



USAFIFC TR 77-1

EVALUATION OF REVISED APPROACH LIGHTING
CRITERIA

MAJOR KENNETH J. KERKERING
PROJECT OFFICER

MR. GERALD C. ARMSTRONG
PROJECT ENGINEERING PSYCHOLOGIST

MARCH 1977

FINAL REPORT

Approved for public release: distribution unlimited.

20060928070

Best Available Copy

USAF INSTRUMENT FLIGHT CENTER
Randolph AFB, Texas 78148

ADA038442

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER USAFIFC TR 77-1	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Evaluation of Revised Approach Lighting Criteria		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Major Kenneth J. Kerkerling Mr. Gerald C. Armstrong		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Research and Development Division USAF Instrument Flight Center Randolph AFB TX 78148		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS SP 76-2
11. CONTROLLING OFFICE NAME AND ADDRESS HQ USAF/X00FSA Washington DC		12. REPORT DATE March 1977
		13. NUMBER OF PAGES 31
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release: Distribution Unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
Category I Approach Light System ALSF-1 SALS SSALR	MALSR Ceiling Visibility Lateral Guidance Vertical Guidance	Visual Cues Pilot Factors
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
The Federal Aviation Administration (FAA) has directed conversion of all ALSF-1 Category I ILS approach lighting systems with sequenced flashing lights to the Simplified Short Approach Lighting System with Runway Alignment Indicator Lights (SSALR) and Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR). The Air Force is concerned that this lighting change may have an adverse affect on the operational capability of some of its units. Therefore,		

Headquarters Air Force requested the USAF Instrument Flight Center (USAFIFC) conduct an in-flight pilot factors (PIFAX) evaluation of the MALSR and SSALR approach lighting systems.

Fifteen subject pilots from the Instrument Flight Center, Randolph AFB TX and Flight Acceptance Branch, McClellan AFB CA, flew 120 sorties against the approach lighting systems being evaluated. The sorties were flown in the RD NT-38 aircraft. The evaluation was conducted both during daylight and night in weather conditions varying from VFR to 200-1/2. Air fields along the Gulf coast of Texas, and in the San Joaquin Valley of California were used for the evaluation. These locations were chosen because of the availability of lighting systems and frequency of low ceilings and/or visibility.

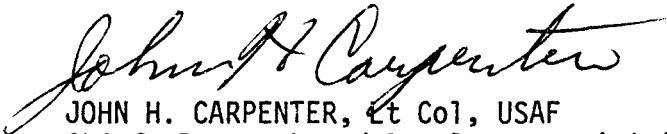
Based on the responses of the subject pilots and observations of the project pilots, the Instrument Flight Center recommends the ALSF-1 remain in use at Air Force and joint-use fields. In addition, if a lighting reduction is necessary, the ALSF-1 systems should be reduced no lower than a SALS (shortened ALSF-1). It is further recommended that published approach minimums for Categories D and E aircraft be reviewed at fields where MALSR is the primary Cat I approach lighting system.

PREFACE

This report summarizes the findings of project SP 76-2, entitled Evaluation of Revised Approach Lighting Criteria, conducted by the Research and Development Division of the USAF Instrument Flight Center. A subjective pilot factors evaluation was conducted at the request of Headquarters U.S. Air Force.

Flying activities on this project were conducted at Randolph AFB TX and McClellan AFB CA. Human factors support was performed by Mr. Gerald Armstrong, USAFIFC Research Psychologist; systems engineering support was performed by Mr. George Rex, USAFIFC Aerospace Engineer; installation of the project equipment was performed by Mr. Orrin C. Kopff and Mr. Raoul G. Canamar, USAFIFC Avionics Technicians; and secretarial support was provided by Mrs. Shirley W. Pauley.

This technical report has been reviewed and approved.



JOHN H. CARPENTER, Lt Col, USAF
Chief, Research and Development Division
USAFIFC



DONALD F. ROBILLARD, Colonel, USAF
Commander
USAFIFC

TABLE OF CONTENTS

	Page
Preface	i
Table of Contents	ii
List of Illustrations	iii
Introduction.	1
Test Objective.	1
Test Aircraft	1
Test Methodology.	1
Description of Test Items	3
Data Collection	12
Results and Discussion.	12
Evaluation of MALSR Approach Lighting System.	14
Evaluation of SALS and SSALR Approach Lighting Systems. .	15
Conclusions	17
Recommendations	18
Questionnaire	Atch 1

LIST OF ILLUSTRATIONS

Figure	Page
1. ALSF-1 Configuration.	4
2. ALSF-1.	5
3. SALS.	6
4. SSALR Configuration	7
5. SSAL.	8
6. MALSR Configuration	10
7. MAL.	11

INTRODUCTION

The Federal Aviation Administration (FAA) has directed conversion of all ALSF-1 Category I ILS approach lighting systems with sequenced flashing lights to the Simplified Short Approach Lighting System with Runway Alignment Indicator Lights (SSALR) and Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR).

Although the FAA directive affects civilian aerodromes only, the Air Force is concerned that the lighting change may have an adverse effect on the operational capability of the Air National Guard, Air Force Reserve, and Aerospace Defense Command units which operate from these airfields. Therefore, Headquarters Air Force requested that the USAF Instrument Flight Center (USAFIFC) conduct an in-flight pilot factors (PIFAX) evaluation of the SSALR and MALSR approach lighting systems. The results of this evaluation will provide the data necessary for the Air Force to formulate a position on the operational acceptability of the SSALR and MALSR systems. This report summarizes the USAFIFC/RD findings of the final portion of the evaluation.

TEST OBJECTIVES

The test objectives taken from the test plan are summarized as follows:

- a. To perform a pilot factors (PIFAX) evaluation of the SSALR and MALSR as Category I (ILS) approach lighting systems.
- b. To perform a pilot factors (PIFAX) evaluation of the SSALR and MALSR as non-precision approach lighting systems.

TEST AIRCRAFT

The test aircraft for this evaluation was a Northrop T-38 Talon aircraft. This test bed was selected to obtain data in a high performance aircraft which closely simulates the majority of Air Force aircraft that will be required to fly into airfields that have SSALR and MALSR approach lighting systems.

TEST METHODOLOGY

The pilot factors evaluation of the SSALR and MALSR approach lighting systems was conducted by USAFIFC/RDF at various military and civilian airfields throughout the United States. The majority of the approaches were flown against the lighting systems at Corpus Christi International, Texas; Stockton Metropolitan, California; Modesto City-County Field, California; Sacramento Metropolitan, California; and McClellan AFB, California. These airfields were chosen, not only because of the availability of the required lighting systems, but also because of the frequency of weather with low ceilings and visibilities. The subject pilots which participated in this evaluation were USAFIFC instructor pilots and pilots assigned to the flight Acceptance Branch at McClellan AFB, California. By selecting subject pilots

from these two sources, the project pilot was able to gather data from both highly experienced pilots current in various fighter aircraft, and from pilots with previous experience in many different types of aircraft.

