

GPS Jamming and its impact on maritime safety

Dr Alan Grant

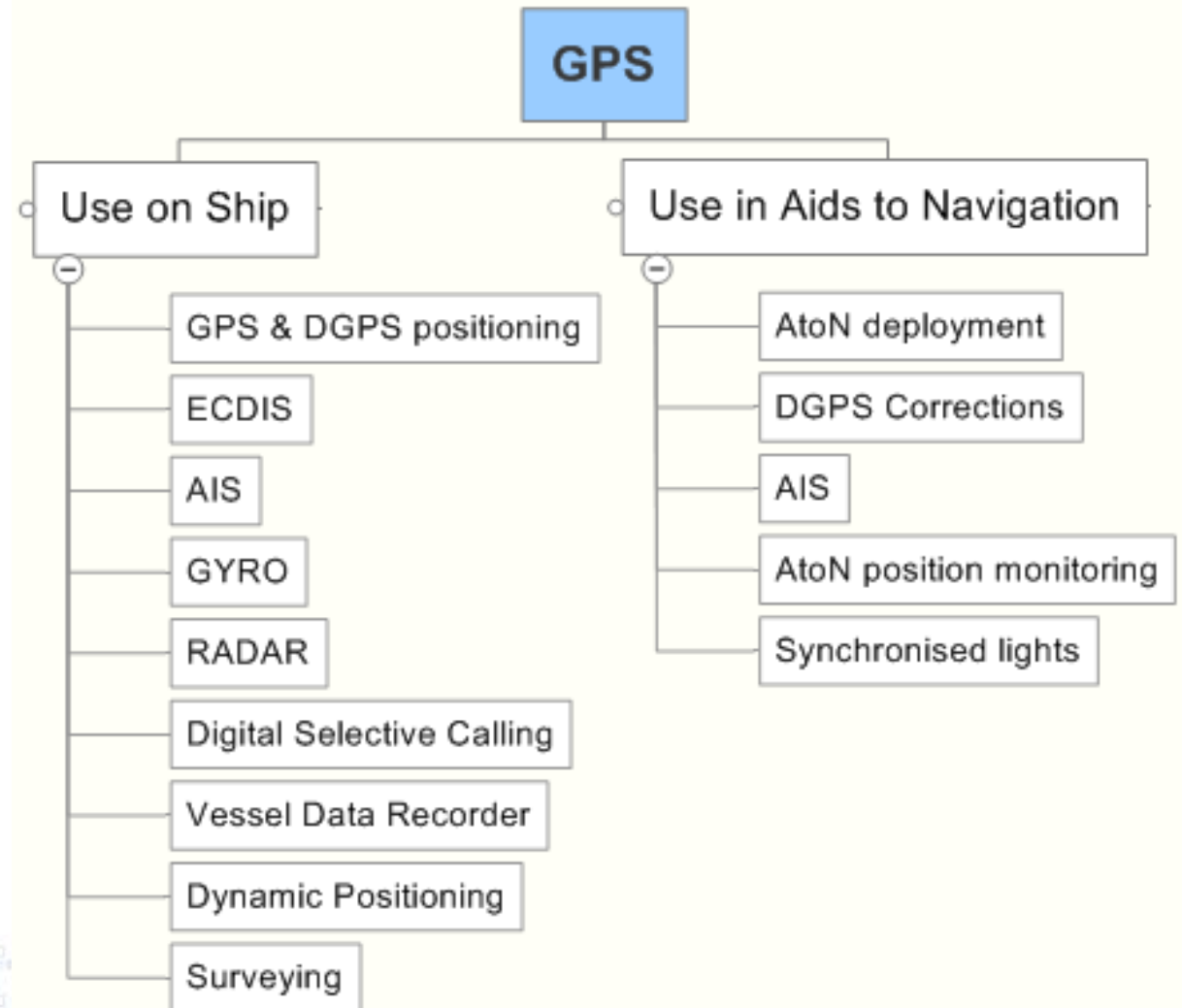
Marine Safety Forum – 27th May 2010



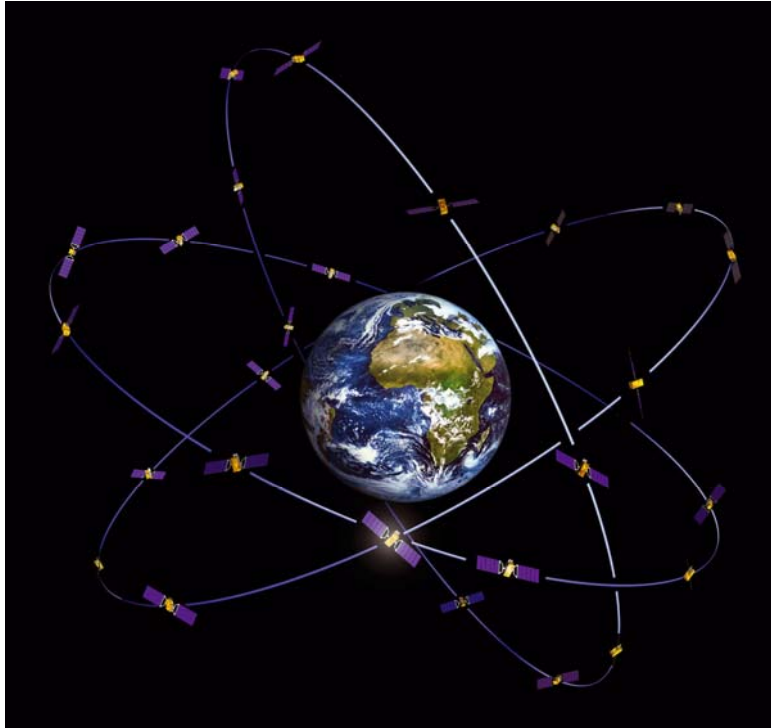
Use of GPS in the maritime sector

GPS has become the normal means for maritime positioning, navigation and timing.

The level of integration onboard is different for each vessel depending on equipment fitted.



