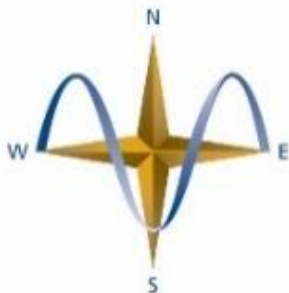




RESILIENT
NAVIGATION
and TIMING
FOUNDATION

C4ADS
innovation for peace

Spoofing GNSS – From fiction to everyday fact



RESILIENT
NAVIGATION
and TIMING
FOUNDATION

C4ADS

innovation for peace

Corporate Members

Premium Members

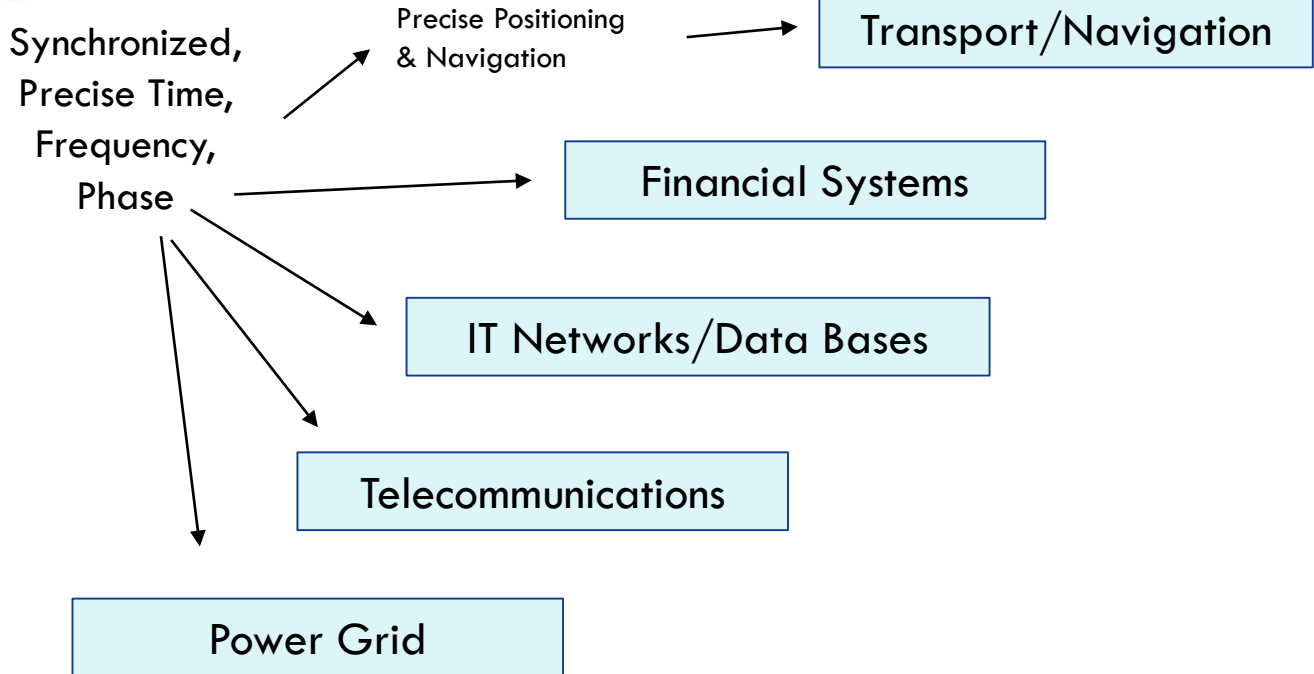
UrsaNav | Harris | Hellen Systems | Research and Radionavigation (GLA)
Google | Orolia | Spirent

Austin Insulators/Navigation | C4ADS | Chronos Technology | Continental Electronics Corporation | Defense Strategies Institute | IAIN | iPosi | The Institute of Navigation | The Italian Institute of Navigation | The Maritime Alliance | Microsemi | NautelNav | Network Time Foundation | The National Defense Industrial Association | The Radio Technical Commission for Maritime Services | Regulus | The Royal Institute of Navigation | SAE | Shine Micro | USMRC

“Tomorrow Never Dies”

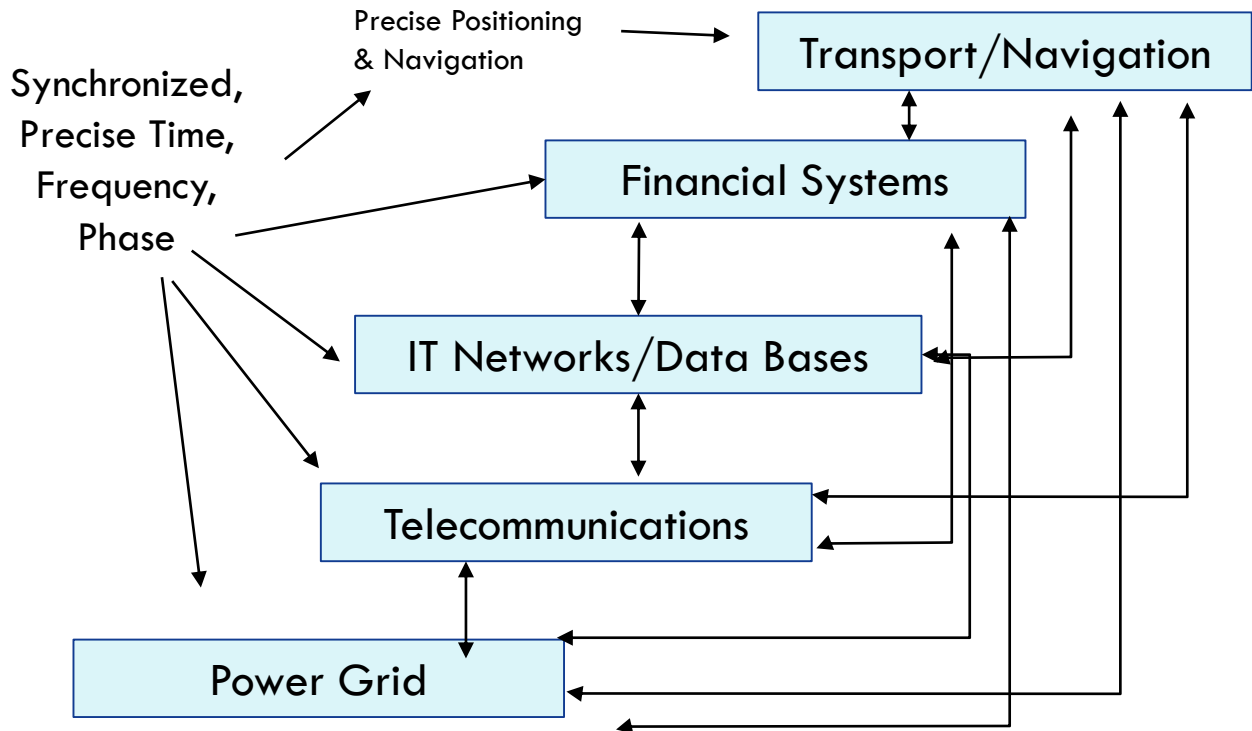


GPS is everywhere

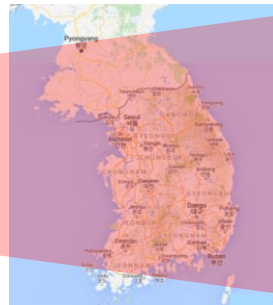
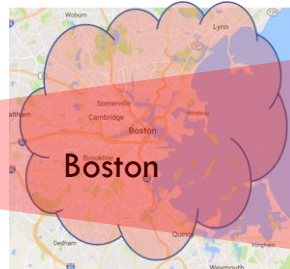
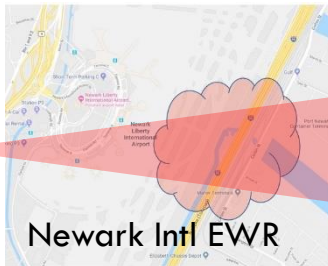




US DHS – “GPS is a single point of failure for Critical Infrastructure”



First there was jamming

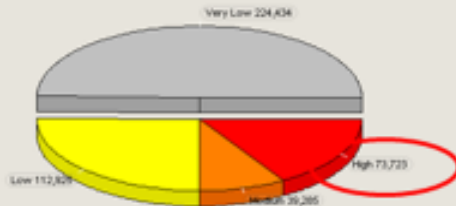


Seconds,
Minutes

Weeks +

Result 2: GNSS Denial Events

Event Priority Levels
(By Classification Type)