To obtain valid data, multiple approaches were flown against all four systems (ALSF-1, SALS, SSALR, and MALSR) under Category I weather conditions. Fifteen subject pilots flew multiple ILS and LOC approaches against the various lighting systems. These approaches were accomplished in daylight and also during the hours of darkness. As many approaches as possible were flown under similar weather conditions against each lighting system. The desire to have subject pilots view the lighting systems under similar weather conditions was accomplished through airfield selection. The fact that Corpus Christi International has both SSALR and MALSR systems located on the field permitted timely evaluation of each system. Stockton and Modesto which have the SALS and MALSR systems, respectively, are located in close proximity and the weather conditions tended to be similar at each field. Approaches at airfields were flown with the lighting systems set at various intensity levels. Many approaches were flown with the aircraft off-set slightly from both glide path and localizer center-line. This was done to evaluate the merits of each system in guiding the pilot to the runway in situations where the approaches were not perfectly flown. To assure a more complete analysis of each system, all approaches were flown to either a touch and go, or full stop landing whenever possible. The following documentary data was recorded for each approach:

1. Airfield and runway.
2. Approach lighting system and intensity level.
3. Minimums for approach.
4. Glide slope angle.
5. Current weather.
6. Approach speed.
7. Sequenced flasher contact height.
8. Approach light contact height.
9. Threshold light contact height.
10. Visual cues for landing.
11. Subject pilot comments.

Briefing

Each subject pilot received a comprehensive pre-mission briefing which included a description of the mission profile and lighting systems to be

flown against. A normal preflight briefing for a T-38 instrument flight was also accomplished. By using the in-flight tapes and the project questionnaire, each subject pilot was thoroughly debriefed at the termination of each flight.

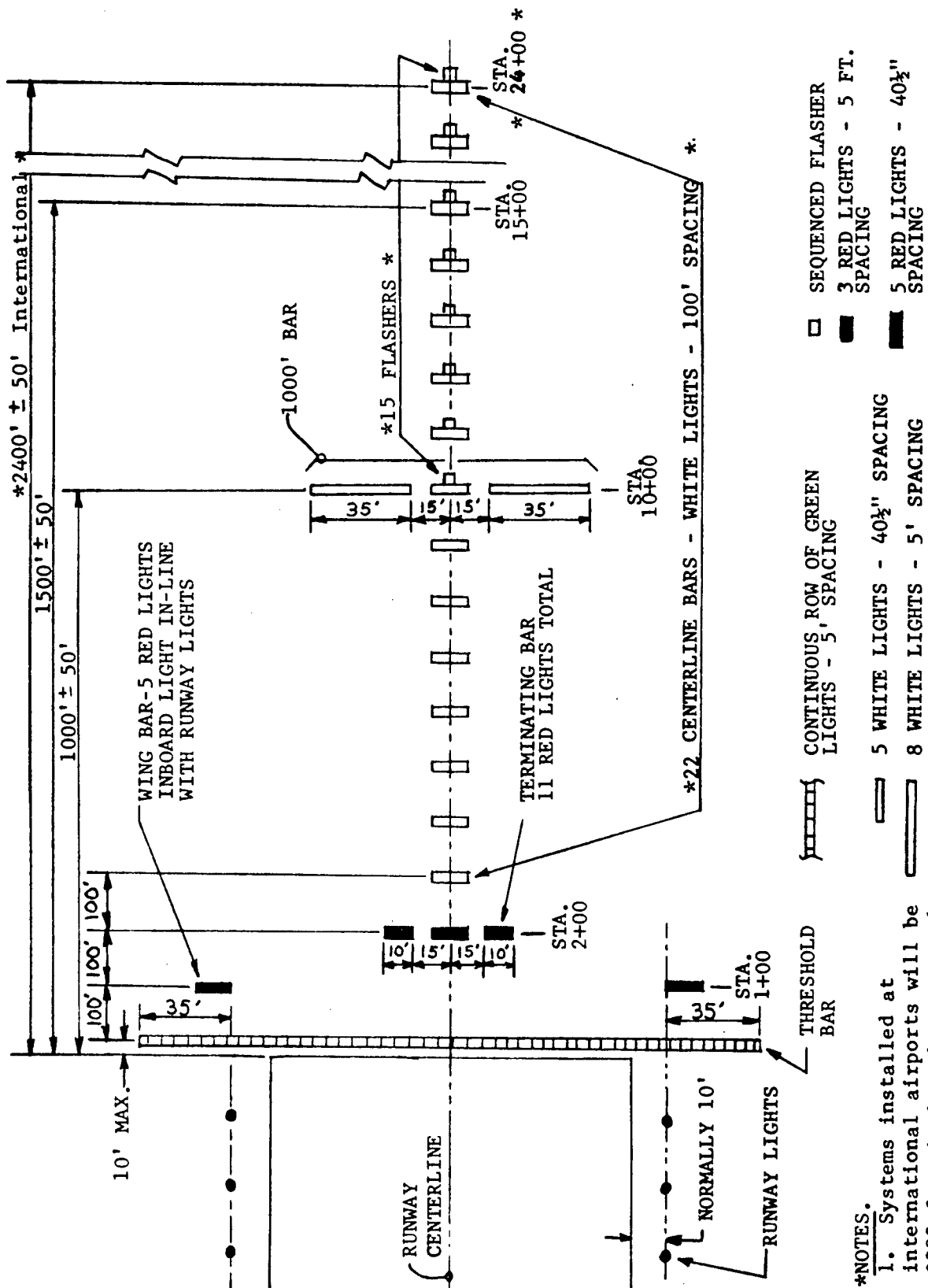
DESCRIPTION OF TEST ITEMS

Pilot factors data was collected on the following four Category I ILS approach lighting systems: (1) Approach Lighting System with Sequenced Flashing Lights (ALSF-1); (2) the Short Approach Light System (SALS); (3) the Simplified Short Approach Light System with Runway Alignment Lights (SSALR); and (4) Medium Intensity Approach Light System with Runway Alignment Indicator Lights (MALSR).