GPS Vulnerabilities



Satellites orbit ~20,000km
above the Earth

Accidental

Natural events

GPS satellite failures

TV antenna amplifier fault

Jamming unit left on accidentally

GPS antenna hardware failure

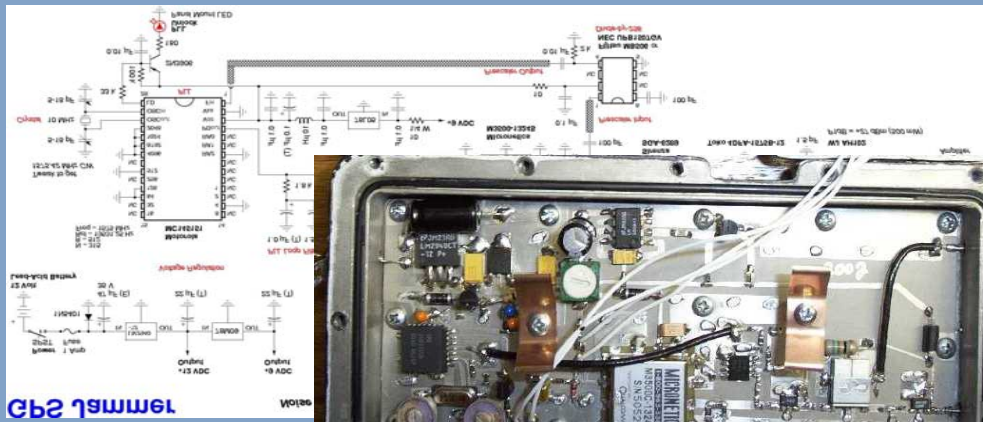
Intentional

Arranged jamming trials

Illegal use of jamming units

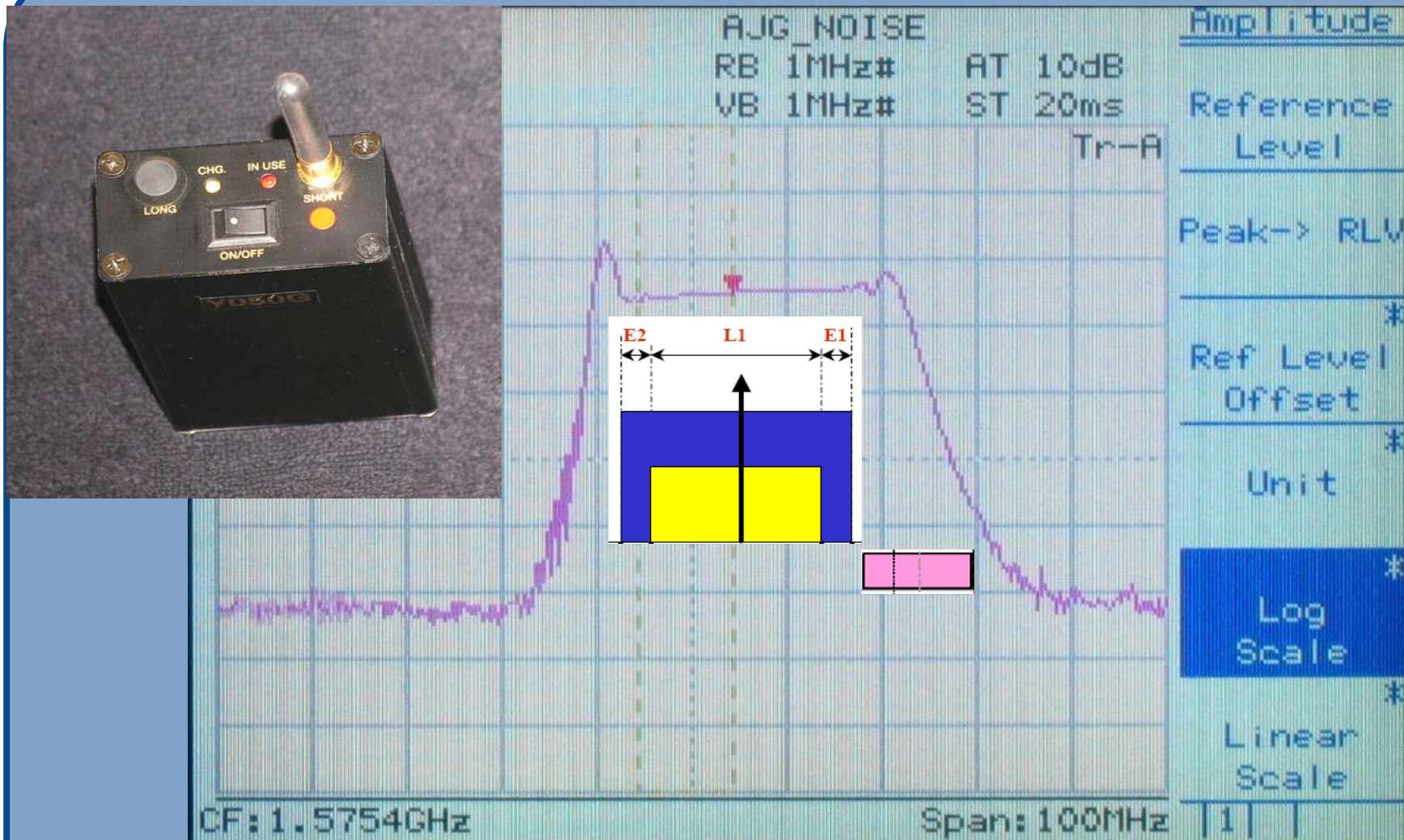


GPS, GSM Cellphone Jammers Hit Mainstream



**Pentagon fürchtet
40-Dollar GPS-
Störsender der
ferngelenkte
Raketen blockiert.**

Pictures: www.redferret.net/?p=7864



GPS Jammer – GPS, Galileo & GLONASS bands

nobody gets you closer

Express & Star

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£6m lorry hijackings gang face ten years

Thursday 6th May 2010, 11:30AM BST.



Two robbers who were part of a violent gang which hijacked 40 lorries around the Midlands with loads totalling £6 million were today facing up to 10 years in prison.

RESEARCH &
RADIONAVIGATION
GENERAL LIGHTHOUSE AUTHORITIES
United Kingdom and Ireland



“Satellite jamming equipment was used to stop lorries being tracked after they were stolen”

Source: <http://www.expressandstar.com/news/2010/05/06/6m-lorry-hijackings-gang-face-ten-years/>

GLA GPS Jamming trials

The GLAs have conducted two trials investigating the effects of GPS jamming.

