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Development of A Visual Aid to Indicate Temporary Runway Closure

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January 1987

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A prototype visual aid to advise pilots that a runway is temporarily closed was cleveloped at the Federal Aviation Administration (FAA) Technical Center. Subject pilots were asked to provide comments as to the effectiveness of the system. Results of the evaluation indicate that the device provides an intuitive indication of a closed runway in adequate time for a pilot to execute a safe missed approach.

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EXECUTIVE SUMMARY

The purpose of this project was to develop a prototype visual aid to advise pilots that a runway is temporarily closed during visual meteorological conditions for both day and night operations, as recommended by Task Group 3-1.6 of the National Airspace Review.

Several prototype systems were constructed and subjected to preliminary evaluation. An array of nine spotlights in the shape of the letter "X" was selected for final evaluation. Subject pilots were asked to provide comments as to the effectiveness of the system.

Results of the evaluation indicated that the device provides an intuitive Indication of a closed runway in adequate time for a pilot to execute a safe missed approach. The signal is effective during both straight-in and circling approaches.

INTRODUCTION

PURPOSE.

The purpose of this project was to develop and test a prototype visual aid to advise pilots that a runway is temporarily closed during visual meteorological conditions. The project was undertaken in response to a request from the Office of Airport Standards, AAS-1, submitted through the Program Engineering and Maintenance Service, APM-1. The development of a lighted visual aid for this purpose was recommended by Task Group 3-1.6 of the National Airspace Review. The work was accomplished under Technical Center Project No. T19-03N, Airport Lighting and Marking. The Technical Project Manager was Rick Marinelli, ACT-310.

DISCUSSION

There have been instances of aircraft landing on runways temporarily closed for maintenance or snow clearing operations. The problem becomes particularly acute at night when runway edge lights must be on for electrical maintenance or for avoidance by snow plow operators. The solution was determined by Task Group 3-1.6 of the National Airspace Review to be the development of a lighted visual aid to provide the closed runway warning. The performance criteria specified by the Federal Aviation Administration (FAA) Office of Airport Standards for evaluation of the visual aid were as follows:

1. The visual aid shall be conspicuous when viewed from the air and readily distinguishable from other visual devices used on airports. The runway edge lights and other visual aids may be on while the runway-closed light is operating.

2. It shall be visible from any point 1/2 mile from the runway threshold and shall have a vertical coverage adequate for both circling guidance and final approach areas.

3. It shall be suitable for night operations down to a visibility of 3 miles.

4. It shall be capable of being quickly set up and turned on.

These criteria were supplemented by the Technical Center Visual Guidance Section in that it was felt the visual aid should have the following characteristics:

5. The message presented by the aid should be intuitively understood.

6. The aid should be readily constructed using "off-the-shelf" components. This would allow it to be built and used at small airports, where lack of a control tower would make it especially desirable.

PRELIMINARY EVALUATION.

Criterium no. 2 suggests an omnidirectional visual aid. Red lighting was selected as intuitively suggesting prohibition. Several versions of single-point red light sources were selected for preliminary evaluation, but all failed criterium no. 1, in that they were not sufficiently conspicuous and/or could be confused with other visual aids (e.g. VASI, PLASI). In fact, a very bright red-light source, color-coded Runway End Identifier Lights (REIL), was evaluated in 1983 as a closed-runway indicator and was found to be confusing to pilots at best (FAA Technical Note No. DOT/FAA/CT-TN83/52).

A message can also be conveyed through lighting by the configuration of a multi-point light source. The configuration chosen for preliminary evaluation was that of the letter "X", which any pilot will recognize as an indication of a closed runway when it is laid out on the pavement. To meet criterium no. 4, the "X" was formed upright to project the signal into the approach area and mounted on a trailer (figure 1). This configuration would not be omnidirectional, but should still provide sufficient horizontal coverage to be effective. Obviously, the larger the device, the more effective it would be. Fourteen-foot arms were chosen as the longest still meeting portability requirements.

Several combinations of clear and yellow spotlights or fluorescent lights were evaluated, along with a strobe-lighted "X" developed for San Francisco International Airport in a parallel effort. Having too many lights was found to be as detrimental as having too few. Pulsing lights were found to be far superior to steady-burning lights for early acquisition. Pulse rates were varied for selection of the optimum cycle. The configuration selected for final evaluation was an evenly spaced set of nine 150W clear spotlights (figure 2) pulsing at a rate of three seconds "on" and one second "off".