The Category I ALSF-1 (figures 1 and 2) consists of a light bar (approximately 13-1/2 feet long with five equally spaced lights) at each 100-foot interval starting 200 feet from the runway threshold and continuing out to 3000 feet from the threshold. All light bars are installed perpendicular to the extended runway centerline, and all lights are aimed away from the runway threshold. The centerline light bar, at 1000 feet from the threshold, is supplemented with eight additional lights on each side forming a light bar of 100 feet and containing 21 lights. This bar is called the 1000-foot distance marker crossbar (or simply, 1000-foot bar). All of the aforementioned lights are white. The light bar, 200 feet from the threshold, is 50 feet long and contains eleven red lights. This light bar is called the terminating bar. Two light bars, each containing five red lights, are located 100 feet from the threshold and are positioned one on each side of the runway centerline. These light bars are called wing bars. The inner light (nearest runway centerline) of each wing bar is located in line with the runway edge lights. A row of green lights (approximately five-foot centers [five, not to exceed ten feet]) is located near the threshold and extends across the runway threshold and outwards a distance of approximately 45 feet from the runway edge on each side of the runway. These lights constitute the threshold bar. In addition to the foregoing steady burning lights, the ALSF-1 configuration is augmented with a system of sequenced flashing lights. One sequence flashing light is installed at each centerline bar starting 1000 feet from the threshold out to the end of the system 3000 feet from the threshold. These flashing lights emit a bluish-white light and flash in sequence toward the threshold at a rate of twice per second. The flashing lights appear as a ball of light traveling toward the runway threshold at a high rate of speed (approximately 4100 miles per hour).

The SALS light system is the same as the ALSF-1 system except that the last 600 feet of the centerline light bars and sequenced flashers have been removed (figure 3).

The SSALR light system (figures 4 and 5) consists of seven five-light bars located on the extended runway centerline. The first bar is located 200 feet from the runway threshold and at each 200-foot interval out to



*NOTES.
1. Systems installed at international airports will be 3000 feet in length, Paragraph 20a. *

Figure 1. ALSF-1 Configuration.

DOCUMENT BIBLIOGRAPHY
(For input to OTEMIS - reports file)

TO: AFTEC (OAT) - Stop 82 Kirtland AFB NM 87115		FROM: (Organization) AFTEC / TEB	
AD	LOCATION ATTACHED	DATE MAR 1977	
TITLE EVALUATION OF REVISED APPROACH LIGHTING CRITERIA			
CLASSIFICATION UNCLASSIFIED	REGRADING NOTATION	MONITOR	
SOURCE USAF INSTRUMENT FLIGHT CENTER			
DESCRIPTORS SEE BLK 19, DD FORM 1473, IN REPORT			
IDENTIFIERS EVALUATION OF REVISED APPROACH LIGHTING CRITERIA			
DOCUMENT TYPE FINAL REPORT	REPORT NO. USAFITEC TR 77-1	PROJECT NO. SP 76-2	
TASK NO.	NO. OF PAGES 30	AUTHOR MAJ. Kenneth J. Kerkorian Mr. Gerald C. Armstrong	
ABSTRACT (If more space is required continue on reverse) See BIK 20, DD Form 1473, in report.			
TTED BY Liam L. Childers			DATE 8 MAR 78

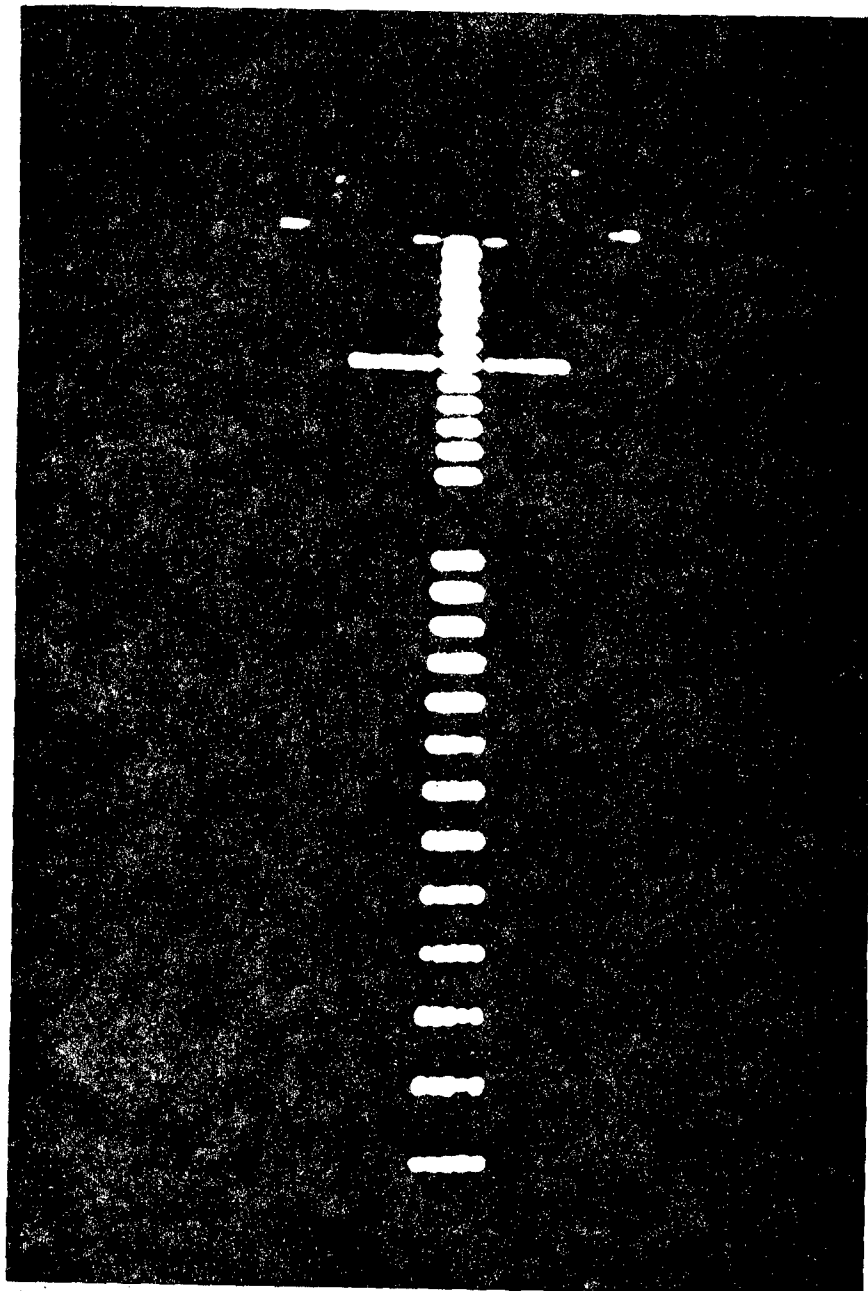


Figure 2. ALSF-1.

NOTE: Gap in lighting system is
an Interstate Highway.

