



***Satellite Navigation
– Truths & Myths?***

Professor David Last

International Sail Training & Tall Ships Conference

***18-19 November 2011
Toulon, France***

Picture: earthobservatory.nasa.gov//ewsroom/BlueMarble/



A Proper Navigator

Photo: Dreamstime.com

The First Handheld Aviation Navigator



From: May, V., 'The first handheld aviation navigator', Navigation News Nov/Dec 2001, pp8-9..



From: www.garmin.com/marine



From: Simmons, 'Practical applications of GPS for GIS and civil engineering',
Suppl. To Civil Engineering, 114, Sp. Issue 2, pp30-34.



Mobil technology resellers, operations consultants

Dynamic Routing Scheduling Software | Vehicle GPS Tracking & Communication | Delivery Cost Analysis

GPS Tracking & Communications



Photo: Ashtech Inc., Optron Pty.

Wireless Phones

SPHn300

Built for Today, Designed for Tomorrow



This cellphone is E911 GPS capable.

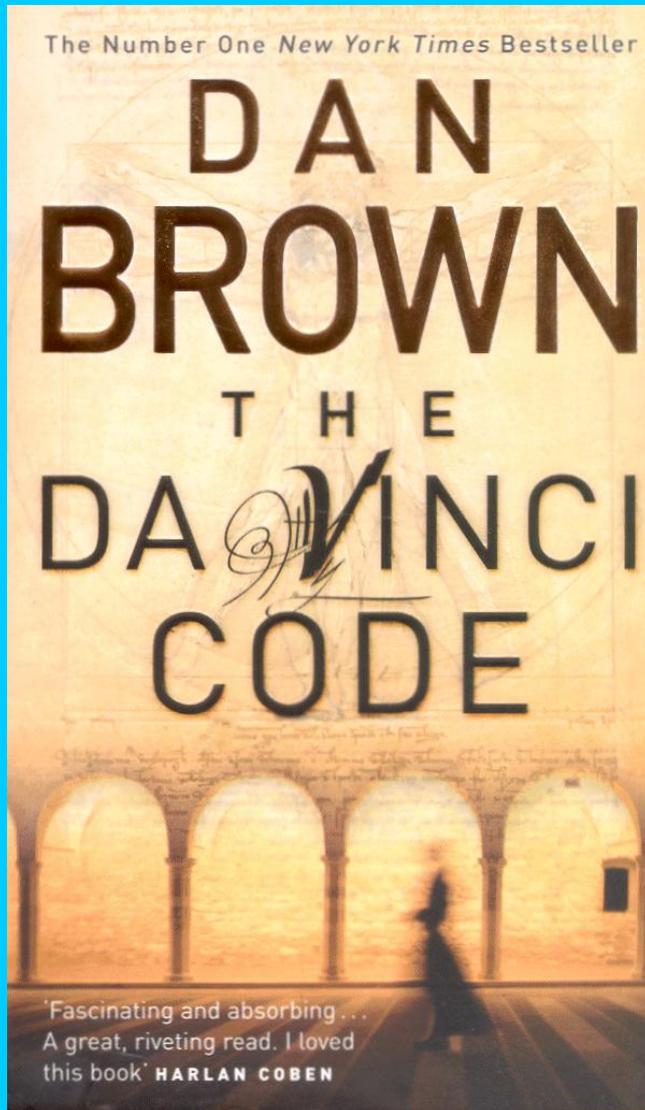
From: www.cellphonesforbusiness.com/
www.samsung.com



Contents: www.cellpoint.com/Presentation/CellPoint-LondonMLSOctober2002.pdf and <http://www.telecomsys.com/>

GPS *is* perfect ...

isn't it?



Captain Fache plants a battery-sized GPS dot in Langdon's pocket to track his location, wherever he is, accurate to 2 feet.

It's tiny!

It's amazingly accurate!

It works indoors!

Copyright: Dan Brown 2003



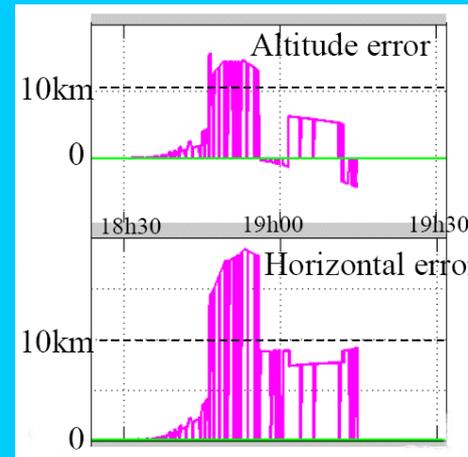
Picture: www.flickr.com/photos/guyburns/1878598347
www.skyscrapercity.com/showthread.php?t=383984&page=3/

Satellite and Control System Failures

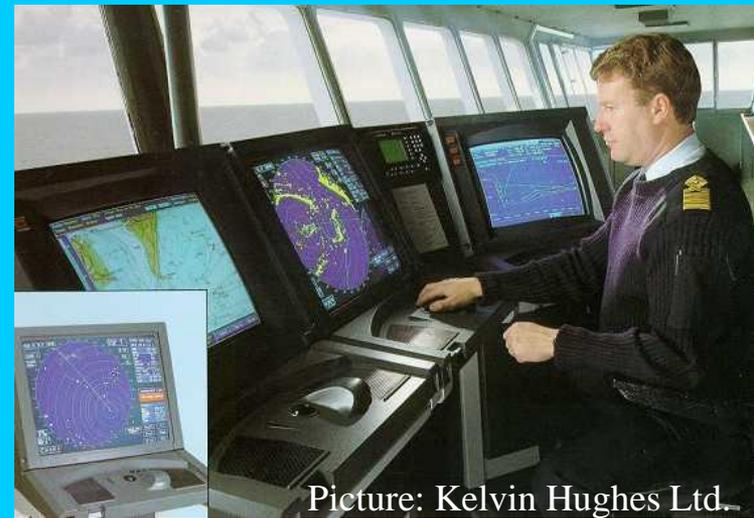
Official announcement:

"A significant GPS anomaly occurred on 1 Jan 04, beginning at approximately 1833Z ... (which) ... affected precise timing and navigation users over large portions of Europe, Africa, Asia, Australia, and ... North America ... and resulted in the transmission of Hazardously Misleading Information."