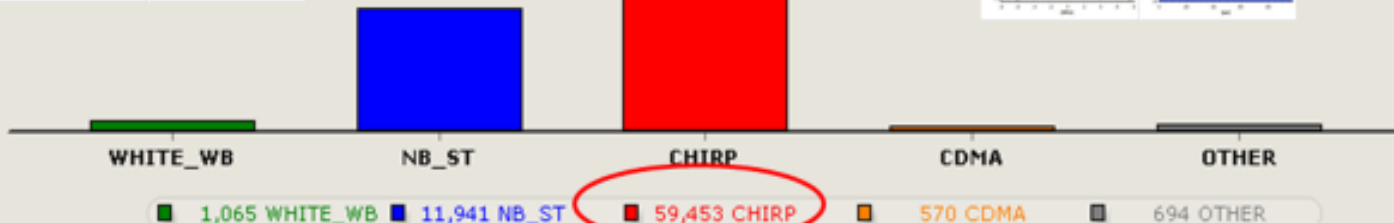
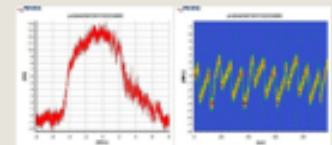
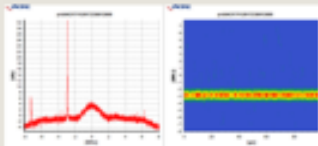


Classification Types

73,000 GNSS denial events

- 59,000 jammers
- 12,000 narrow band
- 2,000 other signals

☒ [450367] ALL
☒ [15253] CDMA
☒ [222720] WHITE_WB
☒ [55170] OTHER
☒ [101811] NB_ST
☒ [59453] CHIRP



Result 3: Durations of interference events

ALL events (450,363 events)



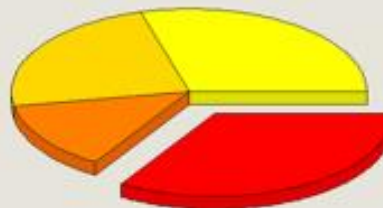
279,208 [00 to 20 sec] 85,832 [20 to 40 sec] 29,339 [40 to 60 sec] 55,368 [60+ sec]

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

Some findings:

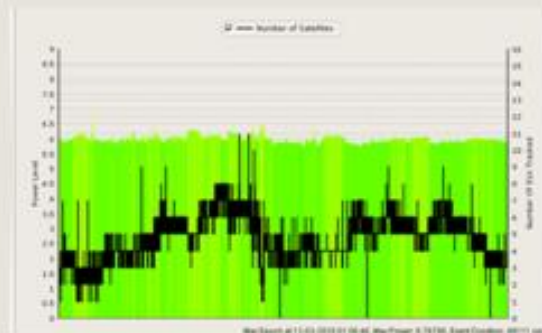
- 7191 events > 5 minutes
- 1112 events > 30 minutes
- 610 events > 60 minutes
- 5 events > 1 day
- Longest event = 5 days

High Priority events (73,723 events)



21,640 [00 to 20 sec] 17,271 [20 to 40 sec] 9,889 [40 to 60 sec] 24,923 [60+ sec]

34% priority events are greater than 60 seconds



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)

	RFI events	Jammers	Jammer/events ratio	Duration > 60secs	GNSS denial	Denial/events ratio
National Airport	8716	95	1%	282	362	4%
National Airport	759	27	4%	200	211	28%
National Airport	2764	595	22%	395	753	27%
Regional Airport	556	31	6%	6	95	17%
National Airport	904	168	19%	158	182	20%
National Airport	776	19	2%	101	35	5%
National Airport	1819	73	4%	9	252	14%
National Airport	4519	133	3%	352	153	3%

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

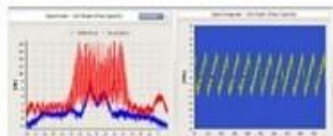




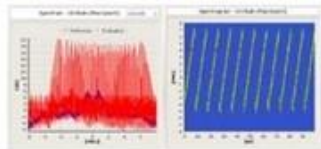
European Commission Project

STRIKE3

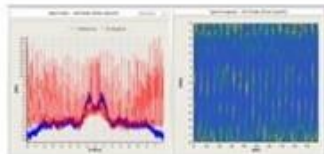
STRIKE3 shows Jammer industry is evolving...



5Mhz bandwidth, 1575Mhz centred



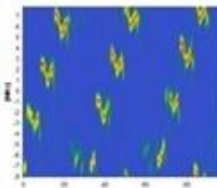
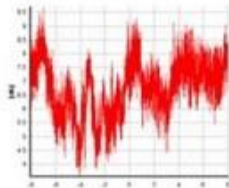
8Mhz bandwidth, drifting centre



Wideband



2012



Waveform detected at 4 STRIKE3 sites
Europe and outside EU



USB L1/L2 jammer



Aviation Jamming Reports

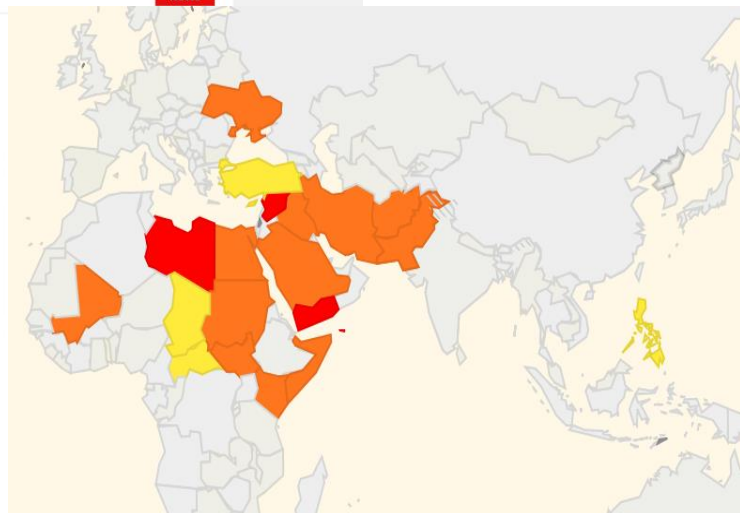


Image: Flight Services Bureau

Maritime Jamming Reports

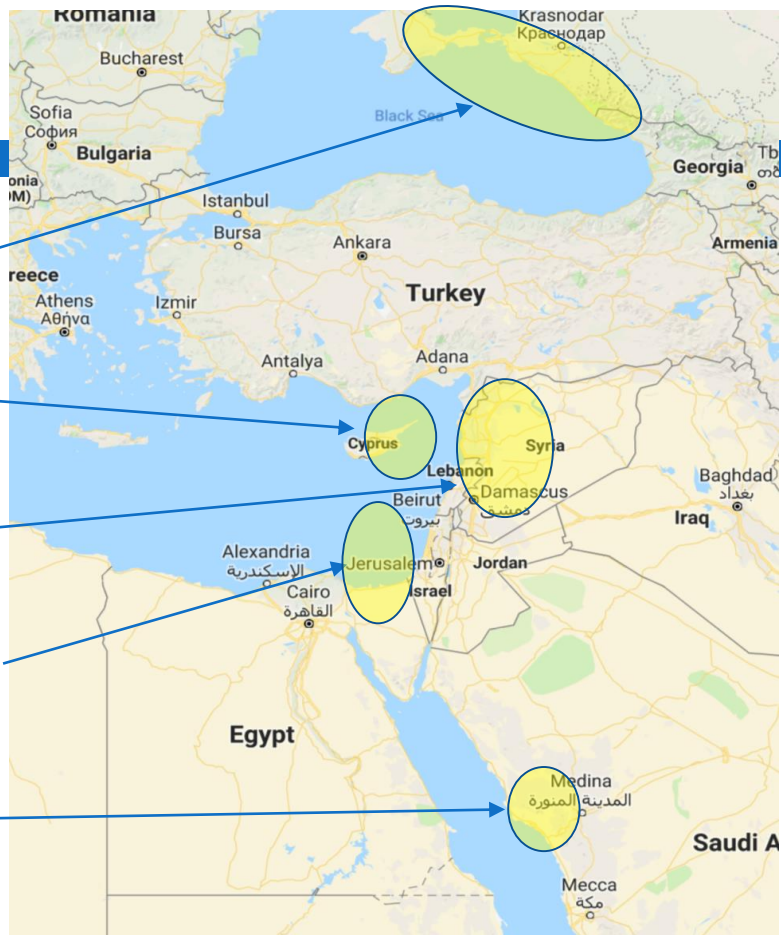
VIP Protection & Conflict

Disrupt Oil/Gas Surveys?

