GNSS Interference Detection and Mitigation

COPUOS Scientific and Technical Subcommittee Meeting
07 February 2017
5 elements

• Spectrum Management in the U.S.
• Status of IDM research in the U.S.
• Spectrum Enforcement Actions
• IDM Reporting
• IDM activities through the ICG
The Problem

• A jammer can *block all radio communications* on any device that operates on radio frequencies within its range.

• Generally *does not discriminate* between desirable and undesirable communications.

• Jammers can:
  – prevent your cell phone from making or receiving calls, text messages, and emails;
  – prevent your Wi-Fi enabled device from connecting to the Internet;
  – prevent your GPS unit from receiving correct positioning signals; and
  – prevent a first responder from locating you in an emergency.
Reported Incidents of Interference

- Jammers overwhelm anti-theft devices on cars and trucks enabling undetected movement
- Have been used in vicinity of airports disrupting air traffic
- Illegally establishing quiet zones and text-free zones in Churches and Schools
- Used to defeat the fleet tracking devices in company cars and trucks
- Interfering with port operations
- These uses of jammers are all illegal in the U.S.
Interference at a Highly Automated Container Port facility

Port of Shanghai throughput:
33.62 million TEUs in 2013

One ship can bring as many as 19,000 20ft containers

TEU = One 20 ft container

http://www.marinevesseltraffic.com
U.S. National Spectrum Agencies

- In the U.S. there are three categories of allocations
  - Government (Federal)
  - Non-government (includes state and local)
  - Shared

- Spectrum is usually separated and is managed by different agencies:
  - Government (Federal) spectrum: National Telecommunications and Information Administration (NTIA)
  - Non-Government (includes state and local) allocations Federal Communications Commission (FCC)
  - NTIA and FCC coordinate actions for those bands that are “shared”
International and National Allocations

• In general, national frequency allocations are aligned with the ITU table of frequency allocation

• However, though they are not identical since each nation has sovereign rights to manage its own spectrum, the U.S. pursues harmonized use of the radio frequency spectrum”.
Recent policies that impact IDM R&D

Implementation Roadmap for National Critical Infrastructure and Resilience Research and Development Plan – released by the White House on 12/20/16

− Enhancing the next generation of civil GPS signals and improving interference detection and mitigation (IDM) approaches for PNT services can increase the robustness and resilience of PNT systems and services.
− Activities for IDM can support R&D efforts to establish a nationwide ability to identify, detect, locate, auto-report, and mitigate GPS disruptions (e.g., interference, jamming, and spoofing). These improvements would enhance the ability of users to share information with stakeholders and enable enforcement actions when appropriate.
Critical Infrastructure Resilience

- Technology enabled by GPS is increasingly yielding benefits
- Need to anticipate, accommodate, and accelerate innovation
- Need to understand and mitigate the risks associated with new technologies
- GPS is now widely used by civil infrastructure users
- With strong support of government we have the responsibility to work with the private, public and international partners to help them become increasingly resilient
Best Practices

In the past 2 years the U.S. has released 2 best practices for mitigating the effects of a localized GPS disruption.

• Best Practices for Improved Robustness of Time and Frequency Sources in Fixed Locations 6 January 2015

• Improving the Operation and Development of Global Positioning System (GPS) Equipment Used by Critical Infrastructure

• Find these documents at:  [www.GPS.gov](http://www.GPS.gov)
  Look for: Guidance for Critical Infrastructures
Spectrum Enforcement Actions

Complaint from a cell provider in Florida that its cell phone tower sites had been experiencing interference:

• Forfeiture Order affirms proposed $48,000 forfeiture against a man for using a cell phone signal jammer in his car while commuting to and from work on a Florida highway over a 16-24 month period.

