

Autonomous Integrity of Navigational Information

- toward Resilient PNT and Unmanned Vessels -

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IAIN

International Association of Institutes of Navigation

- * **IAIN is a non-governmental, non-profit-making organisation**
- * **with the object of uniting national and multinational institutes and organisations**
 - which aim to foster human activities**
 - at sea, in the air, in space and on land, and**
 - who many benefit from the development of**
 - the science and practise of navigation and**
 - related information techniques.**

History of IAIN

The three IONs have thus pointed the way for establishing standards in the international maritime community and could be expected to influence future international developments in marine navigation.

It was also clear that a properly constituted international body with consultative status at IMCO was needed. This matter was brought before all the IONs in 1969 by the Presidents of the British and American IONs.

They proposed the formation of an international council of IONs and distributed a draft constitution for discussion.

History of IAIN

Early in 1975, the Presidents of the Institutes of Australia, France, Germany, Italy, Japan, the United Kingdom and the United States agreed to the formal declaration of an IAIN.

On 15 Oct. 1975, the first General Assembly was held in London and the first constitution was adopted.

Officers of IAIN

President	Yasuo Arai Japan Institute of Navigation (JIN)
Senior Vice President	John Pottle Royal Institute of Navigation (RIN)
Vice President	Elisabeth Fischer Austrian Institute of Navigation (OVN)
Vice President	Hesham Helal Arab Institutes of Navigation (AIN)
Secretary General	Simon Gaskin FRIN FNI Royal Institute of Navigation (RIN)
Treasurer	Rein van Gooswilligen Netherlands Institute of Navigation (NIN)
Immediate Past-President	Dick Smith Royal Institute of Navigation (RIN)
Associate Members Representative	Boris Rivkin Academy of Navigation and Motion Control (ANMC)



Activities of IAIN



1. IAIN was given consultative status to the Organizations
2. IAIN World Congress
3. Working Group

Activities of IAIN 1. Consultative Status



IAIN was given consultative status to these Organizations, and dispatch delegates to consult and/or proposal.

- ***ICAO** **International Civil Aviation Organisation**
- ***ICG** **International Committee on GNSS**
- ***IHO** **International Hydrographic Organisation**
- ***IMO** **International Maritime Organisation**
- ***US PNT Advisory Board**
 Dr. Bradford Parkinson received 2012 IAIN Necho Award, and received 2016 Marconi Prize
- ***ITU** **International Telecommunication Union**

Activities of IAIN 2. IAIN World Congress

- | | |
|-------------------------------------|--------------------------------|
| Cambridge, Massachusetts, in 1976 | |
| Brighton, United Kingdom in 1979 | |
| Paris, France, in 1982 | San Diego, California, in 2000 |
| Tokyo, Japan, in 1985 | Berlin, Germany, in 2003 |
| Sydney, Australia, in 1988 | Jeju, South Korea, in 2006 |
| Cairo, Egypt, in 1991 | Stockholm, Sweden, in 2009 |
| Beijing, China, in 1994 | Cairo, Egypt, in 2012 |
| Amsterdam, The Netherlands, in 1997 | Cairo, Czech Republic, in 2015 |

The next IAIN Congress will be held in Chiba, Japan, in 2018.

Activities of IAIN

3. Working Group and Forum

- * ICAO
 - * New Compass instead of Magnetic Compass – from 2014
- * IMO
 - * IAIN was aimed at bringing attention to the need for IMO to start formally considering the issues concerning unmanned vessels. It was performed in association with the Maritime Autonomous Systems Regulation Working Group (MASRWG) – 2016/5
- * ICG
 - * Resilient PNT Forum -- from 2014

What is the Resilient PNT and Why is it essential ?

- * PNT means Positioning, Navigation and Timing
- * GNSS presents not only Positioning and Timing but also Navigation
- * Spoofing
- * Jamming
- * So, Back up system should be essential, and consensus and proposed terrestrial transmitting system such as LORAN C or Decca in GPS opening age.

What is the Resilient PNT and Why is it essential ?

Spoofing example

Professional Car Thief – Toolkit

- GPS L1 1575.42 MHz 2W
- GPS L2 1227.60 MHz 2W
- GPS L5 1176.45 MHz 2W
- WiFi 11b/g/n 2.4 GHz 2W
- Remote Control 315MHz 3W
- Remote Control 868MHz 3W
- Remote Control 433/434MHz 3W
- Lojack 173MHz 3W
- Disables.....
 - Remotes for Cars, Garages, Gates - 315/433/868 MHz
 - CCTV, UAVs, Quadcopters, Drones - 2.4 GHz

\$1,250 www.jammer4u.com

Is IMU able to protect Spoofing ?

What is the Resilient PNT and Why is it essential ?

Jamming Simulation

- 100 Watt Jammer Shard – Floor 72
- Simulation courtesy Mike Jones
 - Roke Manor Research

Specifications:

- Model No: C.T.S-8800F
- Output signal strength: 100W
- Effective range: Up to 500-1000 meters
- Frequency: GPS (L1, L2, L5), 44.5
- 24*7 long time working
- Waterproof
- System: All systems worldwide
- Input power: 110-240V

How long is IMU able to protect from Jamming by only one 100 w Jammer?
The radius of Blue circle is approximately 10 km at Rochester near the outlet of the Thames.

What is the Resilient PNT and Why is it essential ?

