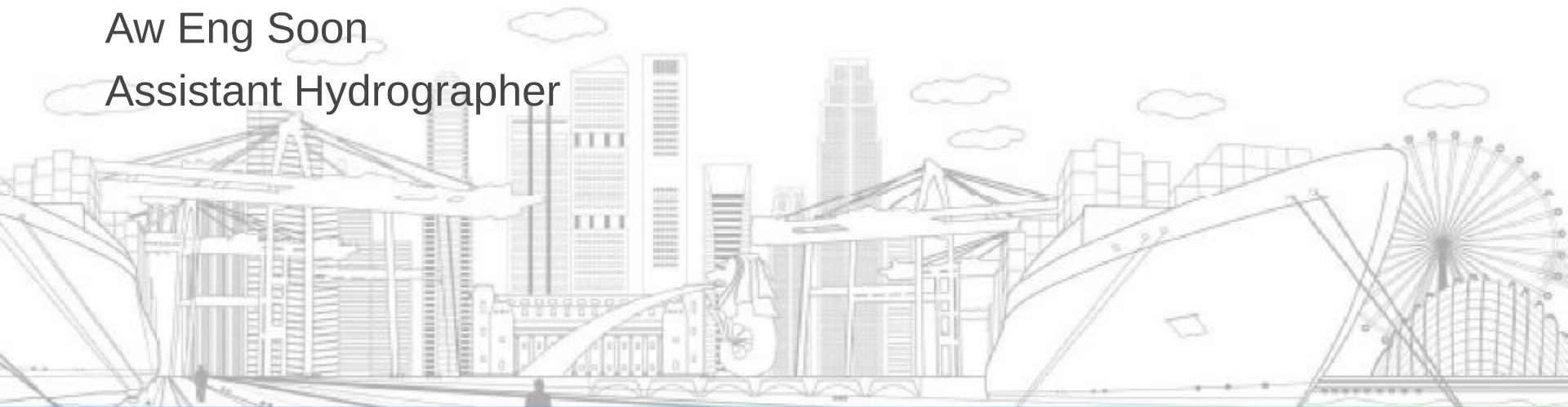


Enhanced Real-Time Positioning System using e-Radar & e-Racon



Aw Eng Soon
Assistant Hydrographer



Outline

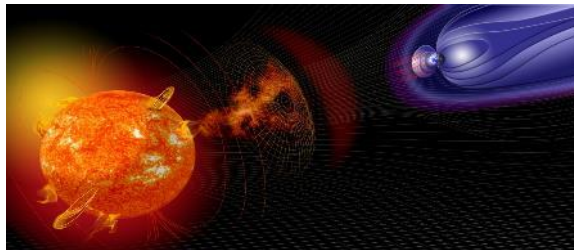
- Background
- e-Radar & e-Racon
 - Methodology
 - Advantages
 - Configuration
- Results of Sea Trials
- Roadmap
- Joint development



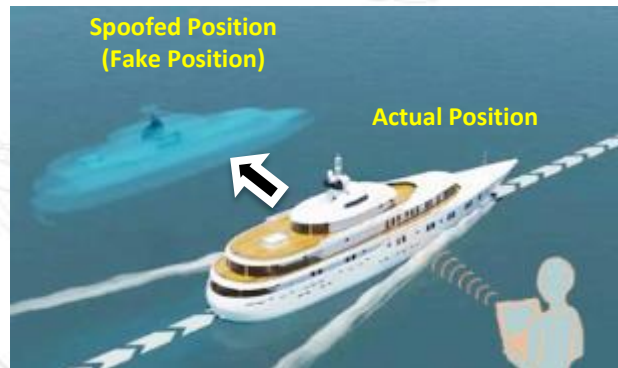
Background

GPS satellite signal:

- Relative weak signal that can be disrupted
- Vulnerable to intentional jamming and spoofing
- Loss of signal due to solar activity



Solar activity



Vulnerable to spoofing

Commercial GNSS (GPS) Jammers



Cyberthreats prompt return of radio for ship navigation

LONDON - The risk of cyber attacks targeting ships' satellite navigation is pushing nations to delve back through history and develop systems with

"we are too dependent on GNSS/GPS position-fixing systems," said Mr Grant Laversuch, head of safety management at P&O Ferries.

