



Evaluation of Fiber-Optic Runway Distance Remaining (RDR) Signs

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16. Abstract The Federal Aviation Administration (FAA) Office of Aviation Research, Airport Technology Research and Development Branch, AAR-410, conducted this project at the request of the FAA Office of Airport Safety and Standards, AAS-1. The purpose of this evaluation was to determine the effectiveness of fiber-optic runway distance remaining (RDR) signs. An initial evaluation conducted at the William J. Hughes Technical Center, Atlantic City International Airport, New Jersey, revealed that the prototype fiber-optic distance remaining signs were a significant enhancement over the traditional sign units currently installed across the country. To validate this finding, it was decided to conduct an in-service evaluation at the Greater Pittsburgh International Airport. The signs were installed for a 1-year period, at which time questionnaires were distributed to local pilots. The questionnaire responses showed that 93% of the pilots thought the signs were "very effective," and that 79% of them thought the signs were "better than" the traditional RDR signs. Subjects used the terms "sharper," "clearer," and "stood out better" frequently to explain the differences between the traditional signs and the fiber-optic units. The sharper appearance of the sign legend results in better performance during low-visibility conditions, a characteristic that had been noted on occasion during observation of the prototype fiber-optic sign at the Technical Center. This technical note provides a summary of the results found during this evaluation, and suggests that fiber-optic RDR signs be integrated into existing specifications so that they can be used as a safety enhancement at U.S. airports.					
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EXECUTIVE SUMMARY

The effort described in this technical note was accomplished in response to a request for airport research and development from the Office of Airport Safety and Standards, AAS-1. The purpose of this evaluation was to determine the effectiveness of fiber-optic runway distance remaining (RDR) signs.

An initial evaluation conducted at the FAA William J. Hughes Technical Center, Atlantic City International Airport (ACY), New Jersey, revealed that the prototype fiber-optic distance remaining signs were a significant enhancement over the traditional sign units currently installed across the country. To validate this finding, it was decided to conduct an in-service evaluation at the Greater Pittsburgh International Airport.

The signs were installed for a 1-year period, at which time questionnaires were distributed to local pilots. The questionnaire responses showed that 93% of the pilots thought the signs were "very effective" and 79% of them thought the signs were "better than" the traditional RDR signs. Subjects used the terms "sharper," "clearer," and "stood out better" frequently to explain the differences between the traditional signs and the fiber-optic units. The sharper appearance of the sign legend results in better performance during low-visibility conditions, a characteristic that had been noted on occasion during observation of the prototype fiber-optic sign at the Technical Center.

This technical note provides a summary of the results found during this evaluation and suggests that fiber-optic RDR signs be integrated into existing specifications so that they can be used as a safety enhancement at U.S. airports.

INTRODUCTION

PURPOSE.

The effort described in this technical note was accomplished in response to a request for airport research and development from the Office of Airport Safety and Standards, AAS-1. The purpose of this evaluation was to determine the effectiveness of fiber-optic runway distance remaining (RDR) signs.

OBJECTIVES.

The objective of this effort was to install and conduct an in-service evaluation of three fiber-optic RDR signs at a major air carrier airport and identify how the fiber-optic sign performs compared to traditional sign units, both in day/nighttime and low- and high-visibility conditions. In addition, this effort would identify any other characteristics of the sign units that make it different from traditional signs, such as "lamp-out" indicators and simple design construction. Most importantly, this effort identified those modifications to FAA Advisory Circulars that will be required to include provisions for use of fiber-optic signs at airports.

BACKGROUND.

Virtually all of the various guidance signs used on the modern day airport convey their message through use of particular legends (letters, digits, arrows, etc.) and, of equal importance, combinations of colors (white letters/red background, black letters/yellow background, etc.). While painted sign faces sufficed, initially, to provide daytime guidance, it almost immediately became necessary to light the signs for nighttime use as well. Although both externally and internally lighted signs were developed during the early years, the method of lighting the colored translucent faces with conventional internal light sources became, for a number of valid reasons, the preferred technique. As a result, signs utilizing tungsten filament, quartz, and fluorescent lights sources are being used.

In recent years, the use of fiber-optic bundles, concentrating or separating light from a single conventional source, to provide sign symbols and messages has become commonplace. The manufacturers of such fiber-optic signs claim many advantages, both economy and performance oriented, for their products and have taken steps to move into the airport guidance sign market. In fact, some Canadian airports have now completely changed over to fiber-optic signs.