Anonymous complaint alleging that a company was operating signal jammers to prevent its employees from using phones:

• The company will pay $20,500 in civil penalties for unauthorized use for over 2 years of a signal jamming device purchased and mounted in the company’s warehouse to prevent employees from using the cell phones while working.
47 U.S.C.—Interference to authorized communications prohibited

§ 301 - Prohibits the use or operation of “any apparatus for the transmission of energy or communications or signals by radio” within the United States and its territories unless such use is licensed or authorized.

§ 333 - “No person shall willfully or maliciously interfere with, or cause interference to, any radio communications of any station licensed or authorized by or under this Act or operated by the United States Government.”
Spectrum Enforcement Actions

• Forfeiture Order proposing a $34,912,500 forfeiture against manufacturing company for marketing 285 models of signal jamming devices

• A retail business sold a cell phone signal blocker device to a private citizen for use in a child care center.

• Omnibus Citation and Order to 20 Online Vendors for marketing signal jamming devices to consumers via the Internet in the United States or its territories.
47 U.S.C. § 302a(b) Manufacturing, importing, selling, offer for sale, shipment or use of devices which do not comply with regulations are prohibited.

“No person shall manufacture, import, sell, offer for sale, or ship devices or home electronic equipment and systems, or use devices, which fail to comply with regulations promulgated pursuant to this section.”
Federal Communications Commission (FCC) Rules

• Section 2.803 - prohibits the manufacture, importation, marketing, sale or operation of these devices within the United States (47 C.F.R. § 2.803)

• Section 2.807 - provides for certain limited exceptions, such as the sale to U.S. government users (47 C.F.R. § 2.807)
The Criminal Code
(Enforced by the Department of Justice)

• Title 18, Section 1362 - prohibits willful or malicious interference to U.S. government communications; subjects the operator to possible fines, imprisonment, or both (18 U.S.C. § 1362)

• Title 18, Section 1367(a) - prohibits intentional or malicious interference to satellite communications; subjects the operator to possible fines, imprisonment, or both (18 U.S.C. § 1367(a))
Comprehensive GNSS jamming prohibition provisions must be incorporated under four different authorities:

- National Statutes – Legislation
- Telecom Agency Rules
- The Criminal Code
- International Treaties
Interference Reporting

U.S. process starts with problem report to NAVCEN, FCC or FAA

- Different than ITU form
  - Problem Rpt vs After Action Rpt
- Service Center triage to confirm problem
- Initial interagency conference call to provide for a coordinated government response/Discussion on way fwd
- Priority assigned will determine level of response and agencies involved

Interference Report Form:
https://www.navcen.uscg.gov/?pageName=gpsUserInput
IDM and the ICG

- At the inception of the ICG, the Working Group on Compatibility and Interoperability was tasked to develop a strategy supporting mechanisms to detect and mitigate sources of electromagnetic interference, taking features of GNSS signals and existing regulatory mechanisms into consideration.

- An IDM Task Force was formed by the working group to undertake this work.

- Under the newly structured ICG Working Group on Systems, Signals and Services, IDM efforts have been combined with Compatibility and Spectrum Protection under a Sub-group chaired by Japan and the EU.

- 5 IDM workshops and 2 IDM& Spectrum seminars have been conducted to date.
Interference Detection & Mitigation Task Force

- **Co-Chairs:**
  - Rick Hamilton, U.S., Co-lead stephen.r.hamilton@uscg.mil
  - Weimin Zhen, China, Co-lead  crirp_zwm@163.com

- **Members:**
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  - Hiroaki Maeda, Japan  Hiroaki.Maeda@LighthouseTC.jp
  - Frank Clark, USA
## Cooperation and Information Sharing Between Provider Service Centers

<table>
<thead>
<tr>
<th>Name</th>
<th>Country</th>
<th>URL</th>
</tr>
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<tbody>
<tr>
<td>Information Analysis Center</td>
<td>Russia</td>
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<tr>
<td>US Coast Guard Navigation Center</td>
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<td>William J. Hughes Technical Center WAAS Test Team</td>
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Significant IDM Technologies

