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Improved Marking of Taxiway Intersections for Instrument Flight Rules (IFR) Operations

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16. Abstract A new visual aid to advise pilots that a taxiway intersection is being approached was developed at the Federal Aviation Administration (FAA) Technical Center. Subject pilots were asked to comment on the effectiveness of the taxiway intersection markings. Results of the evaluation indicate that the markings provide adequate advance warning of the approaching taxiway intersection and an indication of where to stop to ensure clearance from aircraft using the intersecting taxiway.			
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EXECUTIVE SUMMARY

The purpose of this project effort was to develop a visual aid to warn pilots that a taxiway intersection is being approached during low visibility conditions during both day and night operations.

Several prototype markings were developed and subjected to preliminary evaluation. The markings selected for final evaluation were as follows: Each approach to the taxiway intersection contained an enhanced centerline marking consisting of the existing taxiway centerline stripe paralleled by two 150-foot by 6-inch stripes. This marking segment was designed to provide distance-to-intersection warning information. Also present in the approach area was a 75- by 1-foot segmented stripe placed perpendicular to the existing taxiway centerline. This marking was designed to indicate where the aircraft must be stopped, if required by air traffic control, to ensure adequate clearance from other aircraft crossing the intersection. Subject pilots were asked to comment on the effectiveness of the markings.

Results of the evaluation indicate that the markings provide adequate advance warning that a taxiway intersection is being approached and an indication of where to stop to ensure clearance. The markings are effective during both day and night operations.

INTRODUCTION

PURPOSE.

The purpose of this project effort was to develop a visual aid to warn pilots that a taxiway intersection is being approached during low visibility conditions. The project was undertaken in response to a request from the Federal Aviation Administration (FAA) Advanced System Design Service submitted through the Office of Airport Standards. The work was accomplished under Technical Center Project No. T19-03N, Airport Lighting and Marking. The Technical Project Manager was Eric S. Katz.

BACKGROUND.

A need for improved marking and lighting of taxiway intersections for Instrument Flight Rules (IFR) conditions has been identified. Specifically, there is a requirement for a visual aid to provide pilots of aircraft taxiing under conditions of reduced visibility with advance warning that a taxiway intersection is being approached. The performance criteria specified for development of this visual aid were as follows:

1. The visual aid will provide adequate advance warning that a taxiway intersection is being approached, along with an indication of distance to the intersection.
2. It will provide a clear indication of where to stop to ensure adequate clearance from other aircraft crossing the intersection.
3. It will not be confused with any other airport visual aid.

International Civil Aviation Organization (ICAO) Annex 14 provides for a taxiway holding position marking, which has been incorporated into the final intersection warning design, as a component of the taxiway intersection markings. However, this ICAO marking was enhanced with additional warning stripes to meet criteria numbers one and three as stated above.

A decision was made that the taxiway intersection markings and lights should be evaluated separately. To date, only the taxiway marking evaluation has been completed, since the effectiveness of the markings used alone had to be determined. This then is an interim report describing only the evaluation of the markings. At airports where snow cover may obscure markings, the addition of lights may prove essential. A final report which will include details of the evaluation of taxiway intersection lights will follow at a later date.

DISCUSSION

PRELIMINARY EVALUATION.

For the preliminary evaluation, several different taxiway intersection markings were considered. These patterns all included (1) warning stripes in parallel with the existing taxiway centerline and (2) a holding position marking perpendicular to the taxiway centerline.

The purpose of the warning stripes is to provide distance-to-intersection information. Warning stripes of 100- and 200-foot lengths were evaluated. The 100-foot length was immediately eliminated from further consideration since, especially under low visibility conditions, it did not prove to be long enough to provide adequate warning of the approaching intersection. On the other hand, the 200-foot length seemed to be longer than was needed for warning purposes. A length of 150 feet was therefore chosen as optimum. Also considered at this point in the evaluation was the number of warning stripes required. Configurations containing a standard taxiway centerline stripe plus either one or two additional warning stripes were evaluated. The design containing the two warning stripes was chosen for the final evaluation because it was symmetrical and more conspicuous. All of the warning stripes were painted with standard yellow taxiway paint, and all of the stripes had a 6-inch width. This width was selected because it provided adequate visual guidance and was the same as the standard taxiway centerline stripe dimension.

The purpose of the holding position marking is to indicate where the aircraft must be stopped, if required by air traffic control, to ensure adequate clearance from other aircraft crossing the intersection. Several different configurations of holding position markings were evaluated initially to include the standard ICAO taxiway intersection marking. It soon became apparent, however, that changes or modifications to the ICAO marking would only be required to make it more conspicuous at a distance. Since this function would be more effectively achieved by use of the warning stripe component, it seemed reasonable to retain the standard ICAO marking without alteration as the "limit" indicator portion of the total configuration to be evaluated.

