

# **Alternating Yellow and Green Taxiway Centerline as a Runway Safety Enhancement**

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16. Abstract <p>This research effort was conducted to investigate and validate the suitability of installing alternating yellow and green taxiway centerline lights on taxiway segments located between the runway hold position marking and the runway centerline in the direction approaching the runway. This lighting configuration is the same configuration frequently used to identify the centerline of a taxiway exiting a runway, except that it is viewed from the opposite direction. This lighting configuration would serve as a visual cue to pilots and vehicle drivers that they are about to enter the runway environment/runway safety area (RSA). The objective of this research effort was to determine how the proposed lighting configuration would appear to pilots approaching the hold line (runway environment/RSA), if presently available lighting fixtures are adequate for the purpose, if present spacing standards are adequate for the purpose, if pilots interpret the purpose of the alternating yellow and green taxiway centerline lighting configuration correctly, and the cost factors involved in making such a change.</p> <p>The alternating yellow and green taxiway centerline lighting configuration was found to be suitable for various reasons. Presently available fixtures, such as the L-852 taxiway centerline fixture, were found to be adequate in color, intensity, and alignment, for this purpose, as long as they are installed, aligned, and maintained as required in the appropriate Advisory Circulars. Subjects were unanimous in judging the spacing as satisfactory for this purpose. The results of this research effort showed that subjects were able to recognize that there was some kind of transition at the point at which the lighting changed from green to the alternating pattern. The cost to modify a taxiway/runway entrance to the alternating yellow and green taxiway centerline configuration is dependent on the length of the taxiway section, the complexity of the intersection, and the number of fixtures available. Price estimates for replacing the appropriate filters, as well as other serviceable parts, ranged from \$50 to \$200 per fixture, including labor and parts. This price makes the alternating yellow and green taxiway centerline lighting configuration one of the cheapest alternatives for potentially reducing runway incursions compared to many of the more expensive stop bar or radar-based warning systems.</p> <p>Having considered all of the data and information gathered during this evaluation effort, illuminating the runway environment/RSA area with alternating yellow and green taxiway centerline fixtures was found to be a cost-efficient, easy to deploy tool that will assist in reducing runway incursions at those airports that have existing taxiway centerline lights.</p>					
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## LIST OF ACRONYMS

RSA	Runway safety area
FAA	Federal Aviation Administration
ILS	Instrument Landing System
MLS	Microwave Landing System
SDF	Standiford Field

## EXECUTIVE SUMMARY

This research effort was conducted to investigate and validate the suitability of installing alternating yellow and green taxiway centerline lights on taxiway segments located between the runway hold position marking and the runway centerline in the direction approaching the runway. This lighting configuration is the same configuration frequently used to identify the centerline of a taxiway exiting a runway, except that it is viewed from the opposite direction. This lighting configuration would serve as a visual cue to pilots and vehicle drivers that they are about to enter the runway environment/runway safety area (RSA). The objective of this research effort was to determine how the proposed lighting configuration would appear to pilots approaching the hold line (runway environment/RSA), if presently available lighting fixtures are adequate for the purpose, if present spacing standards are adequate for the purpose, if pilots interpret the purpose of the alternating yellow and green taxiway centerline lighting configuration correctly, and the cost factors involved in making such a change.

The alternating yellow and green taxiway centerline lighting configuration was found to be suitable for various reasons. Presently available fixtures, such as the L-852 taxiway centerline fixture, were found to be adequate in color, intensity, and alignment, for this purpose, as long as they are installed, aligned, and maintained as required in the appropriate Advisory Circulars. Subjects were unanimous in judging the spacing as satisfactory for this purpose. The results of this research effort showed that subjects were able to recognize that there was some kind of transition at the point at which the lighting changed from green to the alternating pattern. The cost to modify a taxiway/runway entrance to the alternating yellow and green taxiway centerline configuration is dependent on the length of the taxiway section, the complexity of the intersection, and the number of fixtures available. Price estimates for replacing the appropriate filters, as well as other serviceable parts, ranged from \$50 to \$200 per fixture, including labor and parts. This price makes the alternating yellow and green taxiway centerline lighting configuration one of the cheapest alternatives for potentially reducing runway incursions compared to many of the more expensive stop bar or radar-based warning systems.