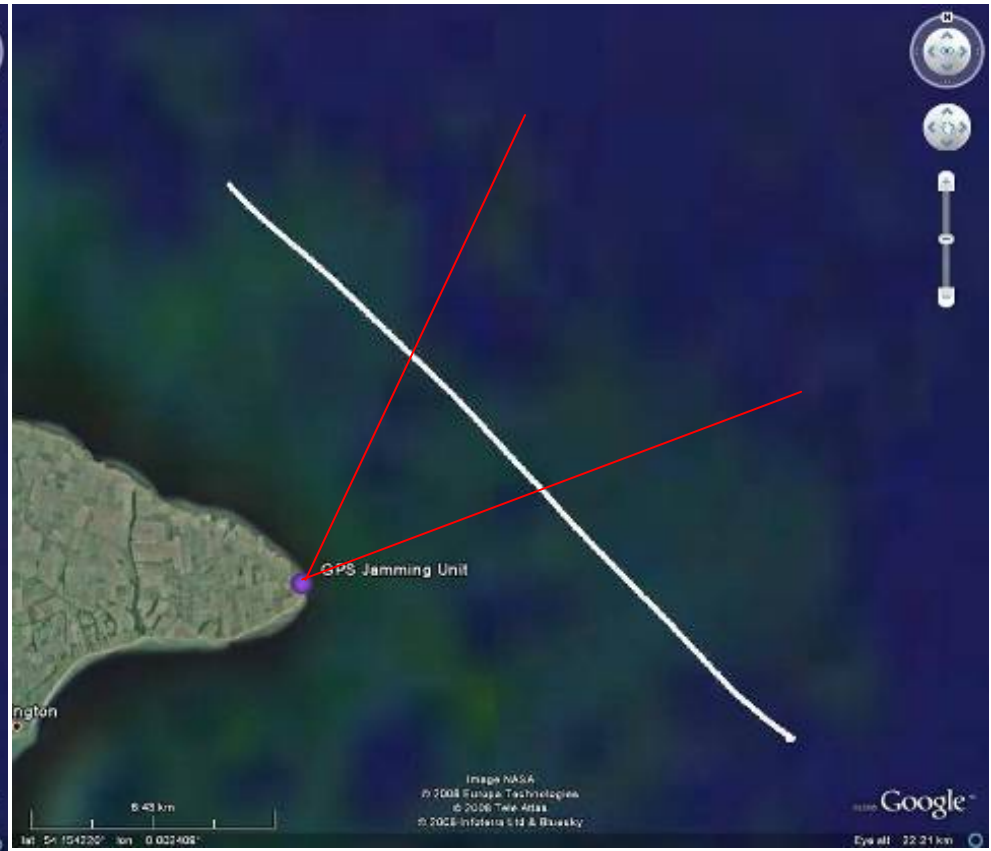
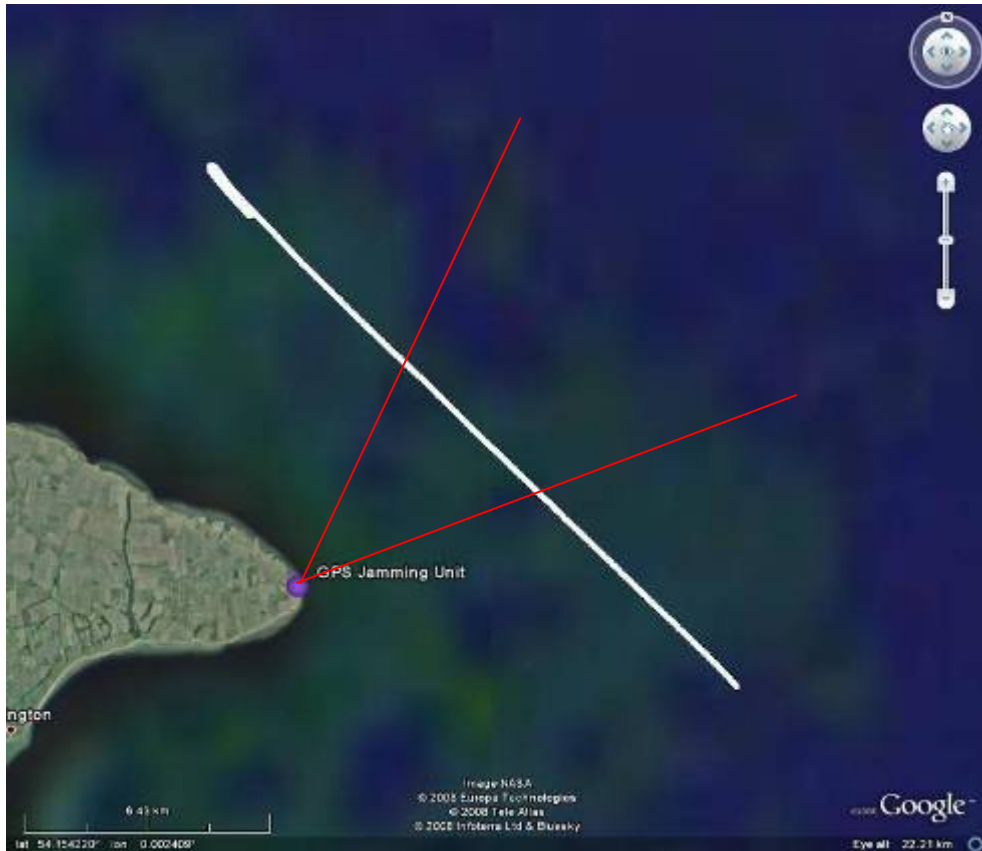
April 2008 off Flamborough Head

December 2009 off Newcastle Upon Tyne

For both trials the jamming units were provided and operated by the Ministry of Defence through their Defence Science and Technology Laboratories (DSTL)



eLoran



Reported position from eLoran receiver operating in Eurofix corrected GPS mode during control run with no jamming.

Reported position from eLoran receiver operating in Calibrated eLoran mode with jamming enabled

Differential GPS



The GLAs operate 14 DGPS stations

Differential GPS

The screenshot displays a software interface for monitoring GPS equipment. On the left is a tree view of the equipment hierarchy. The main area contains four satellite status tables, each with columns for SV, Azimuth, Elevation, SNR, URA, and SV Hlth. The SNR column in all tables is highlighted in yellow and contains the value 0.0. Below these tables is a log of events, and at the bottom left is a 'Digital Outputs Status' window.

Equipment Hierarchy:

- Flamborough Head
 - Reference Stations
 - Reference Station 1
 - RS1-GPS
 - RS1-DGPS
 - RS1-Modulator
 - RS1-Connection
 - Reference Station 2
 - RS2-GPS
 - RS2-DGPS
 - RS2-Modulator
 - RS2-Connection
 - Integrity Monitors
 - Integrity Monitor 1
 - IM1-GPS
 - IM1-DGPS
 - IM1-Demodulator
 - IM1-Connection
 - Integrity Monitor 2
 - IM2-GPS
 - IM2-DGPS
 - IM2-Demodulator
 - IM2-Connection
 - I/O Manager
 - Analog Inputs
 - AnalogInput0
 - AnalogInput1
 - Battery Voltage
 - Antenna Current
 - Digital Inputs
 - Battery Charger
 - DigitalInput1
 - DigitalInput2
 - DigitalInput3
 - Digital Outputs

Satellite Status Tables:

SV	Azimuth	Elevation	SNR	URA	SV Hlth
2	241.4	47.2	0.0	2.0	Healthy
4	198.6	31.6	0.0	2.0	Healthy
7	122.2	59.6	0.0	2.8	Healthy
8	176.9	35.1	0.0	2.0	Healthy
10	294.7	36.7	0.0	2.8	Healthy
13	68.4	54.7	0.0	2.0	Healthy
16	31.1	13.0	0.0	2.0	Healthy
23	71.8	15.9	0.0	2.0	Healthy
25	88.0	58.8	0.0	2.8	Healthy
27	147.2	59.3	0.0	2.0	Healthy
29	321.8	10.9	0.0	2.8	Healthy

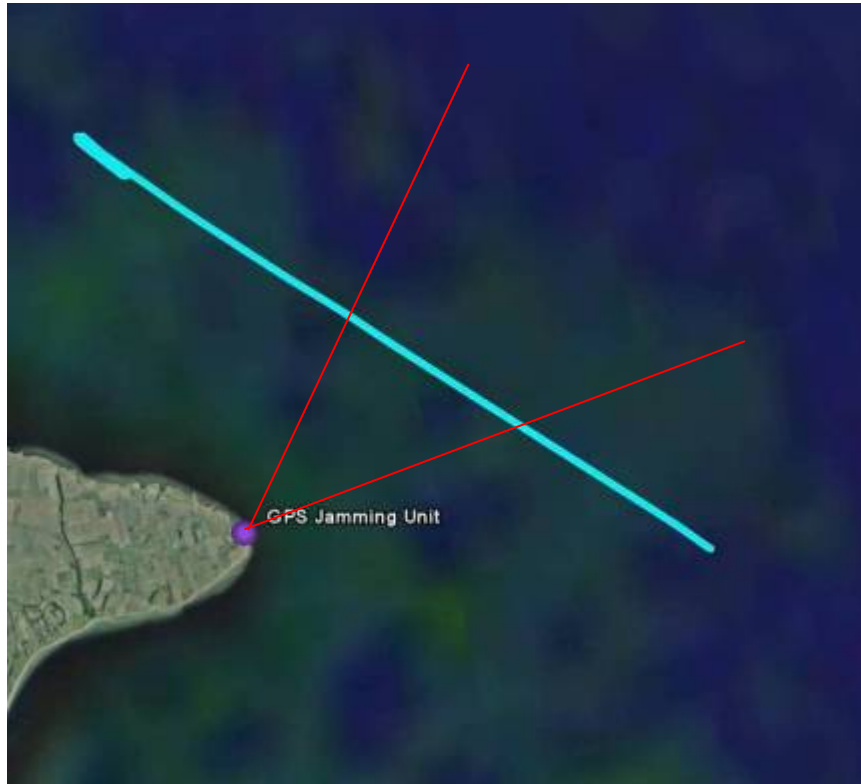
Log of Events:

Time	Site	Device	Message	Timestamp
9:50 PM	Flamborough	RS1	IM Feedback from Monitored to Unmonitored	4/3/08 2:29:50 F
0:19 PM	Flamborough	RS1	Number of SVs from Sufficient to Insufficient	4/3/08 2:30:19 F
0:19 PM	Flamborough	RS2	IM Feedback from Monitored to Unmonitored	4/3/08 2:30:19 F
0:22 PM	Flamborough	IM1	RTCM Health Change from Healthy (0) to Unmonitored (6)	4/3/08 2:30:22 F
0:22 PM	Flamborough	IM2	RTCM Health Change from Healthy (0) to Unmonitored (6)	4/3/08 2:30:22 F
5:01 PM	Flamborough	RS2	Number of SVs from Sufficient to Insufficient	4/3/08 2:45:01 F
7:08 PM	Flamborough	IM1	Number of SVs from Low to Zero	4/3/08 2:47:08 F
3:19 PM	Flamborough	IM2	Number of SVs from Low to Zero	4/3/08 3:19:04 F

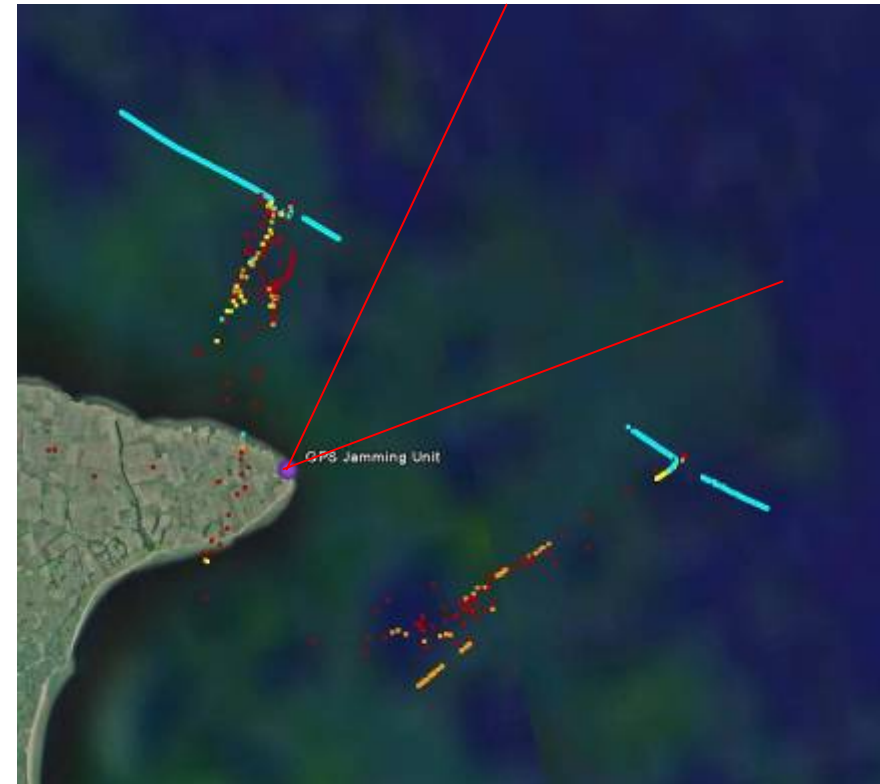
Digital Outputs Status:

RTCM Health	Unmonitored
RSIM Alarm	Alarm

Ship systems



Positions plotted using GPRMC
NMEA data from run without jamming

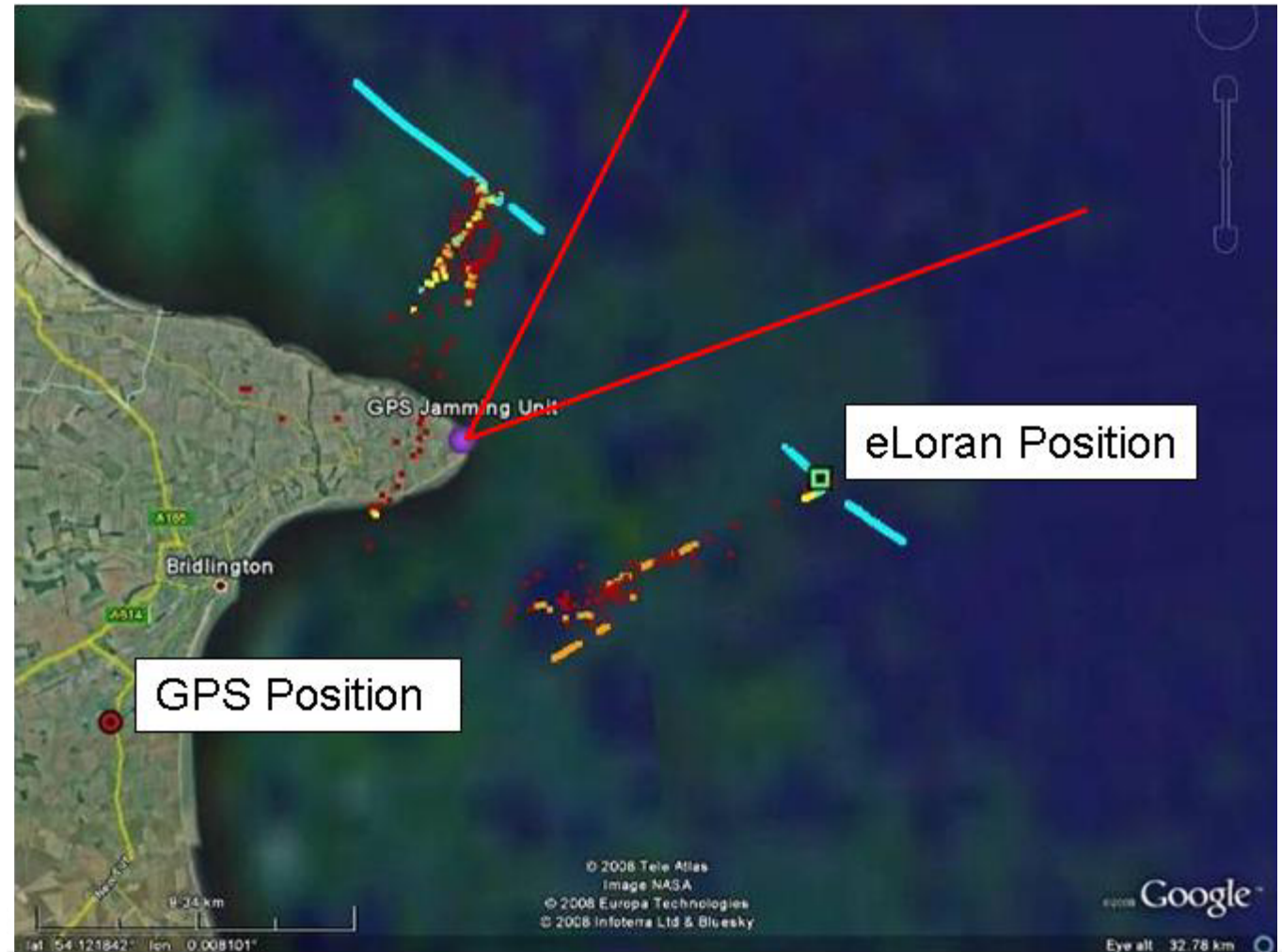


Erroneous reported positions as
effect of jamming signal is observed.

