

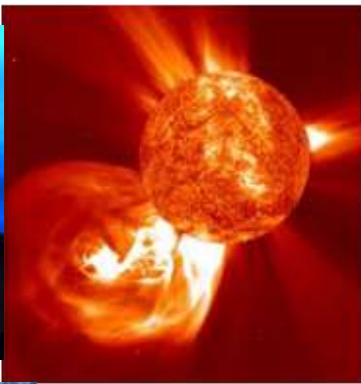


# The Politics of Resilience

*Speaking Truth to Power – the Last 18 Months*

APRIL 2017

Workshop On Synchronization & Timing



# December 2015



“US increasingly at risk from disruption” – 2011 declassified

France, Norway to close Loran Systems



‘US will build eLoran time system, then nav’ Dep Secs  
Defense & Transportation

“Government’s biggest achievements being lost in  
breakdowns.’ – Volker Report



# December 2015 – January 2016



‘Drug traffickers spoofing border drones’ – DHS/CBP

Why GPS is more Vulnerable than Ever

*The* CHRISTIAN SCIENCE  
**MONITOR**



Navy Sailors Spoofed into Iran on State of the Union Day?

# January 2016 – 13.7μsec

GPS Fault Reports Received by National Coordination Center and USCG Navigation Center  
25- 26 January 2016 GPS SVN23 Anomaly

Geographic Area	Use/Application	Comments
Worldwide	Telecoms	Loss of synchronization frequency and timing
	Not Specified	Several thousand GPS clocks, receivers with timing errors"
Europe		Error, UTC offset info coming & going across Europe
		GPS Receiver errors across Europe
North & South America, Frankfurt, London, Tokyo		A large number of NIST time and frequency customers disrupted, including some critical infrastructure applications
Norway		Disruption of timing receivers across Norway
France		Equipment experiencing timing interval errors across France
Finland		GNSS equipment with timing problems
Spain & Canary Islands	Broadcast	Digital television network synchronization, receiver disruptions
Switzerland		Network lost synchronization, receivers got un-equal time stamps
United Kingdom	Broadcast & Telecom	Disruption or loss of timing to GPS cards affecting telecom and digital radio systems
Luxembourg	Satellite Communications	Time synchronization loss of two-way internet over satellite communications platforms

# January 2016 – 13.7μsec

Canada & United States	Public Safety Communications	250 customers affected
United States	Aviation	Multiple FAA ground-based transceivers
New Jersey, Pennsylvania		Alarms received at 911 centers for aviation ground stations for air traffic information/data
North Carolina to Wyoming	Public Safety Communications	Base station sync problems
Arizona, Pennsylvania, Connecticut, Louisiana		First responder equipment indicating GPS receivers 'out of lock'
Colorado		Statewide P25 radio systems
Utah		Utah - Trunked radio systems for emergency communications
New Hampshire, Georgia, Tennessee, Minnesota	Telecom	Errors in receiving GPS timing signal
New York	Not Specified	GPS timing module errors
Arizona		GPS timing system alarms



