Problem - GPS is everywhere

Synchronized, Precise Time, Frequency, Phase

Precise Positioning & Navigation

Transport/Navigation

Financial Systems

IT Networks/Data Bases

Telecommunications

Power Grid

GPS is everywhere
DHS – “GPS is a single point of failure for Critical Infrastructure”

Synchronized, Precise Time, Frequency, Phase

Transport/Navigation

Financial Systems

IT Networks/Data Bases

Telecommunications

Power Grid

Precise Positioning & Navigation
But first, there was Jamming

Seconds, Minutes

Newark Intl EWR

Boston

Weeks +
Result 2: GNSS Denial Events

73,000 GNSS denial events
- 59,000 jammers
- 12,000 narrow band
- 2,000 other signals

Classification Types

Event Priority Levels
(By Classification Type)
- Very Low 224,004
- Low 112,816
- Medium 39,285
- High 73,723

Classification: CHIRP 59,453

Other signals:
- WHITE_WB
- NB_ST
- CDMA
- OTHER

European Commission Project

www.nsl.eu.com
Result 3: **Durations** of interference events

**ALL events (450,363 events)**

Most events are very short durations.
12% of ALL events are greater than 60 seconds.

**High Priority events (73,723 events)**

34% priority events are greater than 60 seconds.

Some findings:
- 7191 events > 5 minutes
- 1112 events > 30 minutes
- **610 events > 60 minutes**
- 5 events > 1 day
- Longest event = 5 days
Result 5: **Comparisons of Sites**

- Results from **8 Airport installations**
- Most are “national” airports. Most are **air-side** installations.
- 30 days data (may not be the same 30 days)

<table>
<thead>
<tr>
<th></th>
<th>RFI events</th>
<th>Jammers</th>
<th>Jammer/events ratio</th>
<th>Duration &gt; 60secs</th>
<th>GNSS denial</th>
<th>Denial/events ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Airport</td>
<td>8716</td>
<td>95</td>
<td>1%</td>
<td>282</td>
<td>362</td>
<td>4%</td>
</tr>
<tr>
<td>National Airport</td>
<td>759</td>
<td>27</td>
<td>4%</td>
<td>200</td>
<td>211</td>
<td>28%</td>
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<td>National Airport</td>
<td>2764</td>
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<td>22%</td>
<td>395</td>
<td>753</td>
<td>27%</td>
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<td>556</td>
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<td>6</td>
<td>95</td>
<td>17%</td>
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<td>20%</td>
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<td>5%</td>
</tr>
<tr>
<td>National Airport</td>
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<td>4%</td>
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<td>14%</td>
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<tr>
<td>National Airport</td>
<td>4519</td>
<td>133</td>
<td>3%</td>
<td>352</td>
<td>153</td>
<td>3%</td>
</tr>
</tbody>
</table>

- Helps to diagnose issues with unintentional interference & jamming
- Helps to compare with other sites

[European Commission Project](https://www.nsl.eu.com)
STRIKE3 shows Jammer industry is evolving...

- 5Mhz bandwidth, 1575Mhz centred
- 8Mhz bandwidth, drifting centre
- Wideband

Waveform detected at 4 STRiKE3 sites, Europe and outside EU

2012
Domestic US Jamming

“GPS Disruption Halts Ports, Endangers Ships” – US Coast Guard

GPS Disruption Halts Wireless Provider in Kansas, 150 Mile -Wide Area Impacted
Maritime Jamming Reports

VIP Protection & Conflict

Disrupt Oil/Gas Surveys?

Armed Conflict

Illegal Fishing?

Unknown
Year-Long ocean cruise finds GPS disruption... everywhere

Figure 5. Vessel route from September 2017 to January 2018 recorded by DLR’s GNSS receiver prototype.
Aviation Jamming Reports

Fresh terror fears as hackers trying to disable planes at Cairo Airport

It is believed pilots are being targeted by GPS jamming just days after the EgyptAir tragedy.
Spoofing – Hazardously Misleading Information
December 2011
Spoofing Demo
June 2012

University of Texas, Austin
Prof Todd Humphreys
Spoofing Demo
June 2013

https://www.youtube.com/watch?time_continue=17&v=ctw9ECgJ8L0
Tutorial – Build Your Own GPS Spoofer
December 2015

Hackers Convention
Las Vegas
First Open Source Spoofing Report
December 2015

DHS: ‘Drug Traffickers Are Spoofing Border Drones’ – Defense One
Reposition 2 RCB 90s from Kuwait to Bahrain through International Waters

January 12, 2016
January 12, 2016

Spoofing?
January 12, 2016

Spoofing?

