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Trials of e-Radar/e-Racon Positioning System at Singapore port

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Takuo KASHIWA

Furuno Electric Co., Ltd.

Agenda

- Concept of Radar Positioning
- Singapore Trial Overview
- Trial Results
- Conclusion

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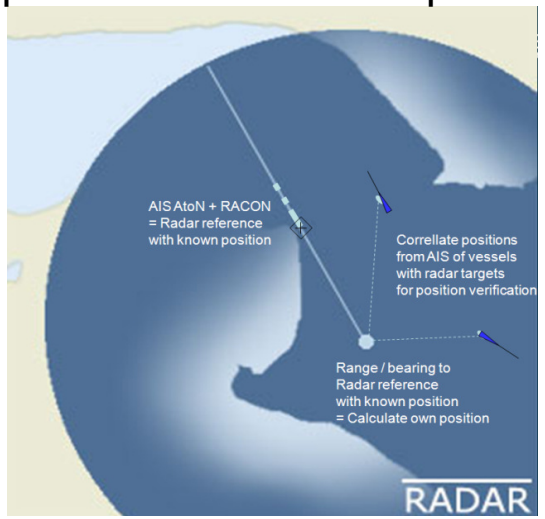
Concept of Enhanced Radar Positioning

Enhanced radar positioning is a proposal for a position fixing system in maritime navigation, based on radar navigation. It is the automation of the process of determining own position by means of radar fixing, using a multitude of objects with known position as reference.
The proposal was originally made by Jens K. Jensen from the Danish Maritime Safety Administration in 2009, in relation to the need for an independent source for position fixing, due to the vulnerabilities of GPS and other satellite navigation systems, identified during the work at IALA on IMO's e-Navigation strategy.
This proposal is currently being brought forward to the maritime industry through IALA, and an opportunity for practical testing of the concept in 2011 is being considered in the EfficienSea project[1] partly financed by the Baltic Sea Region Programme[2] and coordinated by the Danish Maritime Safety Administration The second opportunity for practical testing was in 2013 and considered in the Resilient PNT stream of the ACCSEAS project and coordinated by the General Lighthouse Authorities of the UK and Ireland.
Both of these trials were successful and demonstrated the high potential for the concept.



From Wikipedia, the free encyclopedia

[1] EU part-financed project: Efficient, Safe and Sustainable Traffic at Sea.
[2] Baltic Sea Region Programme 2007-2013 eu.baltic.net.