Fiber-optic use for airfield signs was first suggested and tested at the Federal Aviation Administration (FAA) William J. Hughes Technical Center several decades ago, without encouraging results. The light transmission efficiency of fiber-optic bundles available at the time was relatively poor and light intensities attainable at the sign surface were extremely low. In addition, RDR sign systems were virtually nonexistent at civilian airports, and all other forms of airfield signs required back lighting of the areas surrounding the legend.

RDR signs, with a white legend on a black background, are finding increased usage at all airports and would seem to be an ideal application for fiber-optic sign techniques. Furthermore, the small, point source characteristic of fiber-optic bundles, now having considerable intensity capability, has potential for providing improved RDR sign performance under both high- and low-visibility conditions.

RELATED DOCUMENTS.

Federal Aviation Administration Advisory Circulars (AC) pertaining to RDR systems and equipment are:

- AC 150/5340-18C Standards for Airport Sign Systems
- AC 150/5345-44F Specification for Taxiway and Runway Signs

Documentation describing earlier fiber-optic sign testing includes the following:

- Fiber-Optic Airfield Sign Evaluation, Final Report. April 5, 1996. Authors: Thomas H. Paprocki and James W. Patterson.

DISCUSSION

In order to properly evaluate the concept of a fiber optically equipped RDR sign, and since no such device was commercially available, it was necessary to obtain a prototype unit constructed as nearly in accordance with the FAA specifications as possible. Arrangements were made with an established manufacturer of fiber-optic materials and devices to construct such a sign. This prototype sign, shown in figures A-1 and A-2 of appendix A, was temporarily installed within the standard RDR sign system at the Atlantic City International Airport (ACY), New Jersey. It remained in the field for approximately 2 years for preliminary evaluation, during which time FAA lighting engineers observed and evaluated the fiber-optic sign in comparison with the other conventionally lighted RDR signs within the system. Whenever possible, the evaluation was conducted under good and poor visibility conditions. The light characteristics of the sign unit were also varied during this evaluation by use of both neutral density filters and differing lamp sources. The following is an excerpt from the interim report describing the preliminary testing at ACY.

“A prototype sign, prepared as closely as possible to the appearance and operation of standard internally lighted runway distance remaining (RDR) signs, was obtained on loan from a fiber-optic system vendor. The sign was installed at the FAA Technical Center for evaluation and was compared directly with installed conventional RDR signs for both daylight and nighttime effectiveness.

One of the standard internally lighted RDR signs, located at the midpoint of the principal runway 13/31 at the Technical Center airport, was replaced with the prototype fiber-optic sign displaying the appropriate “5” and “5” back-to-back legend and powered with the existing 6.6 ampere circuit. FAA test pilots and visual

guidance engineering personnel were afforded the opportunity of evaluating the sign's appearance and effectiveness under varying day and night conditions while high-speed taxi runs were conducted past the sign. The remaining standard RDR signs, to include a sign with the same legend located immediately across the runway, provided the opportunity for direct comparisons.

Pilot opinions and ratings of effectiveness, as expressed on post-session questionnaire forms, revealed that the fiber-optic signs were very effective and, in several respects, superior to conventional internally lighted RDR signs.”

The results of this preliminary evaluation were most encouraging, and a decision was made to continue testing under in-service conditions at a nearby air-carrier airport. The Greater Pittsburgh International Airport (PIT) was selected for a number of reasons, as enumerated below:

1. Nearness to the FAA William J. Hughes Technical Center, to facilitate installation and monitoring tasks.
2. A wide variety of weather conditions to determine suitability for sign use under both fair and inclement environments.
3. A cooperative maintenance establishment to ensure assistance with initial installation and service. Also, PIT personnel had participated in several previous FAA evaluations.

Since some relatively minor changes to the prototype fiber-optic sign were recommended as a result of the preliminary evaluation, three additional signs were obtained from the initial fabricator for evaluation at PIT. Once again, the new signs were constructed to closely approximate the standard FAA specification RDR signs and were identical with regard to physical size and legend dimensions. The original ACY installation light sources (50-watt reflector type halogen lamps) were retained for this evaluation due to their favorable performance/illumination level. When not energized, the fiber-optic RDR sign appearance was virtually identical to that of the standard conventional sign as illustrated in figure A-3 of appendix A.