In June, a ship in the Black Sea reported its GPS system had been disrupted; over 20 ships in the same area had been similarly affected.

Russia have also explored adopting versions of the technology, which works on radio signals. The drive follows a series of disruptions to shipping navigation systems. It was not clear if they involved deliberate attacks; navigation specialists say solar weather effects can also lead to satellite signal loss.

Unlike aircraft, ships lack a back-up navigation system and if their GPS ceases to function, they risk running aground or collision. Last year, South Korea said hundreds of fishing vessels' GPS signals were disrupted in the Black Sea, which denied the claim. A ship in the Black Sea had been similarly affected. US engineer Brad Parkinson, known as the "father of GPS" and its chief developer, is among those who have supported eLoran's deployment as a

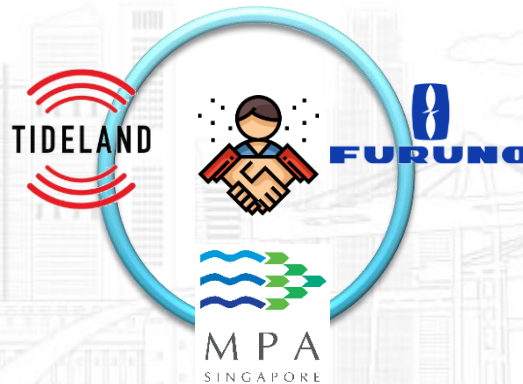
Straitstimes

Last year, South Korea said hundreds of fishing vessels' GPS signals were jammed by hackers from North Korea.



Methodology

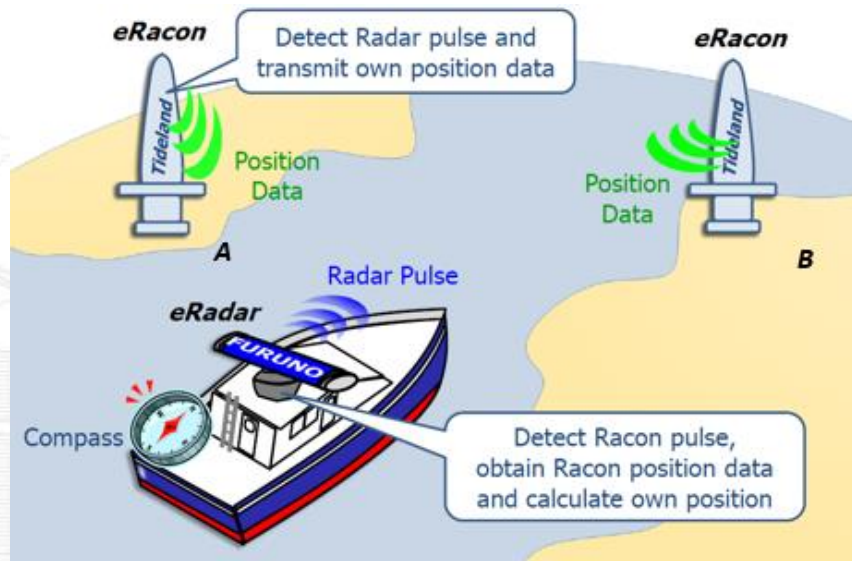
- The need for an alternative backup system for real-time position terrestrial based navigation system to supplement GNSS.
- Enhancing use of modified racon to encode digital data for e-Racon identification and accurate positioning.
- Utilising a modified e-Radar to detect and demodulate the unique data, the receiver can calculate and report accurate positioning for the vessel in Singapore waters.



Test bedding of e-Radar & e-Racon

Advantages of e-Racon & e-Radar:

1. Terrestrial based radar system, independent of GNSS
2. Provide real time, accurate and reliable positioning data
3. Radio signal stronger and difficult to jam
4. Runs on solar power
5. Ease of application (Upgrade to e-Racon and e-Radar)
6. Good signal range per e-Racon (About 10 NM) – Suitable within port areas