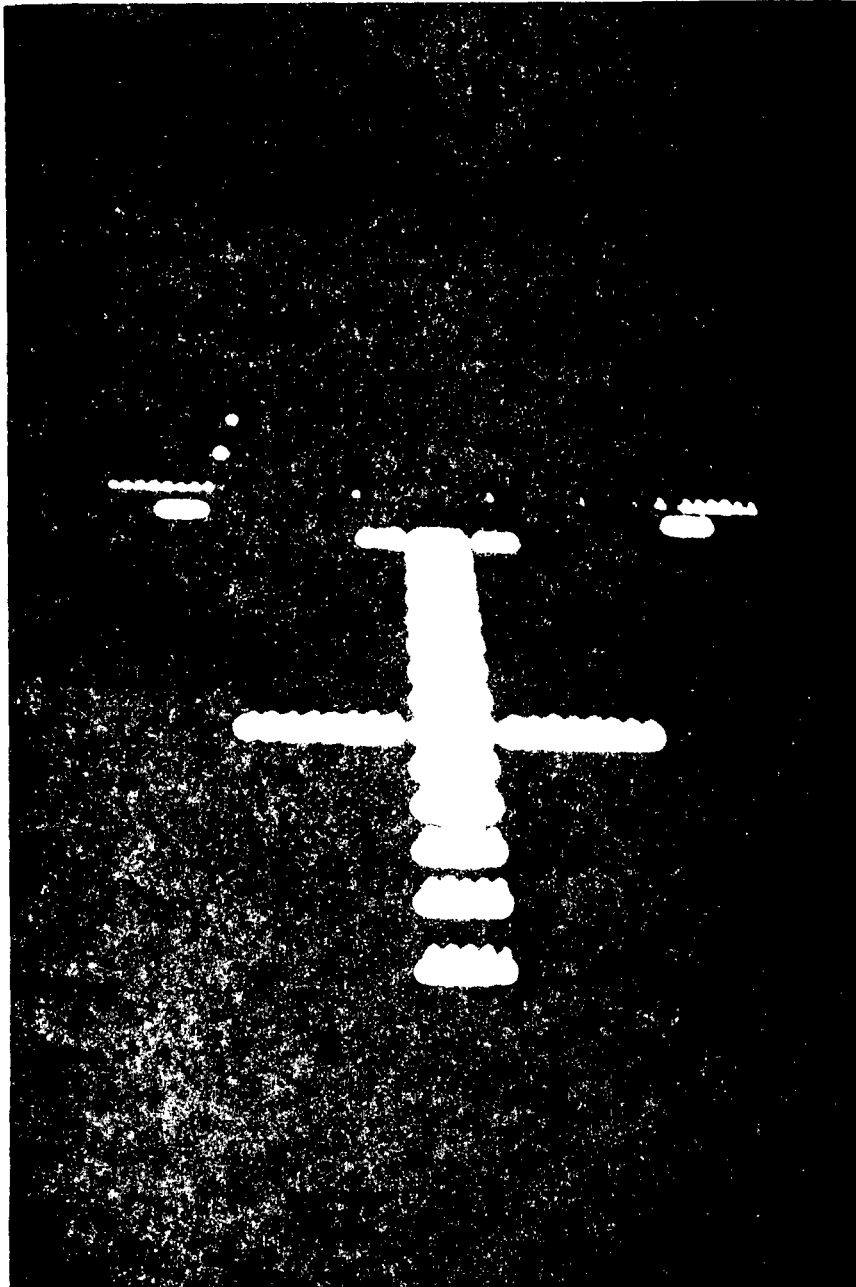


Figure 3. SALS (Shortened ALSF-1)

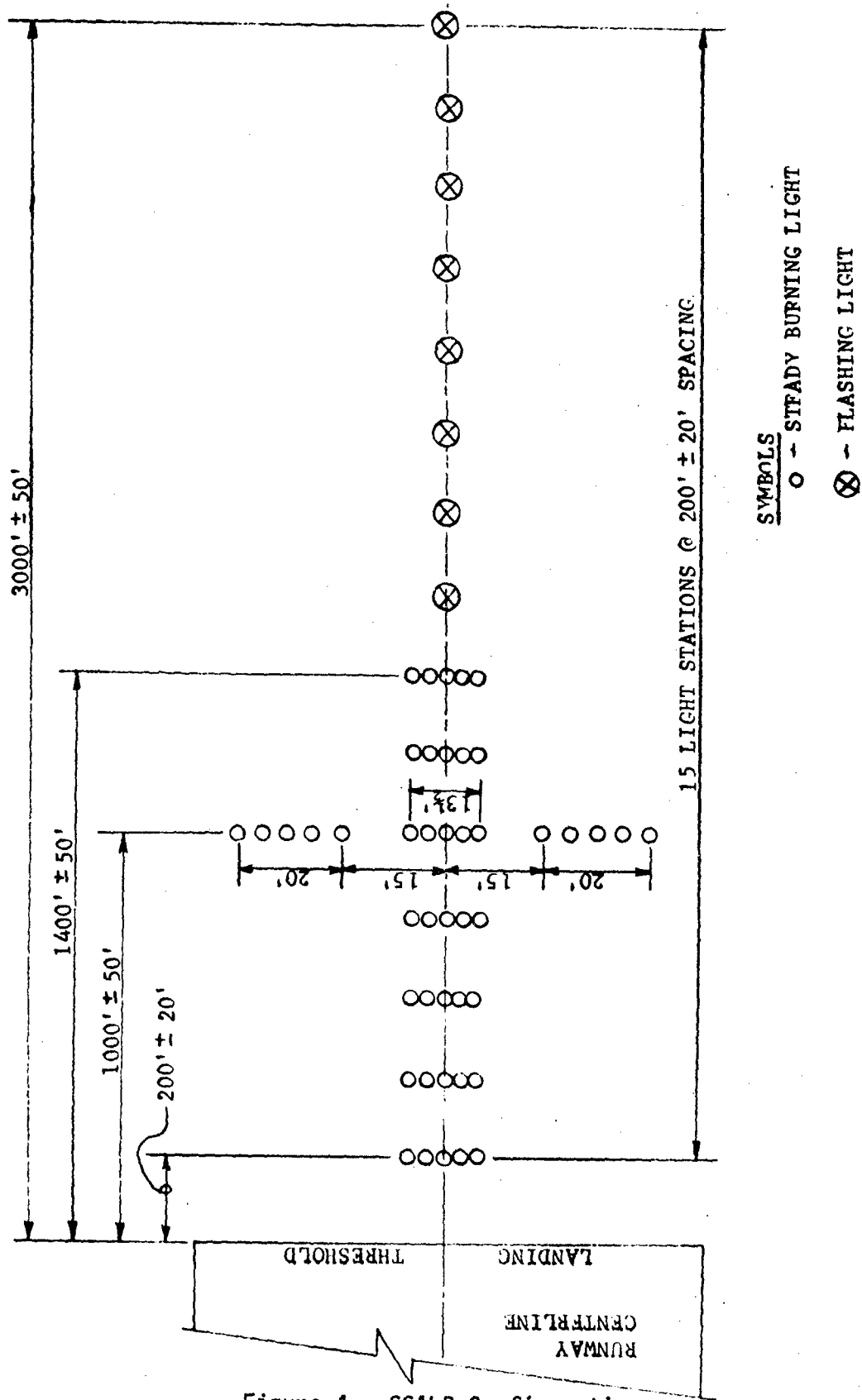


Figure 4. SSALR Configuration.