Having considered all of the data and information gathered during this evaluation effort, illuminating the runway environment/RSA area with alternating yellow and green taxiway centerline fixtures was found to be a cost-efficient, easy to deploy tool that will assist in reducing runway incursions at those airports that have existing taxiway centerline lights.



## INTRODUCTION

### PURPOSE.

This effort was conducted to investigate and validate the feasibility of installing alternating yellow and green taxiway centerline lights on taxiway segments located between the runway hold position markings and the runway centerline in the direction approaching the runway. This lighting configuration would serve as a visual cue to pilots and vehicle drivers that they are about to enter the runway environment/runway safety area (RSA).

### OBJECTIVE.

The objective of this research effort was to determine how the proposed lighting configuration would appear to pilots approaching the hold line (runway environment/RSA) and to also determine the following associated considerations:

- Are presently available lighting fixtures adequate?
- Are present spacing standards adequate?
- Will pilots interpret the new configuration correctly?
- What are the cost factors involved in making such a change?

### BACKGROUND.

The Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5340-30, “Design and Installation Details for Airport Visual Aids,” provides airports with guidance for lighting exit taxiways with color-coded alternating yellow and green fixtures to warn pilots and vehicle drivers that they are within the runway environment or within the Instrument Landing System/Microwave Landing System (ILS/MLS) Critical Area. These coded lights are installed from the runway centerline on the curve to the limit of the runway environment or ILS/MLS Critical Area, facing only towards the runway side of the hold position marking. This makes the lights only visible when exiting the runway.

### DISCUSSION.

It has been suggested that the already existing use of alternating yellow and green taxiway centerline lights to warn pilots exiting a runway or the runway environment could, by using the same color coding in the reverse direction, serve as a warning of approach to the runway environment from an intersecting taxiway. A lighting configuration such as this would act as an enhancement to the hold position area, adding a safety factor that could lead to a reduction in runway incursions. It could also be applied to any airport with existing taxiway centerline fixtures, and would have a minimum cost since it would entail only the replacement of a limited number of colored filters in existing fixtures.

## RELATED DOCUMENTS.

The following ACs provide guidance, specifications, and standards for lighting of airport surfaces:

- AC 120-57, “Surface Movement Guidance and Control System”
- AC 150/5340-30, “Design and Installation Details for Airport Visual Aids”
- AC 150/5345-46, “Specification for Runway and Taxiway Light Fixtures”

## EVALUATION APPROACH

### METHOD.

This evaluation was conducted at the FAA William J. Hughes Technical Center, Atlantic City International Airport, New Jersey, on September 16, 2004.

The color-coded configuration was temporarily emplaced on the FAA ramp, in a typical curved taxiway entrance configuration (figure 1) using standard L-852 taxiway lighting fixtures installed above ground and powered with on-the-surface cables connected to portable generators. Variable voltage transformers (Variacs) were inserted in the circuits to provide the capability of varying the fixture intensity as required. The wiring on the surface was arranged so that it was possible to drive vehicles along the length of the configuration.

The simulated taxiway lighting configuration included the following characteristics:

- A lead-in segment of solid green colored centerline lights for a distance of 200 feet prior to the hold line location (the beginning of the runway environment).
- A continuing segment of alternating yellow and green taxiway lights along the straight and curved section of the taxiway/runway entrance to the point of tangency with the runway centerline.
- All spacing and alignment was in accordance with the appropriate FAA AC.
- All fixtures were standard FAA-approved L-852 taxiway lights, with standard lamps and filters.

### EVALUATION SUBJECTS.

The evaluation subjects included pilots holding commercial and private certificates and, in addition, experienced airport engineers from both the FAA Headquarters in Washington and from the FAA William J. Hughes Technical Center.