Armed Conflict

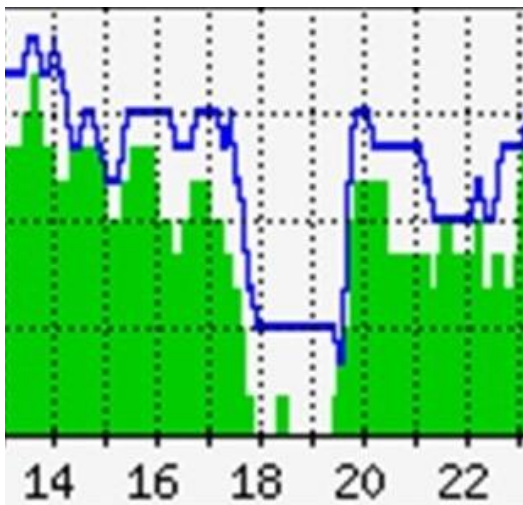
Illegal Fishing?

Unknown



US Jamming

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



GPS Disruption Halts Kansas Wireless
Provider, 150 Mile -Wide Area
Impacted

US Jamming

Qulsar Sees About 3 Jamming
Events a Day Near San Jose
Airport - Impact Unknown



Fatal and Severe Injury Crashes: 2013 to 2017 - City of San Jose



GPS Tracker Shows Child
90 Miles From School

Spoofing — Hazardously Misleading Information

December 2011



Spoofing Demo

June 2012



Prof Todd Humphreys, University of Texas, Austin

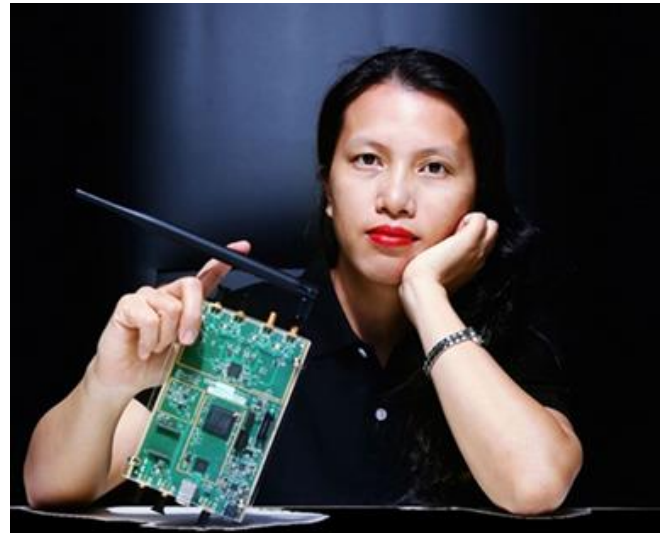


Tutorial – Build Your Own GPS Spoofer

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



Spoofing?

January 12, 2016



- Right after US/Iran nuclear agreement
- Same day as US President's last State of the Union speech

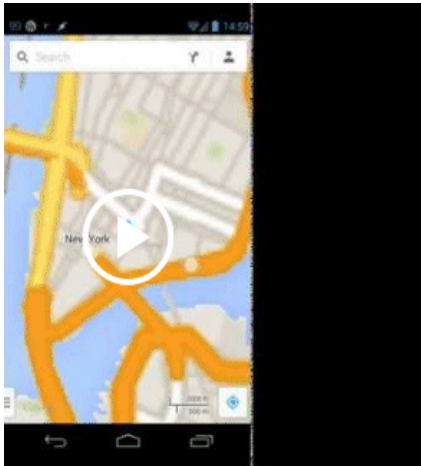
Pokémon Go – Location Deception for All

July 2016

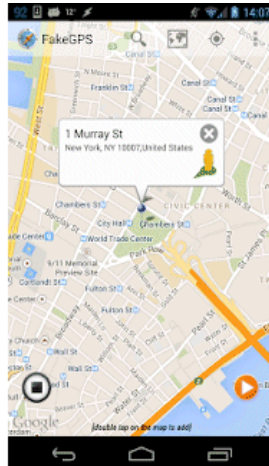


Fake GPS GO Location Spoofer
Free

Download Fake GPS GO Location Spoofer Free
on the Google Play Store



Phone App



Software-Defined Radio

June - July 2016



RUSSIA BEYOND

English

Lifestyle Culture Travel Education Business His

Why is the Kremlin 'transporting' GPS users to Vnukovo airport?

LIFESTYLE OCT 24 2016 YEKATERINA SINELSCHIKOVA RBTH



C4ADS
innovation for peace

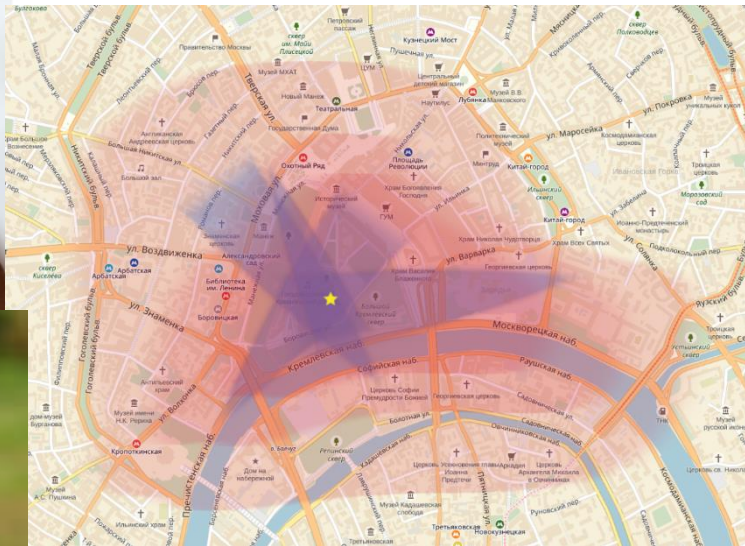
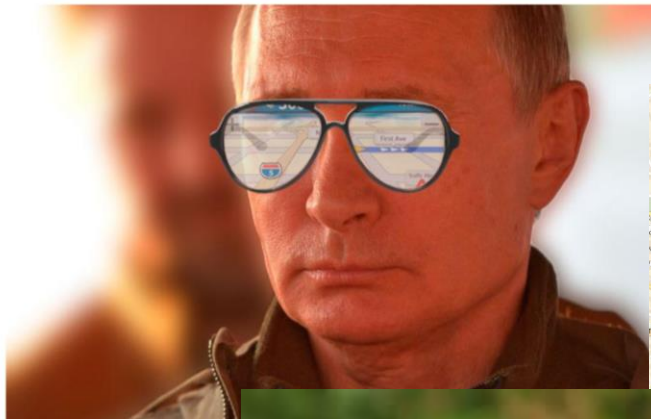
The Moscow Times