Figure 5. SSAL.

1400 feet from the threshold. Two additional five-light bars are located, one at each side of the centerline bar, 1000 feet from the runway threshold. These light bars form a crossbar 70 feet wide. The spacing between individual lights is 40-1/2 inches for the centerline bars and five feet for other bars. All lights in the system are white. In addition, Runway Alignment Indicator Lights (RAIL) are included in the system. The RAIL portion of the facility consists of sequenced flashers located on the extended runway centerline, the first being located 1600 feet beyond the approach end of the runway threshold with successive units located at each 200-foot interval out to the end of the system (2400 or 3000 feet). These lights flash in sequence toward the threshold at the rate of twice per second.

The length of the SSALR may either be 2400 feet or 3000 feet depending on the glide slope. When the glide slope is less than 2.75° , the length of the approach lighting system will be 3000 feet. The length is reduced to 2400 feet when the glide slope angle is 2.75° or higher (figure 2).

The MALSR consists of seven five-light bars located on the extended runway centerline. The first bar is located 200 feet from the runway threshold and at each 200-foot interval out to 1400 feet from the threshold. Two additional five-light bars are located, one to each side of the centerline bar 1000 feet from the runway threshold forming a crossbar 66 feet long. The spacing between individual lights in all bars is approximately 2.5 feet. The RAIL portion of the facility consists of sequenced flashers located on the extended runway centerline, the first being located 1600 feet beyond the approach end of the runway threshold with successive units located at each 200-foot interval out to the end of the system (2400 or 3000 feet). These lights flash in sequence toward the threshold at the rate of twice per second. The MALSR system is normally 2400 feet long (figures 6 and 7).

The standard SSALR system has three intensity levels for the steady burning lights (approximately 100%, 20%, and 4%). Most of the SSALR systems encountered were cut back from ALSF-1 systems with five intensity levels of 100%, 20%, 4%, 0.8%, and 0.16%. The standard MALSR system has two intensity settings, 100% and 10%. The standard ALSF-1 sequenced flashers do not have an intensity control. Both the SSALR and MALSR systems receive power from the same source as the runway edge light to control the flasher intensity; therefore, the flasher intensity depends on the edge light step setting. When the runway edge lights are on steps five or four, the MALSR and SSALR systems are HIGH and the flasher intensity is 100%.

When the edge lights are step three, the MALSR and SSALR systems are MED, and the flasher intensity is 8% brightness (8% of what you normally see on an ALSF-1 or 2).

When runway edge lights are on steps two or one, the MALSR and SSALR systems are LOW, and the flashers are only 1%.

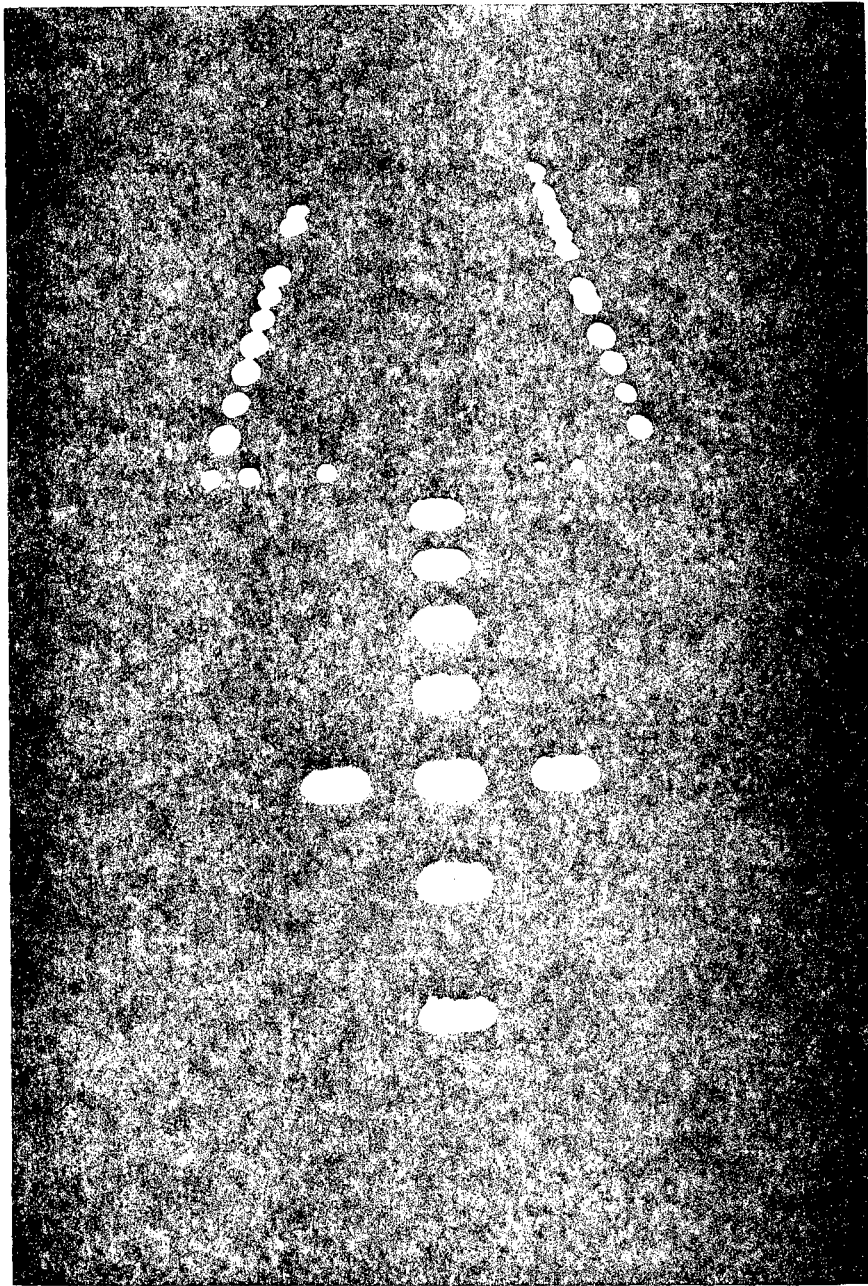


Figure 7. MALS.