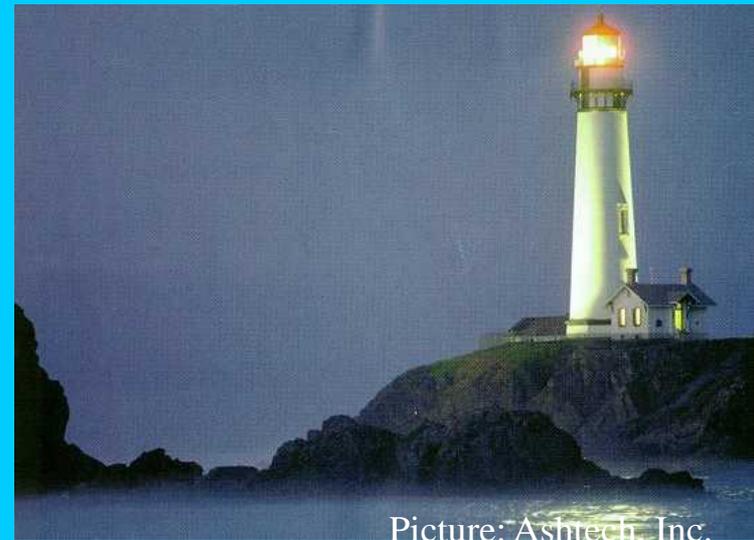
SVN23 clock failure



Sources: Vogel, Macabiau & Suard, 'Effect of a GPS Anomaly on Different GNSS Receivers', ION GNSS 2005, Long Beach, CA, Sep 13-16, 2005, Hoppe & Walterfang, 'Investigation of a GPS Satellite Problem with respect to DGPS and GPS users', European Journal of Navigation, May 2004, www.lr.tudelft.nl/live/pagina.jsp?id=400f4487-ed8c-4274-95cb-ebc2afa7385e&lang=en



Picture: Kelvin Hughes Ltd.



Picture: Ashtech, Inc.



- **GPS satellite radiates 100W**
- **From 20,000km range**
- **Illuminates 38% of Earth**
- **eg Europe + Africa + Atlantic**

Picture: Professor Durk van Willigen

Solar flares

GPS significantly impacted by powerful solar radio burst

NOAA NEWS RELEASE
Posted: April 4, 2007



"Measurements with NJIT's solar radiotelescope confirmed, at its peak, the burst produced 20,000 times more radio emission than the entire rest of the sun. This was enough to swamp GPS receivers over the entire sunlit side of Earth."

Tom Chivers

Tom Chivers is Telegraph.co.uk's Strategic Events Editor. He is a science nerd and pedant, and thinks cinema reached its pinnacle with Fight Club and music with Faith No More. He writes on science, culture and anything that crosses his mind. He is on Twitter at twitter.com/tomchivers.



Nasa's 2013 solar flare warning: how much do we need to worry?

By Tom Chivers | Last updated: June 16th, 2010

23 Comments | [Comment on this article](#)



Recent Posts

Atheists and agnostics 'more knowledgeable about religion than the religious'

September 28th, 2010 15:26

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Portugal drug decriminalisation 'a resounding success': will Britain respond? No.

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85 Comments

Sir Martin Rees and Stephen Hawking in all-star theology smackdown

September 27th, 2010 15:07

Picture: <http://blogs.telegraph.co.uk/culture/tomchivers/100008500/nasas-2013-solar-flare-warning-how-much-do-we-need-to-worry/>

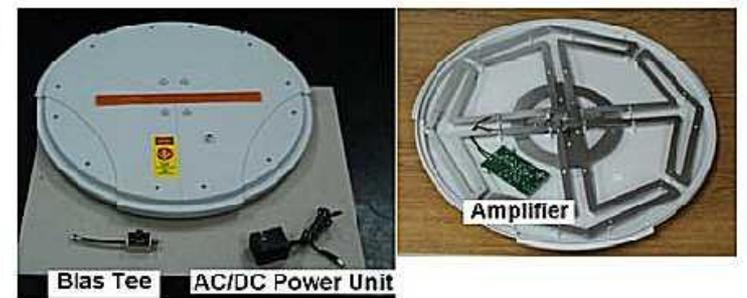
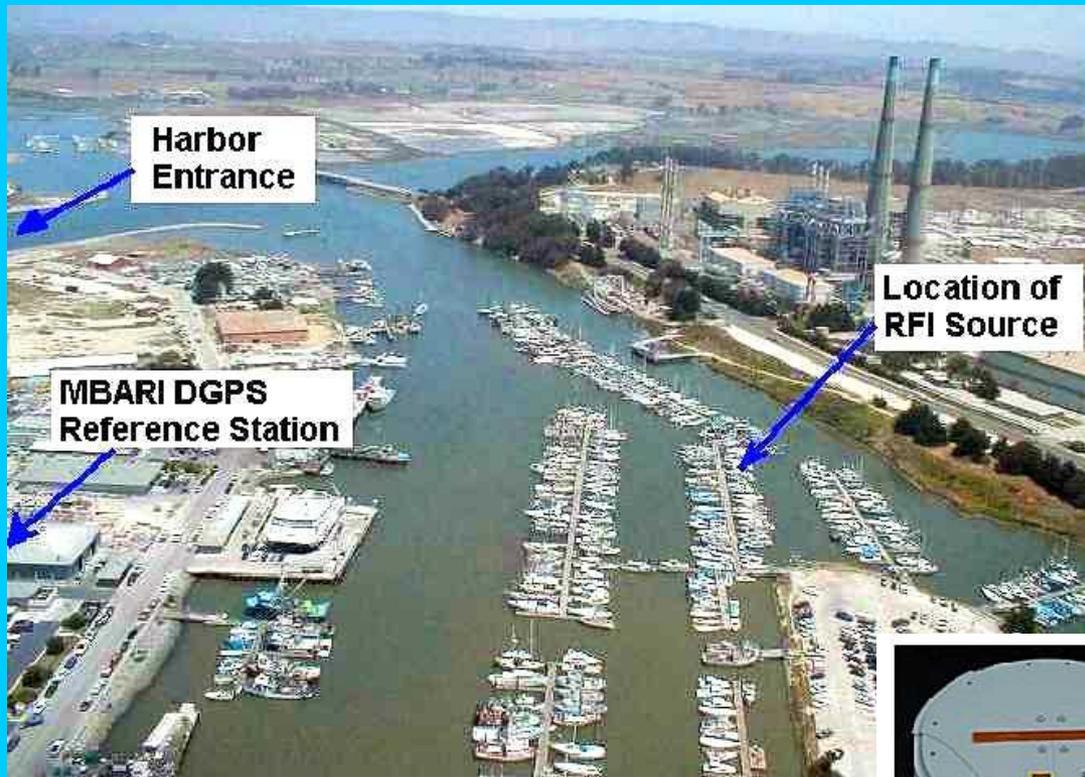