FINAL EVALUATION.

The unit was set up on the runway numbers, with the runway edge lights turned on. Subjects ranged in experience from low-time private pilots to Technical Center test pilots trained in evaluation of visual aids. They were not informed of the nature of the evaluation, other than that a lighting system was being tested. They were asked to indicate to an observor when the system was noticed, when a message was conveyed, and what the message was. Straight-in and circling approaches were made, in no particular order. The pilots were then asked if they had time to execute appropriate maneuvers during both types of approaches, as it was felt that recognition at 1/2 mile might not provide sufficient reaction time. Five types of aircraft-were used, ranging from single-engine to a Boeing 727-100.

A summary of pilot responses to specific questions is shown in figure 3. Pilot comments are summarized in figure 4.

RESULTS

At night, the unit was initially found to be too bright in that, even though it was extremely noticeable, "blooming" of the individual lights obscured the configuration. Reducing the voltage to one-third (40V) at night resulted in the best compromise of acquisition and recognition. Results were then very consistent.

During both high-brightness day and full dark night testing, the unit was acquired as "something on the runway" at from five to eight miles distance during a straight-in approach. A bright pulsing light in the runway touchdown zone should cause any pilot to question the advisability of landing, but without exception, each pilot recognized the signal as an "X" while at least 1-1/2 miles from the threshold, and received a definite "Do not land" signal in plenty of time to execute a safe missed approach (figure 5). The pulsing feature was noted by several pilots as effective in drawing attention to the device. As the white lights were quite visible against the background of a concrete runway, colored filters served only to decrease intensity, with no noticeable improvement in recognition.

Although a limited number of approaches were made with high-performance aircraft, subsequent sharing of information with personnel at San Francisco International Airport, where a similar device is in operational use, has reinforced results obtained at the Technical Center.

The device meets all criteria set forth, except criterium no. 2, that is, that it be visible, omnidirectionally, from any point 1/2 mile from the runway threshold. It was found that the required peak intensity could not be obtained from an omnidirectional source, and that rotation of a large system of lights is not practical. Since all of the subject pilots found the device to be adequate during a circling approach, it is felt that this requirement is not critical.

The device was not tested at the lowest limits of VFR conditions, but as the lamp used is the same one used in the Medium Intensity Approach Lighting System, it is felt that its visibility would be similar.

CONCLUSIONS

From the results of this effort, it is concluded that the performance standards for a temporarily-closed-runway visual aid should be as follows:

1. The device should be a lighted signal in the shape of the letter "X".

2. The device should be capable of being acquired at a range of at least 5 nautical miles both day and night.

3. The signal should be recognizable as a letter "X" from at least 1-1/2 nautical miles both day and night.

4. The signal should provide horizontal coverage to at least 15 degrees on each side of runway centerline, and provide vertical coverage from 0 degrees to 10 degrees above horizontal, both day and night, at a range of 1 1/2 nautical miles.

5. The signal should pulse at a rate of three seconds "on' and one second "Off".

RECOMMENDATIONS

If an FAA standard for a temporarily closed runway indicator is issued, it is recommended that the lighting configuration developed in the performance of this project be specified. The salient features of the device suggested for adoption as meeting the performance standards developed in this report are as follows:

1. Lamps shall be clear 150W/120V PAR-38 spotlights.

2. Lamps shall be arranged in the shape of the letter "X", on arms of fourteen-foot minimum length, crossed at ninety degrees.