Colours indicate reported speed: blue <15knts, yellow < 50knts, orange <100knots and red >100knts

Ship systems

GPS reported position is inland and 22km away from true position (eLoran).

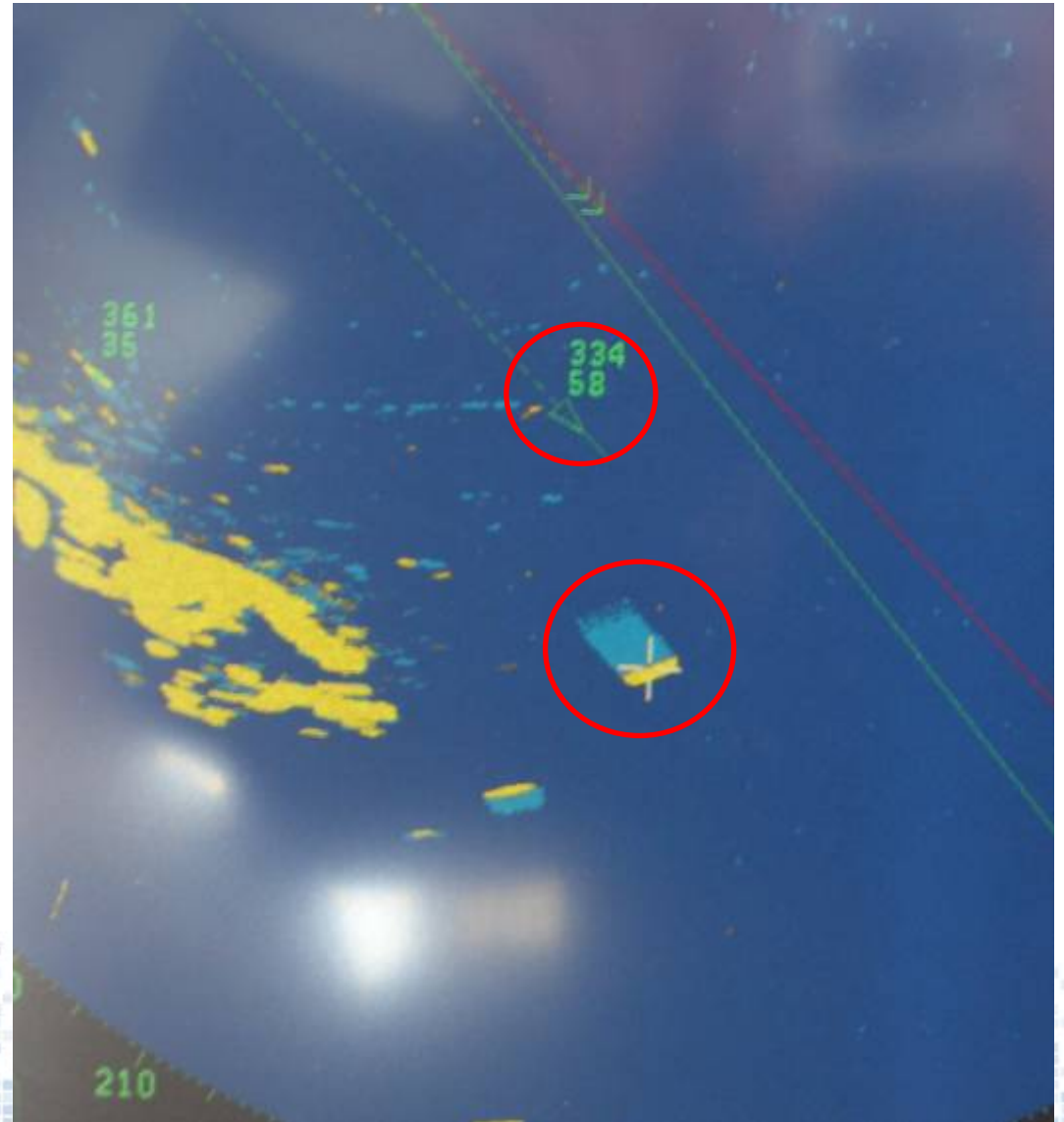


Colours indicate reported speed: blue <15knts, yellow < 50knts, orange <100knts and red >100knts

Effect on Ship & Shore

The effect of GPS jamming on AIS was observed by:

- *NLV Pole Star's* AIS alarmed when GPS was lost.
- Without GPS it could not provide a range or bearing to surrounding vessels or AtoNs.
- Some AIS returns included erroneous positions.