INSTALLATION

As a result of discussions with experienced PIT operations personnel, it was decided that the three fiber-optic signs should be installed as replacements for three conventional signs in the RDR sign system that serves runway 10L-28R. It was recommended that the signs be installed in the midsection of the runway to facilitate evaluation from aircraft operating in either direction on the runway. Being at the center location of the 10,000 foot runway, the fiber-optic signs bore the “4”, “5”, and “6” legends. The signs were mounted on existing standard frangible couplings and powered from the runway edge lighting circuit through existing isolation transformers (figure A-4 of appendix A). Because the cabinets of the fiber-optic sign units were narrower than those of the original sign cabinets, a supplemental mounting plate was added to the bottom of the new

sign units. This plate provided the extra surface required to span between the four existing frangible couplers.

To facilitate maintenance efforts and to reduce the need for immediate replacement of failed lamps, a switch was provided to substitute a second lamp without disassembling the fixture (figure A-5, appendix A). Previous testing at the factory had established that a reduction of input current from 6.6 amperes to 2.8 amperes, the lowest edge light system intensity step on PIT airfield lighting circuits, appeared to have only a minimal diminishing of sign illumination, so no circuitry to compensate for a reduced current operation was incorporated. Figures A-6 and A-7, of appendix A show prototype sign number 4 in both daytime and nighttime conditions.

The following highlights features of the prototype sign unit. Many of these are based on results and conclusions of the original evaluation of the sign at the Atlantic City International Airport.

- The 50W-reflector style lamp used to illuminate the prototype sign units was found to be sufficient without the use of any color filters. A lunar-white filter was initially evaluated but was found to be too white in color. It was decided that the sign should not have any filters.
- The fiber bundles were made of glass fiber, jacketed with PVC for protection from the elements. The exposed ends of the fiber bundles that exit the sign face were highly polished. Each fiber extrusion was spaced 1/2 inch from each other, centered within the character on the sign.
- High-intensity scotch-lite white reflective material was used for the legends, with standard grade engineering black on the background.
- One side of the sign face was hinged to facilitate easy access to the interior of the sign unit.
- Lamp-out indicators were implemented to facilitate easy monitoring from the runway side of the sign unit.

EVALUATION

Once the signs were installed, user pilot organizations were provided with pilot briefing sheets (appendix B) and pilot questionnaires (appendix C). It was intended that the briefing sheets would be distributed initially, requesting that the pilots delay filling out the questionnaires until they had been afforded time to adequately view and compare the new fiber-optic signs. Envelopes for returning the questionnaires were also provided. These materials were distributed to the following PIT-based groups:

1. U.S. Airways flight crews
2. U.S. Air Force KC-135 reserve flight crews

3. U.S. Army C-130 reserve flight crews
4. Various air cargo flight crews

In addition, FAA William J. Hughes Technical Center personnel conducted an evaluation flight to PIT (using a Convair 580 turboprop aircraft) to obtain FAA project engineer and pilot evaluation and comment input. Project personnel also continuously monitored the opinions of PIT operations and airfield maintenance crews that were constantly exposed to the sign units. This specific activity occurred throughout the duration of the project.

TEST RESULTS

Pilot questionnaires were collected at the FAA William J. Hughes Technical Center for analysis. A total of 15 responses were received, consisting of 14 completed questionnaires and one e-mailed commentary. A summary of the responses is provided on the sample questionnaire found in appendix C. At the bottom of the questionnaire, a space was provided for additional written comments. A summary of the written comments received on the questionnaires follows:

1. Much sharper, 3 times the range
2. The new signs seemed clearer
3. Signs were fantastic – definite improvement over traditional
4. Didn't see much difference in new lighting system
5. Clear and stood out better – could find at 3,000 feet
6. Clearer, brighter, and easier to read
7. Not as fuzzy and blurry as 1-3 and 7-9 (conventional RDR signs)
8. Home run – excellent readability
9. Seemed clearer and brighter, thus easier to see and read.
10. Clarity was best.
11. Fiber-optic signs were easier to depict at a distance. We saw them while running up the engines on 28R at PIT.

The content of the e-mail evaluation is included below in its entirety:

1. "I just wanted to let you know that I have seen the fiber-optic runway remaining lights at PIT and find them a great improvement over the older version."