DATA COLLECTION

In-flight recording of the subject pilots' comments was accomplished by use of a portable cassette tape recorder complete with wiring jack that plugged into the aircraft's interphone system. During the approaches, notes were also made by the project pilot occupying the rear seat. A KB26A gunsight camera was used for motion picture recording and visual analysis of the approaches. The camera was mounted on the glare shield of the test aircraft and was oriented to the same "look angle" as the pilot. The motion picture camera proved invaluable for documenting the approaches during both day and night conditions.

RESULTS AND DISCUSSION

The Evaluation of Revised Approach Lighting Criteria was accomplished to determine if the MALSR and SSALR approach lighting systems were adequate to ensure safe operation of high speed fighter type aircraft down to Category I ILS minimums (200-1/2) on a regular operational basis. Due to its convenient location, the SALS system was also included in the study. The acceptability of each lighting system is presented separately; however, during the evaluation several common findings appeared which may affect all current lighting systems somewhat equally. These findings will be discussed further in the report.

Fifteen subject pilots participated in this evaluation. The test plan called for a minimum of 120 approaches consisting of both precision and non-precision approaches flown during daylight and at night against each lighting system. Due to the problem of finding the desired weather conditions at each location, all of the subject pilots did not fly exactly the same number of approaches against each lighting system. This imbalance was considered when the data was analyzed.

Subject pilots were asked to evaluate the acceptability of each system independently. In order to ensure this, a questionnaire was accomplished immediately after flying against each system. Additionally, the subject pilots were not asked to compare the lighting systems. The following text presents pilot responses and highlights several pertinent problems uncovered either by the subject or the project pilots during the flight evaluation.

Background

The pre-validation portion of the evaluation consisted of finding suitable operating locations with MALSR, SSALR, and SALS approach lighting systems. With the assistance of the FAA, a list of MALSR, SSALR, and SALS equipped fields was compiled and Category E minimums established. The climatological data for each area was reviewed to determine the frequency of low ceilings and/or visibility. From this analysis, the California San Joaquin Valley and the Gulf Coast of Texas were found most suitable.

The selected test sites were visually inspected during the summer months when the weather was predominantly VMC. During this initial inspection it was found that some of the approach lighting systems were poorly maintained, i.e., poorly aimed sequenced flashers, inoperative sequenced flashers, and approach lights burned out or improperly aimed. These discrepancies were published in an interim report dated 9 Aug 1976.

With the onset of the reduced ceilings and/or visibility conditions, the data collection flights commenced. The environmental conditions encountered during the evaluation of the MALSR approach lighting system varied from VMC to total obscuration with 1/16 of a mile visibility. The approaches were initiated only when weather conditions were reported at or above published minimums, but frequently the weather conditions deteriorated after the approach was well underway. The various types of weather conditions encountered during the approaches had a direct bearing on the subject pilot comments about the lighting system. In the low visibility environment, pilots seldom experienced a distinct transition from instrument to visual conditions especially during an approach with obscured ceilings. This type of environment presented the pilots with a number of problems not encountered during an approach to a cloud based ceiling. At the discrete point where the aircraft breaks out below the ceiling, the visual cues used to control the aircraft were usually very clear and distinct and there was instantaneous perception of aircraft position relative to the approach lights and runway. With total obscuration or partially obscured conditions, the converse was usually true; visual cues were indistinct, easily lost and it was difficult to determine aircraft position both laterally and vertically relative to the approach lights and runway.

During the "Landing Weather Minimums Investigation" completed by USAFIFC in 1972, it was determined that approximately three seconds were required for the heads-down pilot to integrate the outside visual cues after coming heads-up. This length of time was necessary to adjust to the outside environment, to determine position with relation to the runway, analyze cross-track rate and effect the inputs necessary for visual control. While this visual transition process was occurring, the aircraft was moving forward about 250 feet per second and downward at 10 to 15 feet per second. The pilot's visual information in roll and pitch was extremely limited in this environment. Due to the short visual segment, a sensation of being higher than actual existed, causing an instinctive lowering of the nose, thus creating a false aiming point. Also, if the aircraft was positioned at an angle to the runway centerline, the pilot's first visual impression was perceived as a cross track causing a roll input which produced an actual cross-track.

There was wide disparity between the cues available for day and those available for night operation. First, there were less approach lighting cues available for the day approach. On final, the approach lights and strobe lights tended to wash out due to ambient lighting. Second, at

night these lights were more distinct and became much more useful in providing better guidance cues. Thirdly, it should be mentioned that the landing light was not used for night approaches as it produced a back scatter effect which blanked out the pilot's forward vision and was also extremely distracting.

Early in this study it became very apparent that most pilots were not familiar with the various types of approach lighting systems. The majority of the pilots used the approach lighting more or less subconsciously without much attention to the configuration. They did not know exactly what information was provided by the approach lighting systems or how to use it effectively. Prior to their first flight, each subject pilot was thoroughly briefed on each lighting system to be flown against during the evaluation.

EVALUATION OF MALSR APPROACH LIGHTING SYSTEM

This section of the report presents a summary of subject pilot comments and questionnaire analysis. These findings are limited to the MALSR system and cover both day and night operations.

Fifteen subject pilots flew approaches against the MALSR lighting system under varied environmental and lighting conditions. Most of the subject pilots flew approaches having ceilings and visibilities down to 200 feet and 1/2 mile.

The subject pilots were asked if they thought the sequenced flashers gave adequate lateral guidance under all ambient lighting conditions and visibilities. Sixty percent answered no (9 out of 15), and 40% answered yes. When their questionnaire replies were analyzed, all thought the inadequacy stemmed from a combination of low intensity levels and insufficient number of lights. As the visibility decreased below 3/4 mile during the daylight approaches, the lateral guidance obtained from the sequenced flashers sharply reduced. At night, as was to be expected, the sequenced flashers provided much better lateral guidance even with decreased visibilities. On non-precision approaches having visibility better than a mile, the guidance provided by the flashers was acceptable both day and night.

The overall intensity level of the unmodified MALSR system was considered inadequate by 67% of the pilots. For night evaluation, 87% of the subject pilots considered the intensity levels of the system adequate. Again, as the visibility went down during day lighting conditions, the intensity levels of the system, as well as the sequenced flashers, did not provide adequate penetrating power for nominal visual acquisition.

Eighty percent of the subject pilots felt they did not receive sufficient roll guidance from the unmodified MALSR system. The general opinion was that the 1000-foot cross bar did not extend far enough in width, and the centerline roll bars were too narrow. All pilots felt that at least some

roll guidance was perceived. However, under low visibility conditions, and especially at night with an absence of other visual cues, this minimal guidance was inadequate.