The configuration selected for final evaluation was a 75- by 1-foot segmented holding position marking identical to the ICAO standard taxiway intersection marking, supplemented by two 150-foot by 6-inch warning stripes (figure 1).

FINAL EVALUATION.

During the final evaluation, yellow reflective tape was used for the two warning stripes and for the holding position marking (figure 2). For comparison purposes, a fresh coat of standard yellow taxiway paint was applied to the existing taxiway centerline stripe. At night, the reflective tape was considerably more visible than the fresh paint. During daylight, the tape and fresh paint were about equally visible, except that the reflective tape was more visible than portions of older paint located immediately adjacent. The configuration was located for pilot evaluation at taxiway intersection A/D at the FAA Technical Center. All of the evaluation subjects chosen were Technical Center flight test pilots trained in the evaluation of visual aids. Each pilot was given a briefing to explain the purpose of the evaluation and the appearance of the taxiway intersection markings. During every test session (day and night), the subjects wore "foggles," a vision restricting device that simulated low visibility conditions of approximately 300 feet runway visual range (RVR). The "foggles" were activated well before the pilot encountered the taxiway intersection markings, and the subject was asked to indicate the time or point at which the warning stripes were first acquired. Two types of aircraft were used: a Convair 580 and a Boeing 727-100.

A summary of pilot responses to specific questions is shown on figures 3a and 3b. Pilot comments are summarized in appendix A.