U.S. DOT/Volpe Center

Vulnerability Assessment

of the Transportation Infrastructure
Relying on GPS

- **Threat of unintentional interference and jamming**
- **Risks can be reduced but not eliminated**
- **Consequences severe for safety, economic damage**
- **Tempting target for those hostile to the US**
- **Can be spoofed to give misleading information**
- **Need backup system in critical applications**



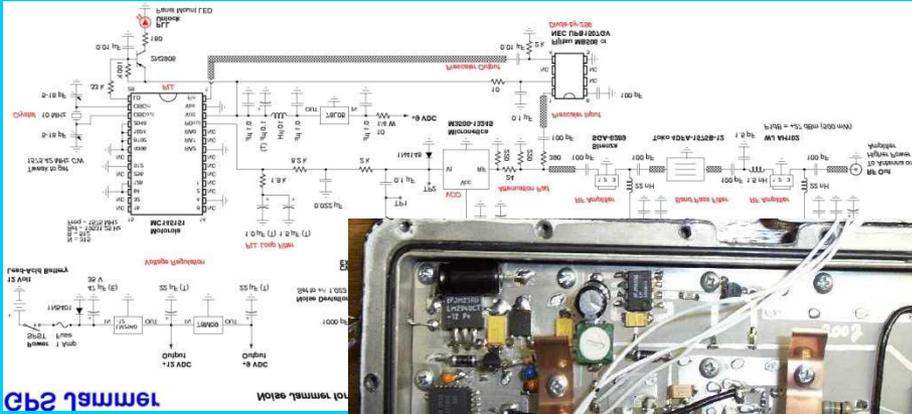
Radio Shack 15-1624 VHF/UHF Antenna

Source: Clynch *et al.*, 'Multiple GPS RFI Sources in a Small California Harbor', ION GPS02, Portland OR.



Picture: www.flickr.com/photos/l23productions/1451697290/

GPS, GSM Cellphone Jammers Hit Mainstream



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

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

BBC Mobile News Sport Weather iPlayer TV

NEWS HIGHLANDS & ISLANDS

Home World UK England N. Ireland Scotland Wales Business Politics Health Education Sci/Env

Scotland Politics Scotland Business Edinburgh, Fife & East Glasgow & West Highlands & Islands NE

10 October 2011 Last updated at 16:20

Military jamming of GPS in Scotland suspended

By Steven McKenzie
BBC Scotland Highlands and Islands reporter

Jamming of global positioning signals (GPS) during Europe's largest military exercise has been suspended, following complaints from fishermen.

The Royal Navy issued warnings in September and October that GPS in parts of Scotland would be disrupted during Exercise Joint Warrior.

But Western Isles fishermen said the first they knew was when their equipment went offline last Friday.



Temporary jamming of GPS is routinely practiced in exercises, the Royal Navy said

Notice to Airmen (NOTAM): AC 5555
07 JUL 1100-1400
30000ft (A1063/02pt)
08 JUL 0715-1015
30000ft (A1063/02pt)
GPS Jamming Activity
5555N 00550W rad
320nm.



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Cornwall area to lose GPS

Release date: 06 Jun 2007

An area of Cornwall has been warned that satnav systems will not work later this week as the MoD carries out a jamming exercise.

The GPS jamming exercise - due between 0800Z and 1600Z on 7 and 8 June - is to determine how interference could affect military systems.



The jamming will be centred around Portreath (5016N 00516W). The effect is expected to extend for a radius of 6 NM (11 km) - which would cover Camborne and Redruth. It could affect aircraft up to 30,000 ft.

Google “gps” and “jammer” ...

Google

+gps +jammer

Search

[Advanced Search](#)

Search: the web pages from the UK

Web [+ Show options...](#)

Results 1 - 10 of about **185,000** for **+gps +jammer**. (0.21 seconds)

Shopping results for **+gps +jammer**



High Power **GPS** Blocker with AC Adapter and Car Charger (110V-220V)

£37.21 new - [Nrebate.com Super Store](#)

[Super Mini Cigarette Lighter GPS Blocker](#)

£74.23 new - [Nrebate.com Super Store](#)

High Power Car **GPS** Tracker Blocker

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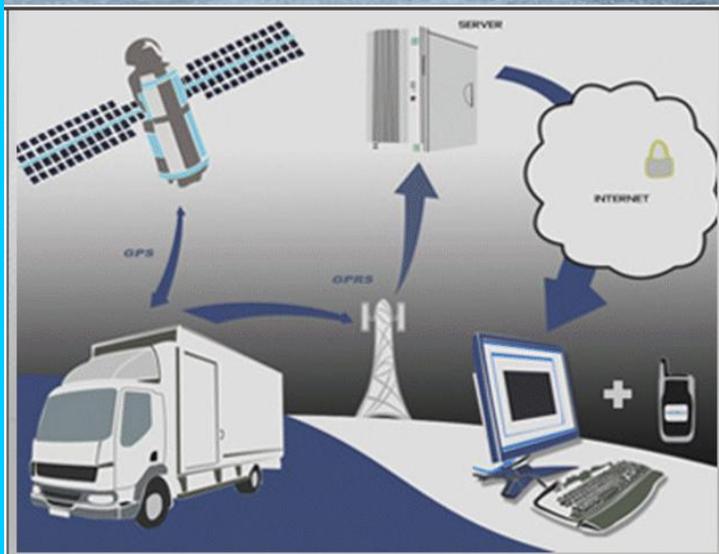
Directly from the manufacturer

[www.Direct-Gadget.com](#)

185,000 hits!



sat³ Trailer Tracking



Only one number stands out

Armed raiders hijack lorry

Keith Blackey, 42, of Melksham, Wiltshire, was bundled into the boot of a car and driven to Bristol. The car was then doused in petrol, but the raiders released him before setting it alight.