The evaluation subjects were afforded the opportunity to view the coded lighting configuration under the existing weather and ambient light conditions after having received a thorough briefing as to the purpose and configuration of the presentation. The weather on the evening of the

evaluation was clear with unlimited visibility and, accordingly, the lights were set to the lowest intensity setting (4.8 amperes) attainable with a three-step regulator.

After viewing the configuration while standing several hundred yards away, individual subjects were driven in ground vehicles, at typical aircraft taxi speeds, through the display. The vehicle was stopped at the simulated hold position, as though waiting for a clearance, and then driven along the curved, color-coded taxiway lights.

Subsequent to the evaluation session, the subjects were required to complete a postsession questionnaire (figure 2).

### SYSTEM DESCRIPTION.

A photograph showing the proposed alternating yellow and green centerline lighting configuration as installed for evaluation is provided as figure 3. As previously mentioned, it involves only the changing of every other normally green centerline taxiway light within the runway environment to yellow as viewed by a pilot approaching the runway intersection. This modification to the standard configuration, if favorably considered, can be accomplished merely by substituting yellow filters for the green filters in the already installed taxiway fixtures. The L-852 centerline lights with yellow filters are already an approved combination, as it is currently used today in taxiway leadoff light configurations.

### DATA COLLECTION.

Briefings for participating evaluation subjects were conducted prior to the evaluation session by project personnel who also distributed questionnaires immediately after the viewing session.

## RESULTS

A total of nine evaluators participated in the evaluation and completed questionnaires after being afforded the opportunity to view the lighting configuration. A summary of the questionnaire responses, with comments as they were recorded and/or written, are as follows:

### QUESTION ONE.

Of the nine evaluators that participated in the evaluation, all nine agreed that the lighting configuration was unique enough to clearly indicate the critical runway safety area, assuming that the pilots had received sufficient training, without any possibility of confusing it with something else.

Comments associated with this question on the questionnaire were as follows:

- “All other hold line markings must be clearly identified”
- “Nothing else looks like it, except the reverse side (same warning)”
- “Looks clear”

## QUESTION TWO.

Of the nine evaluators that participated in the evaluation, eight agreed that the lighting intensity relationship between the yellow and green lights were found to be satisfactory. Only one evaluator indicated that the green fixture was too bright.

Comments associated with this question on the questionnaire were as follows:

- “It seems the green is overpowering the yellow”
- “Green slightly brighter than yellow”

## QUESTION THREE.

Of the nine evaluators that participated in the evaluation, all nine agreed that the spacing used during the evaluation, which is the standard spacing for taxiway centerline lighting, was satisfactory for this application.

Comments associated with this question on the questionnaire were as follows:

- “Spacing looks better as you get closer”

The following general comments were provided by the evaluators in the comment section of the questionnaire:

- “Placing yellow lights on a long string of green gives indication “something” is changing with the taxi i.e. entering runway.”
- “Need to look at signage and markings to ensure if entering or exiting RSA.”
- “No issue with same configuration used for going onto runway versus going off runway.”
- “I like it. Good way to enhance safety area warning with very little cost.”

## RELATED CONSIDERATIONS.

The Office of Runway Safety, under their research program, installed a prototype system such as the one described in this report, at the Louisville International Airport-Standiford Field (SDF). During the installation process, the airport management and maintenance department made a decision to replace various components of the in-pavement lighting fixtures while the new colored lenses were being installed. While this increases the cost of the overall installation, it does make sense to perform the preventative maintenance while the taxiway or runway is closed and the fixtures are already opened, versus returning to the fixture once it has actually failed.

Table 1 shows some of the costs associated with the replacement of the lens, plus the replacement of any preventative maintenance items, as obtained from fixture manufacturers.

The SDF airport project cost a total of \$12,000 to replace and refurbish 80 fixtures, including all of the necessary parts and labor. The airport, in this case, used their own employees to perform the work, versus hiring an outside contractor. The price to implement the system at SDF was \$150 per lighting fixture.