The pilot questionnaire responses, both checked items and subjective comments, show an overwhelmingly positive evaluation of the fiber-optic signs. It is particularly significant that the subjects used the terms sharper, clearer, and stood out better frequently to explain the differences between the older conventional signs and the fiber-optic units. It would appear that the relatively thin fiber-optic legend does not tend to "bloom" as does the wide stroke legend of the standard sign when displayed at the higher intensities. This sharper definition of the legend results in better sign performance during low-visibility conditions, a characteristic that had been noted on occasion during observation of the prototype fiber-optic sign at the Technical Center.

With regard to the one subject that rated the fiber-optic signs as "marginally effective" on the questionnaire, and commented that he "didn't see much difference in the new lighting system," it seems probable that he only viewed the sign system during daylight conditions. In that event, the lighting would be turned off, being interconnected with the runway edge lighting system, and the fiber-optic sign would then look identical to the other standard signs.

The three fiber-optic RDR signs were installed at PIT for slightly over 1 year and, throughout the period, required no maintenance efforts. A single frangible coupling failed and was replaced after approximately 3 months, but this was probably due to the effects of corrosion or to a coupling flaw. No components of the signs failed, and it was not necessary to replace any of the lamps.

CONCLUSIONS

From the results of this evaluation, and from a study of the pertinent FAA Advisory Circular, it can be concluded that:

- The fiber-optic RDR signs, as tested, provides significantly improved nighttime and low-visibility performance in comparison with the standard L-858B internally lighted sign.
- Daylight performance is identical to that of the standard sign since retroreflective material is used to present the white legend.
- Appearance in darkness in the event of a lamp/power failure is significantly better than that of the standard sign since retroreflective material replaces the standard translucent legend material. These sign units used high-intensity, scotch-lite white for the legends.
- Maintenance of the sign unit is very easily accomplished due to the design characteristics of the sign unit. The ability to facilitate "lamp out indicators" on the side of the sign unit is a unique advantage to the fiber-optic system.
- When viewing the sign from a distance, the character of the sign is very legible. As the sign is passed, the viewer begins to leave the "main beam" of the sign face, and the sign appears to fade off. This occurs at the same time the viewer should begin looking for the next sign unit. Many evaluators found this to be a great advantage of the fiber-optics because it fades off as it is passed, thus making the sign less distracting.

APPENDIX A—PHOTOGRAPHS OF PROTOTYPE FIBER-OPTIC
RUNWAY DISTANCE REMAINING SIGNS

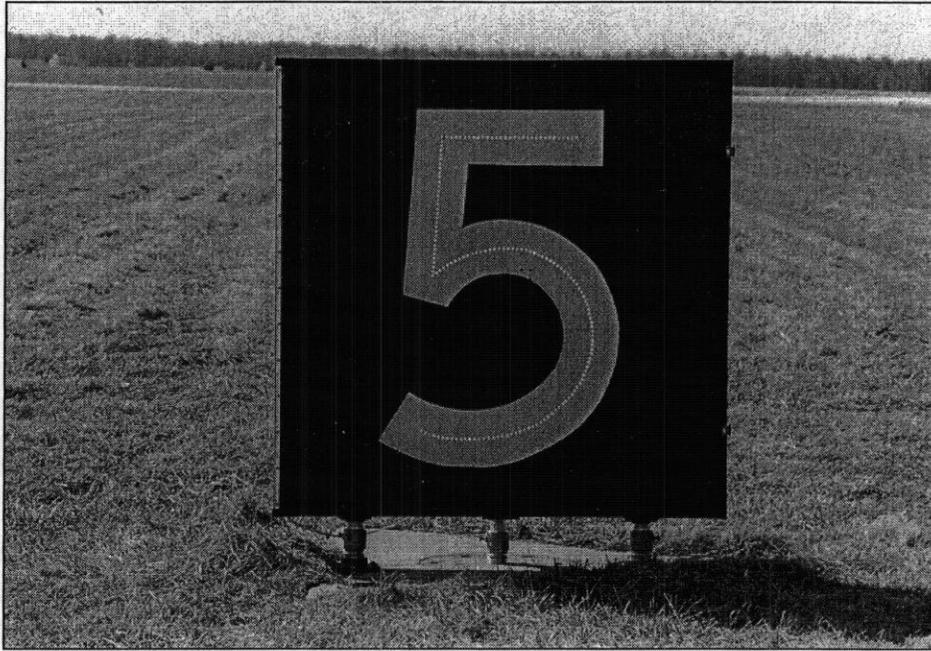


FIGURE A-1. FIRST GENERATION SIGN INSTALLATION AT ACY (DAY)