Electric Power and Scientific Community Told RNTF of Impacts

# January 2016 – 13.7 $\mu$ sec

Microsemi TimeMonitor Analyzer

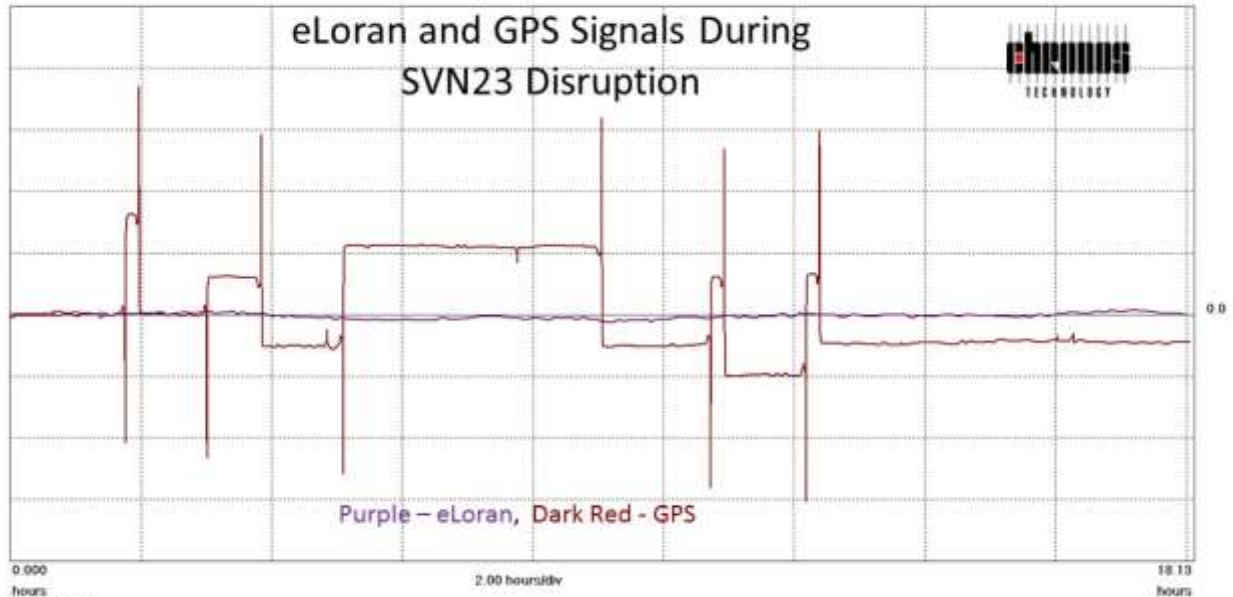
Phase deviation in units of time: Fs=996.0 MHz; Fc=1.0000000 Hz; 2016/01/26, 00:00:28

2 (red): Agilent 53220A; Test: 755; A: CsWatch; B: PRS45A; GPS 1pps; Samples: 65001; Gate: 1 s; Start: 25600; Stop: 90600; Total Points: 148483; Ref ch2: 10.00 MHz; T1Time Data Only; T1 1->2: 172.81 2.55; A=53220  
3 (magenta): HP 63132A; Test: 1346; A: CCLab; B: PRS45A; eLoran E 1pps; Samples: 66071; Gate: 1 s; Start: 286000; Total Points: 361070; Ref ch2: 10.00 MHz; T1Time Data Only; T1 1->2: 53132A sn 3944; 2016/01/26