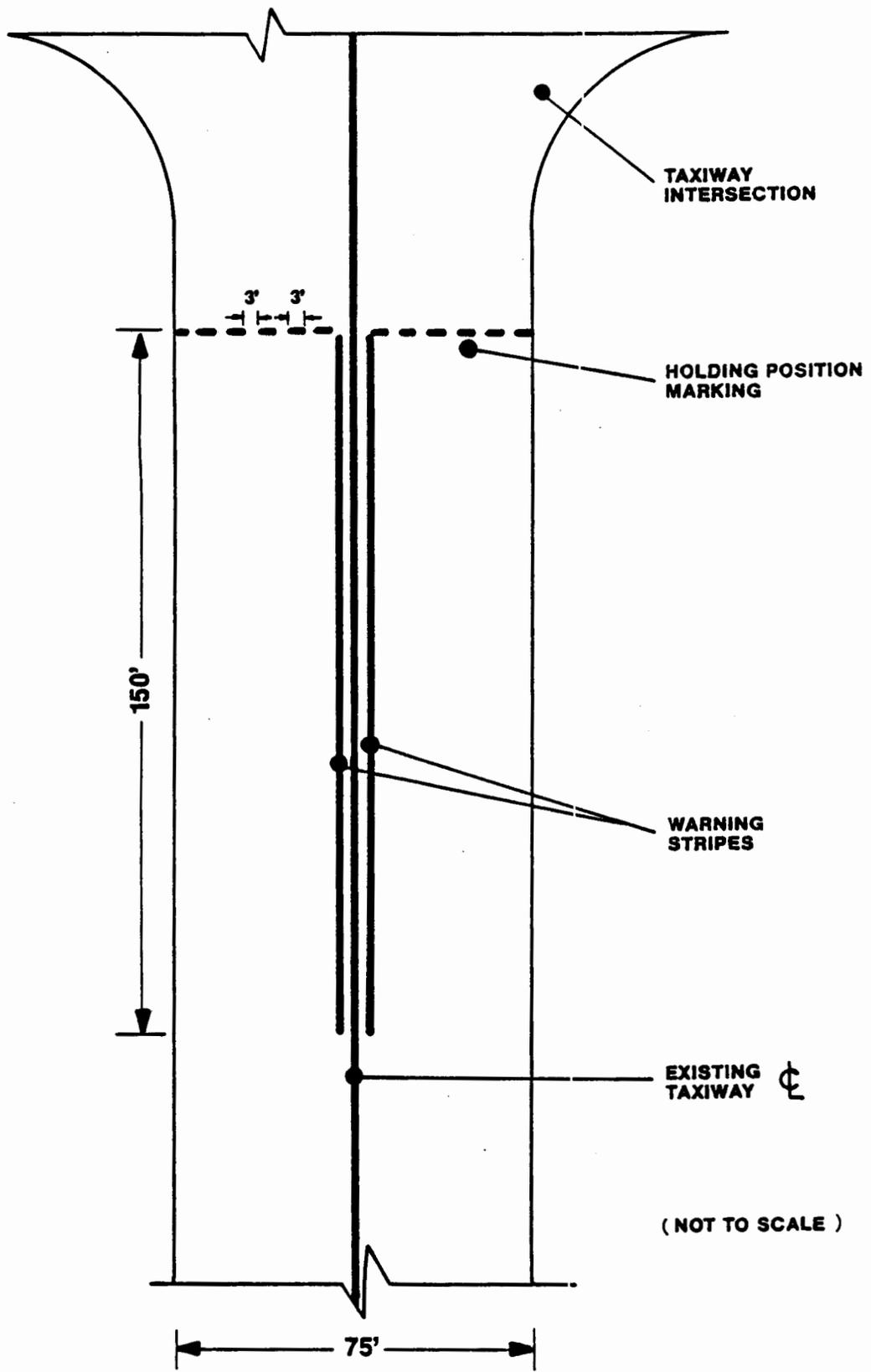


FIGURE 1. TAXIWAY INTERSECTION MARKINGS



FIGURE 2A. PHOTOGRAPH OF TAXIWAY INTERSECTION MARKINGS (NIGHT)

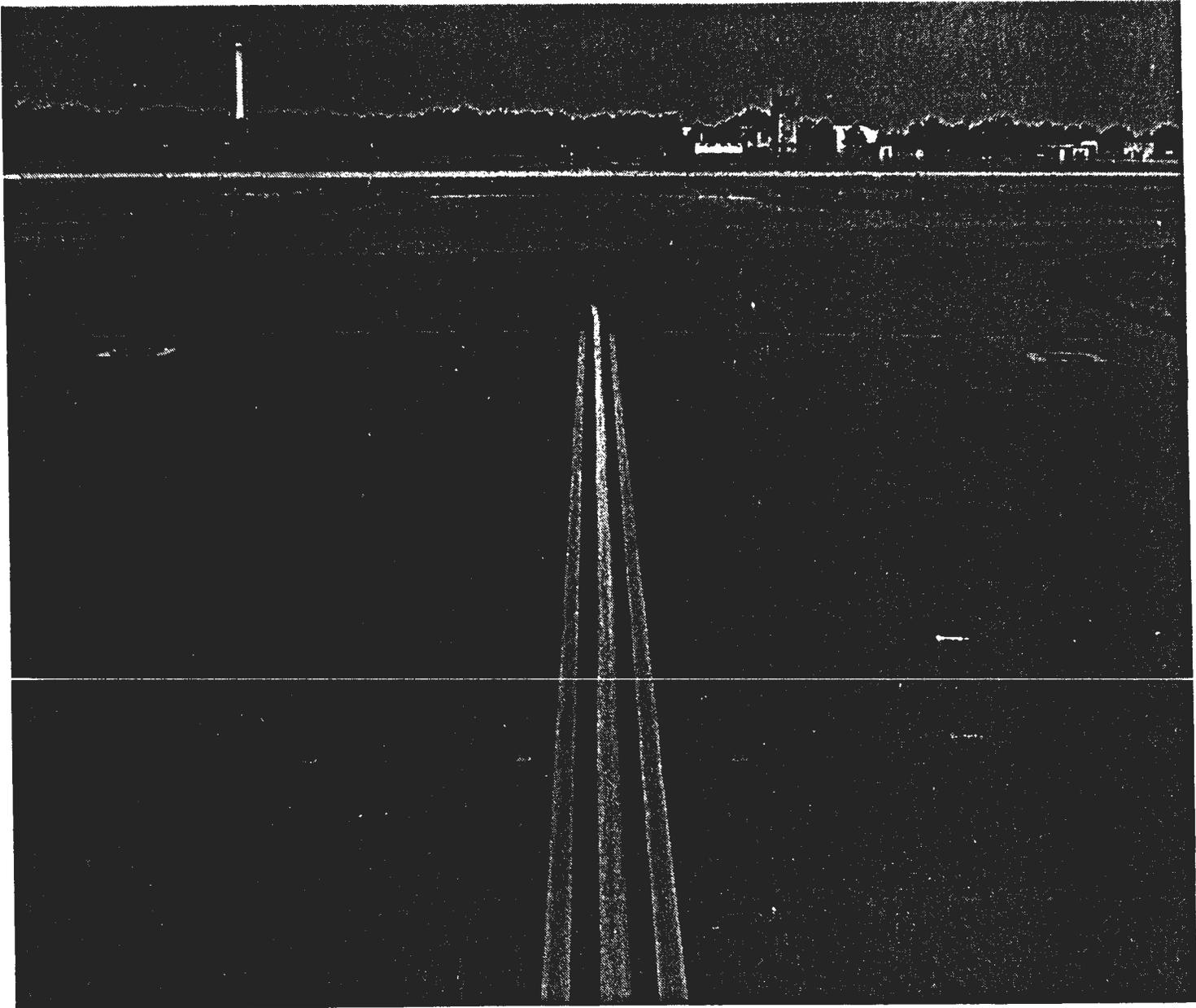


FIGURE 2B. PHOTOGRAPH OF TAXIWAY INTERSECTION MARKINGS (DAY)

TAXIWAY INTERSECTION QUESTIONNAIRE (MARKINGS)

Name 9 TOTAL Date _____ Day X or Night _____

Aircraft Type _____ Visibility (Actual or Simulated) 300 feet

T/W Stripes first acquired at average 255 ft.