When asked how they felt about the length of the system for flying approaches down to 200-1/2, the majority of the pilots (9 out of 15) thought it was too short and the distance between the centerline light bars was too great for aircraft maintaining high final approach speeds of 160 knots or greater. They felt a longer system was better, due to the possibility of it being acquired earlier. The longer system would give the necessary guidance cues in time to successfully correct an approach that was not perfectly flown.

All of the pilots were questioned as to the degree of vertical guidance they received from the MALSR system. Seven percent said they received some, while 93% stated they received no useful vertical guidance. This lack of reliable vertical guidance was compounded by the fewer lights comprising the system and the greater spacing between light bars. This created the illusion of being higher than actual. With this illusion, there was a general tendency by the pilots to decrease the pitch of the aircraft (i.e., increase glide path angle) in an attempt to pick up visual cues with which they were more comfortable. It was obvious that this could lead to a dangerous situation, especially under lower visibility. When a 3° glide path was used in conjunction with the MALSR system, 80% of the pilots stated they were very uncomfortable during the visual transition to landing phase. This uncomfortable feeling stemmed from being higher when closer to the runway as a result of the steeper approach angle and the aforementioned potential for illusion. Thus, a combination of a 3° glide path and a MALSR system could lead to a dangerous situation for high performance aircraft having poor power response.

A decisive majority of the subject pilots (12) felt that the threshold lights associated with the MALSR systems did not adequately define the runway environment in either day or night approaches. This was especially true for night approaches due to less numerous visual cues from which the pilot defines the end of the runway.

From the overall pilot comments, it is apparent that the MALSR lighting system (in its present configuration) is not adequate for high speed aircraft in weather conditions down to 200-1/2. It may be of interest to point out that the majority of the approaches flown against the system when the weather was 300-3/4 or better were successfully completed to landing. All subject pilots felt the system was adequate for non-precision approaches with weather conditions at or above 400-1.

EVALUATION OF THE SALS AND SSALR APPROACH LIGHTING SYSTEMS

The following are the findings of the pilot factors evaluation of the SALS and SSALR approach lighting systems. The airfields used for this portion of the evaluation were Corpus Christi International, Texas, and Stockton

Metropolitan, California. These findings were based on the subject pilot questionnaires and debriefings and cover day and night operations against SALS and SSALR systems.

Approaches were flown against the SALS and modified SSALR systems by fifteen subject pilots. The weather during the course of this evaluation varied from VFR to 200-1/2.

Fifty-three percent of the subject pilots thought the sequenced flashers associated with this system gave adequate lateral guidance under all the ambient lighting conditions encountered. The consensus of the pilots was that the intensity of the sequenced flashers was sufficient, but the spacing of 200 feet between flashers on the SSALR system was too great and did not provide a definite flow toward the runway. This hindered some of the pilots in making adequate lateral corrections prior to decision height. Ninety percent of the pilots felt the sequenced flashers gave adequate lateral guidance for non-precision approaches. Ninety-three percent of the pilots felt that the sequenced flashers associated with the SALS system (having flashers with 100-foot spacing) were adequate for all the weather conditions encountered.

The five step intensity levels associated with the SALS and modified SSALR systems that were flown against were considered adequate by 14 (93%) of the pilots. With a five step intensity level, the systems proved quite adaptable to all ambient lighting conditions. This was especially helpful at night when the levels could be cut back to reduce the blinding effect as the approach lights were overflowed in the final phase of the approach.

When asked to comment on the roll guidance received from the system, 73% of the pilots felt that the guidance was adequate. It was felt that both the centerline roll bars and the 1000-foot cross bar were of sufficient width to aid in leveling the wings. The subject pilots stated that they received better roll cues from the SALS system than from the SSALR or MALSR systems. The reason for this was that the 100-foot intervals between the roll bars provided a much better bank of lights from which to obtain cues. The subject pilots stated that the importance of the roll cues received from the lighting system, especially during night low-visibility approaches, could not be overemphasized.

The length of the approach lighting system was not considered adequate by 60% of the pilots for approaches in weather conditions down to 200-1/2. As with the MALSR system, they felt that any approach lighting less than 3000 feet was too short for high-speed aircraft to make corrections if the approaches were not perfectly flown. The effect of the shortened length was heightened by the increased spacing between roll bars and flashers on the SSALR system. This was verified by the fact that when approaches were purposely flown offset, the subject pilots found it extremely difficult to correct back to runway centerline after the lights were visually acquired and to transition to land safely. This problem was not encountered during approaches using the standard ALSF-1 lighting system.

The pilots were questioned as to the degree of vertical guidance received from the SSALR and SALS approach lighting systems. Eighty-seven percent felt they received no useful vertical guidance. As with the MALSR system, the majority of the subject pilots did not feel comfortable flying against the SSALR system when using a 3° glide path. Additionally, the pilots were accustomed to lower threshold crossing heights under normal VFR conditions.

Sixty-seven percent of the pilots felt the threshold lights were inadequate for outlining the end of the runway. This situation occurred with all the approach lighting systems flown against, including the ALSF-1. All of the subject pilots stated there was a definite need to better define the threshold and/or touchdown zone. Additionally, the pilots stated there was a lack of visual cues between the approach lights and the touchdown zone of the runway. This is more commonly known as the "black hole," and the pilots felt improved threshold or touchdown zone lighting would definitely help to alleviate this problem. One interesting phenomenon that recurred was that the subject pilots could visually acquire the blue taxiway lights before the green threshold lights. One reason for this was thought to be the higher level of ultra violet radiation emitted by the blue lights which gave the taxiway lights a greater penetrating power in the low visibility environment. A study was recently completed at NASA Ames on the subject of approach light colors which confirms that the blue lights have a greater penetrating power, especially under low visibility conditions.

As a result of the data analysis, it is felt that the SALS is acceptable for high-speed aircraft in weather conditions down to 200-1/2. The SSALR, when modified for five intensity levels, is marginally acceptable for approaches in weather conditions down to 200-1/2 by high-speed aircraft.

CONCLUSIONS

The following conclusions are based on the subjective data obtained from subject pilots and the observations made by the project pilots.

Specific

- a. The intensity levels of the unmodified MALSR system were not sufficient to provide adequate lateral guidance under all ambient light conditions.
- b. The MALSR system's centerline light bars were spaced too far apart and were too narrow as was the 1000-foot cross bar to provide adequate roll guidance.
- c. The MALSR system gave the pilot the illusion of being higher than actual due to the overall size, spacing between light bars, and fewer lights comprising the system.
- d. No usable vertical guidance was provided by the MALSR approach lighting system.

e. Pilots found it more difficult to transition to land when flying a 3° versus a 2.5° glide path into the MALSR system.

f. The runway threshold lights associated with the MALSR system were insufficient in number and intensity to adequately define the runway environment.

g. The intensity levels of the SALS and modified SSALR systems were sufficient to provide adequate approach guidance under most ambient lighting conditions.

h. The roll guidance obtained from the centerline roll bars and 1000-foot cross bar of the SSALR and SALS systems was adequate.

i. No usable vertical guidance was provided by the SALS and SSALR approach lighting system.

j. The threshold light intensity associated with the SALS and SSALR systems did not adequately define the runway environment.

k. The approach capability of high-speed aircraft was degraded due to the shortened length and increased spacing between light bars of the MALSR and SSALR systems.

