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Original article

Proposed Minimum Luminous Range for Existing Lighthouses in This Age of Global Navigation Satellite Systems by Using the Correlation between Light Intensity and Luminous Range ☆

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Abstract

Long-range visual marine aids to navigation are not required for current marine navigational practices. Therefore, the objective of this study was to develop a minimum luminous range for major lighthouses that are still in existence to sustain the operation of the lighthouses in the future. Two steps were involved in the determination of the minimum luminous range, namely the modification of the existing geographical range formula, and the finding of a strong linear correlation between the light intensity and the luminous range with the lowest gradient possible in a graph. The application of the minimum luminous range would eliminate the loom of light beyond the geographical range of the lighthouse. This approach was applied to seven major lighthouses in Peninsular Malaysia, which resulted in a minimum luminous range of between 12 nm to 14 nm, which was a reduction from the existing range of 18 nm to 25 nm. The validation of the minimum luminous range was performed in two ways; using a Full Mission Ship Simulator (FMSS), and matching the proposed minimum luminous range with the lighting system available. The results of the validation by using the FMSS between the luminous range of 25 nm and 14 nm showed that the light could be sighted and identified at 58.7 nm and 58.6 nm, respectively, which was, therefore, not significant. The validation by matching with the lighting equipment available in the market showed that the eight-tier VLB-44, which has replaced the rotating lighting system in the US since 2008, was highly matched with the proposed minimum luminous range. This further validated the minimum luminous range. The minimum luminous range is sufficient for current navigational uses and may reduce the costs for procuring and maintaining lighting systems, and will be able to sustain the operations of lighthouses in this GNSS age.

Keywords: Lighthouse, Luminous range, Marine navigation

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1. Introduction

A lighthouse is a large conspicuous structure on land close to the shoreline or in water, which acts as a daymark and provides a platform for a higher range of marine Aids to Navigation (AtoN) signal lights (IALA, 2014). Among the functions of a lighthouse are to mark the landfall position, mark an obstruction, and provide a reference for mariners to take their bearing or line of position (IALA, 2014). This study focused on the role of a lighthouse as a landfall light. Landfall is defined as "the first sighting of land when approaching from seaward" and a landfall light is defined as "the first light to be seen by the observer approaching the coast from the open sea. It is so situated and has a luminous range and geographical range that are so great that it can be identified at a great range" (Hooff, 1982). During the era before the introduction of a Global Navigation Satellite System (GNSS), mariners used to navigate in the open sea by using celestial navigation and approached the coast by following the guidance from the landfall light. This marked a change in the phase of navigation from open sea navigation using a celestial body to coastal navigation using references on land. In order to ensure that vessels navigating in the open sea sighted the landfall light, with a certain error of position from the distance as far as possible, the landfall light was built to deliver a luminous range in order to create a window with as large a radius as possible.

GNSS was introduced widely to marine commercial users in the 1990s. GNSS, or widely known as Global Positioning System (GPS), has changed the navigational practices of mariners (Theiss, Yen, & Ku, 2005). For instance, GPS has eliminated the change in phase from open sea navigation to coastal navigation by using the same method to fix the position in both areas and to achieve the same level of accuracy. To make life easier, GPS has been integrated with a radar, Electronic Chart Display and Information System (ECDIS), Automatic Identification System, and autopilot, which enable many inputs into a single screen. The current navigational practice of using GPS as the primary means of navigation has caused long-range marine aids to navigation, such as lighthouses, to play a secondary role in navigation. In the event of GPS failure, the radar can still be used to fix the position of the ship, thereby further reducing the dependence of mariners on lighthouses. Despite the fact that the introduction of GPS has changed the navigational practices of mariners, the luminous range of lighthouses in Malaysia has remained unchanged.

The current luminous range for lighthouses in Malaysia was set during the 70s, prior to the GPS era (Hooff, 1982; Hooff & Sirks, 1979). During that period, lighthouses were manned and the lighting system was powered either by using an engine generator or domestic power supply. Starting from the 90s, the obsolete lighting system was changed to a more advanced lighting system that was unmanned (automatic). This system was more reliable and consumed relatively little energy as the system was powered by renewable energy such as solar energy. However, the luminous range of the light from the lighthouses remained the same. Hitherto, the luminous range for major lighthouses in Malaysia has not been reviewed by the relevant authority, unlike in other countries such as the United Kingdom (UK).

The 2010 Marine Aids to Navigation (AtoN) Review in the UK resulted in the decommissioning of 20 lighthouses and the transfer of another 14 lighthouses to local authorities (ATKINS Ltd., 2010). A recent review conducted by the General Lighthouse Authority UK for the period 2010 to 2015 resulted in the following: reduced luminous range for 41 lighthouses, discontinuance of operation for 6 lighthouses, transfer of 14 lighthouses to local authorities, replacement of 1 lighthouse with Port Entry Light (PEL), increased range of light for 1 lighthouse, reduced fog signal range for 1 lighthouse, establishment of AIS for 1 lighthouse, and no changes for 76 lighthouses (Commissioners of Northern Lighthouses, Trinity House, & Commissioners of Irish Lights, 2010). The majority of the 76 unchanged lighthouses had a range of light that was below 18 nm, which was assumed to have been reviewed during the period 2005 to 2009. The results of this review showed that the dependence of mariners on lighthouses was gradually decreasing, thereby resulting in a reduction in the luminous range of lighthouses and even in the discontinuation of lighthouse operations.

However, the review did not mention the use of any specific method to reduce the luminous range of existing lighthouses. Therefore, to address this issue, this research proposed a new method for determining the minimum luminous range for lighthouses based on the height of the existing structure and the linear correlation