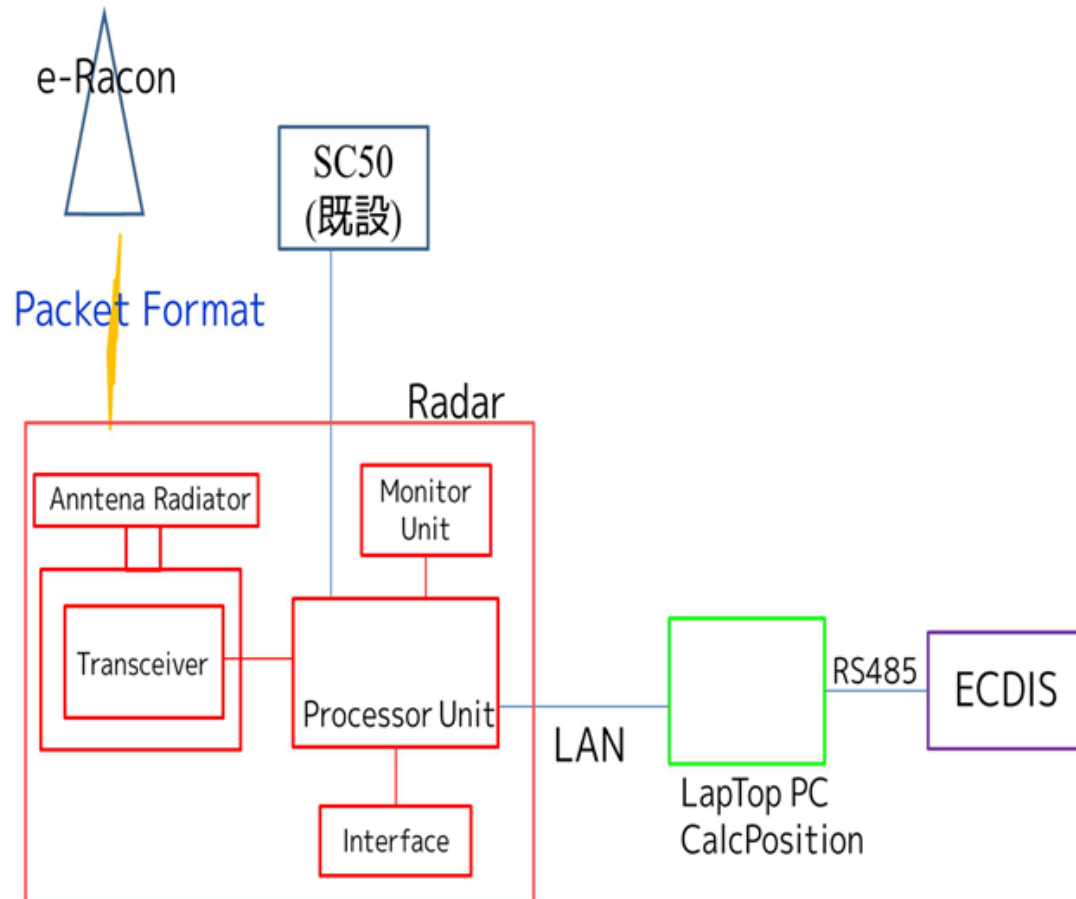
Furuno's Real Time e-Radar



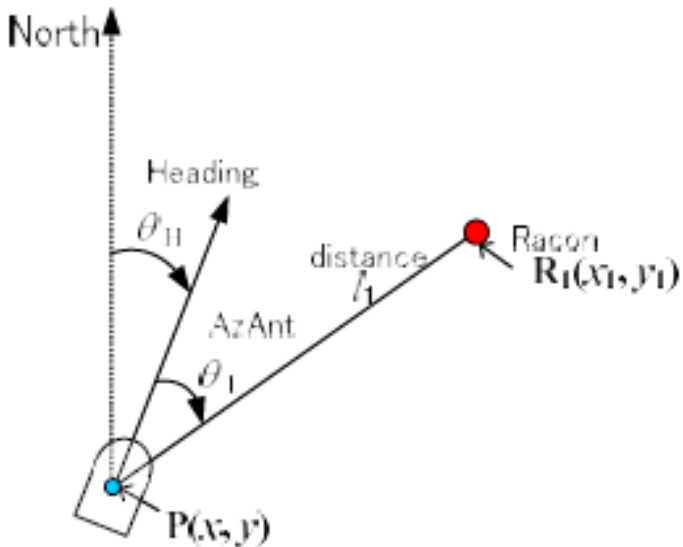
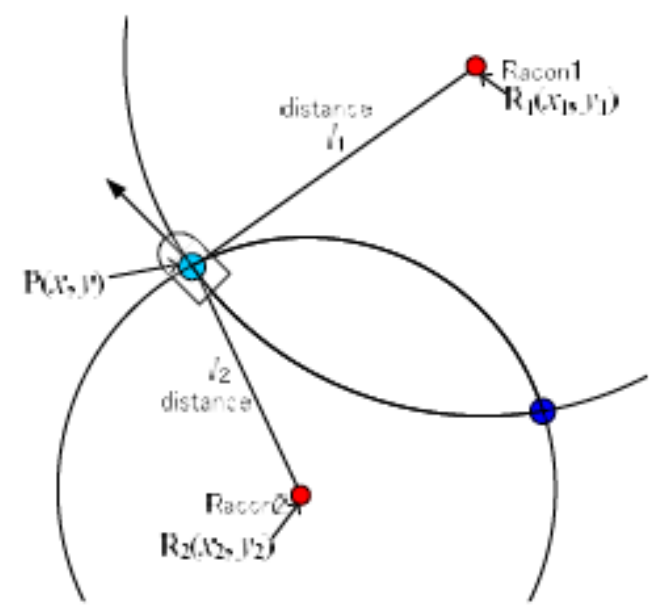
Furuno's e-Radar System specification