Oct. 21 2016 - 03:10

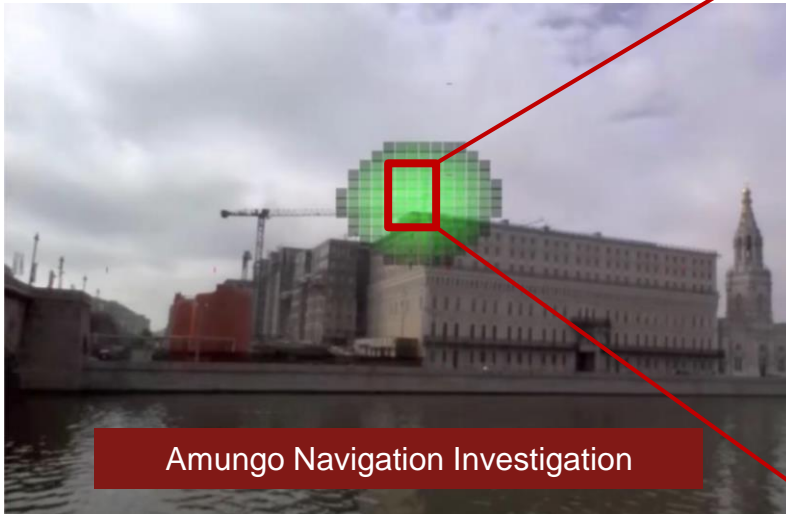
The Kremlin Eats GPS for Breakfast

Why geolocation in central Moscow has become a real headache

October 2016



September 2017



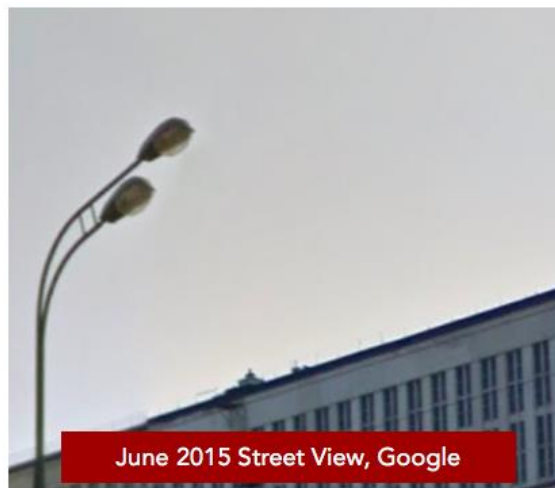
Amungo Navigation Investigation



June 2015 Street View, Google



September 2016 Street View, Google



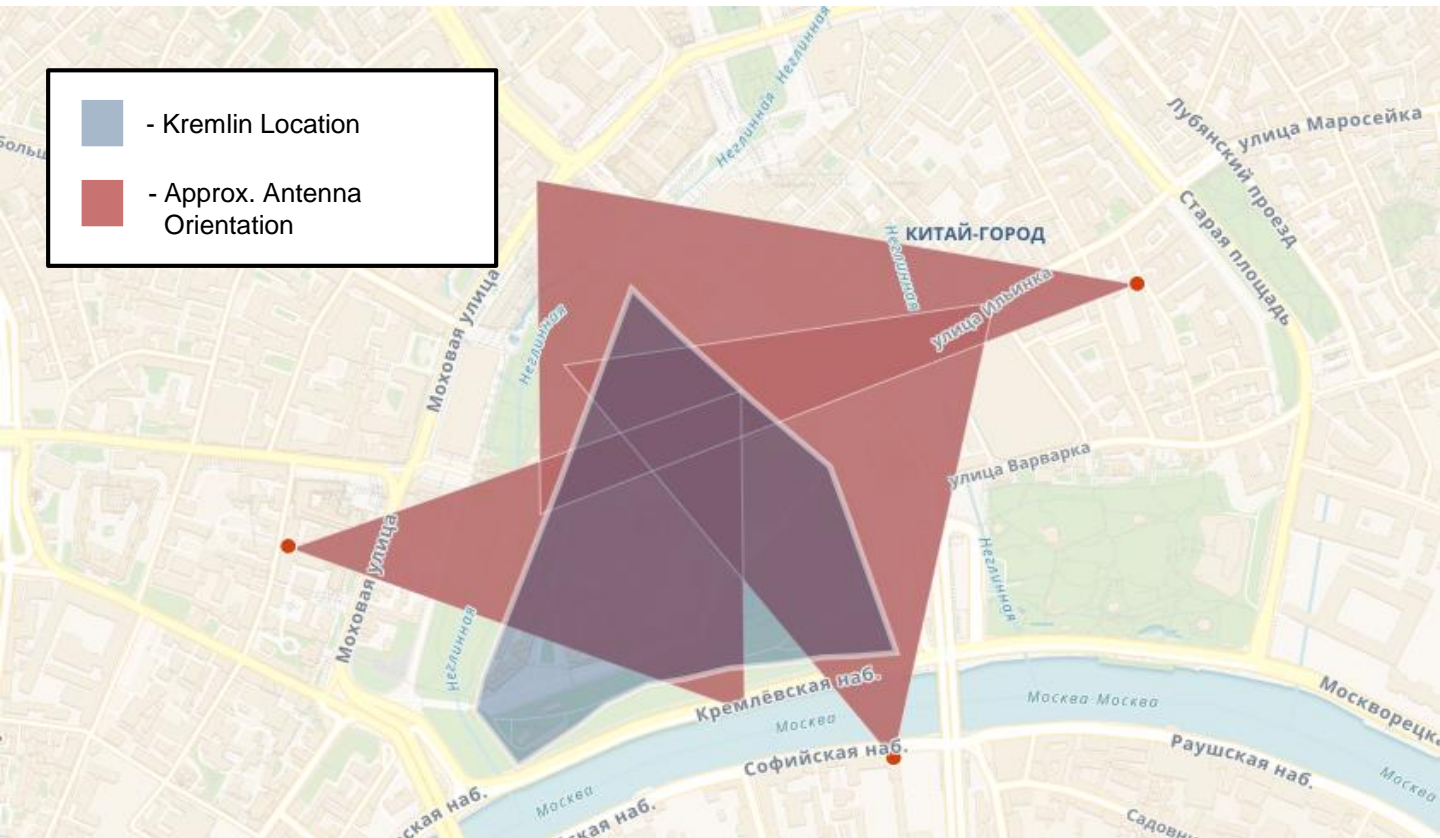
June 2015 Street View, Google



September 2016 Street View, Google

June 2016: First Public Reports of GNSS Spoofing Near Kremlin

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Motor Vessel Atria, June 2017

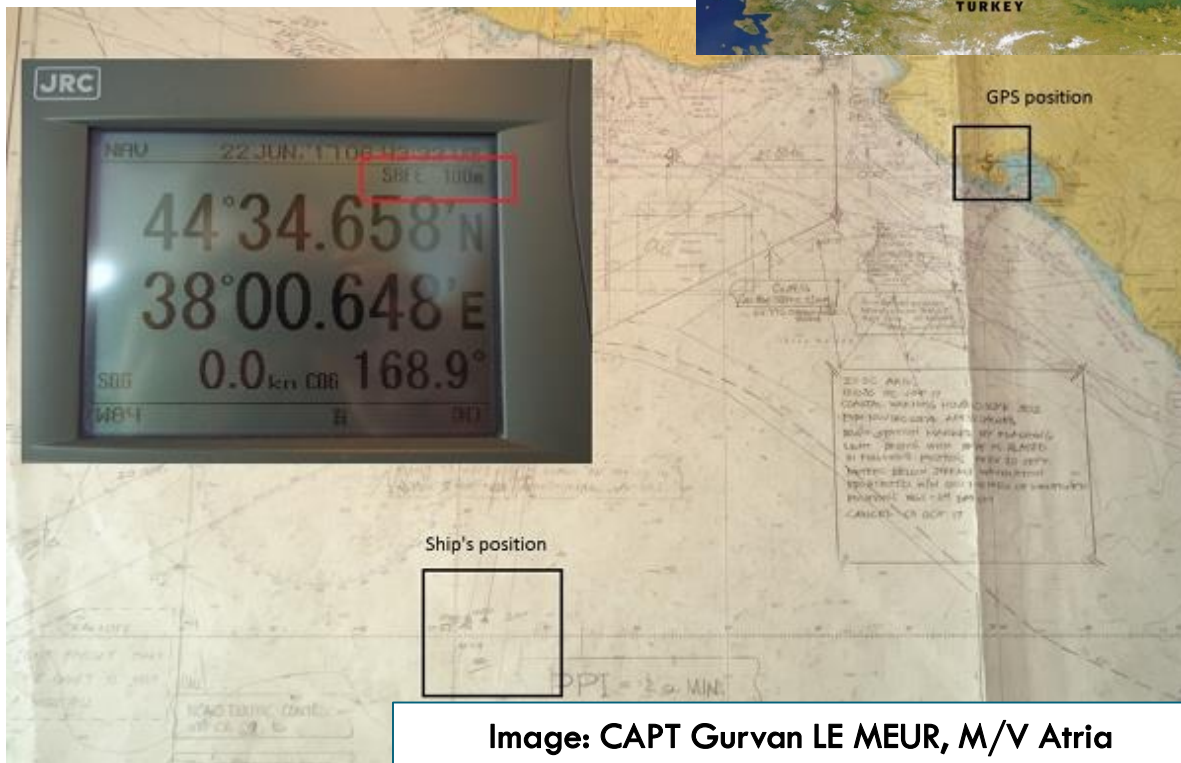
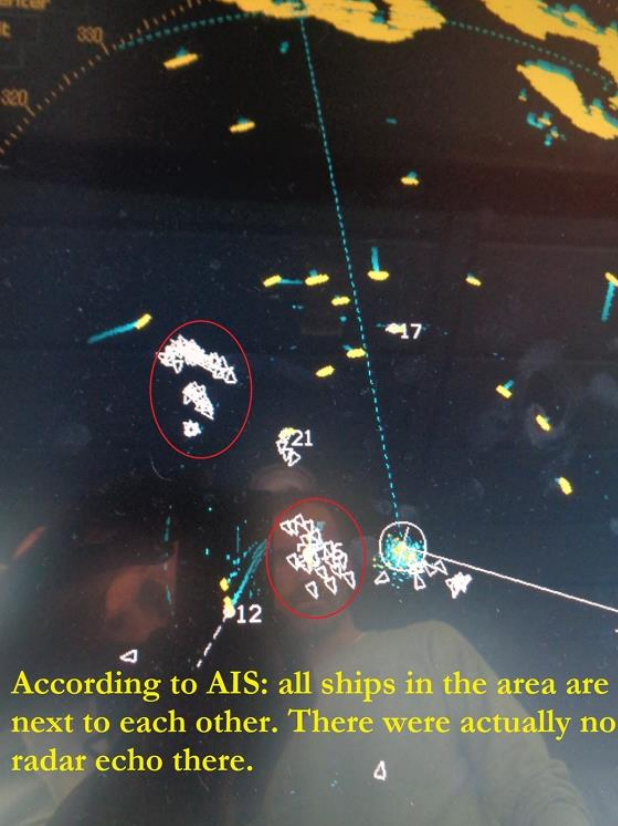
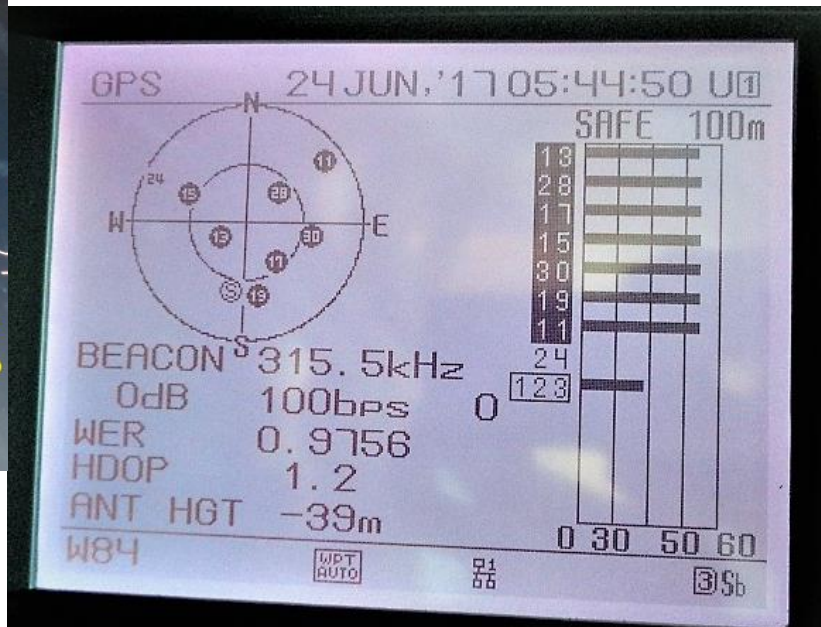