Nottinghamshire stops vehicle thieves in their tracks thanks to Masternaut

Leeds, UK, 10 November 2009 - Police forces from South Yorkshire and Nottinghamshire took just 30 minutes to intercept and recover a stolen Nottinghamshire County Council pick-up truck. The vehicle had recently been equipped with a Thatcham Category 5 satellite tracking device from Masternaut Three X.

Using live tracking on the web, Mick Monaghan of the Council's Highway Operations team helped to direct Nottinghamshire Police Force's helicopter and South Yorkshire patrol vehicles to intercept the stolen vehicle. Within 30 minutes the vehicle was recovered undamaged, saving the Council the cost of replacing it and also stopping further inconvenience caused by the theft.



Pictures: dreamstime.com, findarticles.com, masternaut.co.uk, www.wire3-t.co.uk



GPS Jammer

£6m lorry hijackings gang face ten years

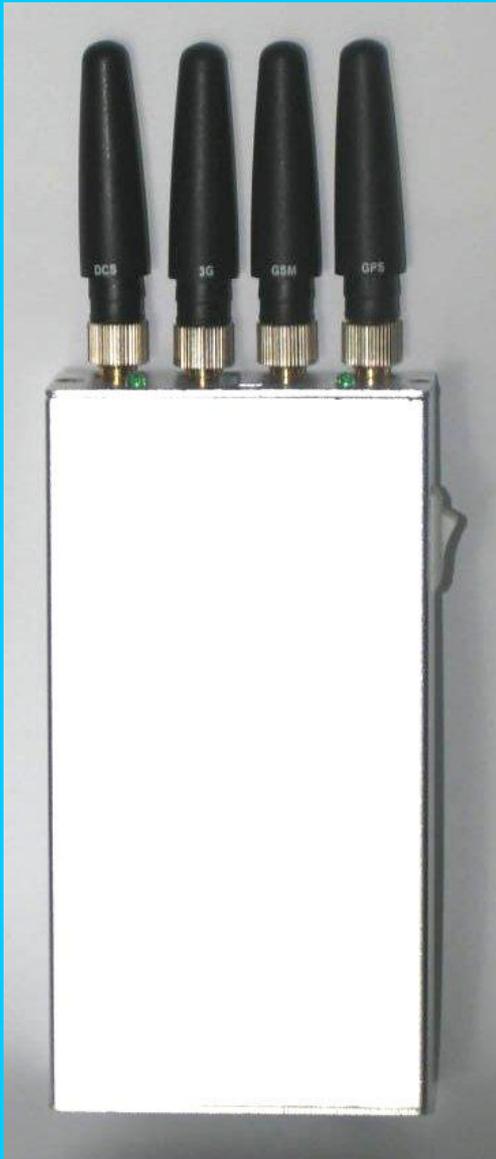
Thursday 6th May 2010, 11:30AM BST.

nobody gets you closer

Express & Star



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



GPS & Mobile Phone Jammer

GJ5 is the first GPS jammer blocker to jam all civil GPS L1, L2, L5 bands - GPS blockers - Jammer-Store.mht

Jammer®
The price of silence

GJ5 GPS L1, L2, L5 Jammer + 2.4G Wifi Bluetooth Blocker



No Sales Tax!