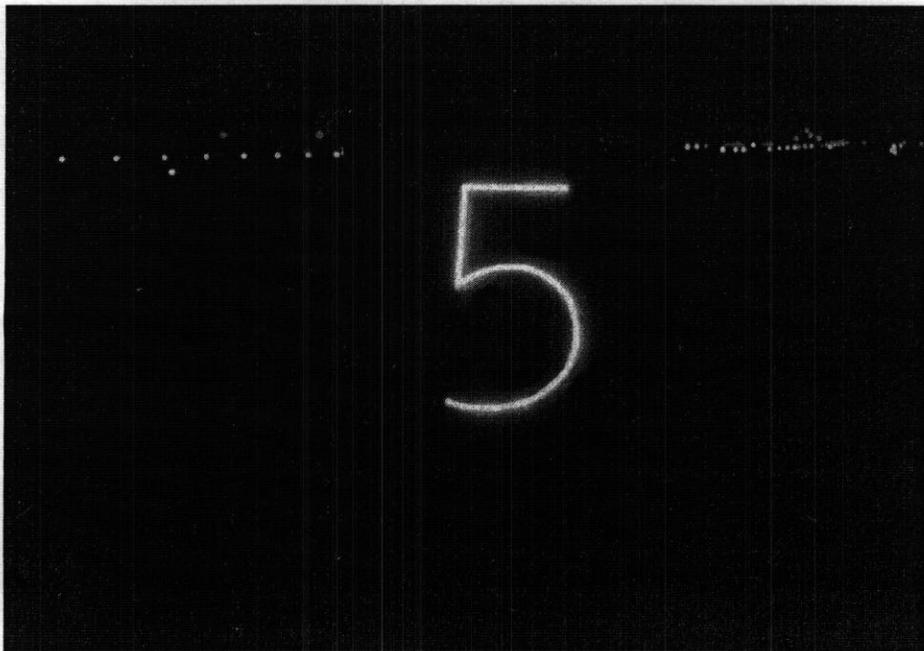


FIGURE A-2. FIRST GENERATION SIGN INSTALLATION AT ACY (NIGHT)