Image: CAPT Gurvan LE MEUR, M/V Atria

June 2017, M/V Atria

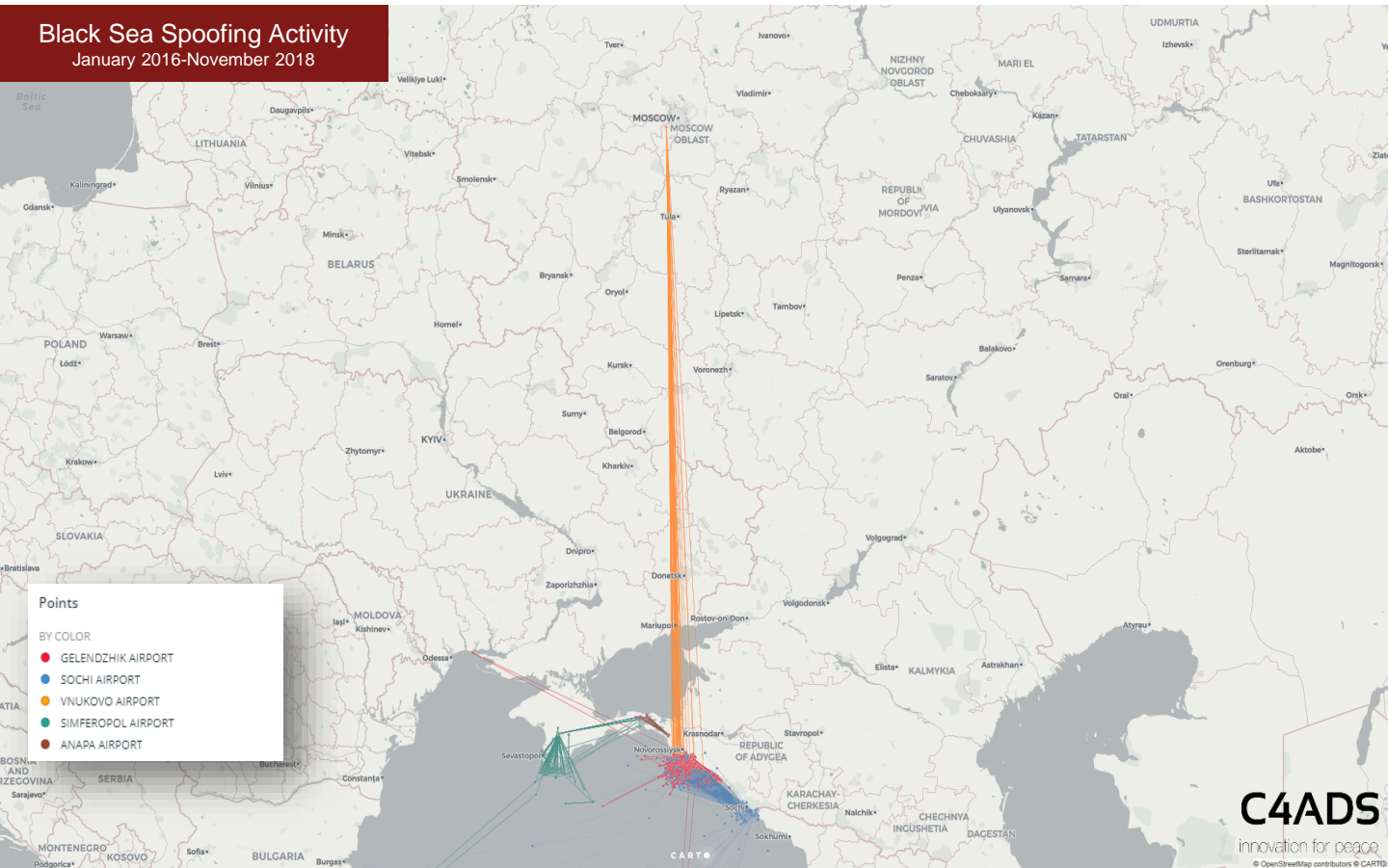


According to AIS: all ships in the area are next to each other. There were actually no radar echo there.



Images: CAPT Gurvan LE MEUR, M/V Atria

Black Sea Spoofing Activity January 2016-November 2018



Ships at Gelendzhik Airport



С/Т "ВИНОГРАДАРЬ-3"

С/Т "ВЕТЕРАН"