1.00  
usec

200  
nsec/div

-800  
nsec



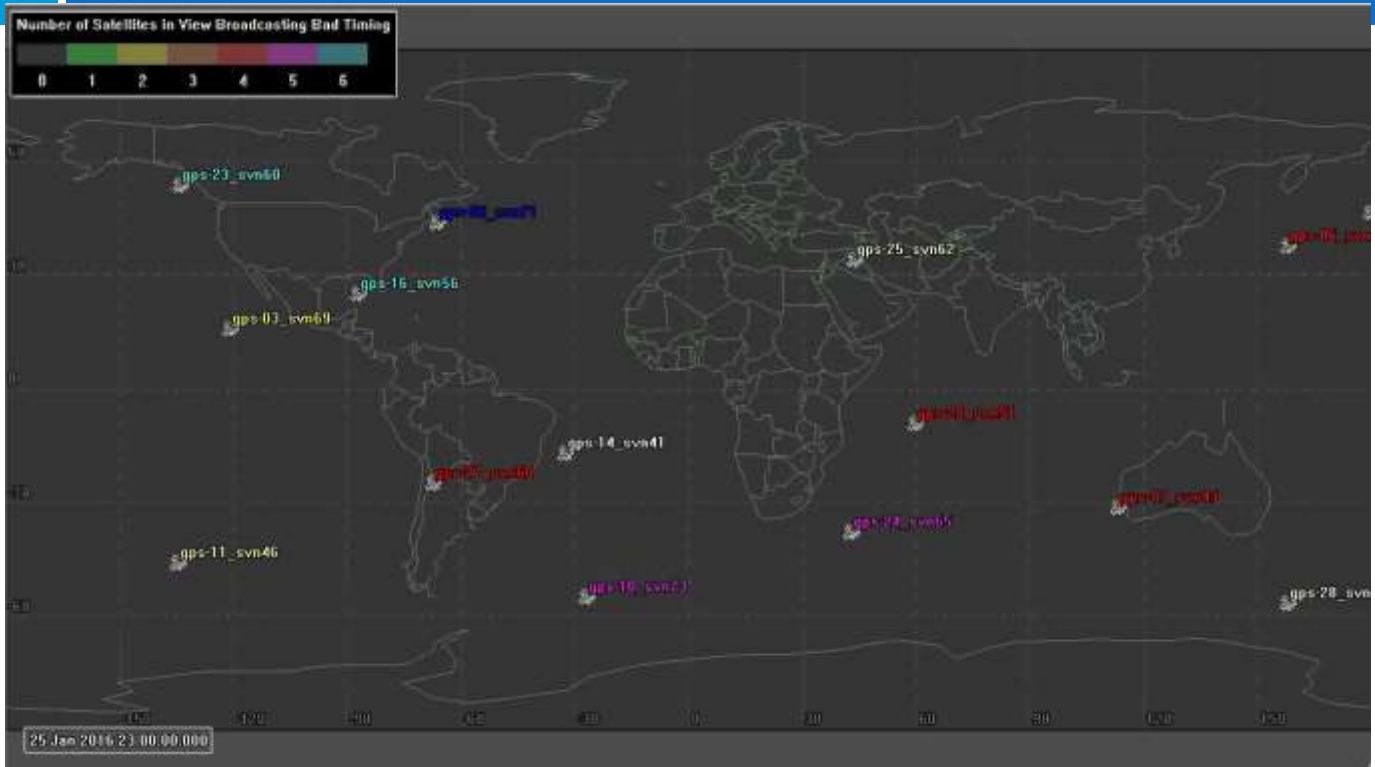
26 Jan 2016

Note: Signal segments parallel to X axis are providing accurate time

26 Jan 2016

# January 2016 – 13.7 $\mu$ sec

Video Courtesy John Lavrakas, President Advance Research Corp.

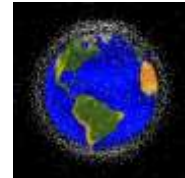


# February – March 2016



‘We will fund eLoran on a chip’ - NIST

‘More Ain’t Necessarily Better’



The Washington Post



‘Best Jammer Ad – Ever!’

# March 2016

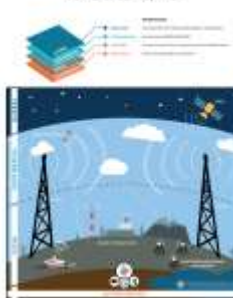


## DOT Begins Adjacent Band Compatibility (ABC) Study

### Norway, UK Discuss eLoran Time



Positioning, Navigation, & Timing (PNT)  
Multi-Layer Resiliency Model



### Congressmen Oppose NDGPS Decom w/o Resilient PNT Architecture

# April 2016



DHS Touts eLoran at NY Stock Exchange Workshop

‘GPS Failures Endanger National Security’ –  
Norway Armed Forces Journal



Army RFI for Resilient PNT – ‘eLoran is a Pseudolite’

# April 2016



## Summary of GPS Jamming by North Korea 2010 to April 5, 2016

Testing Equipment for...?

Dates	Jammer Locations	Affected Areas	Disruptions
2010, Aug 23-26 (4 days)	Kaesong	Gimpo, Paju, etc.	181 cell towers 15 airplanes 1 Battleship
2011, Mar 4 – 14 (11 days)	Kaesong Mtn, Kumgang	Gimpo, Paju, Gangwon etc	145 cell towers 106 airplanes 10 ships
2012, Apr 28 – May 13 (16 days)	Kaesong	Gimpo, Paju, etc.	1,016 airplanes 254 ships
2016, Mar 31 - ongoing	Mt. Geumgang Haeju	Easter Gagnwon Seoul	962 airplanes 700 ships 1,786 cell towers

2010 – 2012 information from South Korean Central Radio Management Office

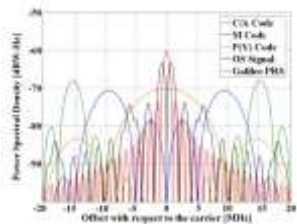
2016 information as of 5 April and from reports by Yonhap News Agency and KBS News