FIGURE A-2. SIGNWORKING DETAIL



FIGURE A-3. SECOND GENERATION SIGN AT PIT

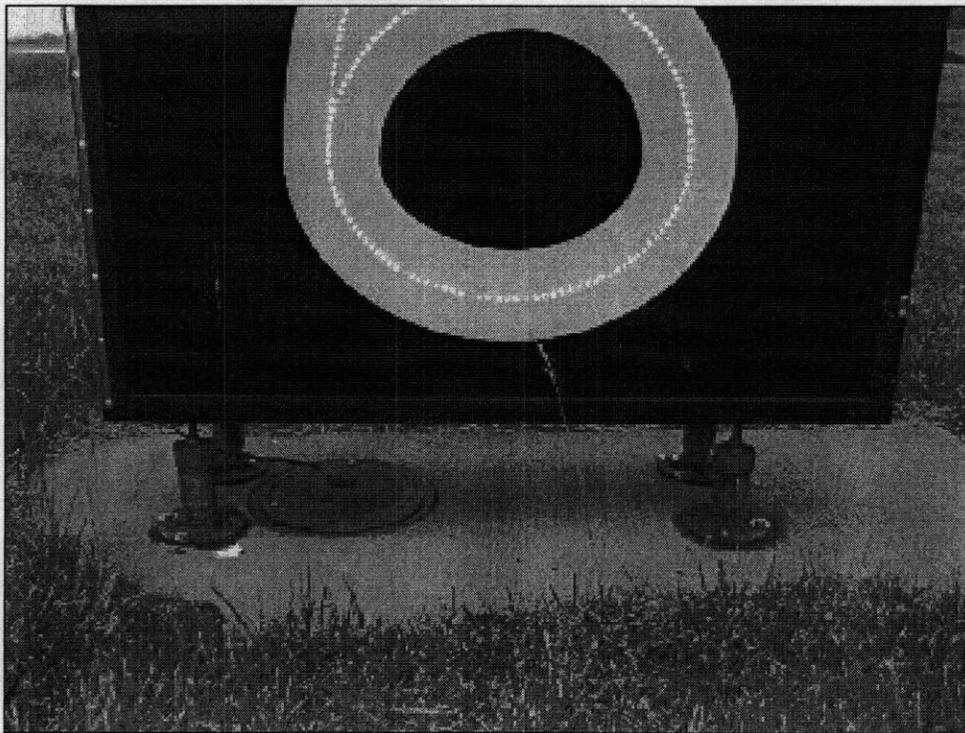


FIGURE A-4. SIGN MOUNTING DETAIL

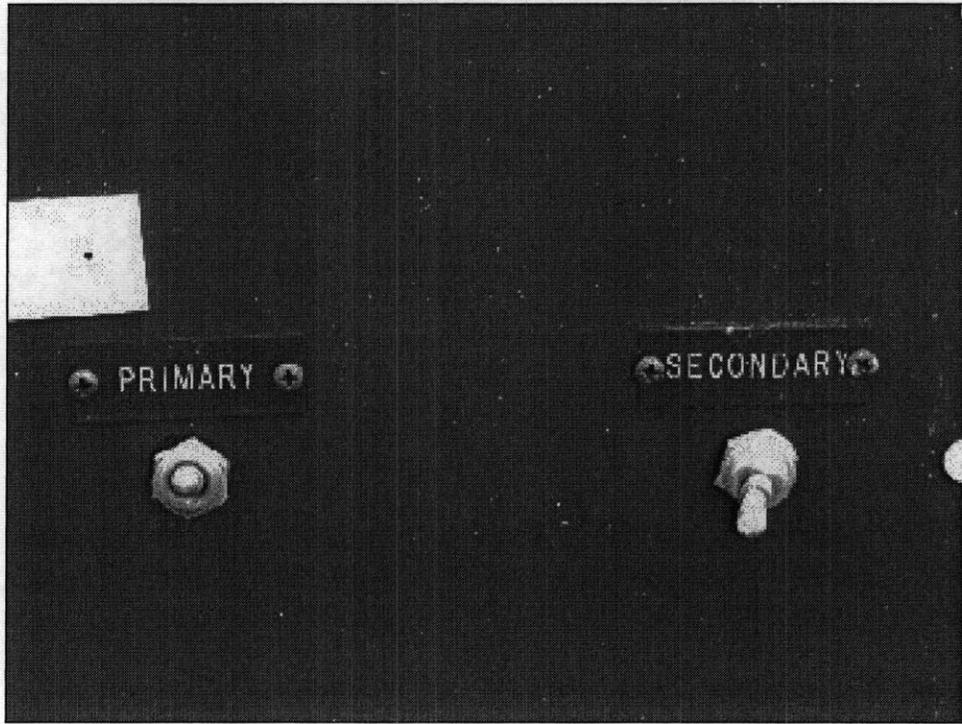


FIGURE A-5. ALTERNATE LAMP SWITCHES

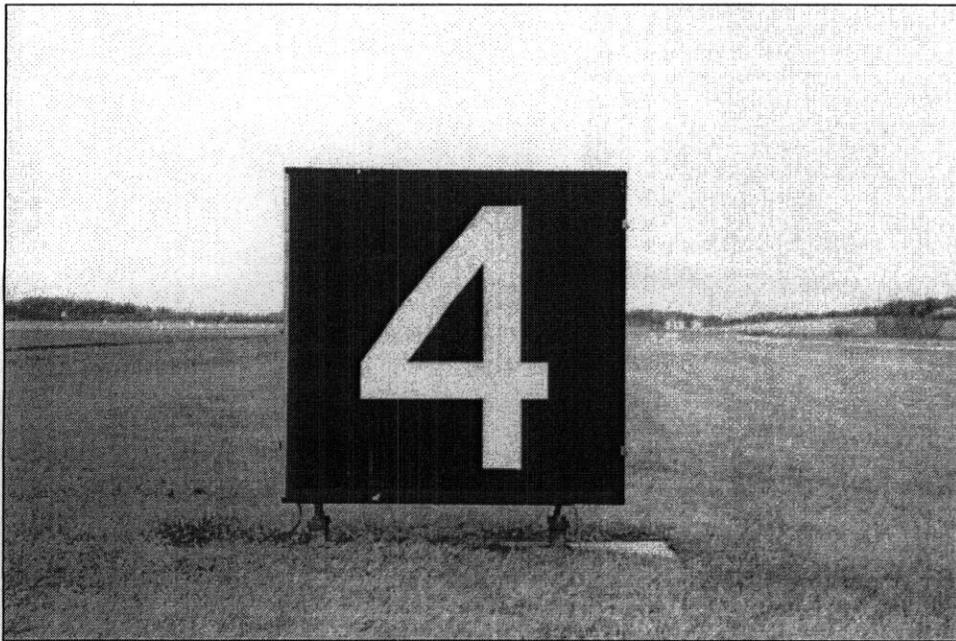


FIGURE A-6. SIGN AT PIT ILLUMINATED DURING DAYTIME

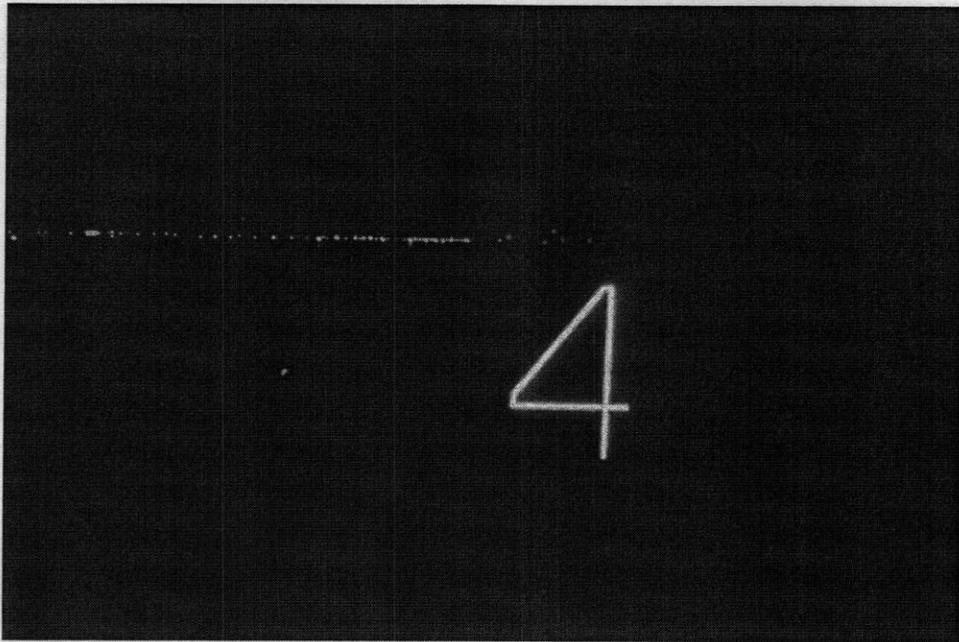


FIGURE A-7. SIGN AT PIT ILLUMINATED DURING NIGHTTIME

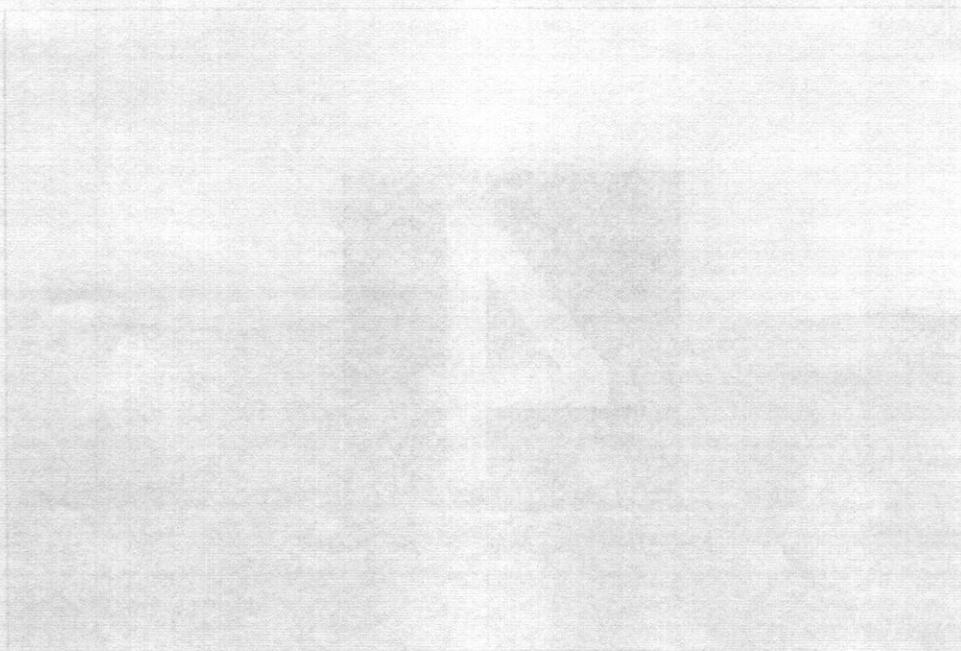


FIGURE A-8. SIGN AT PIT ILLUMINATED DURING DAYTIME

APPENDIX B—PROJECT DESCRIPTION/PILOT BRIEFING SHEET

FIBER-OPTIC RUNWAY DISTANCE REMAINING SIGN EVALUATION AT

PITTSBURGH INTERNATIONAL AIRPORT (PIT)

PROJECT DESCRIPTION/PILOT BRIEFING SHEET

The purpose of this project is to evaluate the effectiveness of fiber-optic technology as applied to the illumination of airport signs. Three prototype runway distance remaining (RDR) signs have been installed for evaluation at Pittsburgh International Airport (PIT). The signs have been placed within the array of standard RDR signs that are located on the North side of runway 10L-28R. Specifically, the three fiber-optic signs have replaced the three standard signs at the 6000-ft, 5000-ft, and 4000-ft runway distance remaining locations. These signs will appear as a fiber optically illuminated “6”, “5”, and “4” during operations conducted in either the 10L or 28R direction.