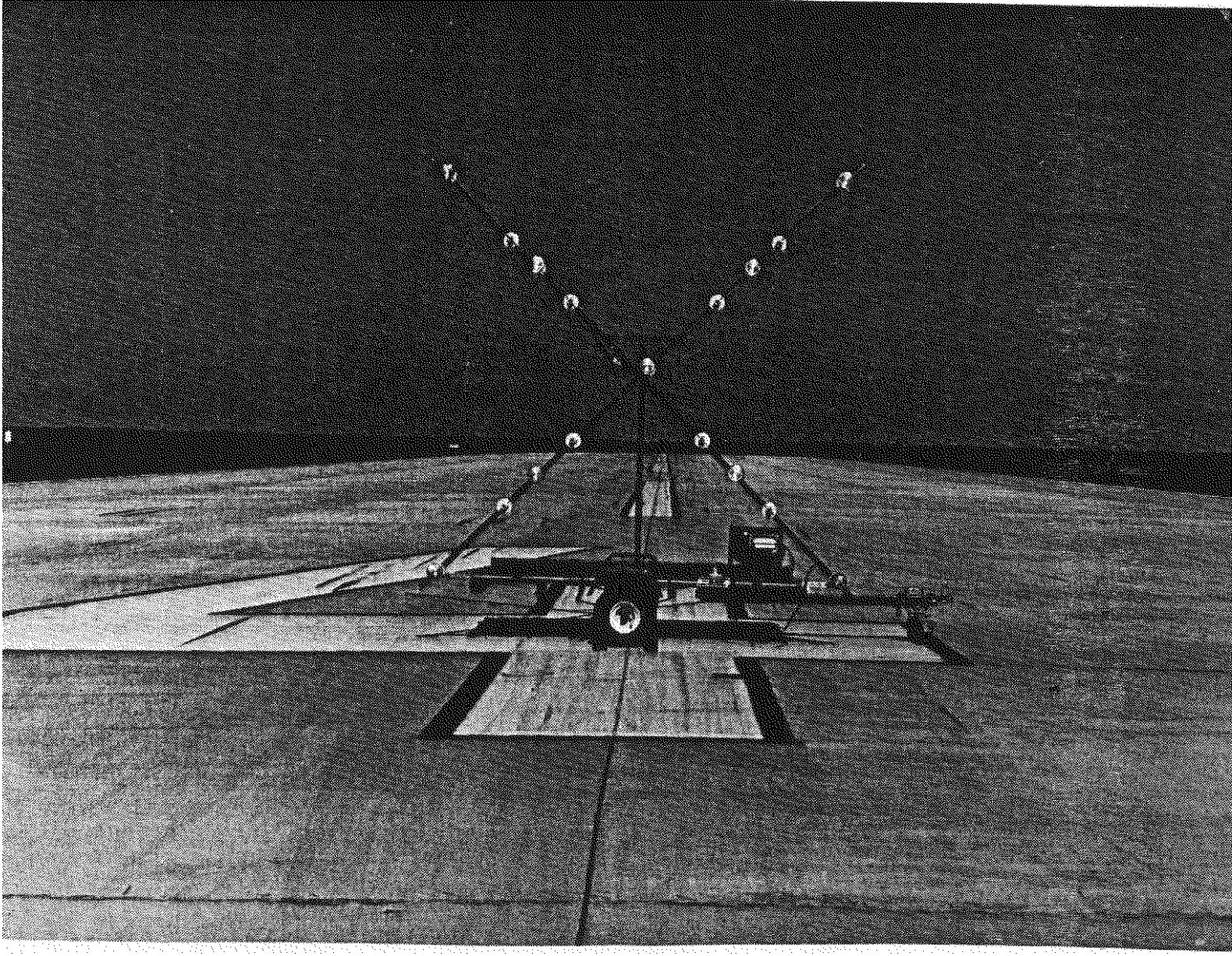
3. Lamps shall be placed on 3-foot B-inch centers.

4. Lamps shall be operated at 120V during daylight hours, and at 40V at night.

5. The device shall be energized by a portable power source.

6. The device shall be controlled by a timer causing the signal to pulse at an approximate rate of three seconds "on" and one second "off".

7. The vertical aiming of the array shall be adjustable to allow tilting to an optimum aiming angle of five degrees from vertical.



