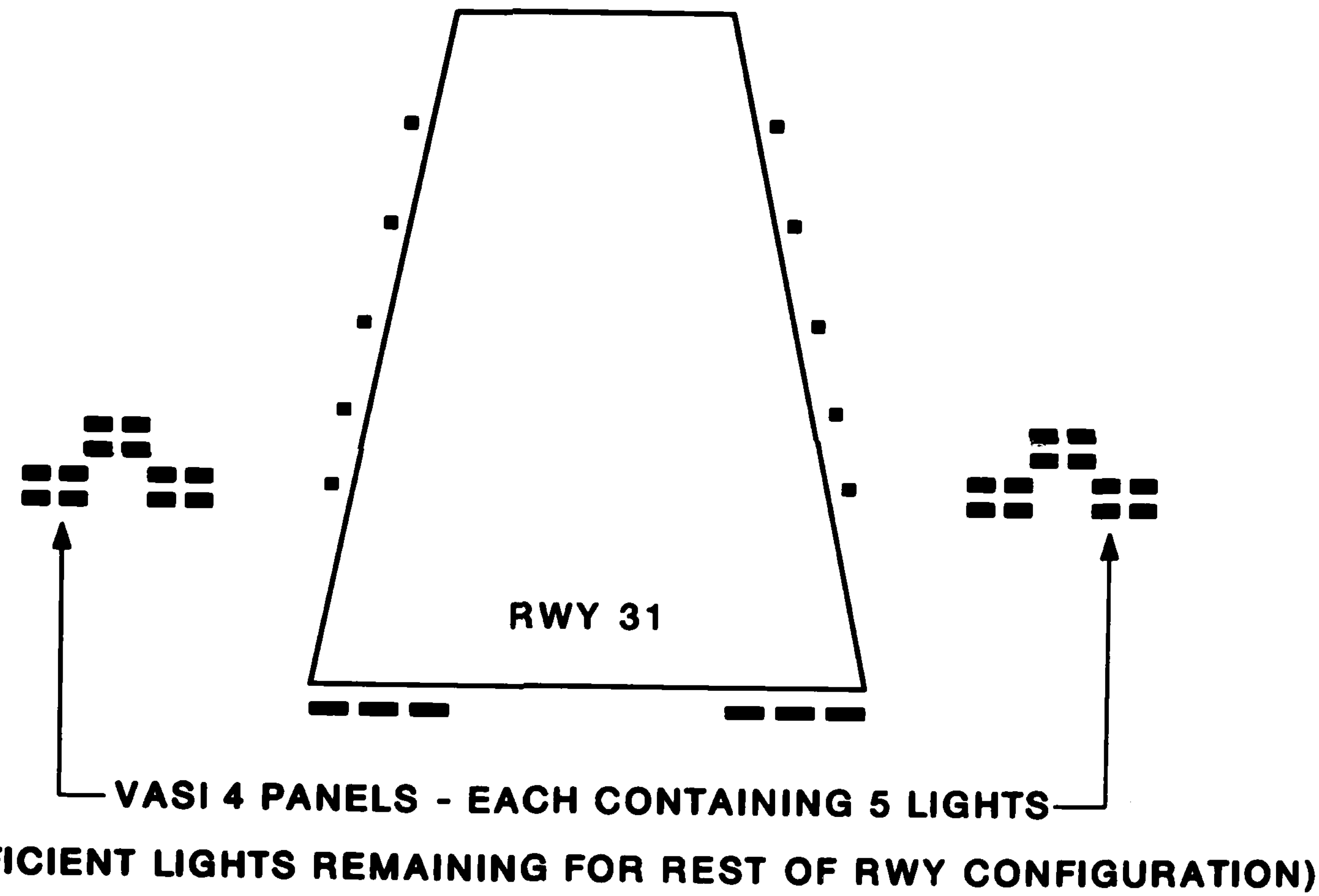

Figure 12. Eielson AFB - 14 Dec 83 - VASI Test Only

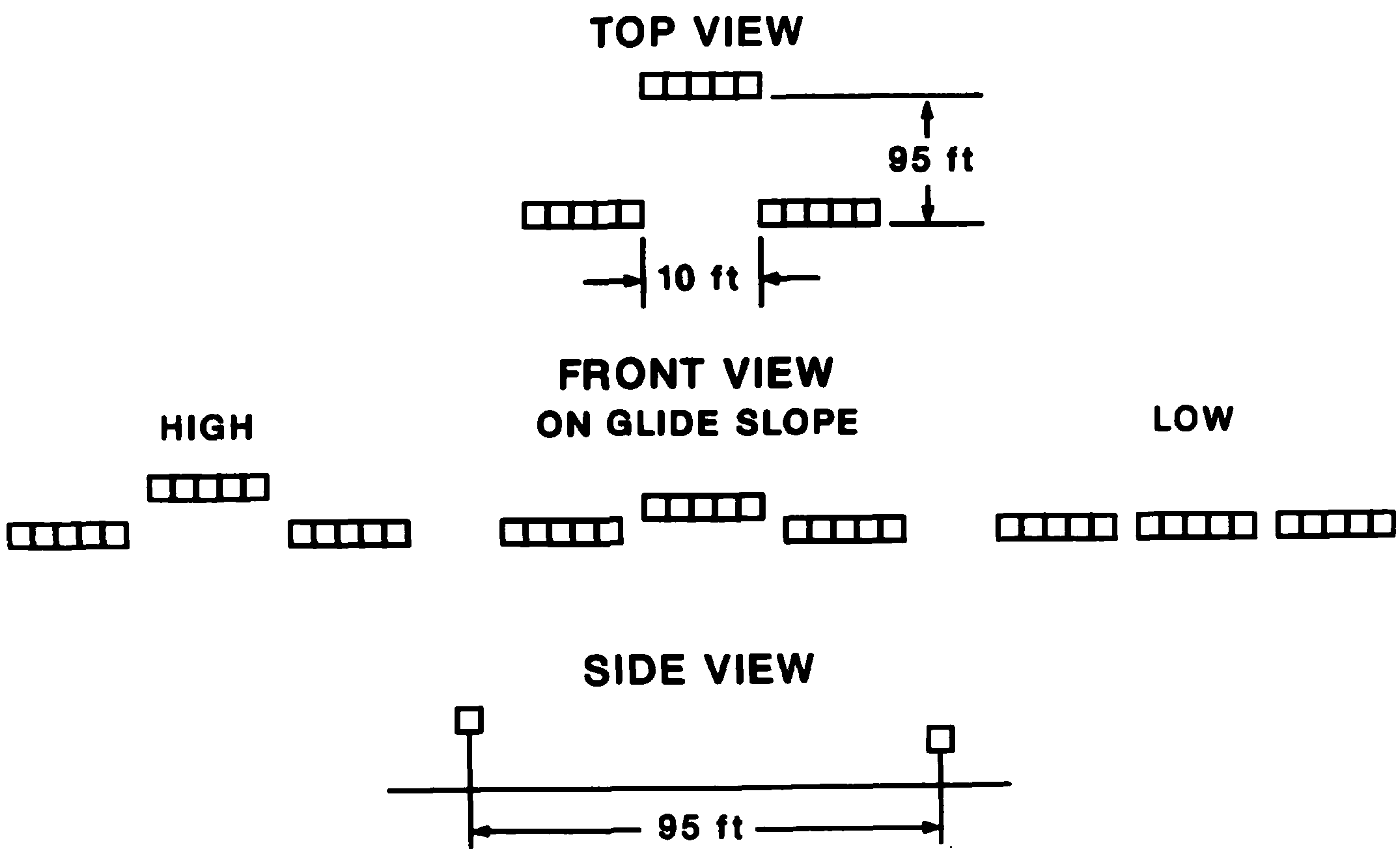

Figure 13. Standard VASI Configuration

SECTION IV

TESTING

On 17 November 1983, the lighting system departed McGhee-Tyson AFB on an Alaskan Air National Guard C-130 transport, arriving at AAAF, Ft. Greely, Alaska, on 18 November 1983. The lights were inventoried, then stored and locked in the AAAF hangar. On 19 November 1983, the lights were set up on Runway 09 for State of Alaska and Federal Aviation Administration flight testing. On 21 November 1983, the lights were set up on Runway 06 (Figure 5). Prevailing weather conditions were: clear skies, strong winds, and full moon. Two O-2 pilots flew low approaches but could not land because of winds. The pilots acquired the lights at a greater distance on each succeeding approach. The VASI lights were not installed because of the strong winds.

The lights were again set up on Runway 06 on 22 November using the configuration shown in Figure 6. Prevailing weather conditions were: partly cloudy skies and strong winds, and O-2 pilots acquired five-panel threshold lights at 4 to 5 miles and three-panel lights at 2 to 4 miles. Twenty-one TFW C-12 pilots flew numerous approaches and the pilot/passengers acquired the lights at 4 miles minimum once they became accustomed to them. Both O-2 and C-12 pilots made full-stop landings using the RL lights.

On 23 November 1983, the lights were deployed on Runway 06, as shown in Figure 7. Prevailing weather was: complete cloud cover and snow showers. An Alaskan ANG C-130 crew flew multiple approaches and landings using the lights. Lights were acquired at 2 to 3 miles.

The weather (strong winds) prevented setting up the lights at the DLZ on 28 November 1983. However, they were deployed at DLZ on 29 November (Figure 8). The VASI was not put up due to high winds. Between 30 November and 1 December 1983, numerous C-130 sorties were flown to DLZ to full-stop landings. Weather conditions varied; but winds, blowing snow, and cloudy conditions predominated. Most aircraft turned onto final at 3 to 4 miles and the lights were normally acquired at that time.

On 2 December 1983, flight operations were cancelled due to heavy snow and severely restricted visibility. On 3 December, the lights were removed from DLZ and placed in storage at AAAF.

The lights were again deployed at AAAF on 5 December 1983 on Runway 18 (Figure 9). Weather was scattered to broken clouds, with light easterly winds. The A-10 pilots made multiple low approaches but did not land due to an icy runway. The first A-10 pilots flew approaches at mid-twilight (dusk), and they acquired the lights at only 1 to 1 1/2 miles.

On 6 December, the same lighting conditions existed as on the previous night. Weather was scattered to broken clouds with very strong, gusty easterly winds. Six A-10 pilots flew multiple approaches but did not land due to the icy runway. Pilots' visual acquisition range varied between 2 and 3 miles.

During the period 12-14 December 1983, the lights were deployed on Runway 31 at Eielson AFB, Alaska. On 12 December (Figure 10) weather conditions were clear and there was a half moon. The A-10 pilots flew low approaches and made full-stop landings. On 13 December (Figure 11), the configuration was changed based on pilot input and recommendations. The A-10 pilots again flew low approaches and made full-stop landings. On 14 December the lights were deployed as shown in Figure 12. Emphasis was placed on VASI system improvement, which required increasing the number of lights. This did not allow full runway outline with the remaining lights. Approaches were made in a UH-1 helicopter only, as no A-10s were scheduled to fly. Acquisition range with this configuration was approximately 6 miles and usable range was 3 miles. Additionally, moon illuminiation was over one-half and peripheral airfield lighting was rated high.