Effect on Ship & Shore

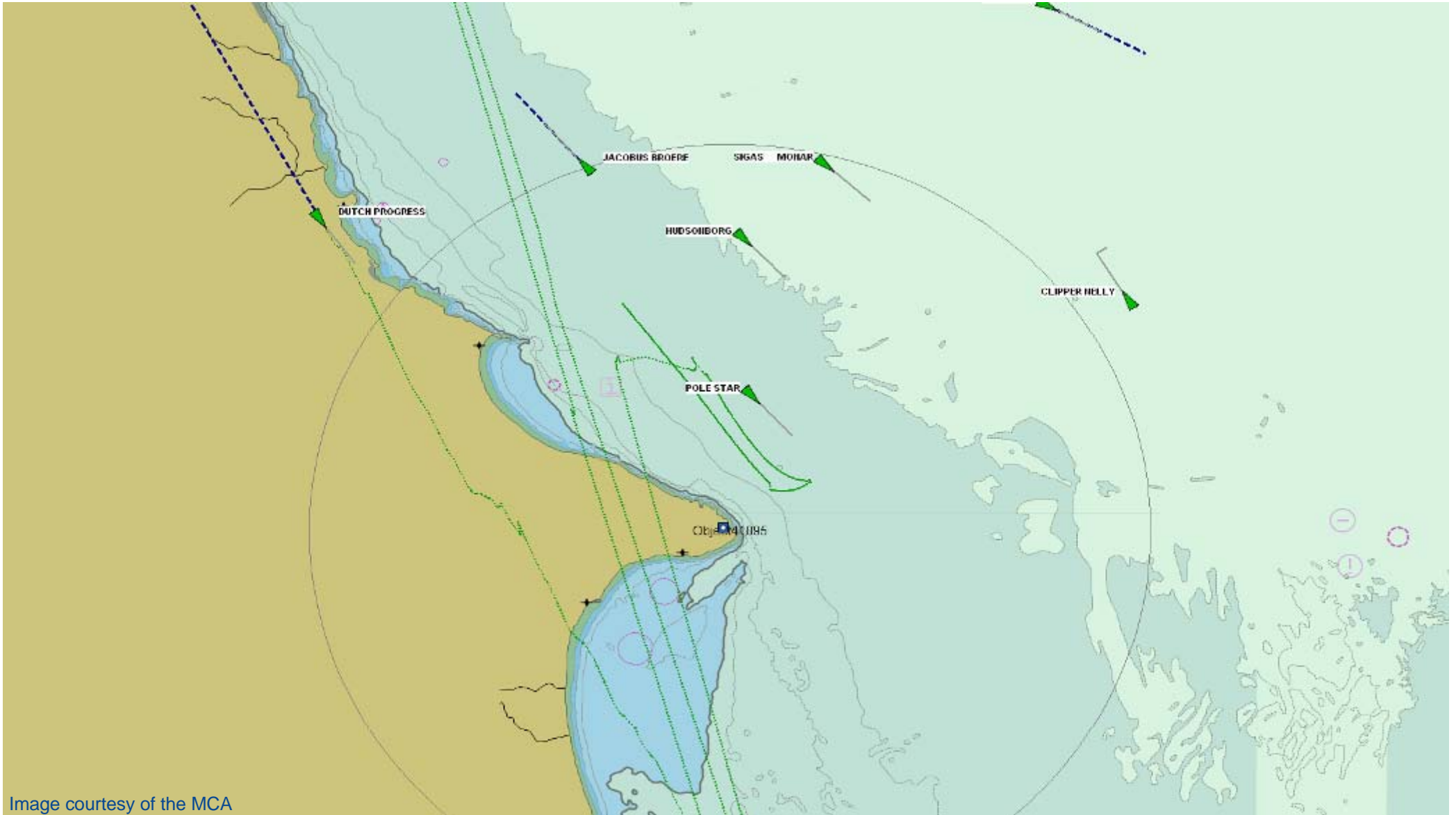


Image courtesy of the MCA

People

NLV Pole Star's crew were able to navigate safely during GPS outage.

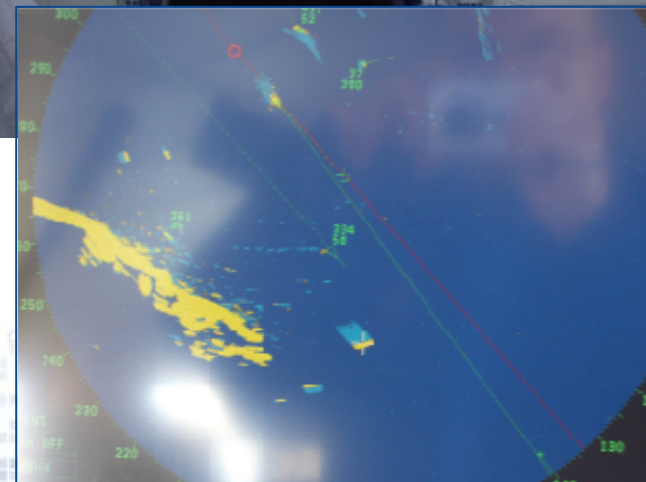
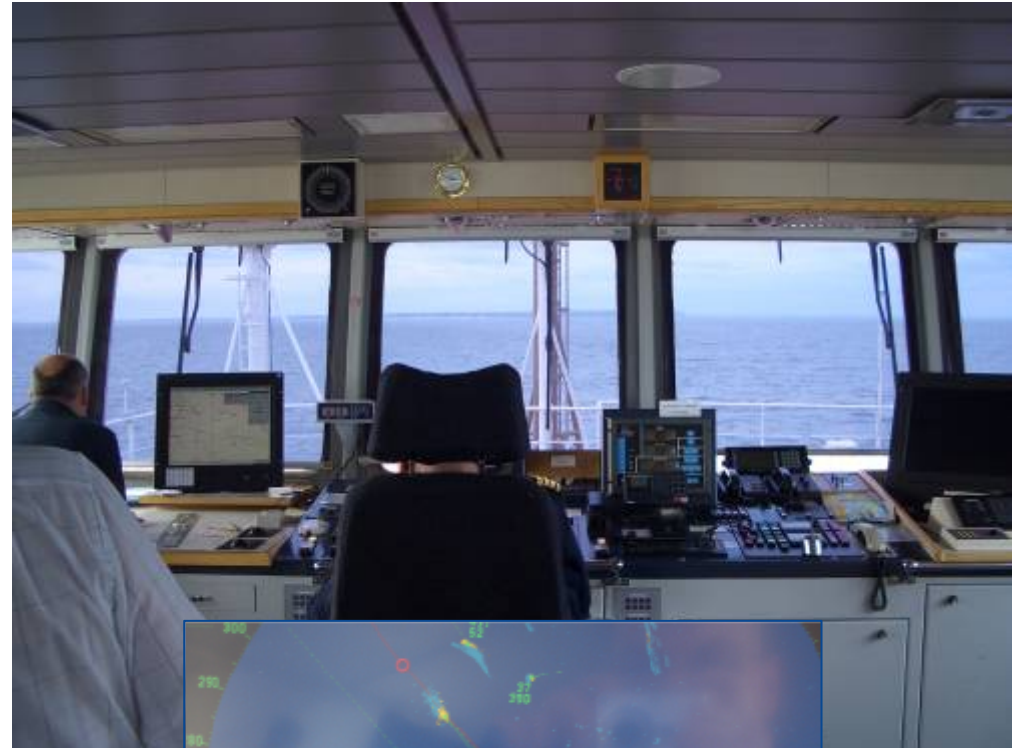
However, it should be noted:

- Vessel's crew had advance knowledge
- Parallel indexing on Radar
- Switched ECDIS screen off

Severity of GPS denial depends on:

- Ability of crew to use traditional means
- Availability of traditional means

During entry and exit of the jamming region system alarms sounded for around 5 minutes.



Flamborough Conclusions

GPS jamming can severely affect the safety of the mariner

GPS jamming resulted in:

- Numerous alarms on the bridge
- Erroneous GPS positions
- Failure of GPS fed equipment
- Erroneous information presented on the vessels ECDIS
- Misleading information presented by the vessels AIS
- Reduced situational awareness



NLB Pole Star

Newcastle Demonstrations

Demonstrations of the effect of GPS jamming on a typical vessel to encourage the development of resilient Position, Navigation and Timing information.