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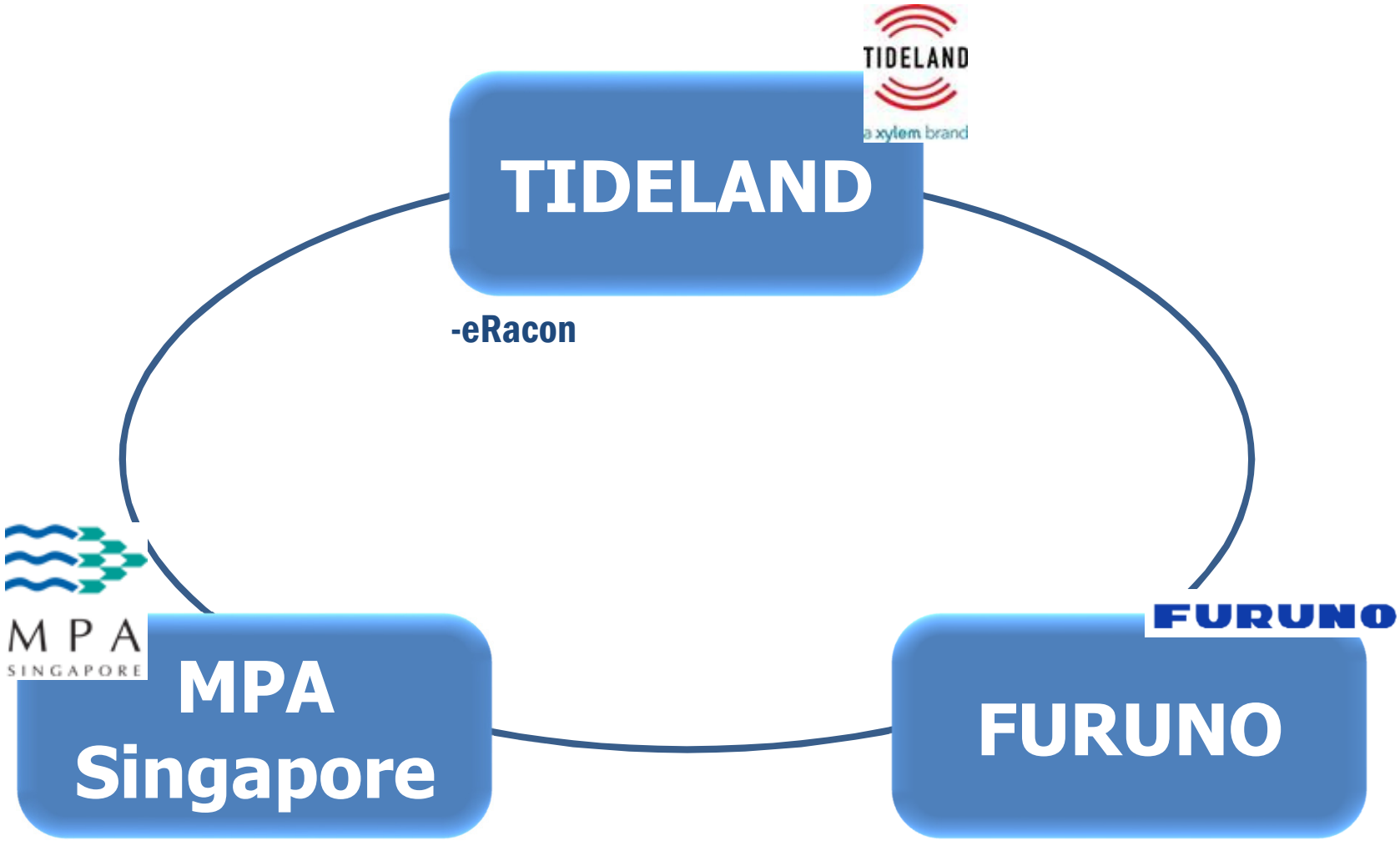
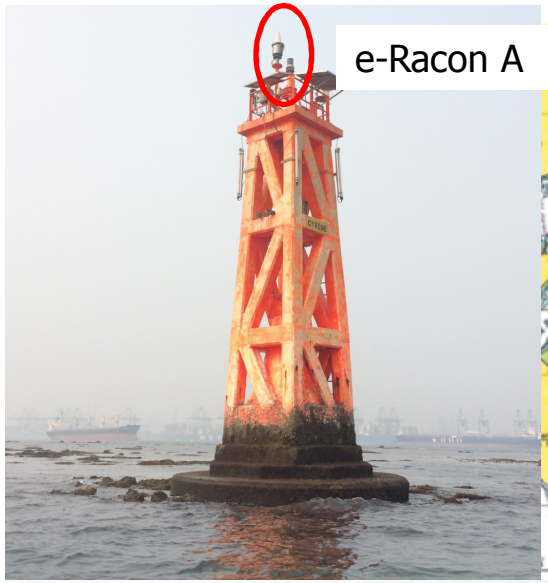
Purposes of trial-ENAV17-13.16-

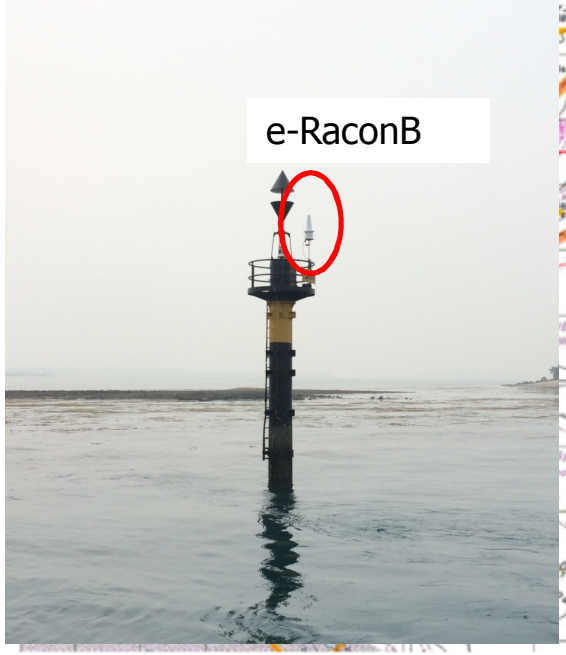
- Recognizing the critical need for real time accurate, terrestrial based positioning to complement GNSS positioning (Resilient PNT), especially in port and coastal areas.
- The positions of the vessel to be displayed in real time based on a modified ECDIS.
- This sea trial area has been selected in a busy channel environment (Singapore port)so as to evaluate the performance of the e-Racon system under real world conditions.
- To study the various eRacon modulation parameters to evaluate the visual quality and effect of modulation on performance.
- To study the accuracy and robustness of the positioning accuracy of eRadar/eRacon (both static and dynamic positioning) as compared to DGPS positioning(within +/- 2.5 meters).