SECTION V

DISCUSSION OF RESULTS

EASE OF STORING AND TRANSPORTING THE RL LIGHT PANELS AND FIXTURES

The tritium RL runway lighting system arrived at AAAF, Alaska, via C-130, loaded on two standard aircraft pallets. The pallets were broken down by hand; and the lights, fixtures, bases, and support equipment were inventoried and loaded into trucks. The system was then taken to the operations hangar and placed in secure storage. This entire operation was accomplished in approximately 1 hour.

The lights were stored at AAAF in an unused room in the north wing of the hangar. While the lights were deployed to DLZ they were stored in a truck with a 14-foot long enclosed cargo box. This held all the RL lights and other equipment except the wood bases. The sandbags, which were used at both Allen and Donnelly, were the heaviest and most cumbersome part of the RL system to be stored or transported.

EASE AND SAFETY OF FIXTURE HANDLING WHILE WEARING ARCTIC CLOTHING

The clothing worn by test team personnel and installation crews varied with the weather and wind conditions each day. In several instances, full arctic gear (mukluk boots, "fat boy" pants, parka and mittens) was required due to the below-zero temperatures and strong, gusty winds. Even with these restrictions, personnel had no problems handling the RL lights, panels, and fixtures. Runway marking, light setup, positioning, and sandbagging/staking were all performed without removal of mittens. The RL lights were also easily installed and removed from the fixtures by personnel wearing mittens.

Some fixture modifications, such as back-to-back panels for bidirectional testing, required the use of hand tools, such as pliers and screwdrivers. In these cases, mittens had to be removed but created no adverse problems as most changes were done inside shelters.

SUITABILITY AND ADAPTABILITY OF FIXTURE SUPPORTS FOR TEMPORARY INSTALLATION

The fixture supports were easy to install since they are relatively lightweight and freestanding. The 2-inch by 6-inch wood bases were fairly stable and only needed anchoring. This was done by sandbagging and staking. Freezing in place was not used, and the fixtures were double sandbagged at AAAF and Eielson AFB. This method proved satisfactory, with the exception of the fixtures placed on the smooth surfaces at the runway ends. Several of these were skidded by air blasts from large aircraft and required extra sandbags.

At DLZ, the fixtures were both sandbagged and staked in place. The stakes (10-inch spikes) prevented the fixtures from sliding caused by propeller blast. Staking alone was not adequate because stakes could only be driven less than 2 inches into the frozen ground. The combination sandbag and stake method of installation proved satisfactory because it was simple, quick, and easy.

A disadvantage was the requirement to either transport the heavy sandbags or have some method of filling them on location. However, if the ground is not frozen, the stakes driven through the predrilled holes would alone be satisfactory to hold the fixtures.