1. Do the T/W Intersection Markings provide adequate advance warning that a T/W Intersection is being approached ?

Yes 8 (89%) No 1 (11%) (Comments) _____

2. Do the T/W Intersection Markings provide a clear indication of where to stop if required by ATC ?

Yes 8 (89%) No 1 (11%) (Comments) _____

3. Could the T/W Intersection Markings ever be confused with any other airport marking system ?

Yes 2 (22%) No 7 (78%) (Comments) _____

4. Do you have any further comments ?

THANK YOU !

FIGURE 3A. SUMMARY OF QUESTIONNAIRE RESPONSES (DAY)

TAXIWAY INTERSECTION QUESTIONNAIRE (MARKINGS)

Name 9 TOTAL Date _____ Day ___ or Night X
Aircraft Type _____ Visibility (Actual or Simulated) 300 feet
T/W Stripes first acquired at average 160 ft.

1. Do the T/W Intersection Markings provide adequate advance warning that a T/W Intersection is being approached ?

Yes 8 (89%) No 1 (11%) (Comments) _____

2. Do the T/W Intersection Markings provide a clear indication of where to stop if required by ATC ?

Yes 7 (78%) No 2 (22%) (Comments) _____

3. Could the T/W Intersection Markings ever be confused with any other airport marking system ?

Yes 0 (0%) No 9 (100%) (Comments) _____

4. Do you have any further comments ?

THANK YOU !

FIGURE 3B. SUMMARY OF QUESTIONNAIRE RESPONSES (NIGHT)

RESULTS

During all runs the simulated visibility restriction through the "foggles" was set to approximately 300 feet RVR. The pilots first acquired the taxiway warning stripes at an average distance from the marking of 160 feet at night and 255 feet during the day. During both day and night conditions, the pilots saw the ICAO holding position marking at varying distances of 50 to 150 feet from the marking. In all cases, the pilots were taxiing at very low speeds of approximately 10 miles per hour or less due to the visibility restriction introduced with the "foggles."

As shown in figures 3a and 3b, the markings satisfy all established criteria in the opinion of the majority of pilots. As evidenced in the pilot comment summary, the pilots appeared to depend heavily on the warning stripes for help in identifying the actual holding position location.

CONCLUSIONS

From the results of this evaluation effort, we can conclude that:

1. The taxiway intersection markings evaluated (figure 1) will provide adequate advance warning of an approach to a taxiway intersection and the clearance location at which to stop, if required, under day and night low visibility conditions.
2. The configuration retains the standard International Civil Aviation Organization (ICAO) holding position marking supplemented by two easily applied advance warning stripes.
3. Additional lighting components may be necessary at locations where snow, water, or other contaminants may obscure surface markings.
4. Retroreflective tape or paint should be used to enhance the effectiveness of the taxiway intersection markings.

APPENDIX A

SUMMARY OF PILOT COMMENTS

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

1. The approximate location of the taxiway intersection markings was known in advance. (3 pilots)

2. During nighttime operations, the taxiway centerline paint is not adequate, but the reflective tape used for the warning stripes and holding position marking is. (2 pilots)

3. Under fog restricted conditions, advance warning of an approaching taxiway intersection is not positive. (2 pilots)

4. The taxiway intersection markings will not be confused with any other airport markings if pilots are properly educated on these new markings. (2 pilots)

5. There is no difficulty in acquiring the holding position marking once the warning stripes have been identified and followed. (5 pilots)

6. The taxiway intersection markings perform their intended function if the aircraft is taxiing at slow speed. (2 pilots)

7. An additional line at the holding position would be an improvement. (2 pilots)

8. The taxiway intersection holding position marking could possibly be confused with an ILS hold line. (2 pilots)

9. The warning stripes are effective indicators. (2 pilots)

10. It would be very difficult to confuse the taxiway intersection markings with any other airport markings. (1 pilot)

11. The taxiway intersection markings would best be suited for small general aviation airports. (2 pilots)

12. The taxiway intersection markings are inadequate, particularly for jumbo jets. (1 pilot)

13. The taxiway intersection markings would be useless in snowy conditions. (1 pilot)

14. Lights at the holding location are necessary. (2 pilots)