Gelendzhik Airport

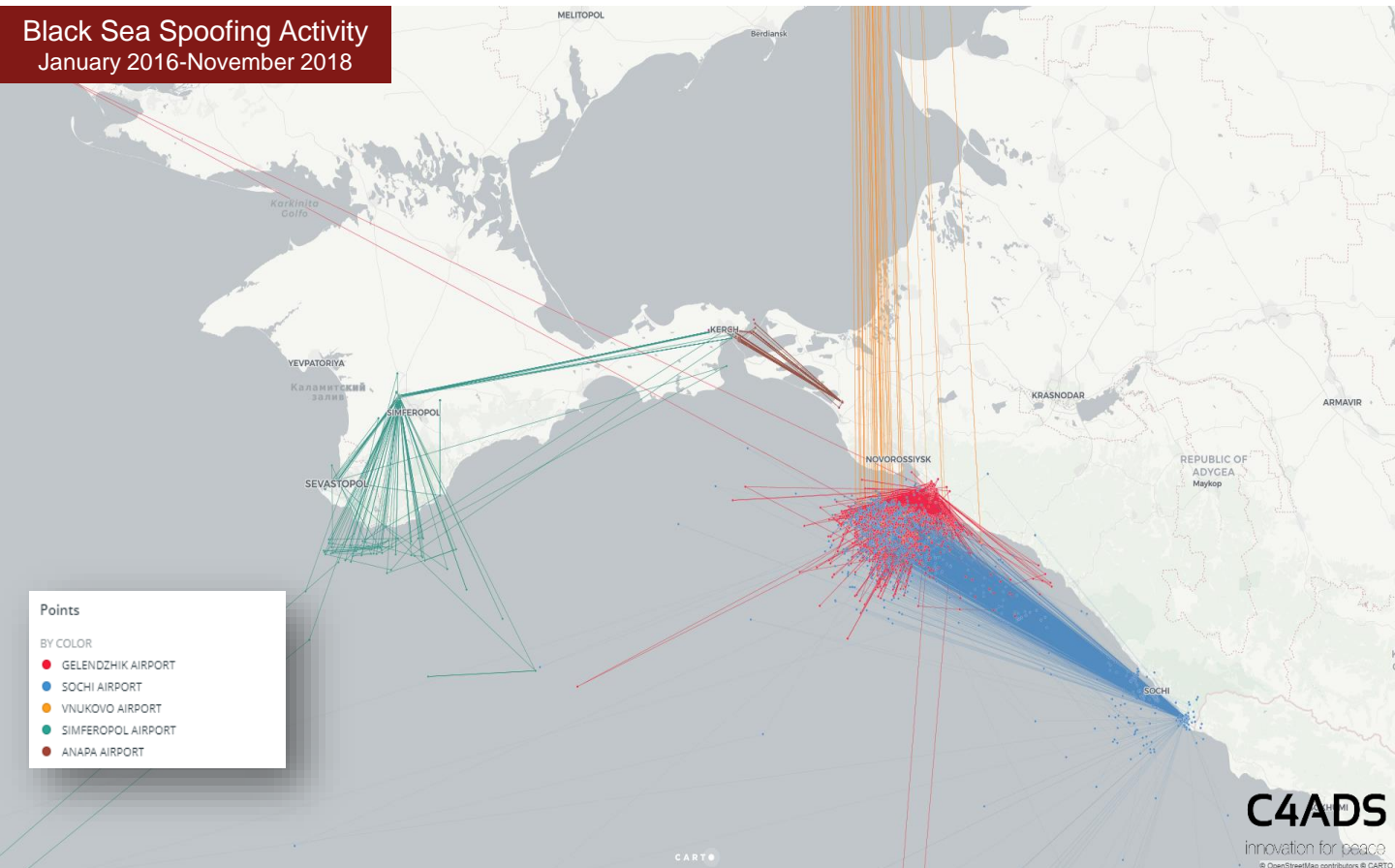
GOLUBAYA BUKHTA

SOLNTSEDAR

Mooring area

Mooring area

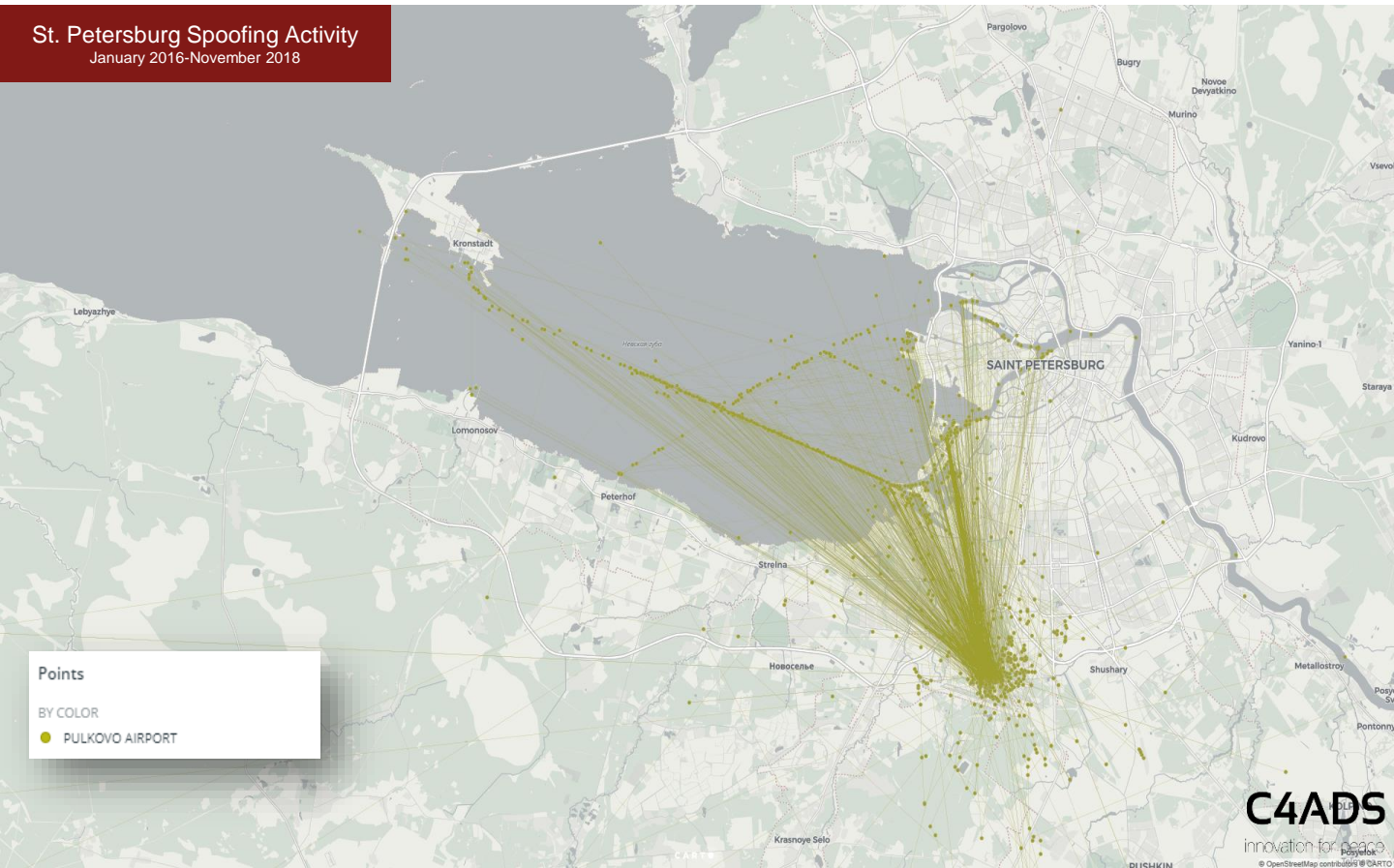
Black Sea Spoofing Activity January 2016-November 2018



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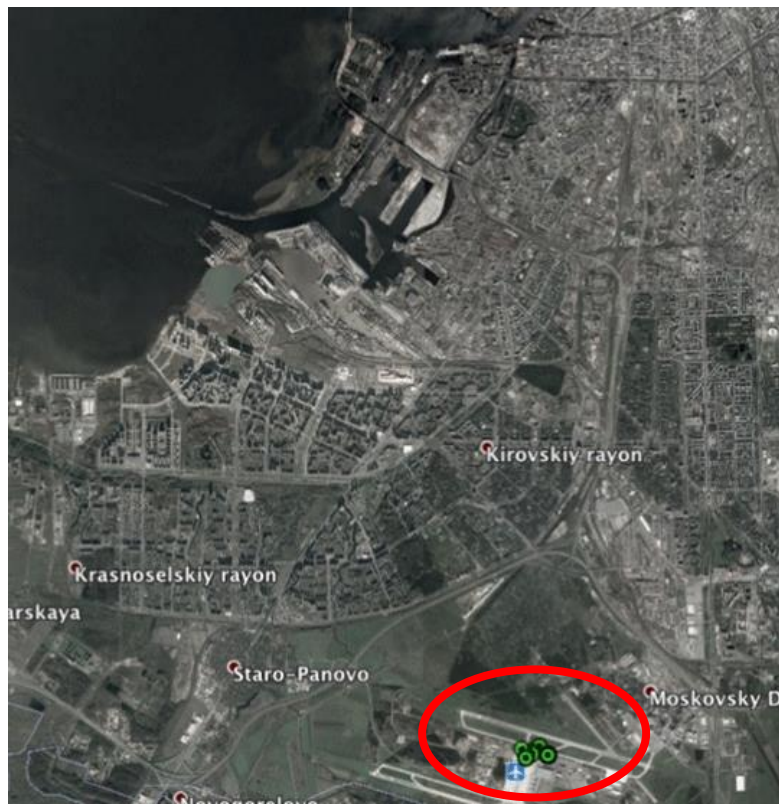
St. Petersburg Spoofing Activity