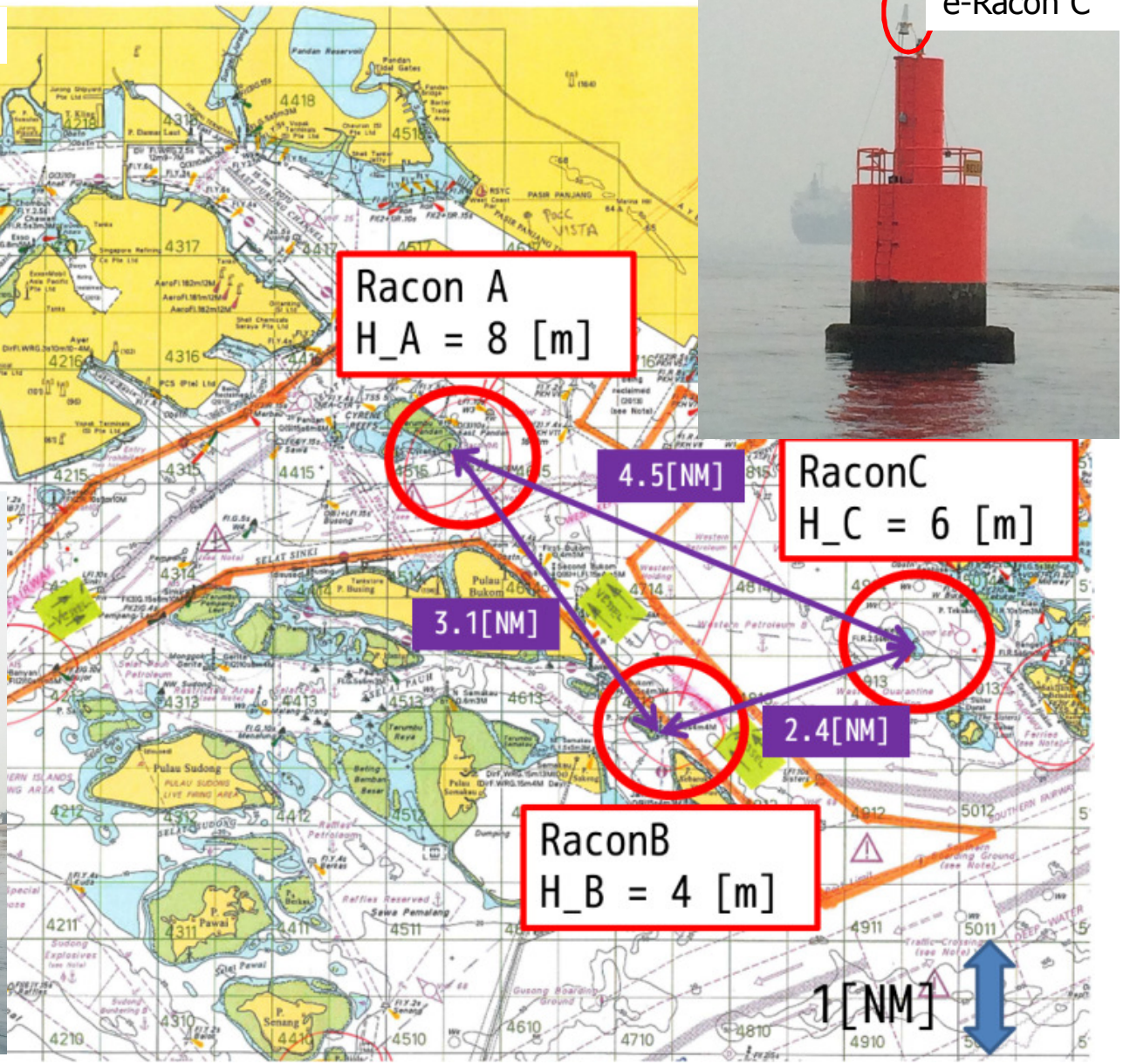
Singapore Trial



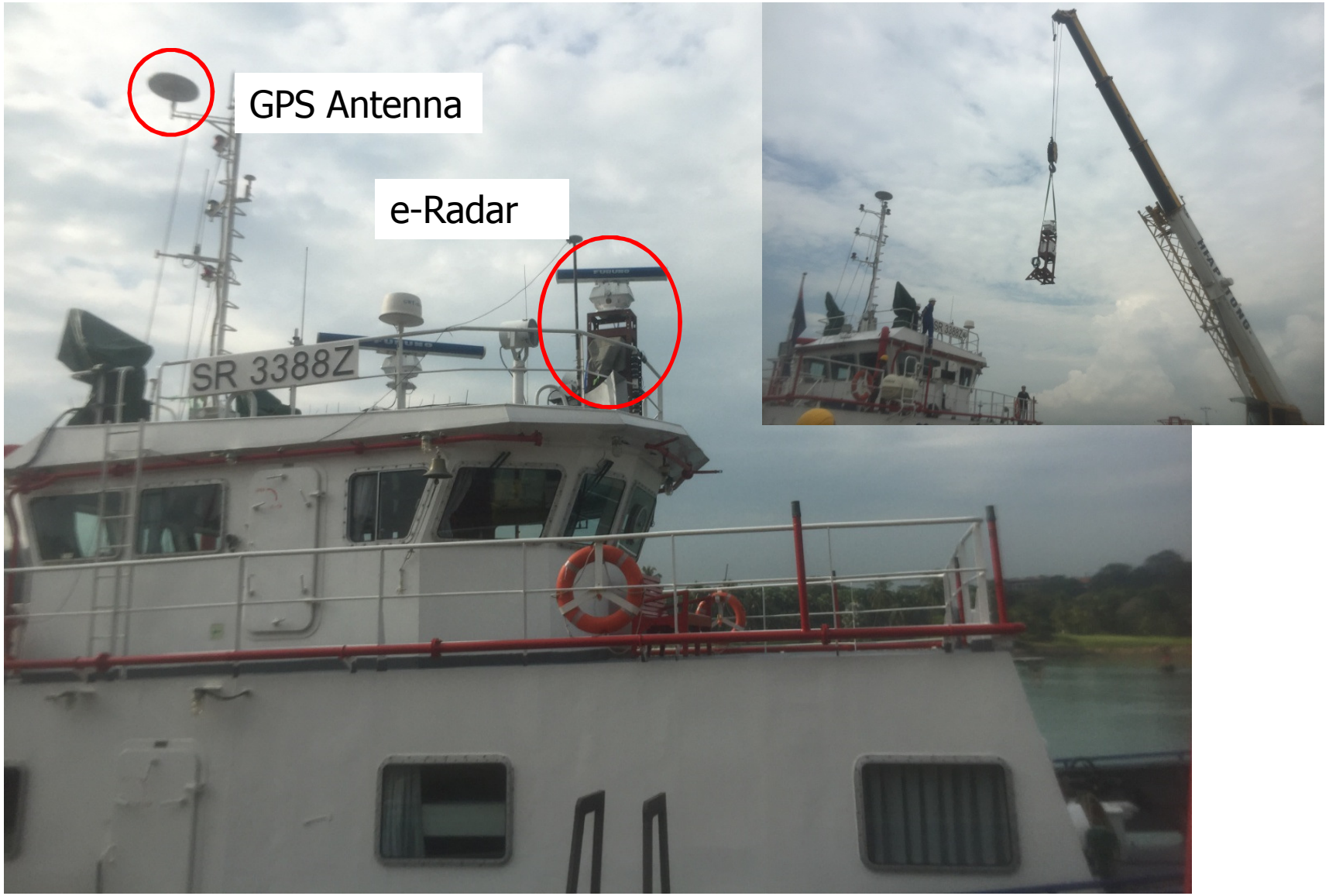
Conditions of installed e-Racon







e-Radar Installation on Panduan



e-Racon's operation difficulties

- **Racons were initially set to operate in frequency agile mode, but the racons appeared to be nonoperational to the Furuno test radar. Operating mode was changed to fixed frequency and the test radar was able to receive responses.**

- **The most likely problems in frequency agile mode are blocking due to:**
  - **With a huge number of radars, the racon is continuously responding, which blocks reception of new radar signals. The response rate to a given radar will be very low.**
  - **Side Lobe Suppression (SLS) may be blocking response to radars of similar frequency, but with lower signal strength. This could cause a given radar to never receive racon response.**