\$ 320.00

excl. Shipping Costs

Free Shipping

Print product data sheet 

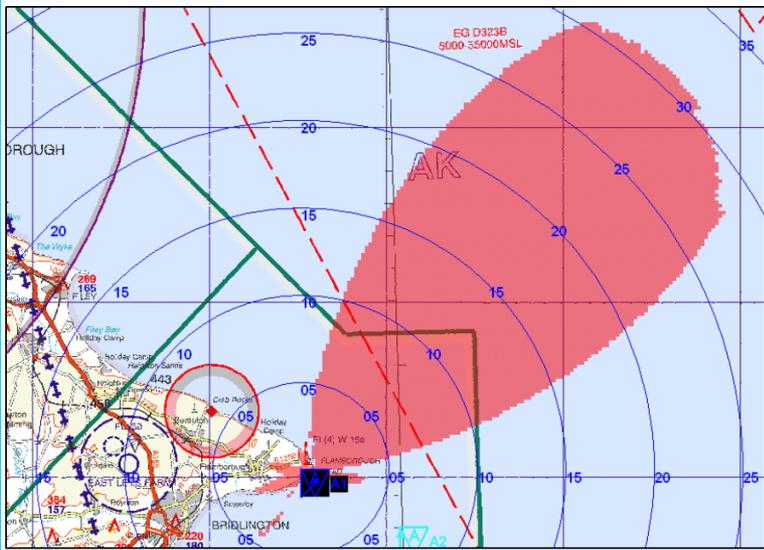
Shipping time: 3-4 Days

Safe & Secure Shopping

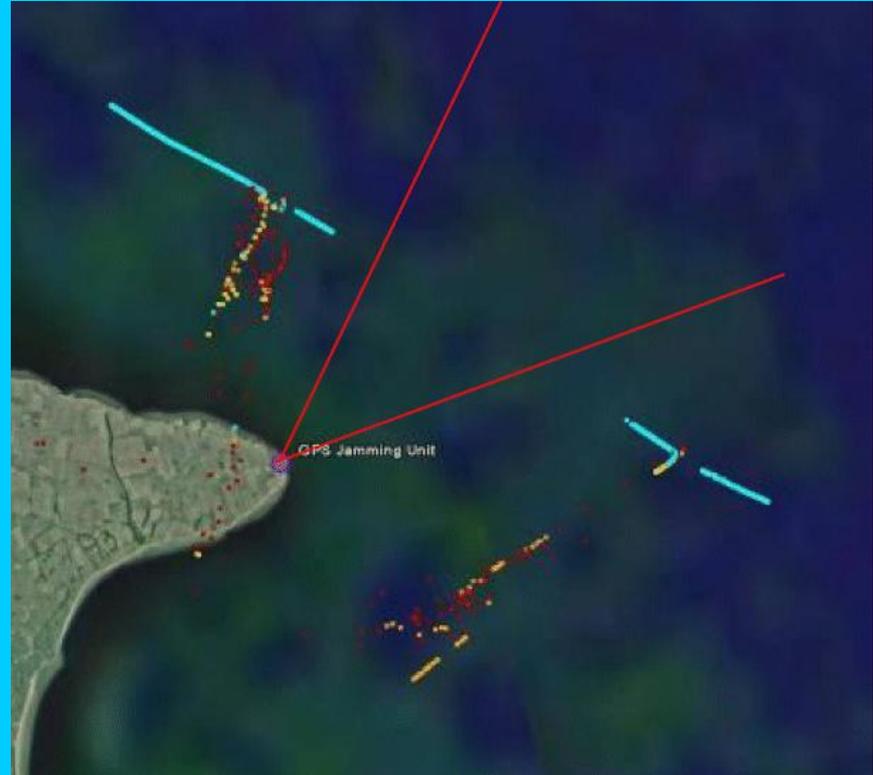
 **ADD TO CART**

Pictures: www.jammer-store.com/gj5-gps-l1-l2-l5-jammer-blocker.html

General Lighthouse Authorities of the UK & Ireland (GLAs) Flamborough GPS Jamming Trials



Jamming zone



Ship's navigation track

Pictures: www.gla-rrnav.org/pdfs/GPS_Jamming_and_the_impact_on_maritime_navigation.pdf

North Sea GPS Jamming Trials

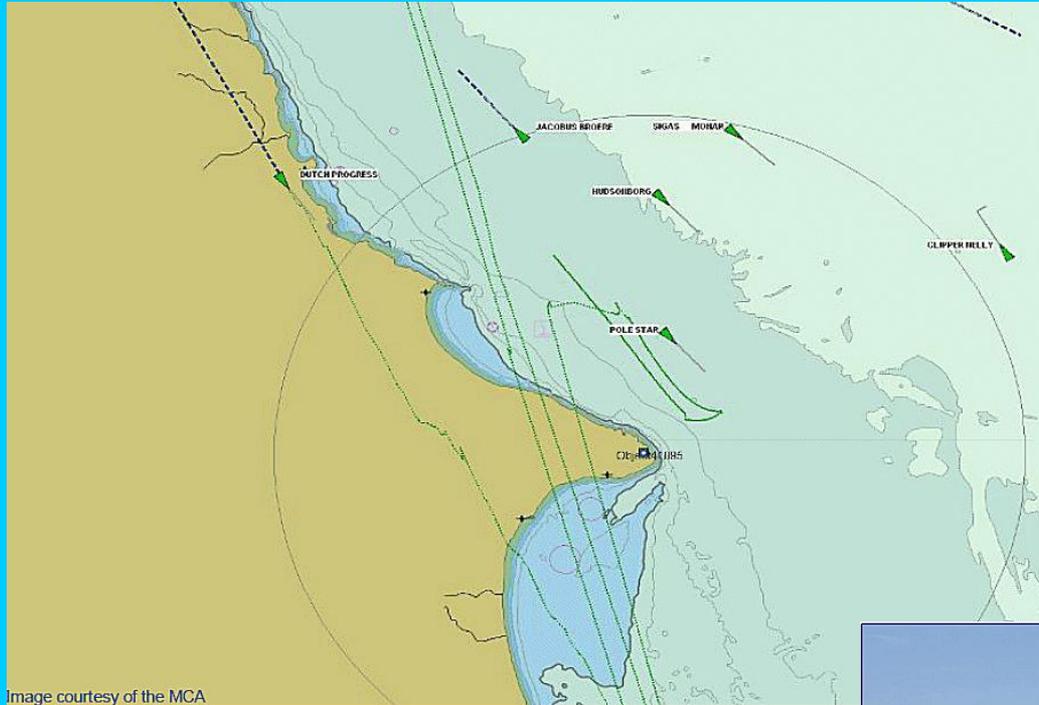


Image courtesy of the MCA

AIS tracks



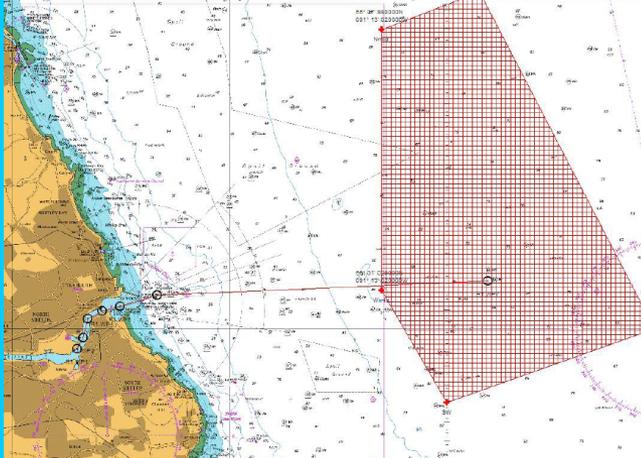
Radar



NLB Pole Star

Pictures: www.gla-rrnav.org/pdfs/GPS_Jamming_and_the_impact_on_maritime_navigation.pdf

Galatea Trials



THV *Galatea*

A very low-powered GPS jammer on board caused **hazardously misleading** information (HMI).

hazardously: no alarms sounded.

misleading: erroneous positions and velocities,
some of them simply not noticeable!

Pictures: www.gla-rrnav.org/pdfs/GPS_Jamming_and_the_impact_on_maritime_navigation.pdf

Galatea Trials

A little more jammer power ...