January 2016-November 2018



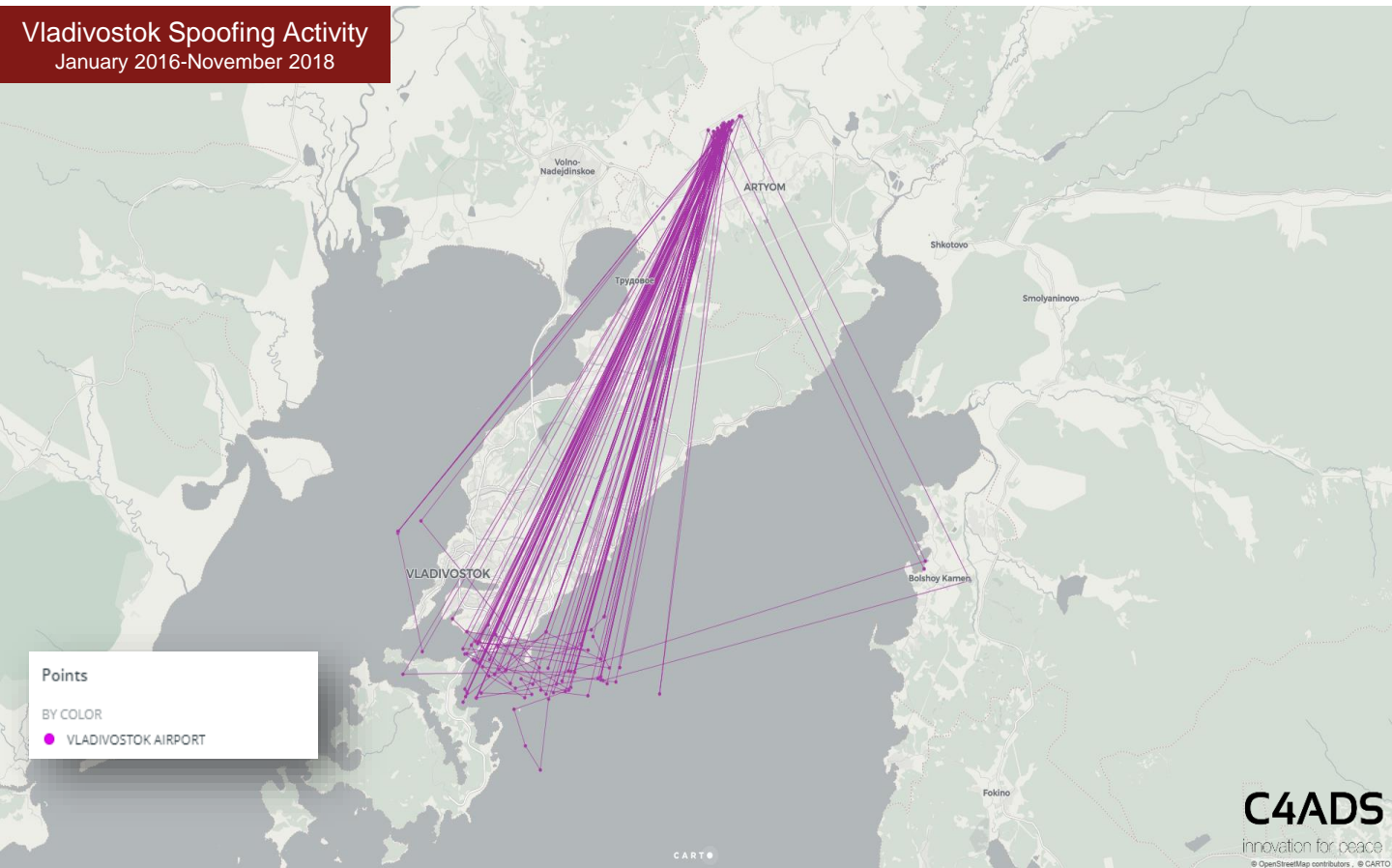
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Ships at St Petersburg Airport



Vladivostok Spoofing Activity

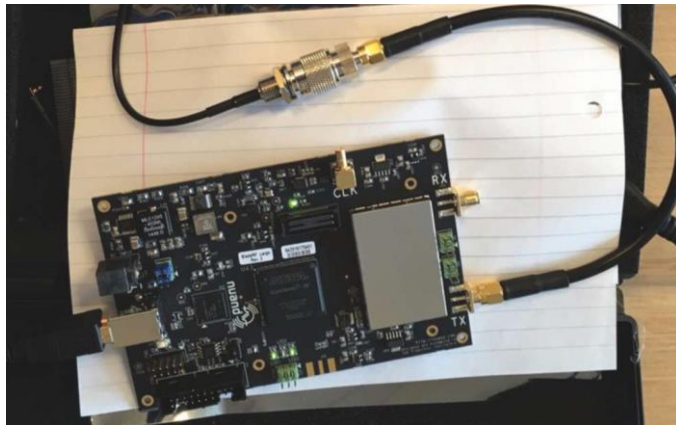
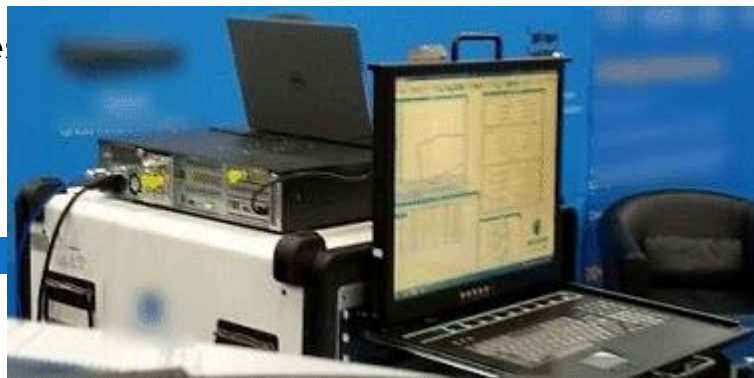
January 2016-November 2018



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GPS Spoofing Nails Mobile Phone at ION GNSS 2017

Oct 2017



Easily Spoofing Them All at
Once – Inside GNSS

June 2018



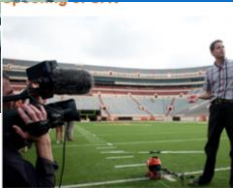
Spoofing GPS & Your Maps –
The next Level of Danger

Virginia Tech & China Institute
July 2018

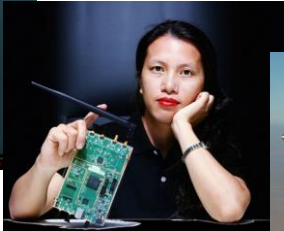
Spoofing — Cost ↓ Capability ↑ Ease of use ↑



Iran, Dec 2011



UT Austin, 2012-13



Las Vegas, Dec 2015



US Southern Border
Dec 2015



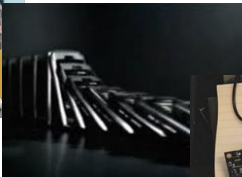
Persian Gulf, Jan 2016



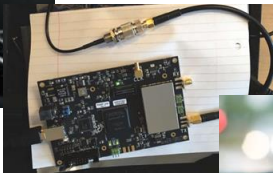
4 sites Russia
600+ ships
2016 - Present