INSTALLATION AND REMOVAL TIME REQUIREMENTS

The typical installation sequence for installing the RL lighting system was:

a. A three-person crew measured and marked the runway for the appropriate lighting configuration. This was done with a measuring tape, a measuring wheel, and spray paint.

b. Fixture bases were positioned and sandbagged/staked as necessary.

c. RL light panels were placed in the racks to complete the fixtures.

Under normal conditions, the three-person team can mark a 4000-foot runway and install the lights in less than 2 hours. Conditions such as high winds extend the installation time or require additional personnel. Disassembly and removal time also took approximately 2 hours, depending upon conditions.

MAINTAINABILITY, TO INCLUDE CLEANING THE PANELS AND FIXTURES

The RL lighting system required almost no maintenance and minimal upkeep. Several fixtures had to be realigned and sandbagged after sliding several feet from aircraft blast. Although the RL lights were not affected by temperature, they did collect a layer of dust from C-130 operations at DLZ and had to be wiped off daily. At Eielson AFB, a thin layer of frost formed on the lights, and light scraping was required to remove this.

At AAAF, the vertical pipe on one fixture broke off from the base. It was not needed for the remaining tests but could easily have been repaired by welding or replacement. Also, several wooden bases became loose where cross members were nailed together. This was remedied with a hammer and a few extra nails.

ABILITY TO WITHSTAND WEATHER, PROPELLER, AND JET BLAST EFFECTS

The tritium RL runway lights, panels, and fixtures easily withstood all winter conditions encountered during testing. This included temperatures to -25°F, winds to 50 miles per hour, and blowing snow and dust. A needed precaution was extra sandbagging on lights susceptible to direct jet or propeller blast. On several occasions at DLZ, fixtures were turned by C-130 propeller blasts; and, in one instance, several panels were blown out of their fixtures. The lights sustained no damage and were immediately placed back in operation. The only physical damage to these lights was chipping and peeling of the reflective tape around the edge. The A-10 aircraft at Eielson AFB had no effect on the lights.

The VASI light system was much more affected by weather conditions. At both AAAF and DLZ, it could not be installed for a portion of the testing due to strong winds. The front panels were nearly 5 feet above the ground and were supported by two pipes connected to the fixture base. Strong, gusty winds whipped these panels, and no amount of sandbagging or staking could have held them in place. Other types of support, such as guide wires, were not available to be evaluated.

PHYSICAL AND ENVIRONMENTAL SAFETY AND SECURITY REQUIREMENTS

Safety and security of the RL lights were primary concerns of the test team during the project. The lights were inventoried each time they were transported, installed, or removed. Installation personnel were thoroughly briefed on the potential hazard of breaking a tritium tube fixture and what to do if such an accident should happen. They were instructed to handle and installed the RL lighting as they would a conventional lighting set. Throughout the test no RL lights were damaged or broken. This was in spite of multiple installments/removals at three separate airfields under adverse weather and wind conditions.

Security of the lights also was proven not to be a significant problem. During the first few nights of testing, the lights were retrieved and stored. But, when the lights were deployed to DLZ with the concurrence of all parties, they were left continuously in place on the airfield for over 72 hours. During this period with minimal security, no lights were damaged, stolen, or tampered with. The consensus of opinion was that no incidents occurred because the lights were part of a runway environment and appeared to be powered by an external source.

One of the first things done in this project was to thoroughly brief all personnel, including USAF installation team members, AAAF operations staff, and flight service station personnel. The briefing covered the purpose and sequence of the test and concentrated heavily on the high value of the RL lights and the Federal laws which could be violated if a light was stolen or intentionally vandalized. Additionally, personnel were told that information about the test, although not classified, should not be released or discussed with nontest team personnel without permission. Finally, all personnel were requested to assist with security by ensuring that unauthorized individuals were not allowed access to the RL lights while installed or in storage.

Secure storage of the RL lights was easily provided. During the testing at AAAF, a corner room in the main hangar was used. Both entry doors were padlocked and the area was monitored by Army personnel. During other phases of testing, the lights were stored in a truck which had an enclosed lockable metal cargo box. The truck was always locked and parked in a secure location. No security violations occurred during any test phase.

VISUAL ACQUISITION RANGE

Visual acquisition range was most affected by the level of peripheral (external) light, the number of RL panels used, and the prior experience a pilot had with RL lighting. Using five panels for the threshold and touchdown zone lights under low-light conditions, experienced pilots had no difficulty acquiring the lights between 4 and 6 miles. Decreasing the number of panels in each light to three reduced acquisition range to approximately 3 miles.

The visual acquisition range increased as a pilot flew several approaches and became familiar with the characteristics of RL lighting. In some cases, acquisition range nearly doubled after a pilot became accustomed to the lights.

Peripheral lighting had undoubtedly the most significant influence on visual acquisition range. Other things being equal, a full moon on a cloudless night could decrease acquisition range from 4 to 6 miles to 2 to 4 miles. Dusk or twilight conditions effectively decreased the range in some cases to approximately 1 mile, which was the same range at which the total runway environment became visible. Also, bright aircraft cockpit and landing lights could cut acquisition range considerably.

The range at which the RL becomes usable is that point at which pilots start receiving visual cues as to distance, height, glide angle, and alignment. For most pilots, this occurred at the same time the lights were acquired or shortly thereafter. Under ideal conditions, this range was 3 to 4 miles. The pilots (especially those of high-performance aircraft) generally felt useful range had to be at least 2 miles. They felt this was the minimum distance needed to provide reaction time necessary for flight corrections. Pilots that couldn't acquire and use the RL lighting by 2 miles usually rated them marginal or unsatisfactory.

The acquisition and useful ranges of the runway edge lights were also evaluated. Generally, each was about 25 percent less than that of the threshold and touchdown zone lighting. Initially, the test team did not consider edge light acquisition a critical factor; however, pilot debriefings showed this to be untrue. The edge lights aided the pilots in connecting the runway ends, thereby improving depth perception and proper glide-path determination.

A summary of the reported distances, as reported by pilots and non-pilot observers, taken from the questionnaires is presented in Appendix D.

RADIOLUMINESCENT VISUAL APPROACH SLOPE INDICATOR

The RL VASI system differs from conventional types and is referred to as the "top hat" system (Figure 13). The primarily tested configuration used three panels, each with five RL lights. Two panels were set near the runway end approximately 8 feet apart. The other panel was placed further down the runway and centered between the first two panels.

All pilots received thorough briefings on the VASI system and its unique characteristics. Even so, most pilots had difficulty using the system properly. Some pilots could not adequately differentiate between the touchdown zone lights and the nearby VASI lights (both being the same size and color). The VASI lights were then moved further away from the other lights and this partially solved the problem.

Some pilots commented that the VASI light system was too small and therefore difficult to use in determining proper glide path. Although the lights could be seen at 2 to 3 miles, it was actually a mile or less before the "top hat" profile could be interpreted and used. At that point, the VASI could only be used as a quick cross-check of the previously established glide path prior to transition to the landing phase.