Some significant IDM technologies have been presented to the ICG IDM workshops:

• China is experimenting with a Grid Radio Monitoring Network detection system that can cover large areas

• The EU has funded the “Detector” program. Captures and archives screen shots and can differentiate between jammers

• The Chronos company in the UK has undertaken 3 specific R&D projects, now includes photograph of jammer vehicle

• Harris in the U.S. has developed a working IDM capability called the Signal Sentry 1000

• Russia has shown us a method by which we can characterize the noise environment around any given piece of critical infrastructure
Crowd Sourcing

Every cell phone can be a GPS jamming detector. Requires a Public/Private Partnership.
GNSS Spectrum Protection

• Starts with good foundations, the ITU; but it is crucial to protect GNSS spectrum at BOTH international and national levels.

• Compatibility analysis of new radio systems is essential before introducing them into operation to avoid interfering with existing GNSS signals.
Interference Detection

• The ITU provides the regulatory framework (Radio Regulations), but it is national regulators that play the key role in finding interferers to GNSS

• Robust enforcement of national and international regulations is vital to limit impacts to GNSS
<table>
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<tr>
<th>Jammers</th>
<th>US</th>
<th>RU</th>
<th>China</th>
<th>EU</th>
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<td>illegal</td>
<td>Nation-by-nation</td>
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<tr>
<td>sell</td>
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<tr>
<td>export</td>
<td>illegal</td>
<td>illegal</td>
<td>illegal</td>
<td>Nation-by-nation</td>
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<tr>
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<td>Undefined (consumer import illegal)</td>
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<td>own</td>
<td>legal</td>
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<td>Undefined</td>
<td>legal</td>
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<tr>
<td>use</td>
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Your Role

• We encourage you to go back to your national regulators and find out how they are protecting GNSS from interferers.

• Do they realize the vulnerability of GNSS reception?

• Do they appreciate the economic impact of GNSS loss?

• Are they doing enough to protect GNSS spectrum from interference?
FINI
Back up slides

Demonstrated GNSS IDM technologies
DETECTOR Characterisation

Characterisation and parameterisation of incoming signals

1. Determine likely **impact** on users
2. Differentiate **unintentional** interference from **jamming**
3. **Differentiate** between jammer types
4. Identify **multiple detections** of the same interference versus one-offs
5. Identify **trends** in the evolving threat
6. Develop **countermeasures**
7. **Catalogue** the threats
UK Research into GPS Jamming

**Chronos Technology Research Projects with Innovate UK**

**GAARDIAN** – 2008 - Technology to detect Jamming

**SENTINEL** – 2011 - Technology to geolocate Jamming

**AJR** – 2013 – Technology to photograph vehicle with Jammer

**Chronos GPS jamming detection technology used in the Harris Signal Sentry™ 1000 System for geolocation**
Signal Sentry® 1000 Overview

> Detects and locates sources of GPS signal interference
> Provides location of interference
> Presented in the form of geographical pin mapping
> Provides actionable intelligence to the user
> Leverages Exelis signal domain knowledge of GNSS
> Patented Exelis Technology
> Signal Sentry 1000 data aids Intelligence Led Policing

Assures safety, efficiency, and revenue
**Section 8. Total estimation of electromagnetic and interference environment**

The basis of the methodological approach - the construction and analysis of special diagrams of the spatial distribution of energy emission in the GNSS frequency bands.
Crowdsourcing for Jammer Detection & Location (J911)

Geographic Coverage Is the Challenge for IDM Systems; Detectable Range May Only Be a Few Hundred Feet and Multipath Effects Can Be Severe

**Collaborative Defense**

- Devices Report Jamming Parameters & Own Position to J911

- Using Aggregate of Reports, J911 Can Determine Jammer Position to ~ 40 meters in near real-time

- J911 Can Report Interference Events to Networked Users (Like Traffic Reports)