- * The history of resilient PNT mentioned. First the resilient PNT forum at Amsterdam held in 2014
- * in last IAIN world congress in Czech the forth forum was held
- * and the report by Dr. Nick had some conclusions
 - (1) A multi-system approach is needed,
 - (2) GNSS receiver standards must be addressed,
 - (3) there is still a need for education, particularly on reporting outages and
 - (4) the question of who bears the cost of better systems must be faced.
- * These conclusions in maritime should be clearly to resolve not only by the academic activity but also by the cooperation with IALA should be essential, and farther more automobile and aviation field.

What is the Resilient PNT and Why is it essential ?

- * Coming this year, Resilient PNT Forum V was held in May. Unfortunately eLORAN in North Sea stopped operation. This system was operated with UK, France, German and Norway. Now only one chain is operated where is over Korea against North Korea jamming.
- * Fortunately, USA will return back to eLORAN again, but operation of eLORAN should have not only the issues of infrastructure budgets and running cost, but also the users do not divers.
- * Automobile will use IMU as multi-sensor, but they come to use eLORAN then the problem will be disappeared. eLORAN will be used not as Back up but as complementary same as multi-GNSS.

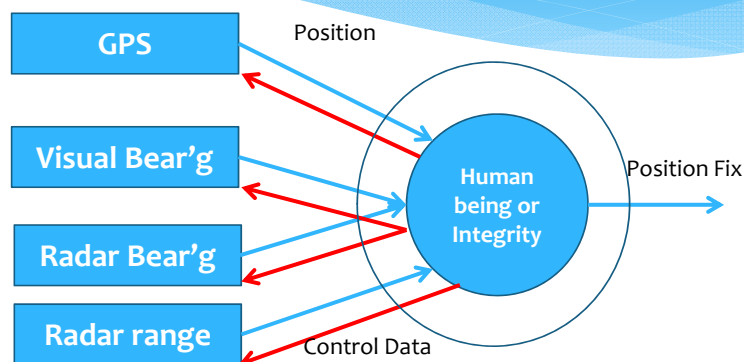
What is Integrity of Navigational Information ?

- * Integrity
- * In differential system, monitoring at base station, and measuring pseudo ranges from SV and calculate the error which are broadcasted around the base station. And monitoring the signal information from SV, if there are some miss or error, it will broadcast not to use no good SV to around the base. This is called “integrity”
- * Now new algorithm called RAIM (Radio Autonomous Integrity Monitoring) is developing, and these procedures will be executed in the Receiver.

Why is the Autonomous Integrity essential ?

- * What are the Navigational Information and buy what sensor?
- * Position -- GNSS, Radar, Visual bearing, so on
- * Heading and bearing – Gyro compass, Magnetic compass
- * Speed, COG -- SDME STW, GPS presents SOG and COG
- * Target Ships’ Position, speed, COG – RADAR : ARPA, AIS
- * ROT (Rate of Turn)
- * Weather, etc.

Why is the Autonomous Integrity essential ?

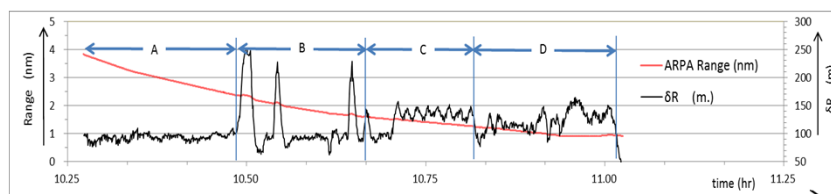


In case of Master or Watch Officer not onboard, each position data and handling should be communicated all ways.

Why is the Autonomous Integrity essential ?

AIS and Radar ARPA fusion

- * Radar is able to detect targets, so to decide AIS information is True or False.
- * The accuracy of Radar range is affected by Radar Pulse width?
- * It is not able to use for R-mode in this case.
- * Theoretical accuracy will be within several meters in marine radar, then it will be able to use R-mode.



Time History on the difference of Ranges between ARPA and AIS

Why is the Autonomous Integrity essential ?

Gyro compass Integrity Algorithm

Using this algorithm, it will be possible to detect the malfunction of Gyrocompass within one second or less autonomously.

- * Power spectrums are calculated in FFT
- * Low freq. Ship's motion
 - * Movement of gyro axis
- * High freq.
 - * Malfunction
 - * Hunching
 - * Compass card

Why is the Autonomous Integrity essential ?

In case of Gyro Compass

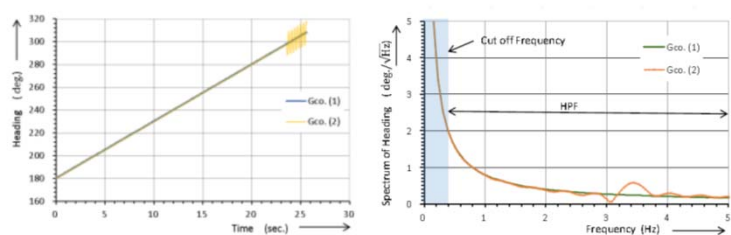


Fig. 8. Time History and Power Spectrum on High Speed Turning
In case of one's Malfunction "Hunching Compass card"
(Hunching Amplitude is 10.0 deg.)

Is Autonomous Control essential for Unmanned Control ?

- * Unmanned Control
 - * Remote Control (Sensor should be automatic control, if not should be communicated to control and to monitor)
 - * Duplex Control (Remote and/or partial Autonomous)
- * Autonomous Control (not need to communicate for ship control. Only should communicate for ship's managements)

Closing

- * Development of Autonomous Integrity on Navigational Information will be essential to safety and/or economical navigation.
- * Development of Unmanned control shall increase requirements of the reliability according to Autonomous Integrity on Navigational Information.
- * Should be taken into Category of Areas, Communication, Supporting infrastructure, etc. with international discussion.

Thank you for your Attention!

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