Input paper: [[1]](#footnote-1) ENAV24-6.1.8

Input paper for the following Committee(s): check as appropriate Purpose of paper:

**□** ARM **□** ENG **□** PAP **□** Input

 ENAV **□** VTS  Information

Agenda item [[2]](#footnote-2) 6

Technical Domain / Task Number 2 …………………………………

Author(s) / Submitter(s) Maritime and Port Authority of Singapore

**Enhanced Real-time Positioning System (ERPS)**

1. **Summary**

The Maritime and Port Authority of Singapore, together with Furuno Electric Co. and Tideland Signal Co., carried out joint sea trials for Enhanced Real-time Positioning System performance improvements. This system comprised of enhanced radar (e-Radar) installed on a vessel and enhanced racons (e-Racons) installed at conspicuous structures. The most recent 3rd sea trial took place in Singapore from 19 August to 22 August 2019.

The sea trials were progressive developments from the previous trials done in Denmark (EfficienSeas Project, 2011, Reference 1) and United Kingdom (ACCSEAS Project, 2013, Reference 2) followed by Singapore (1st and 2nd Sea trial in 2015 & 2017, Reference 3 & 4 respectively).

* 1. **Purpose of the document**

Recognising the critical need for real-time, accurate, terrestrial-based positioning to complement GNSS positioning (Resilient PNT) with redundancy, especially in port and coastal areas, a team was established with representatives from the Maritime and Port Authority of Singapore Hydrographic Division, Furuno Electric Co. and Tideland Signal Co. Periodic developments were conducted in well-equipped workshops located in Japan (Furuno Electric) and US (Tideland Signal) to stay on track with the proposed timeline. These collaborative efforts were leveraged on the positive results acquired from the previous sea trials which allow the team to further improve the test-bedding system over the years since 2015. This paper discusses the need for such ERPS and practical issues and next steps in adopting ERPS, including standardisation.

* 1. **Related documents**

See the ‘References’ section below.

1. **Background**

ERPS is a proposal for a radar position fixing system in maritime navigation. It is the automation of the process of determining one’s own absolute position by means of radar fixing, using a multitude of objects with known positions as reference points. Taking into account of vulnerabilities and over reliance on GNSS positioning, redundancy for independent position fixing systems should be considered.