# May 2016



‘South Korea Revives eLoran Project’ - Reuters

‘GPS Threat to Smart Grid Growing’ - MITRE Paper



‘GPS Spectrum Protection’ – Secure World panel

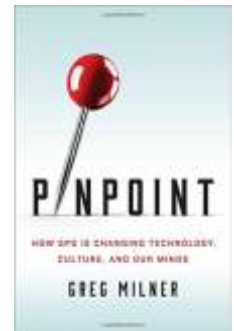
# May 2016



THE NEW YORKER

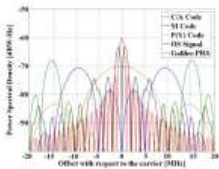
‘What Would Happen if GPS Failed?’ – The New Yorker

‘Air Force Never Really Wanted GPS’ - Pinpoint



‘GPS is Everywhere – Is that a Good Thing?’

# May – June 2016



Ligado Proposal to FCC – Comments Due

GPS Attack at Cairo Airport – Just After Egypt Air Crash



Iran Announces 'Terrestrial GPS' (Loran) System

# June 2016



FAA Announces GPS Disruption Tests – Event Cancelled

BBC/Arqiva Trialing eLoran for Digital Broadcast Timing



*The Atlantic*

“What Happens if GPS Fails?”

# June 2016



Assured PNT Project Announced

Bill Introduced –  
'US Coast Guard Shall Do eLoran'



'Norway Open to Commercial eLoran, Discussions  
On-going' – Western Edge Magazine

# July 2016



‘Homeland Security, PNT ExCom Move on Backing Up GPS’  
– Inside GNSS

‘Surveyors Identify GPS/SatNav Problems in Alaska’  
– GPS World



‘The Night GPS Failed – the Movie’ – GPS World

# July – August 2016



Pokemon Go Recruiting New Generation of Spoofers

‘Protecting GPS From Spoofers is Critical to Future of Navigation’ - IEEE Spectrum



‘Dueling Government Studies’ – DoT vs NASCTN/Ligado

# August 2016

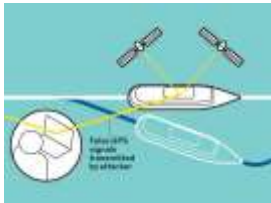


‘GPS Under Attack as Crooks, Rouge Workers Wage Electronic War’ –



‘How Cyberwar From Hacking to GPS Jamming is Changing the Face of Society’ -

**Forbes**



‘GPS Spoofing Surprisingly Easy, Surprisingly Hard to Detect’



# August 2016



‘Providers Must Spend More on Anti-Jamming’ – Discussion in GPS World

‘Global Anti-jam Market for GPS to Reach \$4B+ by 2022’ – Business Wire



‘Spectracom Introduces GNSS Simulators, eLoran Backup for Timing Reference’ – Inside GNSS

# August 2016



‘GPS Spoofing Takes Center Stage at DEFCON 24’

‘UK Firm Develops GPS-Free Positioning’ –  
Maritime Executive



“Seven Easy Ways the Administration or Congress  
Could Get a Quick Win Protecting GPS and America”  
Opinion, Inside GNSS

# August – September 2016



‘SAE International Developing New Standard for PNT – Support to Drones, Critical Infrastructure’

‘GPS Still ‘Achilles heel’ for Internet of Things’ - NIST



‘GNSS & eLoran Most Practical Methods to Support Cell Systems using TDD’ - Euro Commission Report

# September 2016



‘Improved Jammers for Sale!’ - Belarus

‘GPS Interference at Le Mans’ - Spirent



‘China Jamming US Forces’ GPS’ – Crunch Network

# September 2016



“Who is in Charge? PNT Protection in US Leaderless, According to Some”

DHS New PNT Project Management Office



House Passes Bill for GPS Backup System

# October 2016



“GPS-Free Navigation! Except it’s Not”

“American Military’s Greatest Vulnerability in War  
– No GPS” – The National Interest



“Putin Goes All Out Jamming and Spoofing GPS”