Audience represented:

- UK Government
- European Governments
- DGPS Service providers
- Mariners
- Industry
- Press



THV Galatea

Demonstration approach

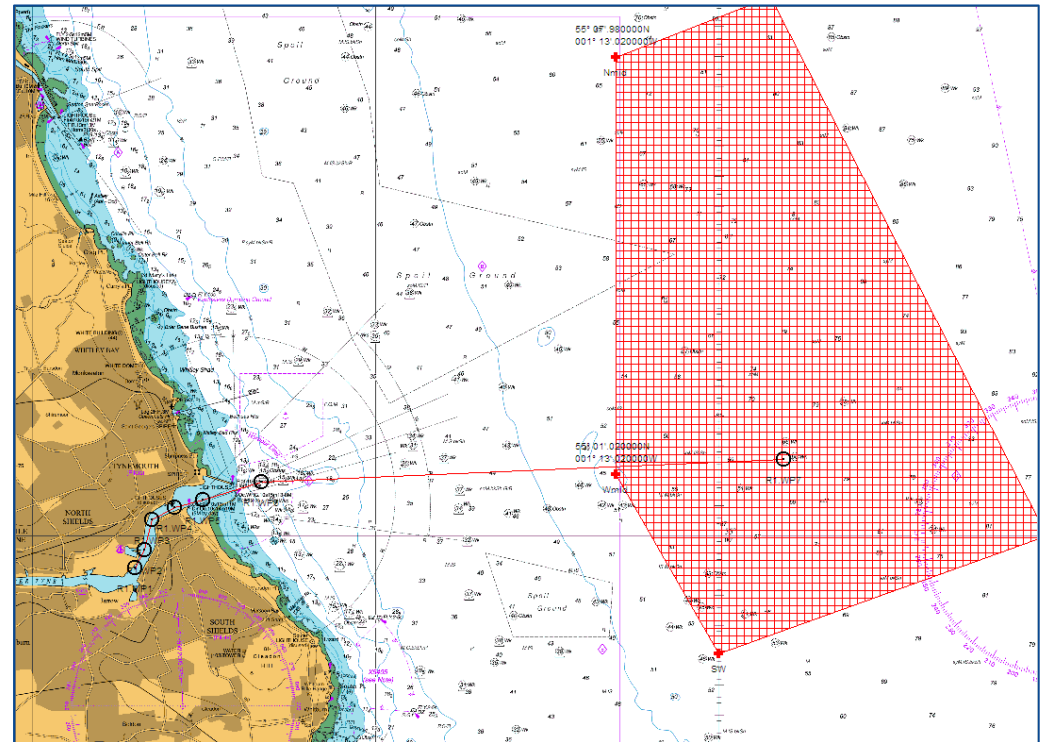
Two scenarios were demonstrated:

Full signal denial

The jamming signal is significantly greater than the GPS signal and prevents GPS reception

Comparable signal

The jamming signal is slowly increased to simulate a vessel steaming towards a jamming source.



Ship installation

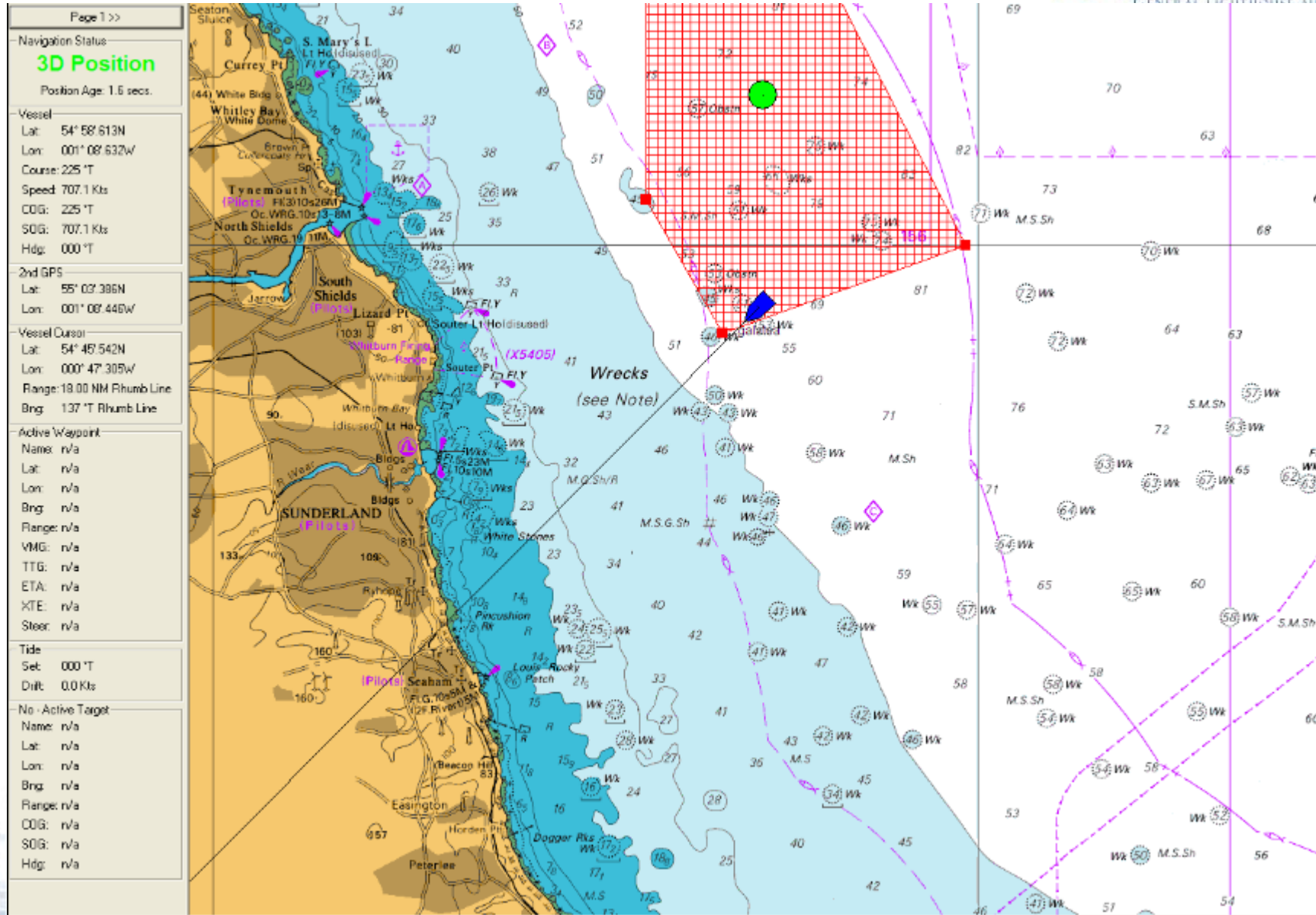
For the demonstrations additional equipment was installed on the demonstration vessel:

A typical Electronic Chart Display amended to show two positions

- A GPS position
- A eLoran position



Observed effects

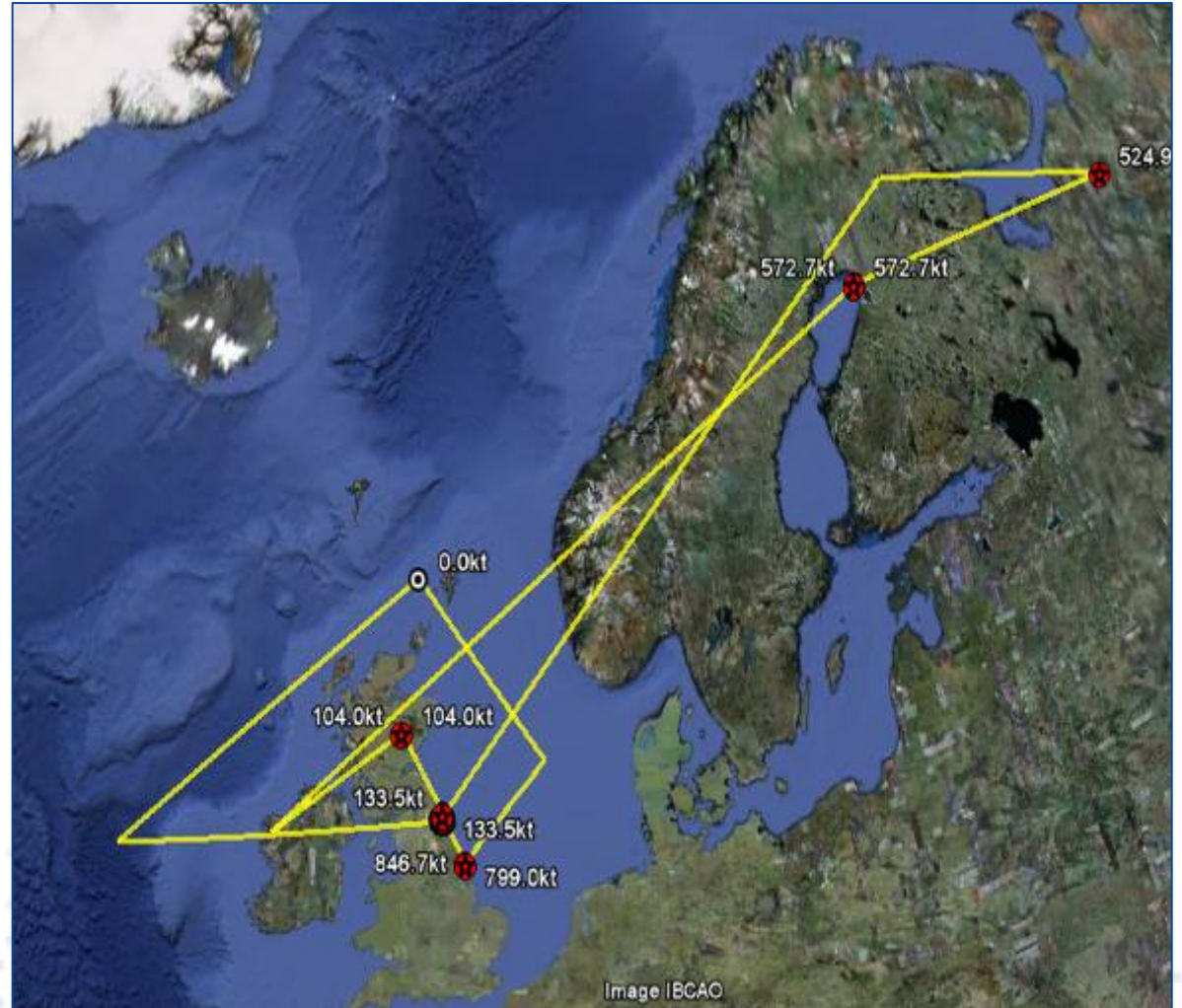


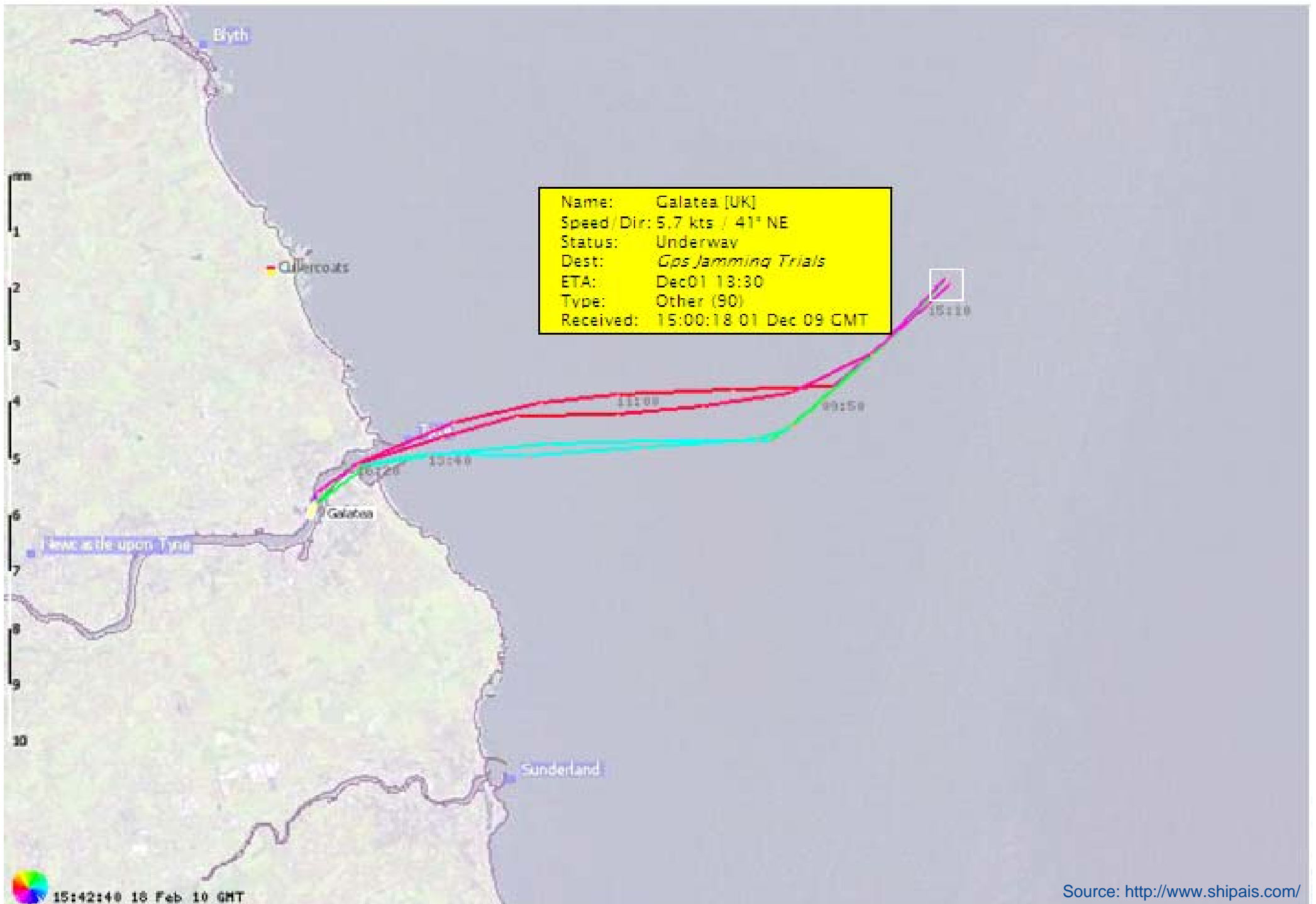
Observed GPS position errors

Erroneous GPS positions were observed on both typical GPS receivers installed for the demonstration.

Observers with their own handheld GPS receivers observed erroneous positions, with Ireland and Eastern Europe favourite destinations.

Not always this marked, subtle errors, giving Hazardous Misleading Information were also observed





Conclusions

GPS jamming whether by intentional or unintentional means ***significantly affects*** maritime navigation.

GPS jamming can cause Hazardous and Misleading information

The level of disruption is dependent on:

- the make and model of the equipment installed on the vessel
- the configuration of the equipment (i.e. inputs to the ECDIS)
- the signal strength of the jamming signal

eLoran was demonstrated as a complimentary navigation system to GNSS providing a position of <9m (95%) providing seamless navigation.

The GLAs recommend the use of multiple means of navigation and support the development of resilient PNT.



Thank you



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