- **Operating at fixed frequency worked better because of the following**
  - **The frequency acceptance band for the racon was narrowed considerably – essentially the racon is not responding to any radar but the test radar.**
  - **SLS issues are not applicable as there are no other radars at the chosen frequency.**

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Test Scenario

◆Dynamic Test:

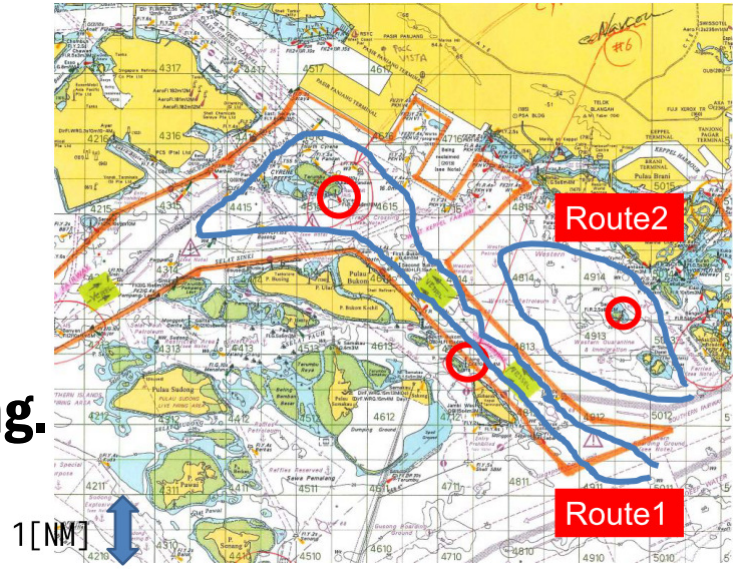
- ➢ Navigating in the port during tests.
- ➢ Various conditions to see the e-Racons.
- ➢ Having possibilities of deviations for obtained positions.

◆Static Test

- ➢ Staying at the 18 test points.
- ➢ Keeping positions while heading to ensure to receive the signal from the e-Racons.
- ➢ Possibilities of drifting

◆Berthing Test

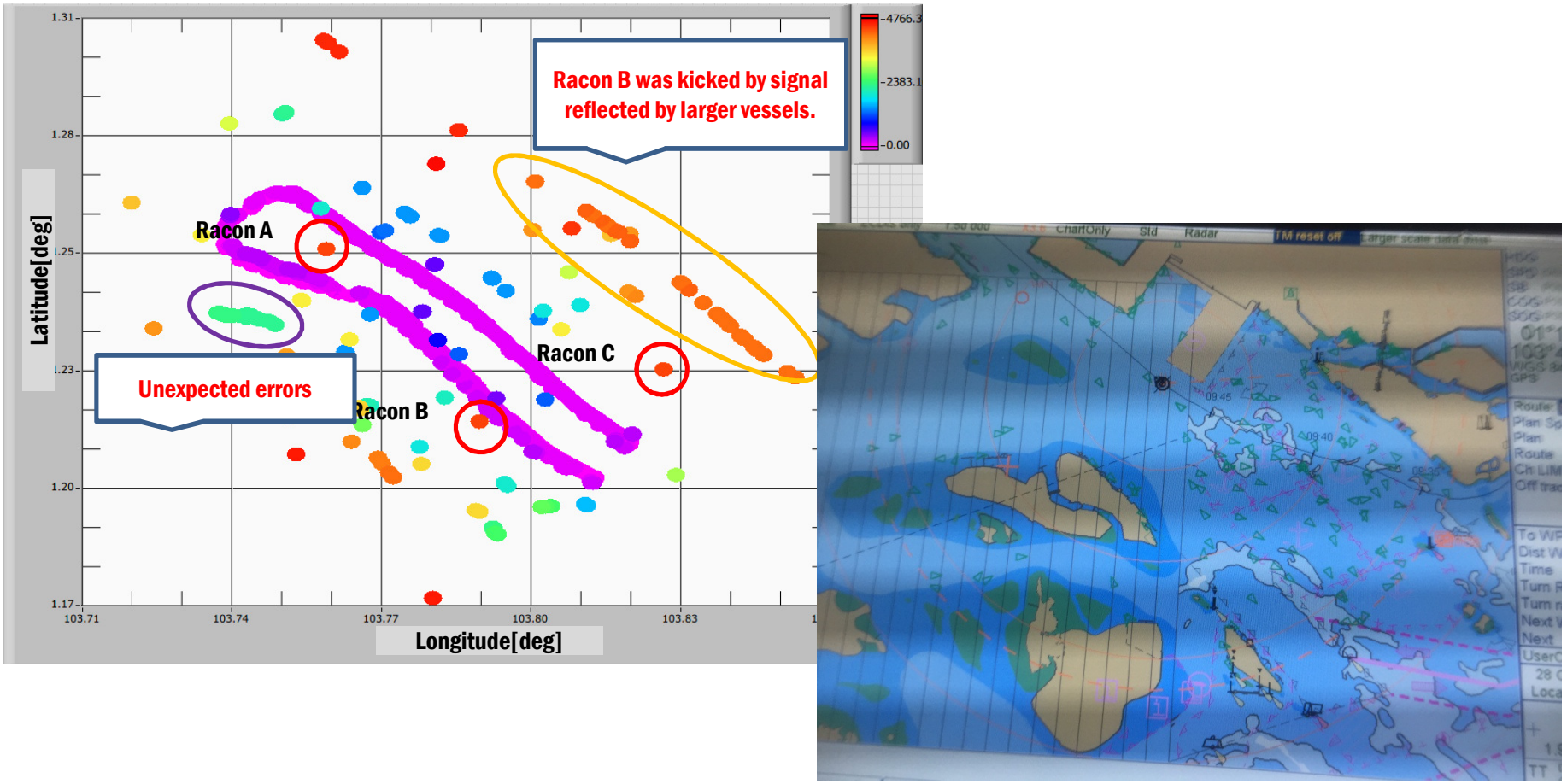
- ➢ Staying at a berth where we have good visibilities to see e-Racons with anchoring.
- ➢ We expect potential accuracy.