Item	Specifications	Remarks
Transceiver	X-band Solid State	
Output Power	150 W	
Transmit Frequency	9370 MHz	
Pulse Width	0.3 us	
Pulse Repetition Frequency	1250 Hz	
Modulation	Non modulated (P0N)	same as conventional Shipborne radar (no pulse compression technique)
Antenna	4 feet, 27.5 dBi	
Antenna Rotation Speed	24 rpm	

Furuno's e-Radar System configuration



Furuno's e-Radar System calculation

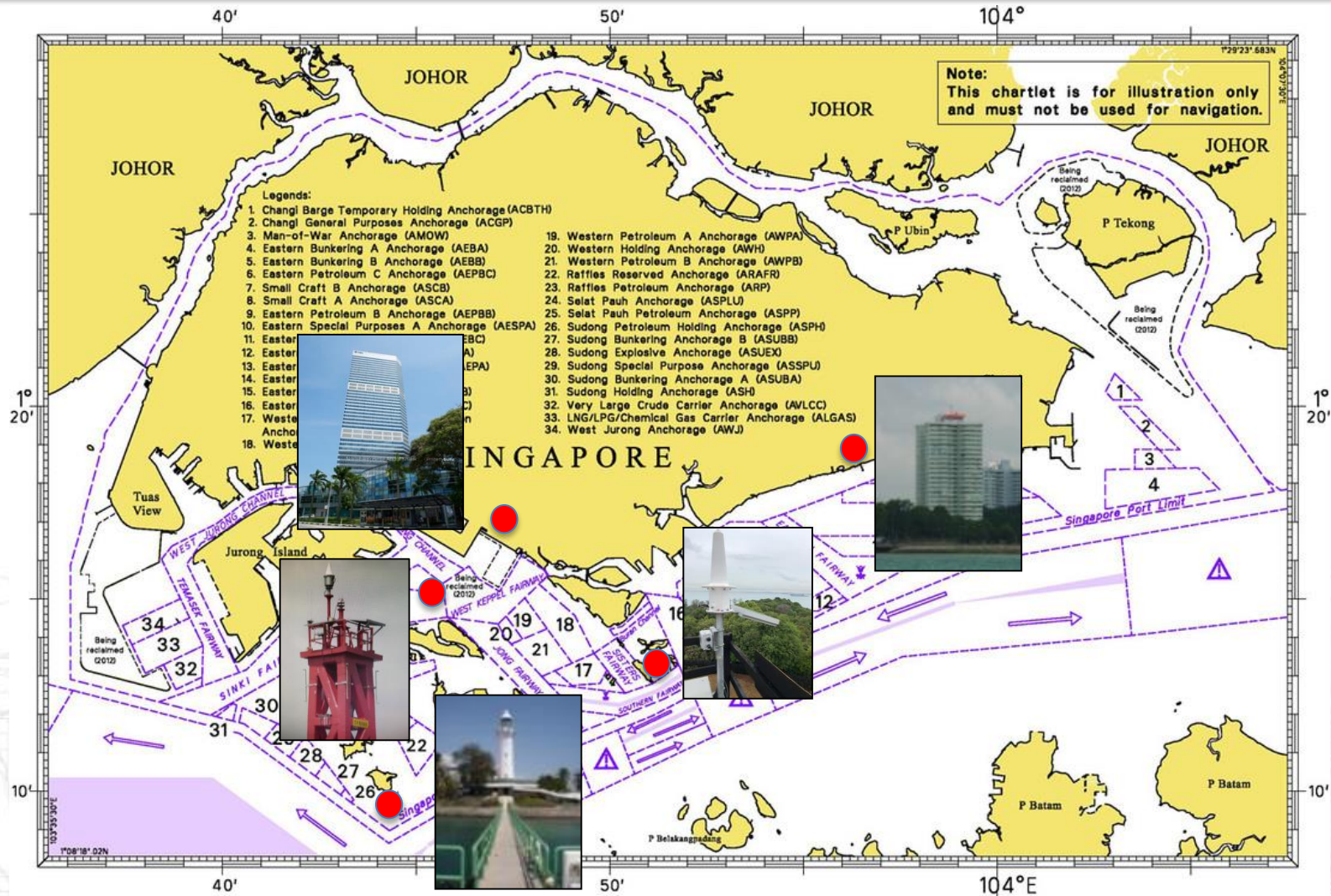
1Racon Positioning	2Racon Positioning
$\begin{cases} x = x_1 - l_1 \cos(\pi/2 - \theta_H - \theta_1) \\ y = y_1 - l_1 \sin(\pi/2 - \theta_H - \theta_1) \end{cases}$	$\begin{cases} (x - x_1)^2 + (y - y_1)^2 = l_1^2 \\ (x - x_2)^2 + (y - y_2)^2 = l_2^2 \end{cases}$
 Diagram illustrating 1Racon Positioning. A ship is located at point $P(x, y)$. The North direction is indicated by a vertical dashed line. The ship's heading is θ_H relative to North. The antenna is pointed at an azimuth angle θ_1 relative to the heading. A Racon target $R_1(x_1, y_1)$ is located at a distance l_1 from the ship.	 