General

a. The MALSR approach lighting system in its present configuration did not prove to be an adequate approach aid for aircraft with high final approach speeds in Category I (200-1/2) weather conditions.

b. The MALSR approach lighting system was acceptable as a non-precision approach aid.

c. The modified SSALR approach lighting system proved to be a marginal approach aid for aircraft with high final approach speeds in Category I (200-1/2) weather conditions.

d. The SALS approach lighting system was an acceptable approach aid for aircraft with high final approach speeds in Category I (200-1/2) weather conditions.

e. The SALS and SSALR approach lighting systems were acceptable as a non-precision approach aid.

RECOMMENDATIONS

The recommendations presented below represent the general opinions of the subject pilots and project pilots:

a. Recommend the ALSF-1 approach lighting system be used at Air Force and joint use fields.

b. If a cutback in approach lighting systems is necessary, the ALSF-1 systems should be reduced no lower than a SALS.

c. That published approach minimums for Categories D and E aircraft be reviewed at fields that have MALSR approach lighting systems for their Category I runways.

d. That a study be made on changing the color and configuration of Category I approach lighting systems.

e. That the threshold lighting of all runways be improved to better define the runway environment.

f. That a training program be established to improve aircrew knowledge of the types of approach lighting and their capabilities.

g. That approach plates and enroute supplement be brought up to date to show current airfield lighting.

1. Did the runway alignment identification lights (sequenced flashing lights) provide sufficient lateral alignment cues for safely flying the following?

	Yes	No
Precision approaches to published minimums	_____	_____
Non-precision approaches to published minimums	_____	_____
Precision approaches to (state ceiling/visibility)	_____	_____
Non-precision approaches to (state ceiling/vis)	_____	_____
If not to published minimums, please explain:		

2.a. Approximately how far from the runway threshold were the sequenced flashing lights visible to you?

	Precision Approach	Non-Precision Approach
Range	_____	_____
Altitude	_____	_____

b. Was this distance adequate for:

	Precision Approach	Non-Precision Approach
200 - 1/2	_____	_____
300 - 1	_____	_____
Other (state)	_____	_____

Please explain your answer.

3.a. When you first observed the sequenced flashing lights did you have any doubts as to what they were?

Yes _____ No _____

Please explain.

b. Were you ever confused or disoriented because of the sequenced flashing lights?

Yes _____ No _____

If yes, please explain.

4. The distance between sequenced flashing lights was adequate for:

	Precision Approaches	Non-Precision Approaches
200 - 1/2	_____	_____
300 - 1	_____	_____
Other (state)	_____	_____

Please explain.

5. The distance between the last sequenced flashing light and runway threshold was adequate for:

	Precision Approaches	Non-Precision Approaches
200 - 1/2	_____	_____
300 - 1	_____	_____
Other (state)	_____	_____

5 (Cont).

Please explain.

6. Did the centerline light bars provide sufficient visual cues for roll guidance for the following:

	Yes	No
Precision approaches to published minimums	_____	_____
Non-precision to published minimums	_____	_____
Precision approaches to (state ceiling/vis)	_____	_____
Non-precision approaches to (state ceiling/vis)	_____	_____

Please explain your answers.

7.a. Approximately how far from the runway threshold were the light bars visible to you?

	Precision Approach	Non-Precision Approach
Range	_____	_____
Altitude	_____	_____

b. Was this adequate for :

	Precision Approach	Non-Precision Approach
200 - 1/2	_____	_____
300 - 1	_____	_____
Other (state)	_____	_____

Please explain your answer.

8.a. When you first observed the centerline light bars did you have any doubts as to what they were?

Yes _____ No _____

Please explain.

b. Were you ever confused or disoriented because of the light bars?

Yes _____ No _____

Please explain.

9. The distance between centerline light bars was adequate for:

	Precision Approaches	Non-Precision Approaches
200 - 1/2	_____	_____
300 - 1	_____	_____
Other (state)	_____	_____

Please explain.

10. The relationship between sequenced flashing lights and centerline light bars was:

Adequate for approaches to 200 - 1/2	_____
Adequate for approaches to 300 - 1	_____
Adequate for approaches (specify)	_____

11.a. At what distance from the runway threshold was the 1000-foot cross bar first visible?

Range _____

Altitude _____

b. What type of visual information did the cross bar provide you?

c. Did the cross bar aid the safety of the approach?

Yes _____ No _____

State conditions (weather, minimums, etc.).

12.a. Did you receive height (vertical guidance) information from the approach lighting?

Yes _____ No _____

If no, explain.

b. If you received height (vertical guidance) information, from which source was it received?

Sequenced flashing lights _____

Centerline light bars _____

1000-foot cross bars _____

Combinations (specify) _____

c. Was the height information received, adequate?

Yes _____ No _____

Explain.

13.a. How far from the runway threshold did you first acquire the threshold lighting?

	Precision Approach	Non-Precision Approach
Range	_____	_____
Altitude	_____	_____

b. Was this adequate for:

	Precision Approach	Non-Precision Approach
200 - 1/2	_____	_____
300 - 1	_____	_____
Other (state)	_____	_____

Explain.

c. Did threshold lighting adequately define the runway threshold?

Yes _____ No _____

If no, please explain.

14. Does the approach lighting system adequately define the runway environment when flying to 200 - 1/2?

Yes _____ No _____

If no, please explain and state at what minimums the environment would be adequately defined.

If unsafe please explain why.

15. Is your operational capability degraded in any manner because of the approach lighting systems? Assume continuous operations to the ceiling/visibility flown.

	Ceiling	Visibility
Yes	_____	_____
No	_____	_____

If yes, please explain.

16. Was sufficient information available during the approach from the approach lighting system to make a decision at DH to go around or continue the approach?

Yes _____ No _____

If no, please explain.

17. At MDA during a non-precision approach were the following visible?

Approach lighting _____

Runway threshold _____

Both _____

Neither _____

Ceiling/Visibility _____

a. If approach lights only were visible, were they adequate for initiating descent from the MDA to touchdown?

Yes _____ No _____

Please explain.

18. What changes to the approach lighting system, if any, do you recommend so that operations could routinely be conducted adequately to published minimums?

Sequenced flashing lights

Light bars

Cross bars

Threshold lights

Other