The VASI system visual acquisition and usable ranges were affected by the same factors which impacted the runway lights. Under optimum conditions, the VASI lights were acquired at 3 to 4 miles and usable at 2 to 3 miles. Twilight, dusk, or full-moon conditions cut these distances in one-half. Inversely, as pilots became more accustomed to the VASI, usable range increased.

In an effort to improve the VASI system range, changes were made during the testing conducted at Eielson AFB. Initially, three-panel VASI systems were placed on each side of the runway. This gave a dual system but did not increase the acquisition or usable ranges. On the last night of testing, the number of RL lights in each panel was quadrupled, and spacing between the panels was increased. Acquisition distance increased to 4 to 6 miles and usable range was a minimum of 3 miles. These distances were achieved despite high background light sources from the military installation and from the surrounding area.

An entirely new VASI system configuration is being tested for future evaluation as a result of these tests.

OVERALL ADEQUACY OF TRITIUM RL LIGHTING

The improved tritium RL runway lighting system tested in this period was significantly improved over the previously tested lights. Pilots flying smaller, slower-moving aircraft, such as the O-2 and C-12, rated the first-generation lights "satisfactory" for remote tactical operating locations. In contrast, the present lighting system was rated "excellent" to "outstanding" by pilots flying these same aircraft. Pilots of larger aircraft, like the C-130, rated the first-generation lights "marginal," while rating the new lights "satisfactory." A number of pilots participated in both tests and indicated the new system was a significant improvement over both the first-generation lights and battery-powered lights.

The results of the VASI system were less spectacular. In both tests they were rated overall "marginal." Only during the last day of testing when the number of RL lights was increased did pilots consider the VASI "satisfactory."

SECTION VI

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

This test showed the durability, dependability, and safety of the tritium RL lights. It also showed that runway threshold, touchdown zone, and edge lights were satisfactory in defining the runway environment. This system is entirely adequate for use at a remote tactical operating location where competing external ground lighting is minimized. The three-panel VASI system was marginal, and further change and testing are required before it can be considered acceptable. The tritium RL lighting is not a navigational aid. Other systems must be utilized for area orientation and initial alignment to the runway — these could easily be an inertial navigation system, TACAN, ground radar, strobe lights, or rotating beacons. This fact does not detract from the usefulness or applicability of the tritium RL runway lighting system.

GENERAL RECOMMENDATIONS

a. Pilots should complete at least one training sortie, flying multiple approaches to the RL lights, prior to using operationally.

b. A method should be developed to cover the lights in case blackout conditions are required.

c. The size of the runway edge lights should be doubled (two panels instead of one) and installed every 500 feet and evaluated.

e. The size and configuration of the VASI system should be examined to develop a more usable system.

f. An improved method of supporting the VASI lights needs to be designed so that they can be used in strong and gusty wind conditions.

RECOMMENDATIONS BY PILOTS

Participating pilots made a number of comments and suggestions for improvement of the tritium RL lights. Some of the most common are listed below, in no particular order.

a. Because the RL lights are different, pilots should receive flight training prior to operational use.

b. The VASI system should be larger and should be further separated from the runway lights.

c. The edge lights could be larger.

d. Additional aids, such as strobe lights or rotating beacons, are needed to help find the airfield.

e. Some method should be found to extinguish or cover the lights when airfield blackout conditions require it.

f. Navy-style meatball-type lights are needed.

g. Lights could be larger and brighter.

h. Keeping cockpit lights low and landing lights off until short final could greatly improve usability.

i. Omnidirectional capability would be useful.

j. In A-10 aircraft, looking over the heads-up display (HUD) would improve acquisition range.

k. External light from the sun (twilight/dusk) or incandescent fixtures cut acquisition range in one-half.

l. The RL lights are satisfactory for remote tactical operating locations.

m. Depth-perception problems occur because the RL lights are different.

n. VASI system was marginal and could not be used under operational conditions.

o. The lights were very easy to use once the user became accustomed to them.

p. Red panels at the end of the runway might be beneficial.

q. Snow showers reduce the acquisition range considerably.

r. The lights were difficult to see at dusk.

s. The lights were better than bean-bag lights.

t. The only problem with the system was the marginal VASI.

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APPENDIX A

EVALUATION OBJECTIVES

APPENDIX A

EVALUATION OBJECTIVES

In an effort to overcome the limitations of currently used runway lighting and provide improved support for air operations, the tritium RL runway lighting was developed and tested. The following evaluation objectives were extracted from the AFESC developmental test plan.

1. Engineering:

a. Ease of storing and transporting the RL lights and fixtures.

b. Ease and safety of fixture handling while encumbered with arctic clothing.

c. Suitability and adaptability of fixture supports for temporary installation.

d. Installation and removal time requirements.

e. Maintainability, to include cleaning lights and fixtures.

f. Ability to stand up to weather, propeller, and jet blast effects.

2. Security and Safety:

a. Evaluate the physical and environmental safety and security requirements of RL lighting.

b. Evaluate security precautions to preclude theft and/or destruction.

3. Operational:

a. Identify and evaluate visual range at which pilots acquire and can use the RL runway lighting. Acquisition range should be at least 4 to 6 miles under ideal conditions.

b. Evaluate the capability of the RL VASI system to provide usable glide-slope information.

c. Evaluate pilot views and comments on the RL lighting as an aid for approach, landing, rollout and takeoff.

d. Assess overall adequacy of the RL lighting to support a variety of aircraft and operations in an arctic and subarctic environment.

e. Provide individual and/or group recommendations to enhance any aspect of RL light utilization.

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APPENDIX B

TEST PROCEDURE

APPENDIX B

TEST PROCEDURE

1. Each organization or agency participating in the Tritium Runway Lighting Test will appoint a project officer or point of contact for scheduling briefing and coordination.

2. Organizations and aircraft which will be directed or invited to participate are as follows:

a. 21 TFW/C-12

b. 343 COMPW/O-2, A-10

c. 616 MAG/C-130

d. 176 TAG/C-130

e. 222 Av Bn/C-12, UH-1

f. USCG/C-130

g. State of Alaska/Unknown

h. Federal Aviation Administration/Unknown

i. Other civilian agencies/Aircraft

3. To gain maximum participation from each organization, flexibility in scheduling each test period will be maintained.

4. Aircraft will be scheduled to fly during a specific time block during each test period on the days of 19-22 November 1983.

5. Pilots using IFR flight plans may execute an instrument approach or may cancel the clearance and proceed VFR.

6. Pilots will thoroughly familiarize themselves with terrain surrounding AAAF and the layout of the airfield and runway.

7. The primary runway for testing the lighting at AAAF is anticipated to be Runway 18. Runway 18 is 7499 feet long and 150 feet wide. Depending upon tritium lights available, only 5000 or 6000 feet will be lighted. Runways 36, 06, and 24 may be used if conditions warrant.

8. Prior to their flights, pilots will receive a thorough briefing on the runway in use, lighting configuration, radio frequencies, and other pertinent information.