We would greatly appreciate input from the user-pilot community regarding the relative effectiveness of the fiber-optic signs, as compared to that of the standard signs, particularly during low-visibility and/or nighttime operations. The signs have been installed for a few months already and will remain in place for the remainder of the year. Hopefully, you have had an opportunity to observe them while operating on that runway or, if you haven't already, you will have a chance to within the next few months. A brief pilot questionnaire is attached to this cover page that solicits your opinion as to the effectiveness of these important airport visual aids. We ask that you fill out the questionnaire after you have had enough opportunity to form an opinion of the fiber-optic signs. Once the questionnaire is completed, please return it to the Federal Aviation Administration (FAA) William J. Hughes Technical Center by using the attached preaddressed, stamped envelope.

We thank you, in advance, for your cooperation. The input that we receive from you is very useful in helping us to determine the effectiveness of these prototype signs, and whether these types of signs should be included in future FAA sign specifications.

If you have any further questions or comments, feel free to contact the Project Manager at:

Project Contact:

Jim Patterson

FAA William J. Hughes Technical Center

Airport Technology R&D Branch, AAR-411, Bldg.#296

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Email: jim.patterson@tc.faa.gov

Once again, thank you for your cooperation.

APPENDIX C—PILOT QUESTIONNAIRE AND SUMMARY OF RESULTS

FIBER-OPTIC SIGN EVALUATION QUESTIONNAIRE

Please complete the following short questionnaire after you have had a sufficient experience with the fiber-optic “4”, “5”, and “6” numbered runway distance remaining sign on runway 10L-28R . We are especially interested in effectiveness during low-visibility conditions and/or at night.

Name: 14 subjects Organization: _____ Date: _____

1. Overall effectiveness of these fiber-optic signs at various distances:

	<u>Very Effective</u>	<u>Marginally Effective</u>	<u>Not Effective at All</u>
2000 Feet	<u>13 (93%)</u>	<u>1 (9%)</u>	<u>0</u>
1000 Feet	<u>13 (93%)</u>	<u>1 (9%)</u>	<u>0</u>
500 Feet	<u>12 (92%)</u>	<u>1 (10%)</u>	<u>0</u>

2. Comparative rating of these fiber-optic signs with the conventionally lighted standard signs displaying numbers “1-3” and “7-9” along the same runway at night:

Better than: 11 (79%) Equal to: 3 (11%) Worse than: 0

3. If you observed the fiber-optic signs under low visibility conditions, how would you compare their effectiveness with the standard signs:

Better than: 8 (80%) Equal to: 2 (20%) Worse than: 0

4. Please give us some indication of why you rated the fiber-optic signs as you did (Better, worse, etc.). This might include comments on visibility, readability, intensity or other characteristics.

SEE TEXT

THANK YOU FOR YOUR PARTICIPATION!

