GPS Jamming and its impact on maritime navigation

Dr Alan Grant
Research and Development - Special Interest Group
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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

Accidental
- Natural events
- GPS failures
- TV antenna
- Jamming unit left on accidentally
- GPS antenna hardware failure

Intentional
- Arranged jamming trials
- Illegal use of jamming units

Satellites orbit ~20,000km above the Earth
GPS, GSM Cellphone Jammers Hit Mainstream

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

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

Courtesy of Prof. David Last
GPS Jammer – GPS, Galileo & GLONASS bands
“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)
Flamborough Head trial

High power 25w GPS Jammer - Anti tracking

CTS-GBOX
25W 300M

Effect of GPS jamming on safe navigation

Coverage area of the GPS jamming unit at 25m above ground level on maximum power of 1.58W ERP.

(Image courtesy of 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
Synchronised Lights

Lights use GPS as a common timing source.
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
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
eLoran

The Newcastle trial used eLoran with a reference station installed in South Shields.

The reference station took under 24hrs to install, reference its position and resulted in an eLoran position accurate to <9m (95%)

eLoran has different failure modes to GNSS and was used as the truth in the demonstrations.
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.
Observed effects on AIS

AIS Display under normal conditions

AIS Display under full jamming conditions
Name: Galatea [UK]
Speed/Dir: 5.7 kts / 41° NE
Status: Underway
Dest: Gps Jamming Trials
ETA: Dec01 13:30
Type: Other (90)
Received: 15:00:18 01 Dec 09 GMT

Source: http://www.shipais.com/
Reverting to traditional means

**RADAR**
- Alarms at the loss of GPS
- Can be misleading if AIS is overlaid

**Gyrocompass**
- Alarms at the loss of GPS
- Drift errors can occur over time
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

Contact Information
Dr. Alan Grant, Email: alan.grant@gla-rrnav.org, Phone: +44 (0)1255 245141