Calculated positions of Dynamic trial

- **Racons were sometimes turned on by reflected radar signals while showing no responses by directed signals.**

Dynamic Trial



Investigation of position errors

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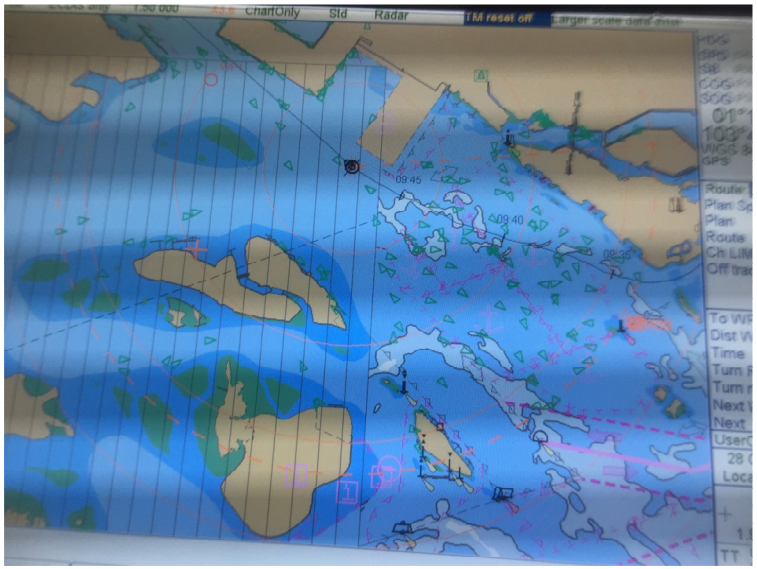
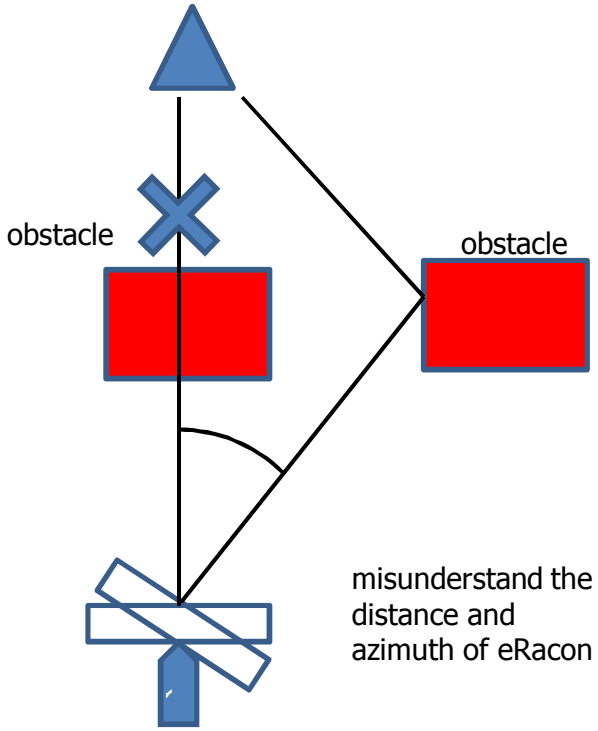
Multiple reflections by obstacles