Diagram illustrating 2Racon Positioning. A ship is located at point $P(x, y)$. Two Racon targets, $R_1(x_1, y_1)$ and $R_2(x_2, y_2)$, are shown. The distances from the ship to the targets are l_1 and l_2 respectively. The intersection of the two arcs centered at the targets and passing through the ship's position is marked with a blue dot.

Furuno's e-Radar System

- ❖ Enhance safety of navigation.
- ❖ Security and create awareness in the marine industry.
- ❖ Expand the usage of e-Radar



Locations of e-Racons for 3rd Sea Trial (Singapore)



Sea Trials Results

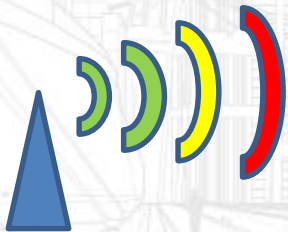
Others trials were done in Denmark (2011) and UK (2013). These trials were concept proofs for e-Radar positioning system.

1st Trial (Oct 2015):

- ❖ First authority in the world to prove independent **REAL**-time positioning system
- ❖ Trial done in busy port environment
- ❖ Positioning accuracies – **Static: 20m** **Dynamic: 55m**

2nd Trial (Aug 2017):

- ❖ Better e-Radar algorithm
- ❖ Auto computation of vessel position on the fly
- ❖ Addressed multi-path and height installation issues
- ❖ Positioning accuracies – **Berthing: 2.5m** **Static: 12m** **Dynamic: 26m**

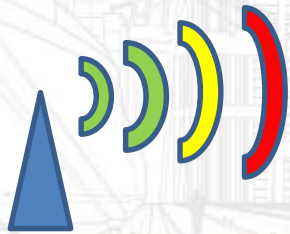


Sea Trials Results

3rd Trial (Aug 2019):