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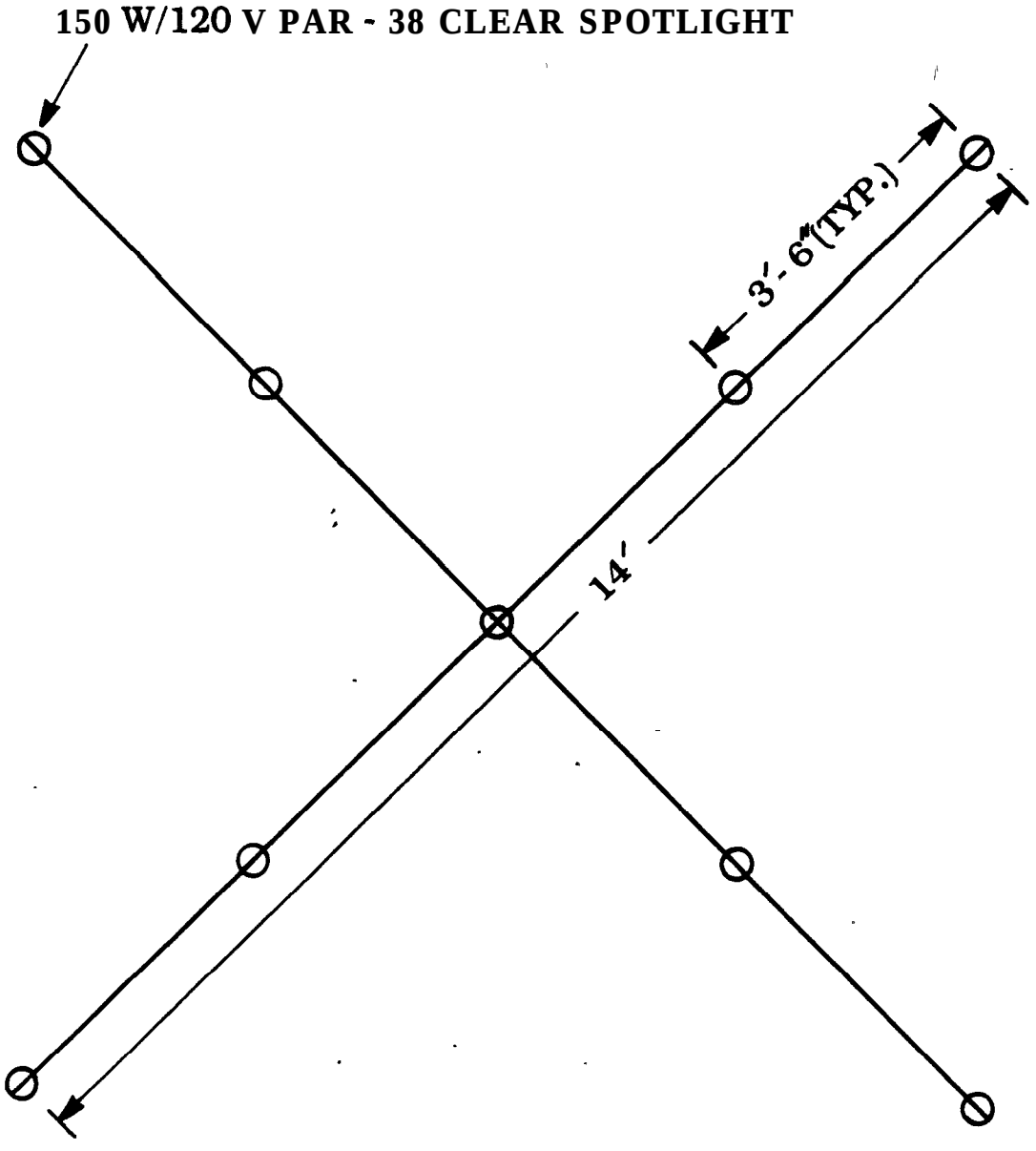

FIGURE 2. ULTIMATE LIGHTING CONFIGURATION

PILOT 15 Total

AIRCRAFT _____

TIME OF DAY _____

CONDITIONS _____

DURING STRAIGHT-IN APPROACH, AT WHAT POINT (DME) DID YOU NOTICE THE LIGHTING CONFIGURATION UNDER EVALUATION? Average 5.5 nm

AT WHAT POINT (DME) WAS A MESSAGE, IF ANY, CONVEYED TO YOU? 1.5 - 2.3 NM

WHAT WAS THE MESSAGE? Do not land - 15 (100%)

WAS THE MESSAGE CONVEYED IN TIME TO EXECUTE APPROPRIATE MANEUVERS? PLEASE_ SPECIFY "BARELY ADEQUATE, ADEQUATE, MORE THAN ADEQUATE", ETC.

STRAIGHT-IN APPROACH Adequate - 14, more than adequate - 1

PATTERN APPROACH Adequate - 15

PLEASE PROVIDE ANY ADDITIONAL COMMENTS:

FIGURE 3. SUMMARY OF QUESTIONNAIRE RESPONSES

Subject pilot comments, as recorded by the pilots on their post-flight questionaire forms, are shown below. The excerpts, while not necessarily direct quotes of individual pilots, reflect the general nature of the comments.

1. The pulsing feature of the device is important in drawing the pilot's attention. (3 pilots)

2. A different color might be better - red or amber. (2 pilots)

3. "X" intuitive for indicating a closed runway. '(1 pilot)

4. Pilot education would be necessary. (1 pilot)

5. Since the device is an obstruction; it should only be used when other equipment is on a temporarily closed runway. (1 pilot)

FIGURE 4. SUMMARY OF PILOT COMMENTS