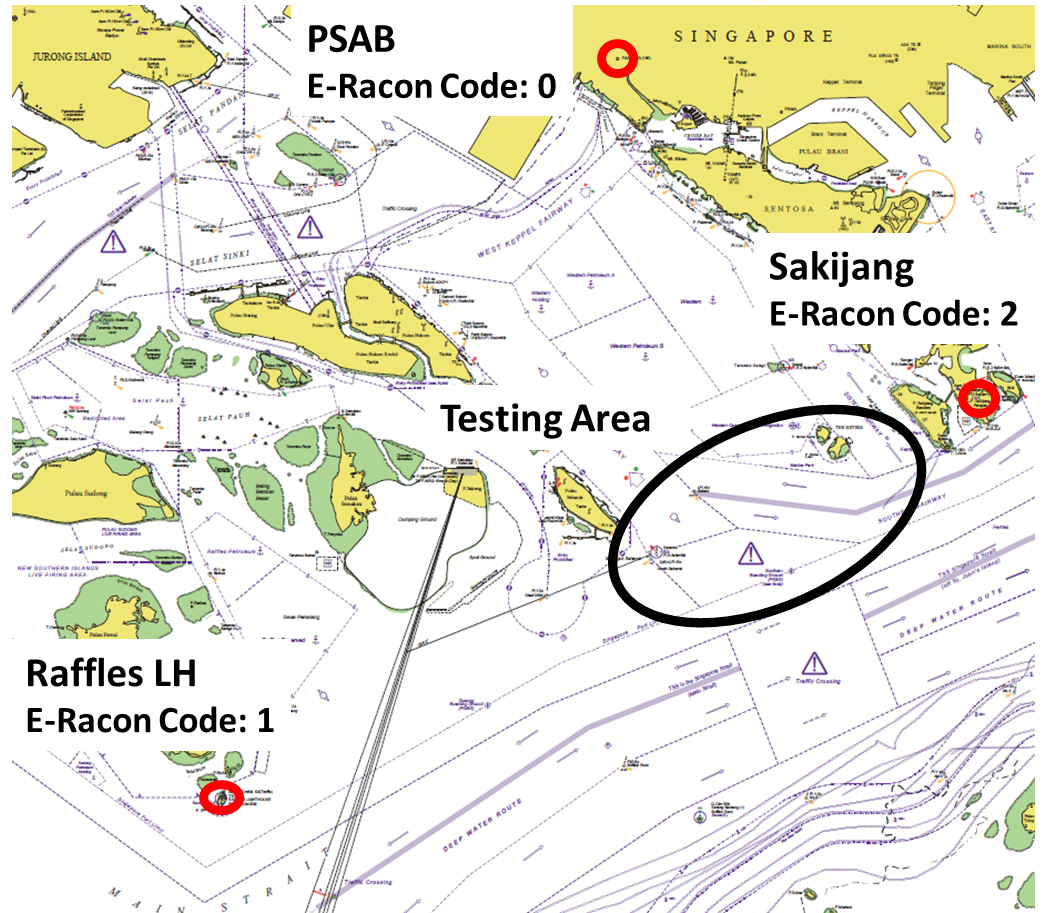
* 1. **System Context – Operational**

E-Racons are essentially normal racons, modified to encode their installed position into the signal response to the radars that interrogated them. Position data, in terms of latitude and longitude, is encoded using FSK modulation in the leading dash of the racons’ Morse code response. The e-Racon position is surveyed and entered as a static parameter in the e-Racon configuration.

E-Radar receivers detect this modulation and demodulate the signal encoded with position data. Utilising a few known information such as azimuth and range of the e-Racon target, and the heading of the vessel, the e-Radar can then calculate and present the position for the vessel on the radar screen. On the radar screen, the signal will be takes the form of a short line of dots and dashes radiating away from the location of the e-Racon.

1. **3rd SEA TRIAL**
   1. **Sea Trial arrangement**

Three locations for e-Racons were chosen: PSA Building (PSAB), Raffles Lighthouse and Sakijang Beacon. The e-Racons were deployed on existing aids to navigation as shown in Figure 1 below. All three e-Racons were mounted at a high elevation in order to minimize the blockage and multipath effects from vessels’ high air draft observed in the previous Singapore trials. In this sea trial, the main objectives were to assess the e-Radar’s software capabilities to receive 3 e-Racons’ signals, demodulate and calculate the positioning accuracies and distances. E-Racons were assessed based on the function of frequency ‘Agile’ mode primarily for the reason of high vessels density in Singapore port waters with radars transmitting at similar frequencies.



*Figure 1: Sea trial area and locations of e-Racons.*

1. **Discussion**

During the 3rd Sea Trial, a few objectives were met. Compared to previous trials, both of the e-Radar and e-Racons’ software had been refined and upgraded with advanced algorithm to enable the following improvements:

a) The upgraded e-Radar software was capable of receiving, demodulating and automatically use three e-Racons Line of Positioning (LOP) from the set of three or four for position solution. In the case that two e-Racons and below were available, the solution will use the remaining e-Racons only.

b) The e-Radar will automatically compensate for latencies and geoid height due to the motion of the vessel and the rotation of the antenna when calculating its position solution.

c) The e-Racons can function on frequency ‘Agile’ mode to transmit responses upon receiving radar signals within any maritime radar bandwidths.

However, to improve on the positioning accuracy, further enhancement would be required to improve the software’s capabilities to calculate the positioning accuracy.

1. **Next step forward**

The Maritime and Port Authority of Singapore had completed the establishment of a permanent test site in the Singapore Strait as the full set of equipment had been acquired and available for development process. This allow the team to conduct trials at any given schedule as at least four or more e-Racons would be permanently installed. Plans were made for expansion of e-Racons coverage within Singapore port waters and approaches to provide reliable and independent source of navigation. Upon maturity, e-Radar & e-Racons would be a viable supplementary positioning system which is capable of equivalent or better accuracy and reliability as compared to GNSS and should be considered as an element in Resilient PNT.

Further assessment of the system’s reliability and accuracy would be conducted in future sea trials and to report the progress of this project in future IALA meetings. This initiative should encourage more industrial players and maritime users to adopt and embrace this new positioning system as retrofitting existing radars and racons into e-Radar and e-Racon respectively could be achieved at low incremental cost at the time of manufacturing.

Standardisation of the system would be required as a baseline for implementation stage. Hence, a draft specifications would be submitted in upcoming working group meetings. As IALA is in the midst of transiting to intergovernmental status, the authors believed that the IALA would be a good venue for initial discussion on standardisation.

1. **References**

[1] E-Navigation Underway, January 2012, Enhanced Radar Positioning as an e-Navigation Service, Jens K. Jensen, Danish Maritime Authority

[2] Radar Positioning - Trials results and feasibility analysis, IALA e-NAV14-9.7.1, Nick Ward, GLA

[3] ENAV19-13.12 Singapore eRadar eRacon Trial (First) 19 October 2015

[4] ENAV19-13.12 Singapore eRadar eRacon Trial (Second) 19 October 2015

1. **Action requested of the Committee**

The ENG committees are requested to review the information of this paper and provide comments (and any additional requirements) to for future upgrading of ERP.

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-1)
2. Leave open if uncertain [↑](#footnote-ref-2)