... alarms began to sound and, one-by-one, these bridge systems failed:



- **ECDIS: Electronic Chart Display**
- **Ship's autopilot**
- **DGPS: Differential GPS**
- **Heli-deck stabilisation system**
- **Satellite voice and data communications**
- **DSC-GMDSS: Maritime Distress Safety System**
- **Radar**
- **Gyro-compass**
- **AIS: Automatic Identification System**

Galatea Trials

Reverting to traditional navigation when GPS is lost



**Radar: Alarm, echo and
AIS don't agree**

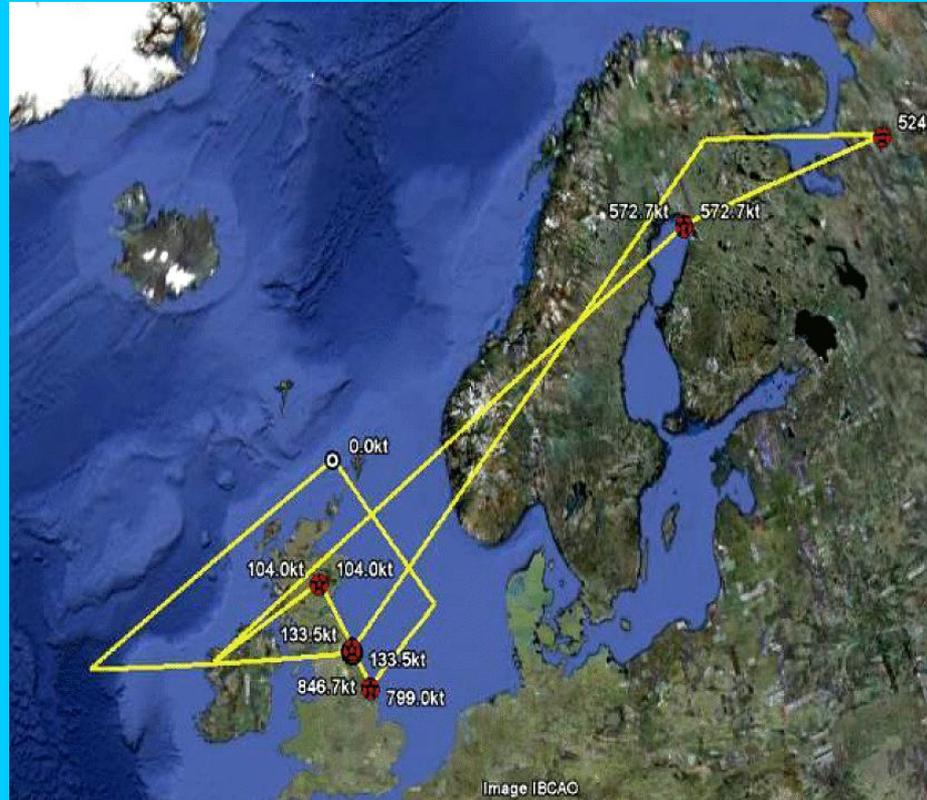


Gyrocompass: Alarm, and drifts over time



Visual: Not in low visibility

Galatea Trials - A Magical Mystery Tour!



Featuring ...

- **Hazardously Misleading Information (HMI)**
- *free from Receiver Autonomous Integrity Monitoring (RAIM)*
- *and with added Sulk Mode!*



Schneier on Security

A blog covering security and security technology.

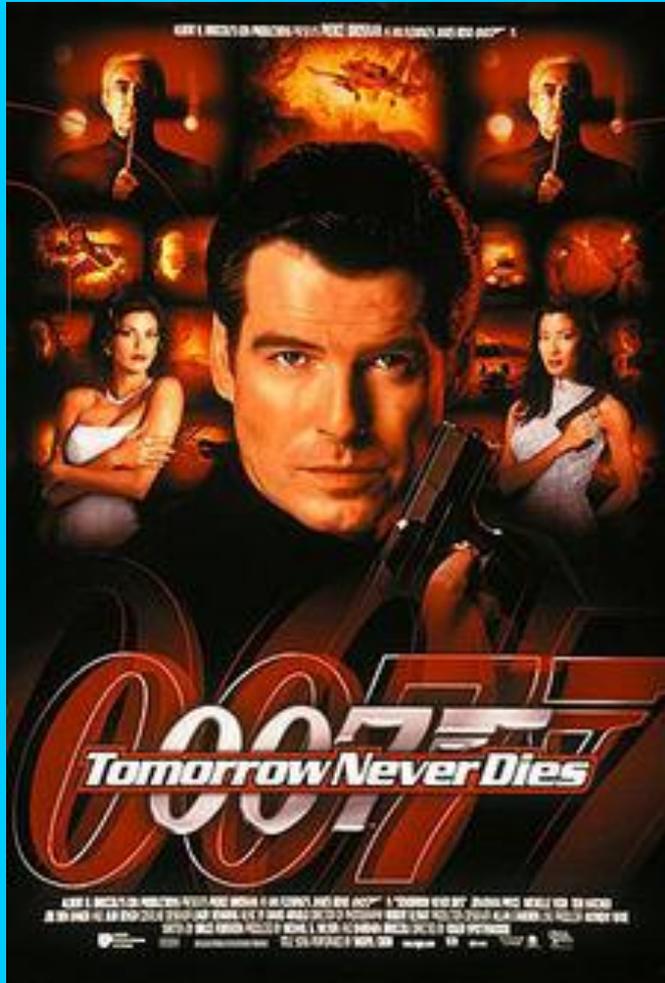


GPS Spoofing

“... Jon used a desktop computer attached to a GPS satellite simulator to create a fake GPS signal ...”