# October – November 2016



‘Timing and Smart Grid’ – NIST Workshop

‘Jumping GPS Hurts Uber’



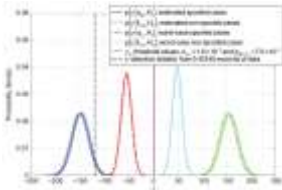
‘Maritime Academies Teaching GPS-Free Navigation... That Requires GPS’

# November 2016



‘GPS Antennas Still Jamming Each Other’ - Chronos

‘US Government Seeking GPS Backup Systems’



“Spoofing will attain viral status,” warns expert – GPS World

# December 2016



‘2017 Defense Act Speaks to GPS Backup, eLoran’

Cyber Commission ‘Protect PNT!’



‘Europe Finding Jammers Everywhere – US Not Looking’  
– PNT Advisory Board Presentation/Discussion

# December 2016



'Need Better PNT for Telecom – eLoran Promising' –  
PNT Advisory Board Presentation

DHS Looking for Tech to Find Jammers, Protect  
First Responders



'GPS + eLoran Greater than Sum of its Parts' –  
Paper by Dr. Gene McCall, Los Alamos

# January 2017



DHS Calls for Fake GPS Antennae, Better Receivers

DOT – ‘GPS Single Point of Failure for Transport Systems’



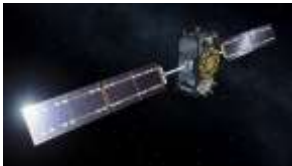
‘Your Smart Phone is Violating the Law’ - FCC

# January 2017



## 'Cascading and Escalating Failures' – World Security Report

2016 eLoran Timing CRADA Results



Galileo Working, But Some Clocks Failing

# January - February 2017



\$\$Millions in US Drones for Ukraine Disappoint  
– Too Vulnerable to GPS Jamming/Spoofing

“Shipping Industry Vulnerable to Cyber Attacks  
and GPS Jamming”



Performance Standard for eLoran Receivers Issued

# February 2017



‘Threats to Damage US via GPS Increasing’ - DHS

“Spirent Security Experts Predict Greater Threat to GNSS in 2017”



Senator Blunt at hearing – “Where are we on GPS backup?”

# March 2017



‘GPS a Big Obstacle to Drone Safety, Productivity’

“GPS Disruption, a Full Fledged Aviation Problem” – GPS World



Senator Cruz at hearing – ‘Critical infrastructure needs GPS backup.’

# March 2017



‘Turkish system reduces dependency on GPS’

Fourth Adjacent Band Computability Workshop  
30 March 2017



6cm eLoran/Chayka/GNSS Receiver (5cm antenna)