- Reflections by obstacles such as large vessels cause position errors because the received signals propagated longer distances.
- We had confirmed that there are many vessels on our ECDIS.
- An angle error with a few degree comes to 100 m error under some conditions of the e-racon's visibilities.

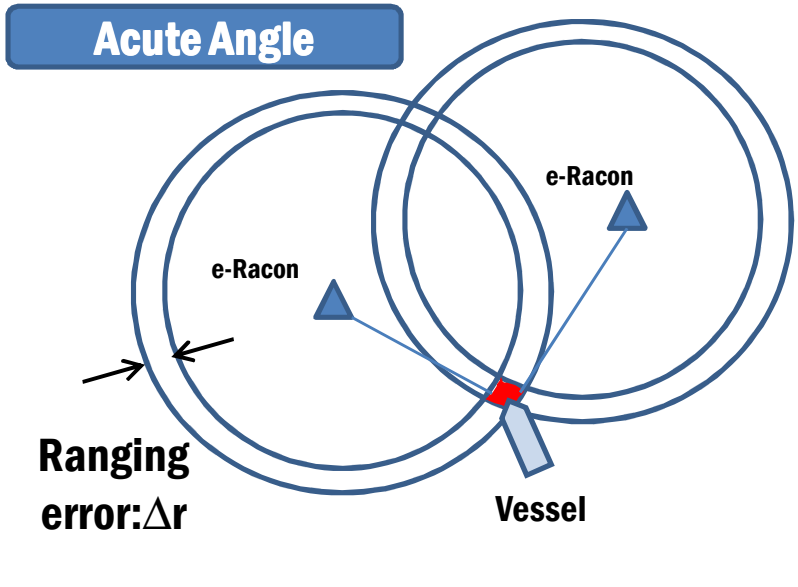


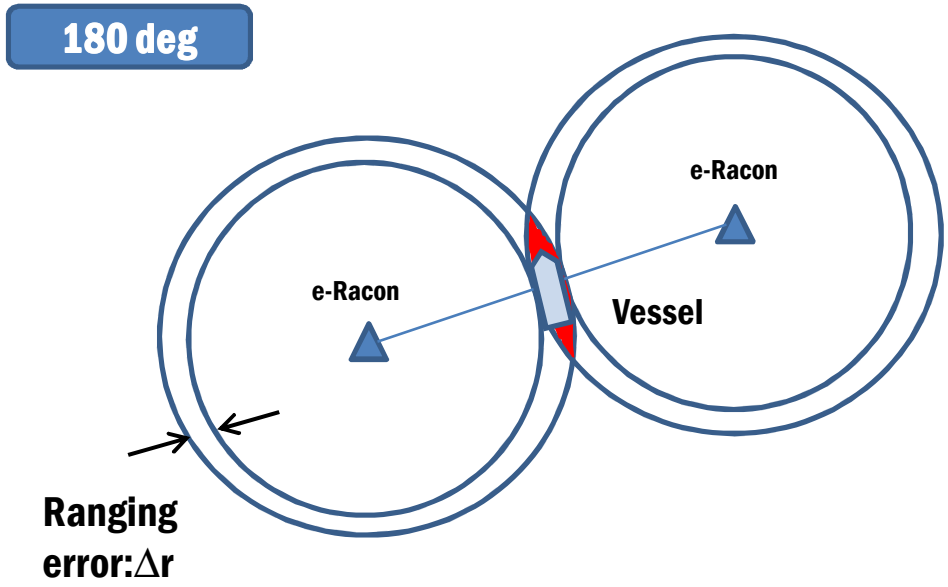


Investigation of position errors

Ranging error

- This system received eRacon signal to determine the ranges from eRacon instead of received radar signal. This also generates ranging errors.
- Ranging errors have various values by angles among eRacons and eRadar. It can be estimated from 1 m to more than 100 m.
- The angle of 180 deg generates larger possible area to be calculated as positions.