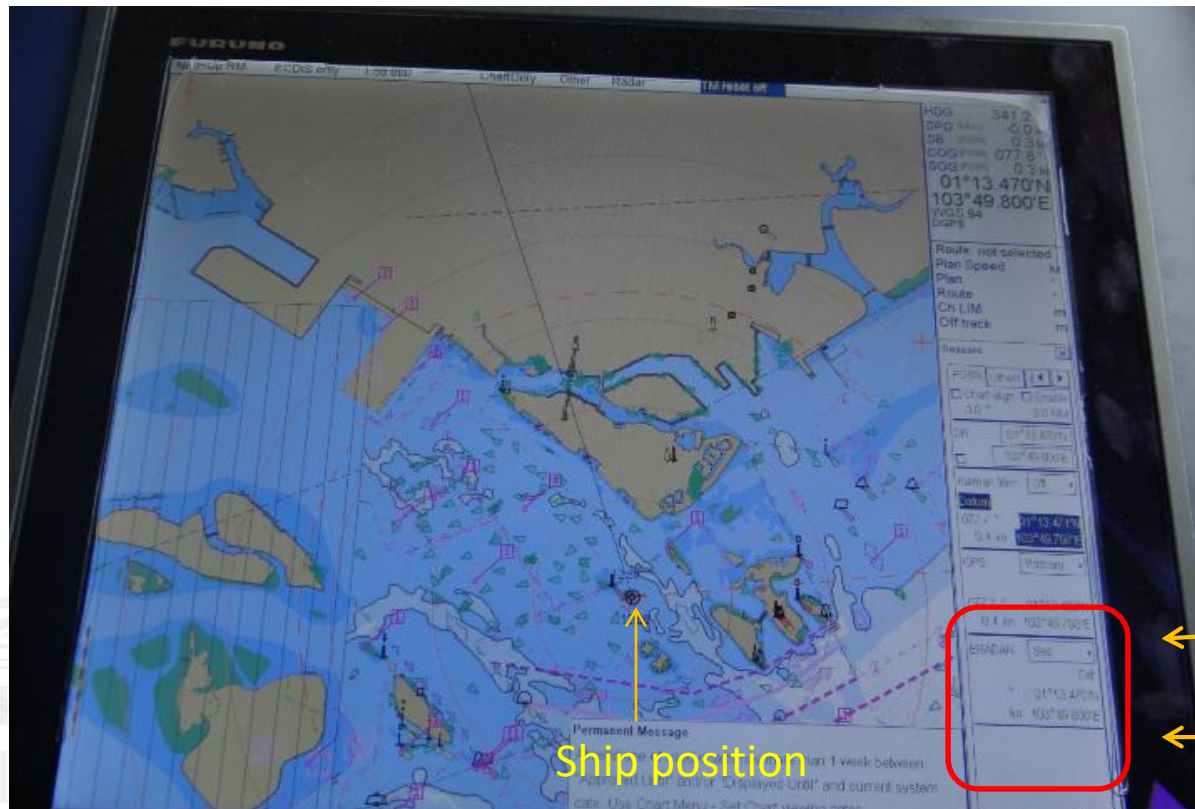
5 e-Racons installed and available

- ❖ Better e-Radar and e-Racon communication package and algorithm
 - ❖ Frequency Agile
 - ❖ 3 e-Racon LOP using 'best' three e-Racon signals received
 - ❖ Reliable data transmission
- ❖ Addressed multi-path and height installation issues
- ❖ Preliminary results
 - ❖ Positioning accuracies – **Berthing: 2.5m Static: 12m Dynamic: 26m**