## SUMMARY

With regard to addressing the four considerations delineated in the objective section of this report, the consensus of the participating evaluators was as follows.

Presently available fixtures, such as the L-852 taxiway centerline fixture, were found to be adequate in color, intensity, and alignment for this purpose, as long as they are installed, aligned, and maintained as required in the appropriate Advisory Circulars.

The evaluation subjects were unanimous in judging the fixture spacing as satisfactory for this purpose, as long as they are installed, aligned, and maintained in accordance with the appropriate FAA Advisory Circulars.

The results of this study show that the subjects were able to recognize some kind of transition point at which the lighting changed from green to the alternating pattern. Many subjects indicated that the lighting pattern would make them search for additional cues, such as airport signage, to determine exactly what they were seeing. With training and/or education, participants agreed that pilots would properly interpret the purpose of the new configuration correctly.

Total costs to convert each taxiway/runway entrance light array would be heavily depended on the length of the taxiway section, the complexity of the intersection, and the number of fixtures available. For planning purposes, it was determined that implementation efforts would only consist of replacing an existing green filter with a yellow filter in one-half of the fixtures present in the segment. Price estimates for replacing the appropriate filters, as well as other serviceable parts, ranged from \$50 to \$200 per fixture, including labor and parts.

## CONCLUSIONS

Having considered all of the data and information gathered during this evaluation effort, the concept of illuminating the runway environment area with alternating yellow and green centerline fixtures was determined to be a cost-efficient, easy to deploy tool that offers pilots additional cues for situational awareness that they are entering the runway safety area. The results showed that currently available lighting equipment and installation specifications exist to support this concept, and that airports could implement this concept with a minimal financial investment. The results also showed that pilots approaching the lighting configuration would be less likely to enter the area without obtaining additional information, which would have a positive impact on reducing runway incursions.