Summaries of test results

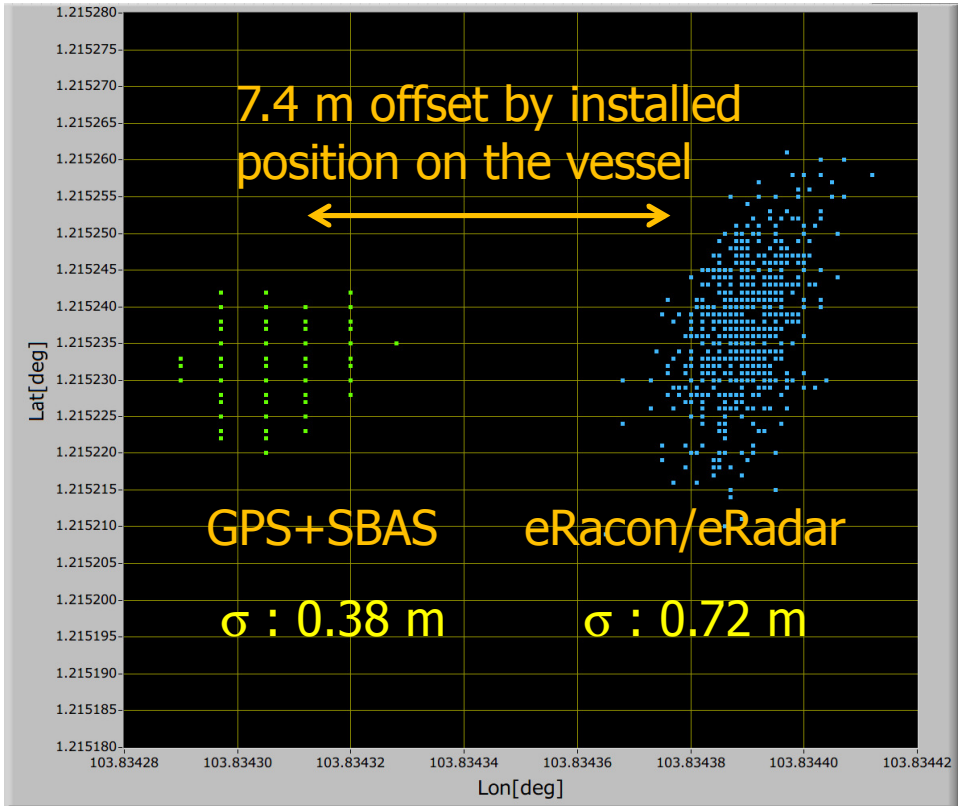
Comparison to position data of GPS receiver with SBAS.

	One eRacon	Two eRacons	Remarks
Dynamic	59.67 m	26.84 m	Not compensate effects of vessel SOG and timing differences between GNSS and RP system.
Static	63.22 m	13.89 m	Effects by angles between lines to eRacons.

- Errors are averaged values of differences between positions of GPS+SBAS and ones of this system at same timing. Offset between GPS receiver and eRadar is also included.
- More than 250 m errors have been eliminated(Dynamic)

Potential accuracies

- 3σ of deviation during berth trials reaches to 2.16 m while 1 m for GNSS sensor at Berth trial.
- Clearly different position caused by different installed positions.
- This deviation still includes some ranging errors caused by non synchronized sampling and uncertain jitter of eRacon responses.



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Conclusions

- E-Racon/e-Radar positioning demonstration had been done from October 26th to 30th at Singapore port. During the demonstration, real time position calculated by this method has been successfully displayed on ECDIS display.
- Obtained accuracies of positions were 27 m using two Racons during the dynamic trial and less than 14 m during the static trial. Potential accuracy may be much better because of 3σ deviation of 2.2 m for Berth trial.
- Reflections seem to be the bulk of the problems. Reflections can lead to large range and angle errors. Blocking of signals by other vessels could contribute to the large number of “missing” responses.
- Ranging errors are also investigated to discuss potential of minimum position errors of eRacon/eRadar positioning.
- We have confirmed that the acute angle among eRacons and eRadar is necessary to obtain higher position accuracies.
- Parties have willingness to improve this system and confirm at next opportunities.

Thank you
for your kind attention.