9. The pilot will contact the test team on the specified radio frequency as soon as possible. At that time, he will receive an additional briefing on current status of lights, weather conditions, and runway condition reading (RCR) or latest reported braking action.

10. Pilots will align the aircraft on the extended runway centerline, at least 5 miles from the threshold. This may be accomplished visually or by use of TACAN DME information.

11. Pilots will, as accurately as possible, document the maximum distance at which the lights are acquired and the distance the lights become usable for runway alignment and/or glide path information. TACAN DME will be noted if used for measurement.

12. If weather conditions permit, the pilot will execute a low approach and return to the final approach for a second view of the test lighting. Pilots may subsequently land or execute additional low approaches. At least one full-stop landing is requested. Pilots will provide comments to the test team while on the ground.

13. Civilian pilots may make low approaches. Full-stop landings are authorized if U.S. Army/civilian use requirements are met.

14. Pilots will complete the handout questionnaire and submit to the unit project officer or mail to HQ AAC/DOOS, Elmendorf AFB, AK 99506.

15. Engineers and/or ground support crews will also complete questionnaires and submit to the project officer or mail to HQ AAC/DEM, Elmendorf AFB, AK 99506.

APPENDIX C

ARCTIC TEST EVALUATION PLAN

APPENDIX C

ARCTIC TEST EVALUATION PLAN

INTRODUCTION

Subjective analysis of ground observations and aircrew questionnaires shall be the primary methods of data collection. The approved tritium light questionnaire (ANNEX IV) shall be briefed and distributed to participating flying organizations by HQ AAC/DOOS. Members of the team shall interview Prime BEEF and other ATS support personnel to determine the success of ground operations. At the conclusion of the exercise, HQ AAC/ADO shall make a written assessment of the overall operational acceptability of the RL lighting system under arctic operations. The Engineering Services Laboratory (ESL), Tyndall AFB, and ORNL shall observe the critique to document the results and recommendations in the final technical report.

METHOD

ORNL shall perform all data reduction and analysis to document test results in the final technical report period.

Part I - Visual Evaluation: Questionnaires shall be distributed to aircrew and ground observers as they in-process the exercise and during daily preflight briefings. The observers will receive an explanation of the purpose of the test. The questionnaires can be returned by self-addressed mail to HQ AAC/DOOS. Those received by the end of the exercise shall be reviewed.

Part II - Physical Evaluation: ORNL shall collect, analyze, and condense the test teams' observations, photographs, and witness interviews at the ATS. Preliminary findings shall be briefed and presented in the final reports.

EVALUATION OBJECTIVES

See Appendix A

DATA COLLECTION

The evaluation objectives shall be evaluated from the following sources collected by AAC and the RL test team.

1. Aircrew questionnaires

2. Ground and airborne observations

3. Individual interviews

4. Mission debriefings

5. Exercise critique

6. Evaluation board

7. Photographic aids

ANALYSIS

The final report shall contain the RL airfield lighting's actual system performance under arctic conditions as determined by expert observers and other data-collection techniques. A discussion shall explain the final fixture designs, fabrication techniques, expedient installation methods, project costs, shipment limitations, and final erection problems.

CONCLUSIONS/RECOMMENDATIONS

Proposed future applications, further R&D, and project economic and operational benefits shall be delineated as an overall assessment of the Arctic Development Test. All conclusions and recommendations shall be substantiated by this analysis.

DOCUMENTATION

ORNL shall prepare the final technical report. The final technical report shall be written in acordance with ESL-HB-84-01. Approving authority will be AFESC/RDCS. Reproducible original will be "camera-ready" copy, reference MIL-STD-847B. Report shall be published as a joint AFESC/DOE technical report.

APPENDIX C

ANNEX I

BRIEFING HANDOUT ON TRITIUM RADIOLUMINESCENT PORTABLE LIGHTING

APPENDIX C

ANNEX I

BRIEFING HANDOUT ON TRITIUM RADIOLUMINESCENT PORTABLE LIGHTING

BACKGROUND

RL lighting is defined as the use of radiation from radioisotopes in combination with phosphors to produce visible light. Radioluminescent lighting has been used in industry for clock dials, exit signs, and light standards in the photographic industry. The military has used light-emitting paints for aircraft dial illumination, minefield markers, and gunsight illumination.

Within the last several years, a joint DOE/DOE effort has been under way to develop tritium RL lighting for airfield application. A first generation of tritium lighting was evaluated at Clear Creek LZ during BRIM FROST 83. These lights proved to have a visual acquisition range of 1 to 2 miles, which was suitable only for slow-moving aircraft.

Since then, comprehensive engineering efforts have produced a significantly improved runway light. It is anticipated that this light can be acquired by aircrews between 4 to 6 miles, which is suitable to support C-130/A-10 type aircraft operations.

Certain known techniques may be used by participating pilots to improve acquisition of the lights, such as keeping cockpit/cabin lighting to an absolute minimum and not staring at the tritium lights; viewing slightly to the side may improve acquisition. It is also helpful not to turn on landing lights until short final as they tend to wash out the test lights.

One final reminder: tritium lights are not incandescent. They give off a smooth glow rather than a bright-point light. Attached are specific procedures to following during the test and a questionnaire to be completed.

APPENDIX C

ANNEX II

PROCEDURES FOR A-10 EVALUATION
OF TRITIUM RADIOLUMINESCENT LIGHTS

APPENDIX C

ANNEX II

PROCEDURES FOR A-10 EVALUATION
OF RADIOLUMINESCENT RUNWAY LIGHTS

1. A primary motive behind tritium lighting development is the enhancement of tactical operations at bare bases, especially in the arctic environment.

2. It is extremely important that A-10 pilots have the opportunity to evaluate the tritium runway lighting and its capability to support their mission.

3. Pilots will receive a briefing prior to their first flight.

4. A maximum number of pilots is desired, but an individual pilot may fly more than one test sortie.

5. At least two sorties are desired daily (1600L to 2000L).

6. Aircraft will depart Eielson AFB to arrive at AAAF between 1600 and 1900 local, with sufficient intervals to allow time for low approaches and landings.

7. Pilots may execute an instrument approach to Runway 18 at AAAF, Alaska.

8. Pilots may execute visual approaches if weather conditions allow VFR operations.

9. Pilots will execute at least one missed approach/low approach prior to a full-stop landing.

10. Prior to a full-stop landing, the pilot will receive the current weather conditions, including an acceptable runway condition reading (RCR) from the test teams.

11. Final decision to land will remain with the pilot; SAFETY WILL NOT BE COMPROMISED.

12. After landing, the aircraft will be taxied to the specified parking area and shut down for mandatory brake cool period.

13. If possible, pilots will be verbally debriefed by the test team.

APPENDIX C

ANNEX III

PROCEDURES FOR C-130 EVALUATION
OF TRITIUM RUNWAY LIGHTS

APPENDIX C

ANNEX III

PROCEDURES FOR C-130 EVALUATION
OF TRITIUM RUNWAY LIGHTS

1. Portable, dependable airfield lighting is a necessary asset in the successful accomplishment of the tactical airlift mission.