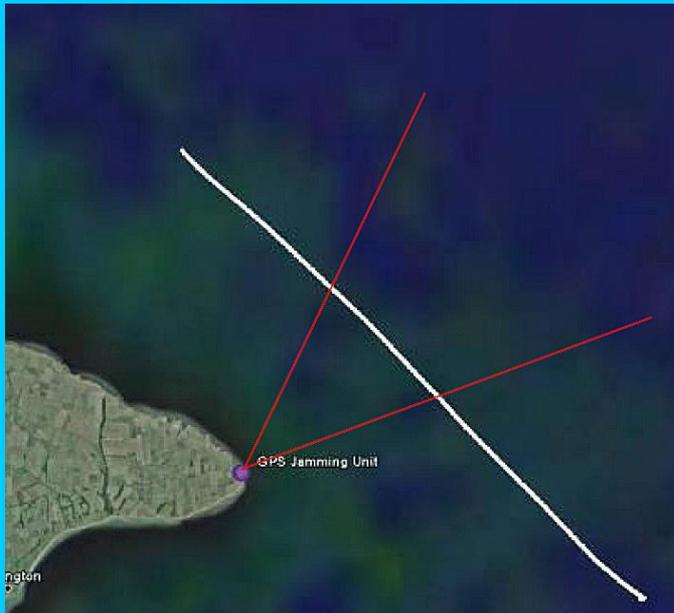
“During later experiments, Jon ... spoofed GPS signals at ranges over three quarters of a mile ... at Los Alamos.”

Pictures: www.schneier.com



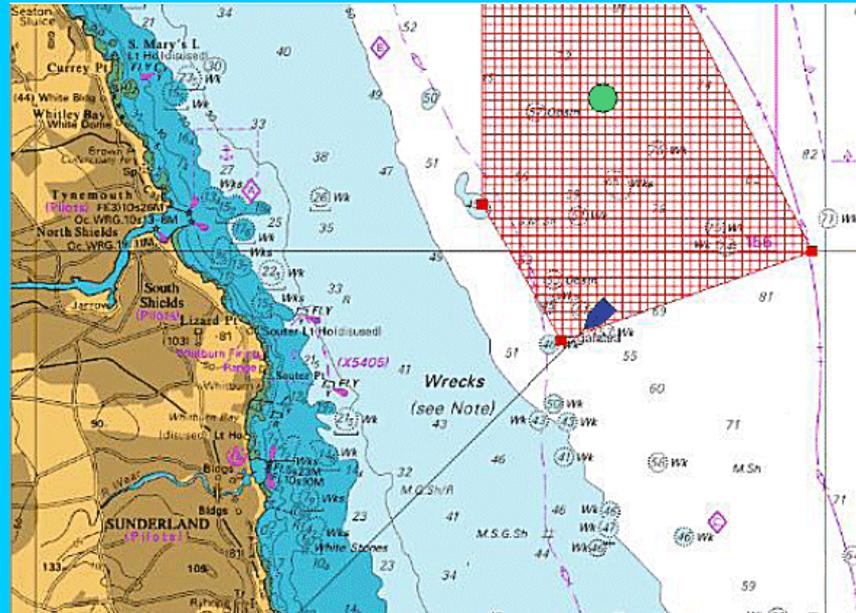
- British ship is sunk by Chinese in international waters.
- Clue is **fake GPS signal** controlled by techno-terrorist.
- Bond discovers GPS device - and wins the girl!

Picture: [/www.imdb.com/title/tt0120347](http://www.imdb.com/title/tt0120347), www.naval-technology.com/projects/t23/



Flamborough trial:

White track: eLoran through jamming



Galatea Trial

Green marker: eLoran

Blue marker: erroneous GPS

Enhanced Loran (eLoran)

- On earth, high-powered
- Different from GPS!
- Digital
- 10m accuracy, precise time



Pictures: Mitchell Narins, Federal Aviation Administration; Reelektronika by





Homeland
Security

February 7, 2008
Contact: (202) 282-8010

**STATEMENT FROM DHS PRESS SECRETARY LAURA KEEHHNER ON THE
ADOPTION OF NATIONAL BACKUP SYSTEM TO GPS**

Today the U.S. Department of Homeland Security will begin implementing an independent national positioning, navigation and timing system that complements the Global Positioning System (GPS) in the event of an outage or disruption in service.

The enhanced Loran, or eLoran, system will be a land-based, independent system and will mitigate any safety, security, or economic effects of a GPS outage or disruption.

GPS is a satellite-based system widely used for positioning, navigation, and timing. The eLoran system will be an enhanced and modernized version of Loran-C, long used by mariners and aviators and originally developed for civil marine use in coastal areas.

In addition to providing backup coverage, the signal strength and penetration capability of eLoran will provide support to first responders and other operators in environments that GPS cannot support, such as under heavy foliage, in some underground areas, and in dense high-rise structures. The system will use modernized transmitting stations and an upgraded network.

Press Office
U.S. Department of Homeland Security



Homeland Security

February 7, 2008
Contact: (202) 282-8010

STATEMENT FROM DHS PRESS SECRETARY LAURA KEEHNER ON THE ADOPTION OF NATIONAL BACKUP SYSTEM TO GPS

Will Obama Kill Navigation Backup System as GPS Threatens to Fail?

Obama's budget attempts to ax LORAN-C, a navigation backup program, even as experts at the Government Accountability Office sound warnings about satellite reliability. What will happen if GPS fails?

By Joe Pappalardo
Published on: May 21, 2009

U.S. Congress Working on 2010 Appropriations for Loran-C and eLoran as GPS Backup

Latest News • July/August 2009 issue

Glen Gibbons

July 29, 2009

Inside GNSS, July/August 2009

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Enhanced Loran (eLoran) has survived through multiple generations of official ambivalence about the proposed