Pokemon
July 2016



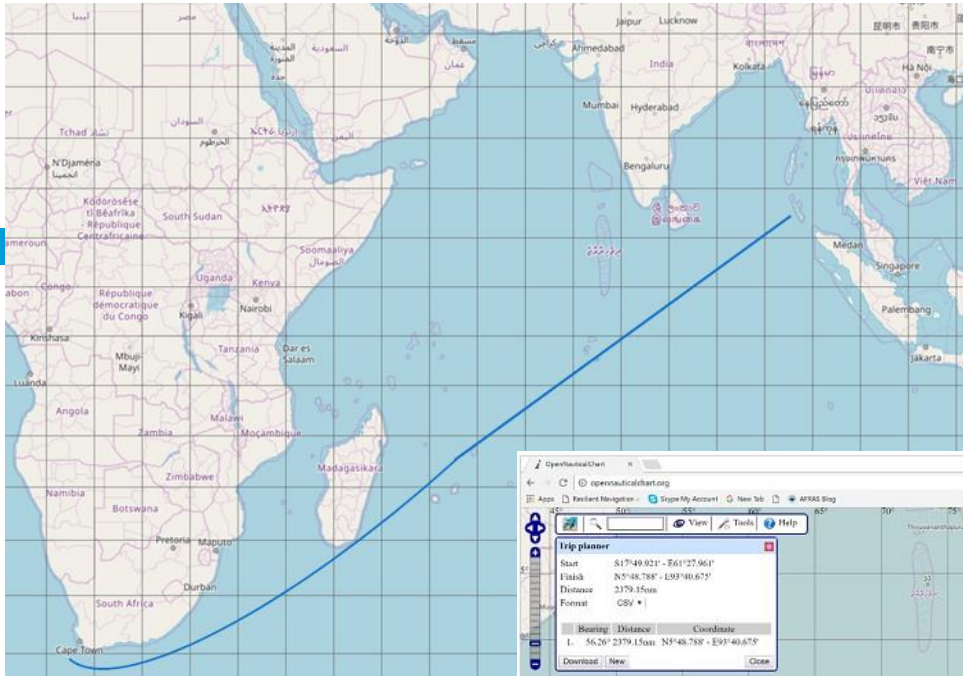
Portland
Oct 2017



All GNSS at Once
June 2018

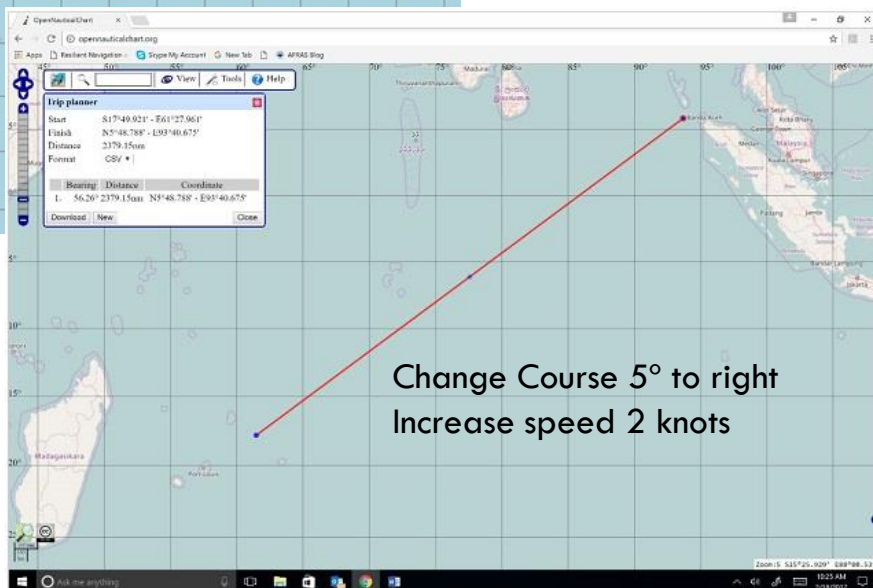


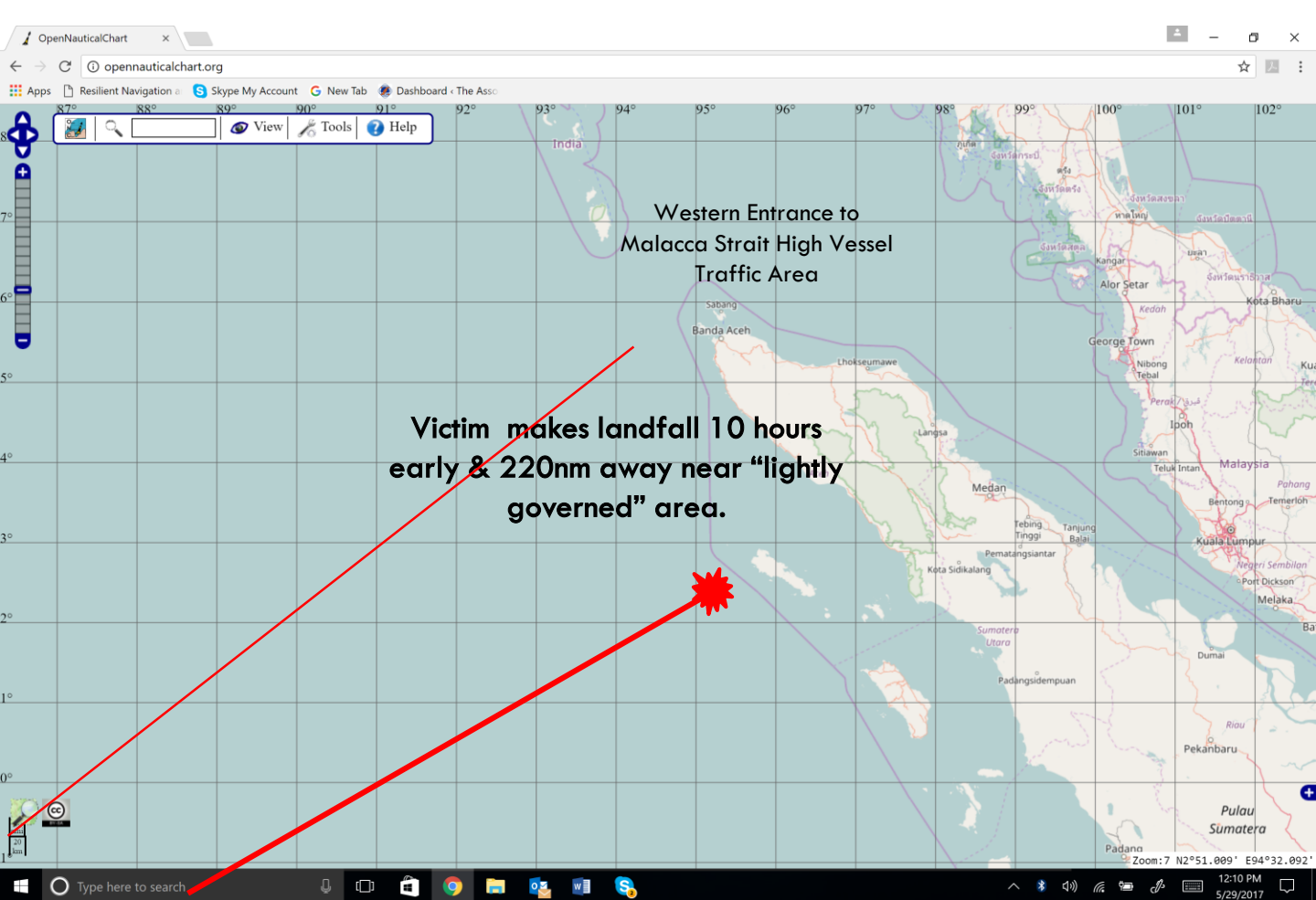
Signals & Maps
Jul 2018



**The MARITIME
EXECUTIVE**
INTELLECTUAL CAPITAL FOR EXECUTIVES

“How To Steal A Ship”
2 June 2017





October 2018

WEAPON SYSTEMS
CYBERSECURITYDOD Just Beginning
to Grapple with Scale
of Vulnerabilities

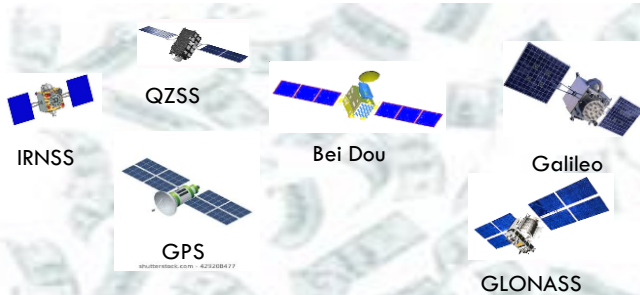
GAO-19-128

‘GPS Hackers could send weapons to
wrong target.’ 17 Oct 2018



Russia claims US spoofed drones to attack
base. 25 Oct 2018

“GNSS alone is insufficient for Safety of Life and other critical applications” – European Union



\$100,000,000,000 invested +
\$6,000,000,000 per year to run +
200,000 people in industry

**1 White Van Man +
All-GNSS & Map Spoofer**

\$255



PNT - Out of Balance

What to Do?

- **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 re “eLoran”





<https://static1.squarespace.com/static/566ef8b4d8af107232d5358a/t/5c99488beb39314c45e782da/1553549492554/Above+Us+Only+Stars.pdf>