2. It is extremely important that the C-130 pilots have the opportunity to evalute the improved tritium runway second-generation tritium lighting and its capability to support their missions.

3. The AAC will appoint a project officer to coordinate all test requirements and ensure that participating C-130 aircrews are briefed and debriefed.

4. C-130 aircrews will receive a thorough briefing prior to their first flight and receive a questionnaire handout package.

5. Pilots will file a flight plan and fly their aircraft to Donnelly, LZ IAW normal MAC and ATC operating requirements and procedures.

6. Pilots will initially position their aircraft approximately 5 nautical miles from the runway threshold to begin a straight-in approach.

7. Pilots will, as accurately as possible, document the maximum distance at which the lights are acquired, usable distance, glide-path information, and other data required by the aircrew questionnaire.

8. Low approaches/missed approaches will not be planned in support of the tritium test.

9. Pilots may request that conventional runway lighting be turned on anytime they feel safety may be compromised.

10. Pilots will complete the questionnaire and return it to the unit project officer.

APPENDIX C

ANNEX IV

TRITIUM RUNWAY LIGHTING — AIRCREW QUESTIONNAIRE

APPENDIX C

ANNEX IV

TRITIUM RUNWAY LIGHTING — AIRCREW QUESTIONNAIRE

Instructions: This questionnaire should be completed as soon as possible after reviewing the test lights. Please identify acquisition distance for each approach made. Return to your project officer or return to HQ AAC/DOOS, Elmendorf AFB, Alaska 99506. When evaluating the RL system (RLS), use "outstanding" as if you were evaluating an excellent incandescent system. A satisfactory system would be your opinion on an acceptable airfield lighting system.

I. General

A. Approach Flown: VOR ___ NDB ___ TACAN ___ Visual ___

B. Maneuvers: Low Approaches ________ Landings ________

C. Have you flown approaches and/or landed at this airfield before? Yes ____ No ____

II. Weather Conditions

A. Cloud Cover: Scattered ____ Broken ____ Overcast ____

B. Ceiling/Visibility: Height ______ AGL; Distance ______ nm

C. Precipitation: Snow ____ Fog ____ Haze ____ None ____

III. VASI Landing System

A. Maximum Acquisition Distance (each approach)

____ ____ ____ ____ ____ ____ nm
1 2 3 4 5 6

B. At what distance did the VASI provide usable "glide path" information? (each approach) ____ ____ ____ ____ ____ ____ nm
1 2 3 4 5 6

C. How was this distance measured? (each approach)

	1	2	3	4	5	6
Estimated	____	____	____	____	____	____
Radar	____	____	____	____	____	____
DME	____	____	____	____	____	____
Chart	____	____	____	____	____	____

D. Rate the VASI for overall performance in providing runway end acquisition and glide path information: Outstanding ____ Excellent ____ Satisfactory ____ Marginal ____ Unsatisfactory ____

IV. Threshold Runway Markers

A. Maximum Acquisition Distance (each approach)

____ ____ ____ ____ ____ ____ nm
1 2 3 4 5 6

B. At what distance did the lights aid in runway alignment? (each approach)

____ ____ ____ ____ ____ ____ nm
1 2 3 4 5 6

C. How was this distance measured? (each approach)

	1	2	3	4	5	6
Estimated	____	____	____	____	____	____
Radar	____	____	____	____	____	____
DME	____	____	____	____	____	____
Chart	____	____	____	____	____	____

D. Rate the threshold and edge lights for overall performance: Outstanding ____ Satisfactory ____ Marginal ____ Unsatisfactory ____

V. Edge Lights Runway Marker Lights

A. Maximum Acquisition Distance (each approach)

____ ____ ____ ____ ____ ____ nm
1 2 3 4 5 6

B. How was this distance measured? (each approach)

	1	2	3	4	5	6
Estimated	____	____	____	____	____	____
Radar	____	____	____	____	____	____
DME	____	____	____	____	____	____
Chart	____	____	____	____	____	____

VI. Landing/Takeoff

A. Could you identify the entire landing/rollout/takeoff area using the test lights? Yes _____ No _____

B. Did the test lights provide similar visual cues (i.e., peripheral vision, depth perception, etc.) as conventional lighting?
Similar _____ Different _____ Better than _____ As good as _____
Not as good as _____
Comments: ____

____

____

VII. Conclusion:

A. Does the RLS meet your requirements as a landing, rollout, and takeoff aid? What recommendations would you make to improve upon this system? Please write your answers to the above questions and any additional comments appropriate regarding the RSL. ____________________

____

____

____

____

____

____

____

B. Name: ______________________ Rank: __________
Organization ______________________ Location: __________

C. Telephone (Autovon and commercial): __________________

D. Type aircraft flown: ______________________________

E. Aircrew duty status: P _____ CP _____ Other _____

F. Aircrew aviation experience years _____ flight hours _____

G. If observer: Type aircraft: ______________________
Have you evaluated RLS before? Yes _____ No _____

VIII. Your cooperation and support are appreciated. Please turn in questionnaire as requested in the coordinating instructions. Your input is essential!!

APPENDIX C

ANNEX V

INSTALLATION BRIEFING PLAN

APPENDIX C

ANNEX V

INSTALLATION BRIEFING PLAN

(30 minutes)

TITLE: "Radioluminescent (RL) Light Handling"

AUDIENCE: Prime BEEF installation team, and HQ AAC Radiological Protection Officer's (RPO) staff

LOCATION: Arctic Test Site (ATS)

- PURPOSE: Explain and demonstrate safe installation of RL lighting fixtures.
- OVERVIEW
- INTRODUCTION: "Test and evaluation of new technology ..."
- DESCRIPTION
  - What are RL lights?
  - How do they work?
  - Are they hazardous?
- GROUND OPERATIONS
  - Why use in Arctic?
  - Method(s) of deployment
  - Physical security
- SAFETY
  - In case of breakage: Reporting & Controlling
  - Function of RPO
- DEMONSTRATION
  - Site preparation
  - Installation
  - Alignment
- SUMMARY: Q & A

• The following list establishes the events and assigns organizational responsibilities.