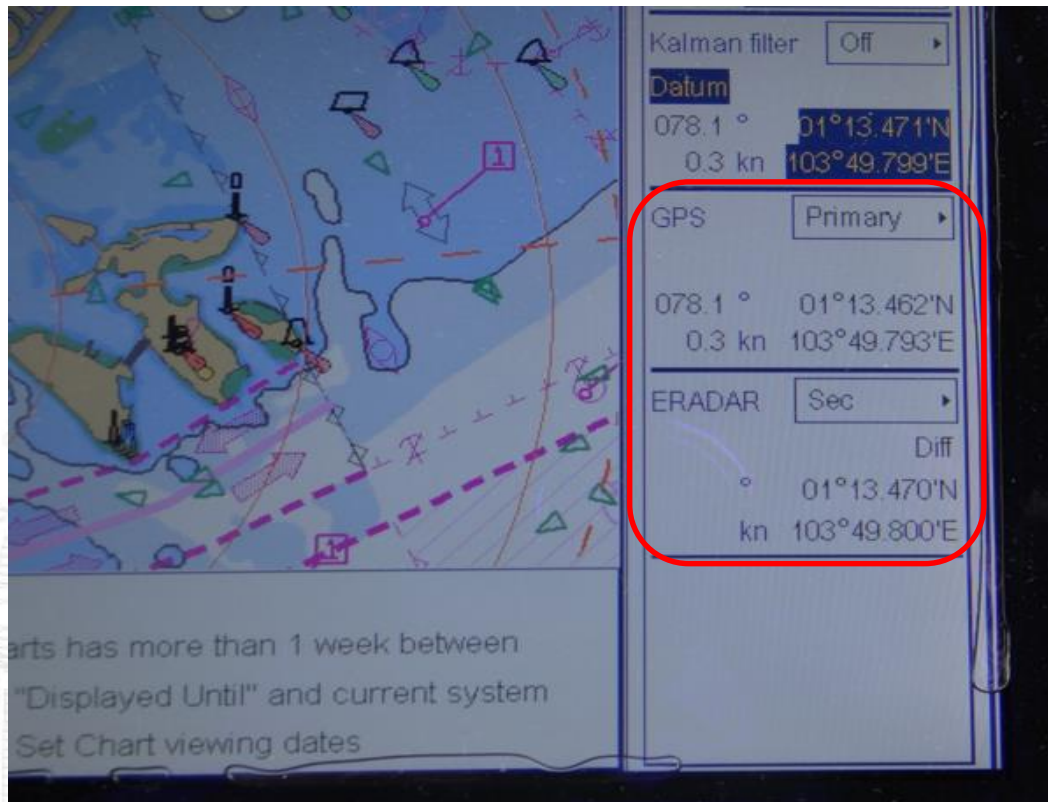
Test Bedding results

- Position of vessel is displayed in real time on a modified ECDIS



Test Bedding results

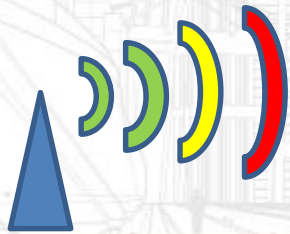
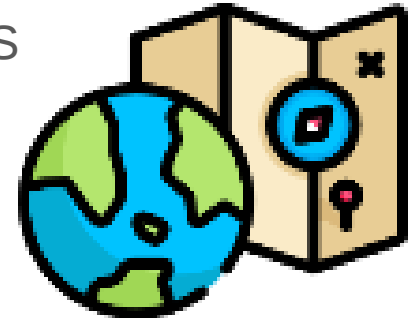
- Positioning accuracies:
 - Berth: 2.5m, Static: >12m, Dynamic: >26m



2nd Trial – Aug 2017: DGPS and eRACON positioning

Impact of e-Radar and e-Racon

- ❖ Ability to provide real time terrestrial based accurate and reliable positioning for ships
- ❖ Serves as a supplementary navigational system to GNSS
- ❖ Enhanced navigational safety in Singapore Port waters
- ❖ Practical and suitable for port waters and approaches
- ❖ Positive impact to international shipping



What's Next: Proposed Roadmap

2019

• 3rd Sea Trial

- 1. Enhancing the capabilities of e-Radar to received and process 3 or more e-Racon signals
- 2. Upgrading of the software with improved transmission
- 3. Provide more locations of e-Racons for more reliable network

2020

• Testing and Development

- 1. Extending the test bedding site areas to Malacca Straits for refined simulation
- 2. Integration with AIS and ECDIS
- 3. Presentation at 21st IALA Conference (ENG & ENAV)
- 4. Feedback for Future sea trials in 2021 for enhancement

2022

• Development of Standards and Specifications

- 1. Propose Standards and Specifications
- 2. Submission of Standards and Specifications to IALA / relevant organizations for approval / recommendations
- 3. IEC Testing of equipment and certification

2023

• Maturity

- 1. e-Radar and e-Racon system is Approved for commercial usage
- 2. Maritime community to adopt and comply as a supplementary to GNSS

2025

• Support and Enhancement

- 1. Initiatives to provide support to end user / authorities
- 2. Recommend enhancements to existing e-Racon and e-Radar system

Joint Development and Partnership





For Information