# March 2017



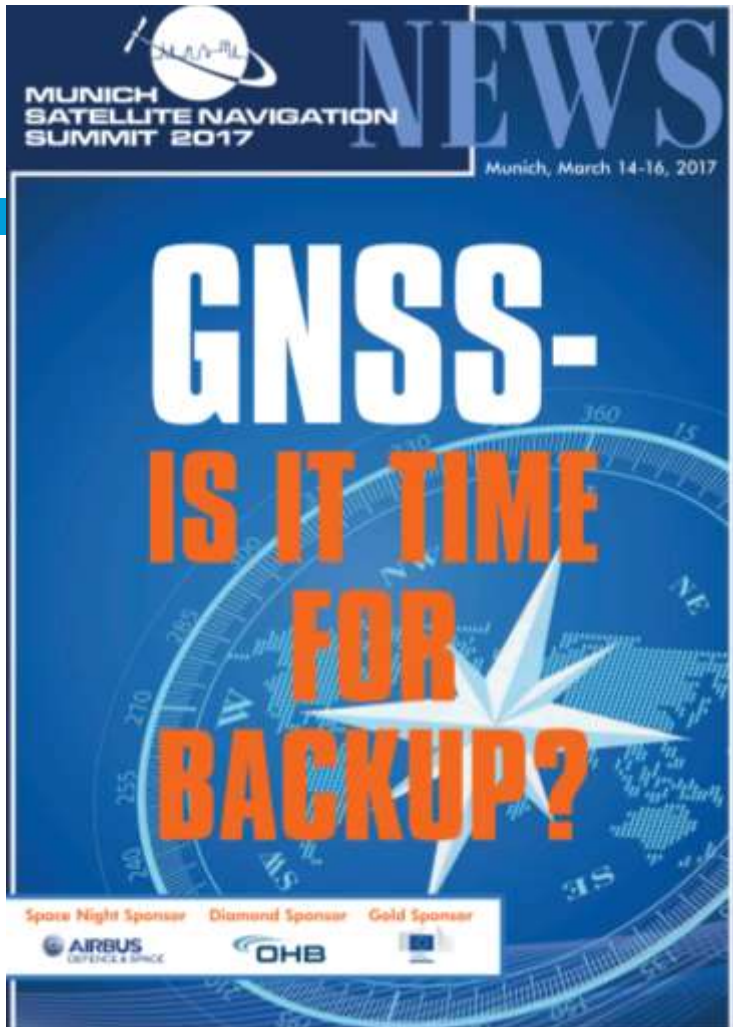
LIVE STREAM

Threats to Space Assets and Implications for Homeland Security



‘Protect, Toughen, Augment...

We are eight years behind where we should be with eLoran’



March 2017

Summary:  
“Yes”

# Munich Sat Nav Summit 2017



- GNSS has been too good (people don't think about failures)
- Using multiple GNSS is good, but not good enough
- Jammers are really nasty, hit all GNSS at once
- Spoofing is getting easier, cheaper, happening more often
- Users need a warning when GNSS is not reliable
- Aviation has a real jamming and spoofing problem
- Network synchronization depends upon space-based time
- Networks are really important

# Munich Sat Nav Summit 2017



- We need to be able to trust electronic navigation sources
- A big obstacle to solving the problem is that we have not had a big failure event
- Who is in charge of protecting GNSS?

# Munich Sat Nav Summit 2017



- The commission has electronic signatures of over 100,000 jammers
- Probably more than one backup system is needed if all users are to be protected.
- Comprehensive approach is required. The EC is considering a European Radionavigation Plan to further this.

# Munich Sat Nav Summit 2017

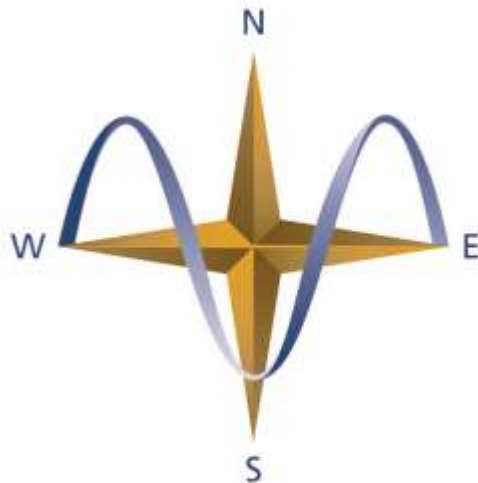


- US President directed action in 2004
- Congress recently reinforced the need for a complementary and backup system for GPS.
- The government is developing requirements for that system
- It is long past time for the system to be in place.

## Attributes of Complementary PNT Systems For More Resilient PNT Architecture

	Less Desirable		More Desirable
Signal	Very Low Power	↔	Very High Power
Frequency	Near GNSS	↔	Far From GNSS
Penetration	Outside Only	↔	Inside
Stand Alone	Needs GNSS/Space To Function	↔	Independent of GNSS/Space
Time	Relative	↔	Absolute
Time	Not UTC Traceable	↔	UTC Traceable
Mobile	Wire/Fiber	↔	Wireless*
\$ to Access	\$\$\$\$\$	↔	\$0
Coverage*	Local	↔	Continent/Global
Accuracy	<GNSS	↔	≥GNSS
Availability	Very Low	↔	Very High
Technical Readiness	Basic R&D needed TRL 1	↔	Operating Now TRL 9

\*Does not consider hypothetical high quality clocks and inertials and broad implementation across most all users



# RESILIENT NAVIGATION *and* TIMING FOUNDATION

The items in this presentation were taken from the RNTF Blog.  
More information about each is available at:  
[www.RNTFnd.org](http://www.RNTFnd.org)