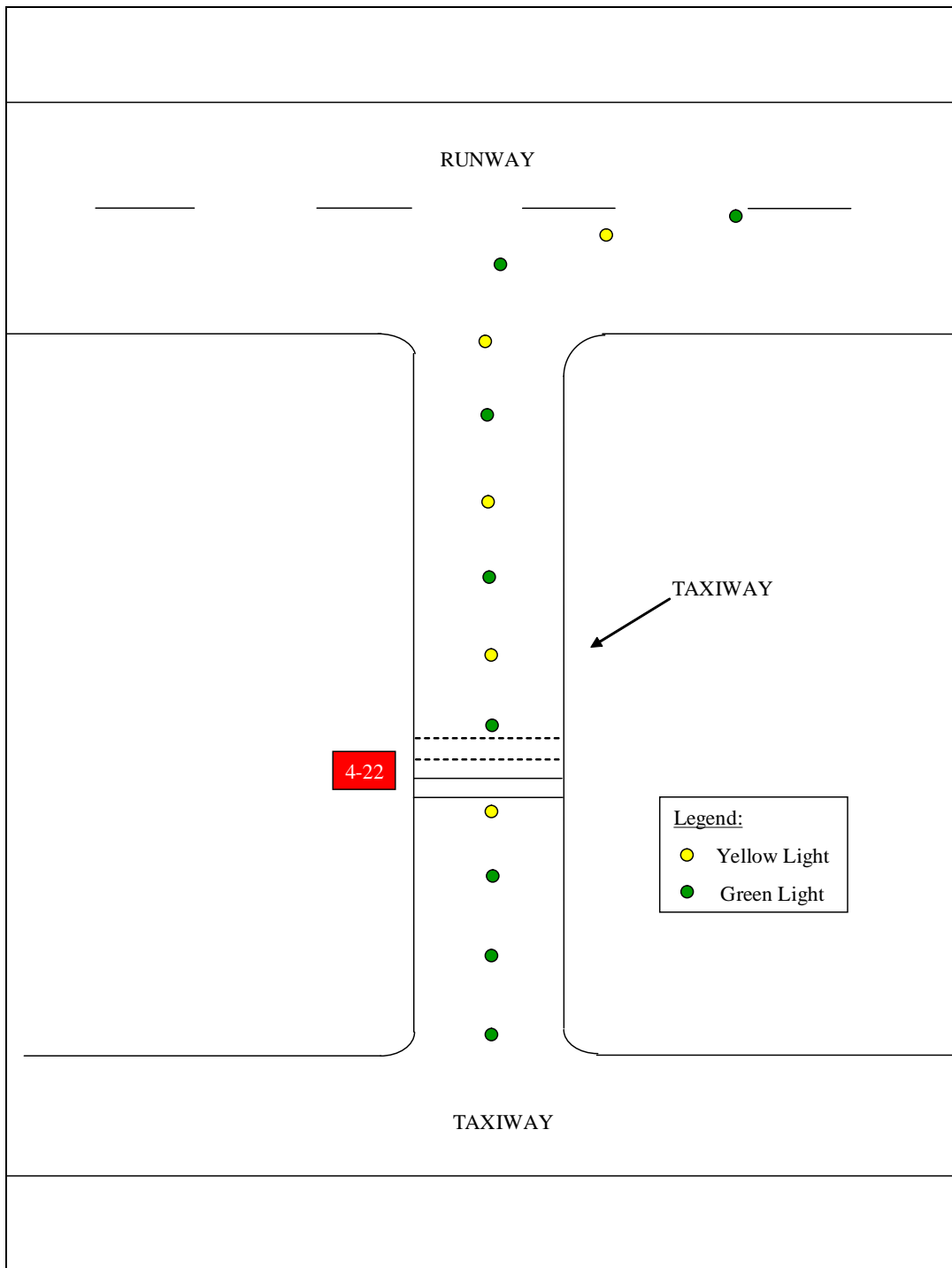


FIGURE 1. COLOR-CODED LIGHTING CONFIGURATION

## CODED RSA TAXIWAY C/L LIGHTING EVALUATION QUESTIONNAIRE

We are evaluating a proposed change to the standard green taxiway centerline lighting system that will, it is hoped, create a unique lighting pattern that will more vividly define the critical Runway Safety Area (RSA). You will be shown a full scale representation of a series of alternating yellow and green taxiway lights leading to a runway and starting at the holding position. These lights are located exactly as they would be if installed in the taxiway/runway surface, and are of the same make and model as would be in a fully installed system.

Please answer the following questions after you have had the opportunity of viewing the configuration.

Subject Name (Opt.) \_\_\_\_\_ Organization: \_\_\_\_\_ Date: \_\_\_\_\_ Wx: \_\_\_\_\_

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1. Was the configuration unique enough to clearly indicate the critical RSA (assuming pilot education)?

Yes: \_\_\_\_\_ No - possibly confused with something else: \_\_\_\_\_

Comments: \_\_\_\_\_

2. Was the intensity relationship between the yellow and green lights satisfactory?

Yes: \_\_\_\_\_ No – Yellow too bright: \_\_\_\_\_ No – Green too bright: \_\_\_\_\_

Comments: \_\_\_\_\_

3. Was the spacing used (standard for taxiway lights) satisfactory?

Yes: \_\_\_\_\_ No – Too close together: \_\_\_\_\_ No – Too far apart: \_\_\_\_\_

Comments: \_\_\_\_\_

4. Please give us any comments or opinions you may have: \_\_\_\_\_

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FIGURE 2. SAMPLE POSTSESSION QUESTIONNAIRE



FIGURE 3. LIGHTING ARRAY AS INSTALLED FOR TEST



TABLE 1. ESTIMATED REPLACEMENT COSTS

Replacement Item	Estimated Cost per Fixture
Yellow Filter or Lens	\$15.50 to \$40
O-Ring	\$2.20
Spring Clip	\$.75
Lens Seal	\$4.00