	Event	Responsibility
1.	Survey and spacing layout to follow the plan depicted in Annex III.	Action: AK-DOT
2.	Securing fixture-mounting bases to surface-mounting bases will be gravel filled and frozen to ground.	Action: AK-DOT
3.	Secure VASI panel-mounting frames to surface; free in place.	Action: PRIME BEEF Coord: Test Team
4.	Install VASI panels; bolt panels to frame.	Prime BEEF
5.	Install edge lights; screw fixtures into mounting cones.	Action: Prime BEEF
6.	Install helipad lights; stake to ground.	Action: Prime BEEF Coord: Test Team
7.	Brief responsible personnel; distribute questionnaires.	Action: AK-DOT Action: HQ AAC
8.	Collect questionnaires.	Action: HQ AAC
9.	Remove all fixtures and panels for relocation to State of Alaska test site.	Action: Prime BEEF Coord: Test Team
10.	Remove fixture bases and frames for relocation to State of Alaska test site.	Action: AK-DOT Coord: Test Team
11.	Transport all equipment and personnel to State of Alaska test site.	Action: AK-ANG and AK-ARNG
12.	Site survey and field layout at State of Alaska test site.	Action: AK-DOT
13.	Fill mounting bases with gravel; secure fixture-mounting bases to surface and freeze to ground.	Action: AK-DOT

Event	Responsibility
14. Secure VASI frames; freeze to surface.	Action: AK-DOT Coord: Test Team
15. Install VASI panels; bolt panels to frame.	Action: AK-DOT Coord: Test Team
16. Install lights; screw fixture to mounting cone.	Action: Test Team Coord: K-DOT
17. Install helipad lights; stake to ground.	Action: AK-DOT Coord: Test Team
18. Conduct State of Alaska evaluation	
19. Remove lights and panels.	Action: AK-DOT Coord: Test Team
20. Remove cones, bases, and frames.	Action: AK-DOT
21. Package all equipment for recovery.	Action: AK-DOT and Test Team

APPENDIX C

ANNEX VI

TRITIUM RUNWAY LIGHTING - GROUND SUPPORT CREW QUESTIONNAIRE

APPENDIX C

ANNEX VI

TRITIUM RUNWAY LIGHTING - GROUND SUPPORT CREW QUESTIONNAIRE

The RL lights to be used for USAF field tests in Alaska during the fall and winter of 1983-84 are experimental devices. Of importance to these fall and winter tests are the ease and efficiency with which they can be deployed, redeployed, used, and stored. Key factors affecting these four operations are handleability, materials performance, attachment, removal, assembly, disassembly, dusting, condensation, icing, and maintenance under the field conditions in which they will be tested.

Instructions: Please complete this questionnaire as soon as possible after conducting one or more of the following operations: (1) storing, (2) deploying, (3) redeploying, and/or (4) observing operation of the tritium RL lights. Limit your comments to those questions that address the activities in which you were personally involved.

I. Type of Operation

A. Storing __________

B. Deployment __________

C. Redeployment __________

D. Operations/maintenance __________

II. Weather Conditions

A. Surface temperature __________

B. Surface wind speed __________ Direction __________

C. Surface Visibility: Distance __________

D. Precipitation: Snow ______ Rain ______ Fog ______ Ice fog ______ Haze ______ None ______

E. Date ____________________ Time __________

III. VASI Landing System

	Outstanding	Excellent	Satisfactory	Marginal	Unsatisfactory
A. Handleability					
1. Time					
B. Assembly					
C. Disassembly					
D. Attachment					
E. Removal					
F. Weight					
G. Materials Performance					
H. Frosting					
I. Dusting					
J. Condensation					
K. Cleanability					
L. Personnel Req'd					
M. Storage					

When evaluating H, I, and U, consider equipment design's ability to limit each characteristic. For L, it is Outstanding when system requires less than conventional system, and more would be Unsatisfactory.

IV. Threshold Lights

	Outstanding	Excellent	Satisfactory	Marginal	Unsatisfactory
A. Handleability					
1. Time					
B. Assembly					
C. Disassembly					
D. Attachment					
E. Removal					
F. Weight					
G. Materials Performance					
H. Frosting					
I. Dusting					
J. Condensation					
K. Cleanability					
L. Personnel Req'd					
M. Storage					

When evaluating H, I, and U, consider equipment design's ability to limit each characteristic. For L, it is Outstanding when system requires less than conventional system, and more would be Unsatisfactory.

V. Edge Lights

	Outstanding	Excellent	Satisfactory	Marginal	Unsatisfactory
A. Handleability					
1. Time					
B. Assembly					
C. Disassembly					
D. Attachment					
E. Removal					
F. Weight					
G. Materials Performance					
H. Frosting					
I. Dusting					
J. Condensation					
K. Cleanability					
L. Personnel Req'd					
M. Storage					

When evaluating H, I, and U, consider equipment design's ability to limit each characteristic. For L, it is Outstanding when system requires less than conventional system, and more would be Unsatisfactory.

VI. Conclusions and Recommendations

A. Give your overall evaluation of the ease of storage/deployment/redeployment/use of tritium RL lights.

____

____

____

____

____

B. List any suggestions you may have for improving the design and use of the RL lights (handling, storage, etc.).

____

____

____

____

____

____

____

____

VII. Responder

Name _________________________ Rank/Rating _______________

Organization _______________________ Location _______________

Telephone Number ____________________

APPENDIX D

SUMMARY OF ACQUISITION DISTANCES

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TABLE D-1. SUMMARY OF ACQUISITION DISTANCES

	Distance (NM)						Date	Aircraft	Airfield	Pilot comments
	VASI		Runway		Edge					
	Acq	Use	Acq	Use	Acq	Use				
1	NA	NA	3.5	2.5	2.0	2.0	21 Nov	0-2	Allen	Edge lights could be brighter
2	NA	NA	3.5	3.0	3.0	3.0	21 Nov	0-2	Allen	Lights satisfactory
3	NA	NA	4.0	3.5	3.5	2.0	21 Nov	0-2	Allen	Lights more than adequate
4	2.3	1.5	3.5	2.3	1.5	1.5	22 Nov	0-2	Allen	Excellent for TOL; lights were outstanding
5	NR	NR	3.0	2.0	3.0	2.0	22 Nov	0-2	Allen	None
6	ID	ID	ID	ID	ID	ID	22 Nov	0-2	Allen	Overall rated excellent
7	3.0	1.5	4.5	3.0	2.5	2.5	22 Nov	C-12	Allen	Full moon degrades range; OK with practice
8	2.5	NR	5.0	5.0	3.0	3.0	22 Nov	C-12	Allen	Nonpilot observer; adequate
9	2.0	1.5	5.0	5.0	3.0	3.0	22 Nov	C-12	Allen	0-2 pilot; OK for TOL
10	ID	ID	5.0	5.0	4.0	4.0	22 Nov	C-12	Allen	Nonpilot observer; strobe would be useful
11	ID	ID	6.0	3.0	5.0	5.0	22 Nov	C-12	Allen	T-33 pilot; outstanding
12	3.0	2.0	4.0	4.0	3.0	2.0	22 Nov	C-12	Allen	A-10 pilot; VASI difficult to get used to
13	2.0	1.0	4.0	4.0	4.0	4.0	22 Nov	C-12	Allen	OK; limited depth perception
14	3.0	2.0	4.0	3.0	3.0	2.0	Unknown	UH-1/H	Allen	Excellent system
15	3.0	1.5	2.0	2.0	2.0	2.0	23 Nov	C-130	Allen	Snow showers affected dist; overall satisfactory

TABLE D-1. SUMMARY OF ACQUISITION DISTANCES (CONT.)