FLOOR STATEMENT OF SENATOR JOHN MCCAIN ON AMENDMENT # 1404 TO STRIKE THE LORAN C PROGRAM

It's the PNT, Mr. President

Feb 20, 2009
By: Alan Cameron
GPS World



Loran Study Finally Unleashed: Says Keep It, Best Option

May 12, 2009
GPS World

Pictures: gpsworld.com, popularmechanics.com, insidegnss.com, mccain.senate.gov

Loran Worldwide

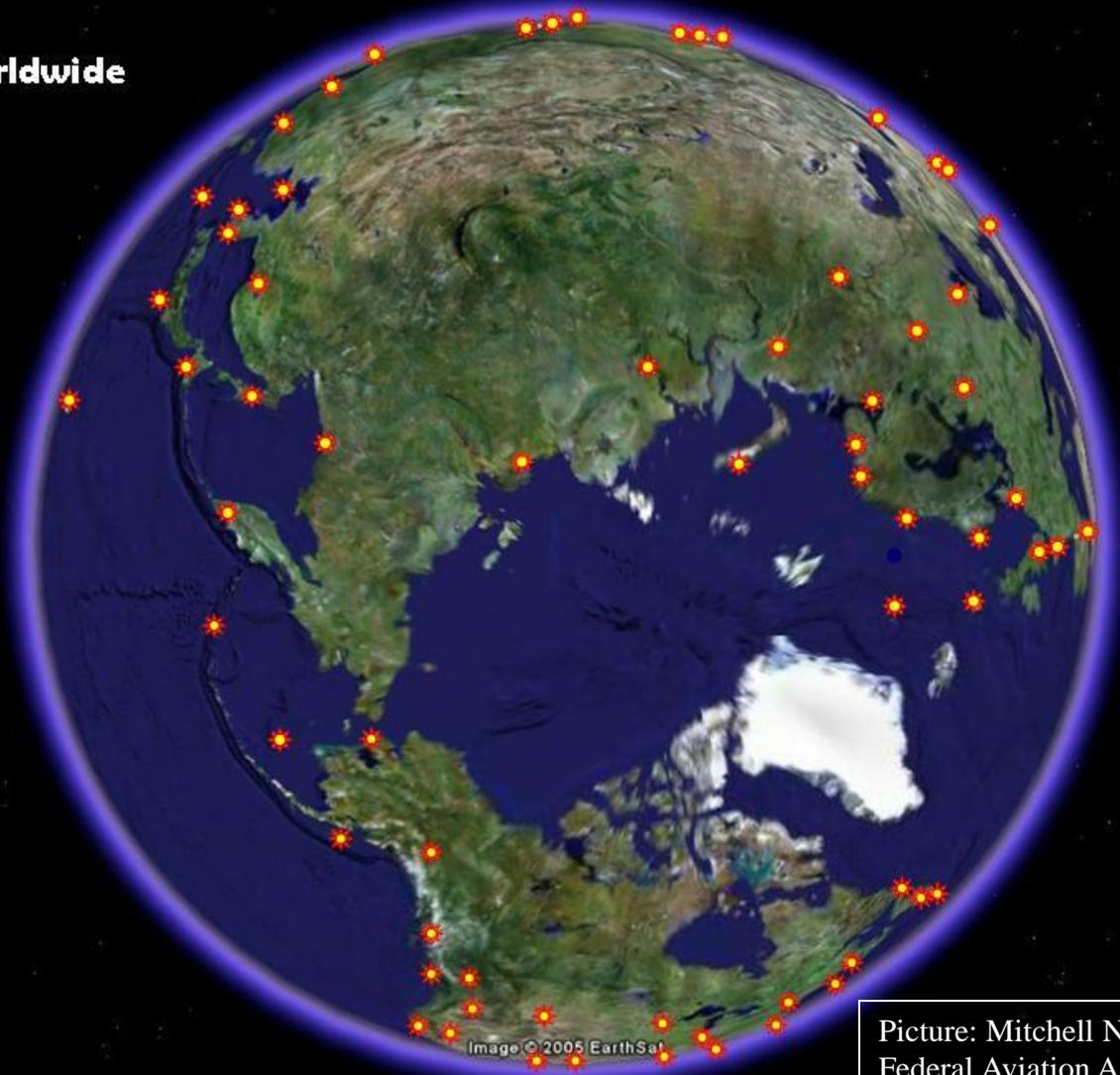


Image © 2005 EarthSat

Picture: Mitchell Narins, US
Federal Aviation Administration



Picture: europa.eu.int/comm/dgs/energy_transport/galileo/intro/index_en.htm



GALILEO

European Satellite Navigation System

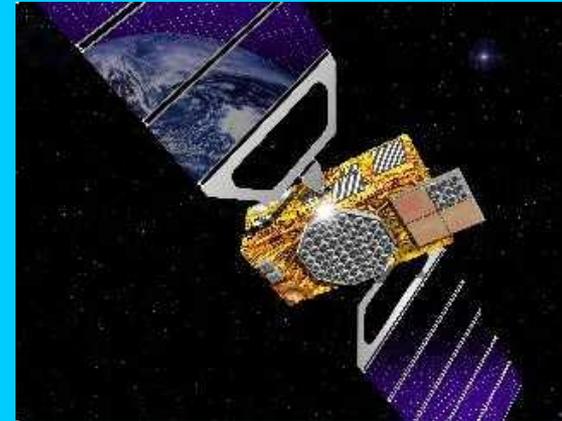
What's new?

- **Real-time integrity - warning of failure**
- **Legal service guarantees**
- **Multi-nation control**
- **Commercial service-provider**
- **Civil, not military**

Galileo plus GPS

- **Technically compatible**
- **More satellites**
- **Higher accuracy**

... plus ...?



Picture: europa.eu.int/comm/dgs/energy_transport/galileo/intro/index_en.htm

Galileo plus GPS

- **Technically compatible**
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plus:



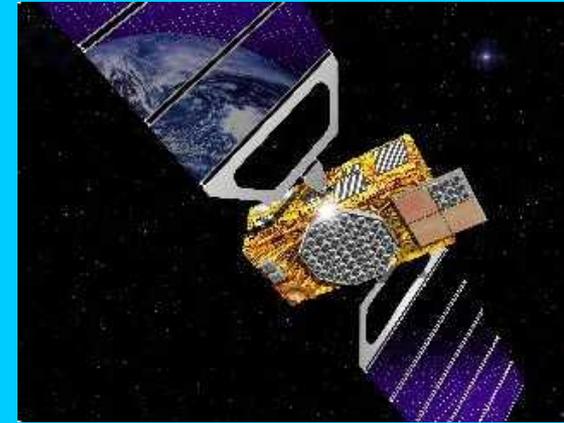
GLONASS (Russia)



Compass-Beidou (China)



QZSS (Japan)



**So ...
where are we headed?**



- *GPS + Galileo + the rest*
- *A secure eLoran terrestrial backup*
- *Accurate and robust Navigation*