- Right after US/Iran nuclear agreement
- Same day as President’s last major speech to the nation
January 12, 2016

Spoofing?

- Right after US/Iran nuclear agreement
- Same day as President’s last major speech to the nation
Pokémon Go – Location Deception for All

Phone App

Software Defined Radio
Why is the Kremlin ‘transporting’ GPS users to Vnukovo airport?
The Kremlin Eats GPS for Breakfast

Why geolocation in central Moscow has become a real headache
June 2015 Street View, Google

September 2016 Street View, Google

June 2016: First Public Reports of GNSS Spoofing Near Kremlin

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Unless specifically stated, the mention of any company, organization, individual, or other entity in this document or any attachments thereto does not imply the violation of any law, statue, or international agreement, and should not be construed as such.
June 2017, M/V Atria

Images
CAPT Gurvan LE MEUR
Motor Vessel Atria
According to AIS: all ships in the area are next to each other. There were actually no radar echo there.
July 2017
Unless specifically stated, the mention of any company, organization, individual, or other entity in this document or any attachments thereto does not imply the violation of any law, statue, or international agreement, and should not be construed as such.
Ships at Gelendzhik Airport
Unless specifically stated, the mention of any company, organization, individual, or other entity in this document or any attachments thereto does not imply the violation of any law, statute, or international agreement, and should not be construed as such.
Ships at Sochi Airport
Unless specifically stated, the mention of any company, organization, individual, or other entity in this document or any attachments thereto does not imply the violation of any law, statute, or international agreement, and should not be construed as such.
Ships at St Petersburg Airport
GPS Spoofing Nails Cell Phones in Portland

Easily Spoofing Them All at Once – Inside GNSS

Spoofing GPS & Your Maps – Next Level of Danger
Spoofing

Cost ↓  Capability ↑  Ease of use ↑

Iran, Dec 2011

UT Austin, 2012-13

Las Vegas, Dec 2015

US Southern Border Dec 2015

Persian Gulf, Jan 2016

4 sites Russia 1,300+ ships 2016 - Present

Pokemon July 2016

Portland Oct 2017

Signals & Maps Jul 2018

All GNSS at Once June 2018
Change Course 5° to right
Increase speed 2 knots
Victim makes landfall 10 hours early & 220nm away near “lightly governed” area.

Western Entrance to Malacca Straits, High Vessel Traffic Area
What to Do?

- Protect — GPS Signals
- Toughen — Users & Equipment
- Augment — w/other signals & sources
What to Do? - Masters

- **Protect** —
  - Who and What is Aboard?
  - Interference detection

- **Toughen** —
  - Secure proximity to GPS/GNSS antennas
  - Standards, requirements, costs

- **Augment** —
  - Prudent mariner - “Every means available”
What to Do? - Companies

• Protect —
  • Support masters per above

• Toughen —
  • GPS receivers w/ anti-jam & anti-spoof
  • GNSS receivers using multiple constellations
  • Two antennas

• Augment —
  • Loran, eLoran, Chayka
  • Engage w/ Govts, IMO, etc.
Loran/Chayka Service Areas 2019

Service Areas Approximate. Consult national authorities in UK, Saudi Arabia, Russian Federation, China, & South Korea for more information.
What to Do? - Nations

- Protect — GPS Signals
  - Interference detection
  - Enforcement

- Toughen — Users & Equipment
  - Anti-jam, anti-spoof
  - Standards, requirements, costs

- Augment — w/other signals & sources
  - US Govt Announcements 2008, 2015 “eLoran”

The Maritime Executive
How To Steal a Ship, Part 2
12 June 2017
The Resilient Navigation and Timing Foundation is a 501(c)3 scientific and educational charity registered in Virginia
www.RNTFnd.org