	Distance (NM)						Date	Aircraft	Airfield	Pilot comments
	VASI		Runway		Edge					
	Acq	Use	Acq	Use	Acq	Use				
16	3.0	1.5	3.0	3.0	1.0	1.0	23 Nov	C-130	Allen	Overall satisfactory; snow and base lighting detracted
17	4.0	2.0	3.0	3.0	3.0	3.0	23 Nov	C-130	Allen	Overall satisfactory; better than flare pots
18	1.0	1.0	2.0	2.0	2.0	2.0	23 Nov	C-130	Allen	Runway lights satisfactory; VASI lights marginal
19	NR	NR	3.0	3.0	NR	2.0	Unknown	UH-1/H	Allen	Edge lights could be brighter
20	NA	NA	2.0	2.0	2.0	2.0	28-30 Nov	C-130	Donnelly	Light snow; limited depth perception
21	NA	NA	3.0	3.0	3.0	3.0	28-30 Nov	C-130	Donnelly	Improved over Generation I lights
22	NA	NA	7.0	7.0	7.0	7.0	28-30 Nov	C-130	Donnelly	None
23	NA	NA	2.0	1.5	1.5	1.5	28-30 Nov	C-130	Donnelly	OK system, but unsatisfactory
24	NA	NA	3.0	3.0	3.0	3.0	28-30 Nov	C-130	Donnelly	Satisfactory
25	NA	NA	6.0	6.0	6.0	6.0	28-30 Nov	C-130	Donnelly	Satisfactory; broader acquisition cone would be nice
26	NA	NA	4.0	3.0	4.0	3.0	28-30 Nov	C-130	Donnelly	Distances halved by twilight
27	NA	NA	4.0	4.0	3.0	3.0	28-30 Nov	C-130	Donnelly	Could be brighter; satisfactory

TABLE D-1. SUMMARY OF ACQUISITION DISTANCES (CONT.)

	Distance (NM)						Date	Aircraft	Airfield	Pilot comments
	VASI		Runway		Edge					
	Acq	Use	Acq	Use	Acq	Use				
28	NA	NA	2.0	ID	3.0	3.0	28-30 Nov	C-130	Donnelly	Need to be brighter; satisfactory
29	NA	NA	4.0	3.0	4.0	4.0	28-30 Nov	C-130	Donnelly	Much better than Generation I lights; outstanding
30	NA	NA	6.0	6.0	4.0	ID	28-30 Nov	C-130	Donnelly	Satisfactory
31	NA	NA	4.0	3.0	4.0	3.0	28-30 Nov	C-130	Donnelly	Twilight cuts distance in half; overall satisfactory
32	2.5	2.0	4.5	4.5	3.8	3.3	5 Dec	A-10	Allen	VASI should be bigger; runway lights satisfactory
33	1.0	NR	1.0	NR	NR	NR	5 Dec	A-10	Allen	App into sunset; unsatisfactory
34	1.2	0.8	1.5	1.3	0.7	0.5	5 Dec	A-10	Allen	App into twilight; unsatisfactory
35	2.0	2.0	2.0	2.0	2.0	2.0	6 Dec	A-10	Allen	Satisfactory; need brighter if possible
36	3.0	1.7	6.0	5.0	4.0	4.0	6 Dec	A-10	Allen	VASI difficult to use; runway outstanding
37	2.0	1.3	3.3	3.3	3.3	3.3	6 Dec	A-10	Allen	Need added aid for orientation; marginal
38	3.3	1.0	3.0	3.0	3.0	3.0	6 Dec	A-10	Allen	Need practice to lights; VASI marginal; runway satisfactory

TABLE D-1. SUMMARY OF ACQUISITION DISTANCES (CONT.)

	Distance (NM)						Date	Aircraft	Airfield	Pilot comments
	VASI		Runway		Edge					
	Acq	Use	Acq	Use	Acq	Use				
39	2.0	0.5	3.3	2.0	3.3	2.0	6 Dec	A-10	Allen	VASI unsatisfactory; runway marginal
40	2.0	1.0	2.0	1.0	2.0	1.0	6 Dec	A-10	Allen	No depth perception; marginal
41	1.0	1.0	2.0	2.0	3.0	3.0	6 Dec	A-10	Allen	Haze; VASI marginal; runway lights satisfactory
42	2.0	2.0	2.0	2.0	1.5	1.5	6 Dec	A-10	Allen	Satisfactory
43	1.3	1.0	3.0	2.7	3.3	3.0	6 Dec	A-10	Allen	Satisfactory; poor VASI
44	4.0	2.0	3.0	3.0	4.0	3.0	6 Dec	A-10	Allen	VASI misaligned; runway lights satisfactory
45	3.0	2.0	3.0	3.0	2.0	2.0	12 Dec	A-10	Eielson	Depth perception problem; need practice with lights
46	1.0	0.5	3.0	2.5	2.0	2.0	12 Dec	A-10	Eielson	Satisfactory; VASI unsatisfactory
47	2.3	1.0	3.3	3.3	3.3	3.0	12 Dec	A-10	Eielson	Half-moon lighting; runway lights satisfactory
48	2.5	0.0	2.5	2.0	1.5	2.0	12 Dec	A-10	Eielson	VASI unsatisfactory; runway satisfactory
49	1.5	0.8	4.0	3.7	4.5	4.5	13 Dec	A-10	Eielson	Need better VASI; runway lights satisfactory
50	2.0	1.8	2.5	2.5	2.0	2.0	13 Dec	A-10	Eielson	VASI marginal; runway lights satisfactory

TABLE D-1. SUMMARY OF ACQUISITION DISTANCES (CONCLUDED)

	Distance (NM)						Date	Aircraft	Airfield	Pilot comments
	VASI		Runway		Edge					
	Acq	Use	Acq	Use	Acq	Use				
51	3.5	1.8	3.5	3.0	3.0	2.3	13 Dec	A-10	Eielson	System satisfactory; VASI marginal
52	3.0	1.0	3.0	3.0	2.8	2.8	13 Dec	A-10	Eielson	System adequate; VASI marginal
53	5.0	2.7	NA	NA	NA	NA	14 Dec	UH-1H	Eielson	VASI only test; satisfactory to very good

NR = Not Reported

NA = Not Applicable

ID = Incompatible Data

NM = Nautical Miles

TABLE D-2. AVERAGE ACQUISITION DISTANCE BY TYPE OF AIRCRAFT

Distance (NM)						Aircraft	Airfield
VASI		Runway		Edge			
Acq	Use	Acq	Use	Acq	Use		
2.3	1.5	3.5	2.7	2.6	2.1	0-2	Allen
2.5	1.5	4.8	4.1	3.5	3.4	C-12	Allen
2.8	1.5	2.5	2.5	2.0	2.0	C-130	Allen
NA	NA	3.9	3.6	3.5	3.1	C-130	Donnelly
2.1	1.4	2.8	2.5	2.6	2.3	A-10	Allen
2.4	1.1	3.1	2.9	2.6	2.6	A-10	Eielson
2.4	1.4	3.4	3.1	3.1	2.8	Overall Average	

NM = Nautical Miles

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