Analysing GPS Jamming Incidents at the UK Border
UK Container Port Trial Deployment

Billy Marshall
Research Systems Engineer
Chronos Technology Ltd
Presentation Overview

- Chronos Technology
- Intentional GNSS Jamming
- Automated Detection & Identification
- Proof of Concept trial at the UK border
  - System setup
  - Results so far
- The Future
  - Technology
  - Engagement and enforcement

26/06/2017 ©2017 Chronos Technology: UNRESTRICTED
Chronos Technology

- Start-up in 1986, 30 years specialising in position, timing, navigation systems

- Synchronisation and timing
  - Frequency, Time and Phase
  - GPS/GNSS products and solutions
  - Network Timing and Service Assurance
  - Testing and Metrology

- Resilient Positioning, Navigation and Timing
  - eLoran Timing Systems
  - Threat detection
  - Threat mitigation

- Innovate UK funded research into techniques for detecting and locating sources of GNSS band interference
  - Key partner, University of Bath
  - Iterative process over 10 years, resulting in various hardware and software platforms
Intentional GNSS Jamming

- Deliberately introducing noise in the RF bands used for GNSS, rendering the real signals unusable
- Personal privacy – usually to defeat employer tracking
- Intentional jamming can also be a marker for other illegal activity
  - Stolen vehicles, Contraband trafficking, Evasion of covert tracking
- Activity of existing ‘person of interest’
- Requirement for actionable intelligence
Since 2010, Chronos research platform, SENTINEL, revealed transient incidents of localised GNSS interference at various locations around the UK

- Sensors at fixed locations in both suburban (near airport) and city environments
- Suspected in-vehicle jammers

Table below shows statistics from this platform (2013-2017):

<table>
<thead>
<tr>
<th>Location</th>
<th>Total Days Detecting</th>
<th>Total Events</th>
<th>Mean Events/Day</th>
<th>Cumulative Event Time (hrs)</th>
<th>Mean Event Duration (s)</th>
<th>Longest Single Event (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>1246</td>
<td>5732</td>
<td>4.6</td>
<td>110</td>
<td>69</td>
<td>60</td>
</tr>
<tr>
<td>Airport</td>
<td>1461</td>
<td>6962</td>
<td>4.8</td>
<td>32</td>
<td>17</td>
<td>10</td>
</tr>
</tbody>
</table>

Similar number of events per day in both locations – approx. 5/day, however in the city location:-

- **Total duration** of detected interference is over **3 times greater**
- **Mean duration** of individual events in the city is **4 times longer**
- **Longest individual event** is **6 times longer**

Cause suspected to be slower moving traffic, and the ability to park up, in the city, meaning vehicles remain in the vicinity of the detector for longer.
Automated Detection & Identification

- Current JammerCam system has been developed from testing in simulated and live environments
- Technology Readiness Level 6 (of 9) – currently prototype demonstration in relevant environment
- Continual improvements to detection algorithms
  - By analysing logged ‘near miss’ raw data
- On-going enhancements to image capture
  - Camera upgrade, positioning and timing modifications
- Potential to develop commercially available system

Photos: With the permission of the Commandant, Sennybridge Training Area

26/06/2017
©2017 Chronos Technology: UNRESTRICTED
System Overview

Installation Location

Monitor Power Level in GNSS Band

Detect Passing Jammer in Vehicle

Trigger Camera System

Sends Data to Server

JammerCam Hardware

VPN Tunnel

Server

©2017 Chronos Technology: UNRESTRICTED
Detection and Image Capture

GNSS Band Sensor

Estimated jammer speed: 24 mph, detector angle: 15.00 deg ccw

AJR Test: 7/8/16 14:07 BST

Power [dBm], Power difference [dB]

Time [s] (negative approaching)

©2017 Chronos Technology: UNRESTRICTED
Server and Database

- Automated alerts
- Logs images and raw interference data
- Allows remote modification of detection algorithms and image capture parameters
- Enables analysis of detection incidents
  - Filtering
  - Correlation by timeframes
  - Raw data views of interference profile - enables visibility of ‘near misses’ or non-triggering events
Proof of Concept Trial

- 7 month trial at large UK container port (can be classed as critical infrastructure), (Oct 2016 to June 2017)

- Port employs automatic container straddle carriers to locate and move containers – this system uses GNSS for positioning and navigation
  - Experiencing intermittent outages of GNSS in localised
  - Outages cause automated systems to stop functioning, port has to fall back on less efficient manual system – affecting all parties

- Suspected in-vehicle jammers
  - Jammer in-out is okay, staying on terminal is a problem!

- Installed on ‘secondary’ (not main) entrance/exit as this afforded easier installation
Sensor Location

- Left lane cars only
- Gatehouse
- Sensor detects both sides
- Camera on both exit & entry roads
- Stop for ANPR image
Detection Results

- Upgraded sensor/camera March 2017, all data since that time
- 420 detections in 74 operational days between 9th March 2017 and 19th June 2017, (gate shut most weekends)
- Average 6/day overall, however recent algorithm improvements have increased this to 10/day
- Total number of vehicles averages 2000/day – around 1.3 per minute, around 1 detection in 350 overall
- Maximum was 22 detections in 24 hours (1% ‘hit’ rate)
- Manual logging of number plate and identifying information into interference detection logs
‘Gaps’ are weekends when gate usually shut - indicates that detection events are ‘real’ and caused by human/vehicle activity

- Max 22 detections in one day

- Increase over time due to improvements to detection algorithm
Time of Day Analysis

- Port is 24 hours so detections span all hours of the day
- Increase with traffic, during normal business hours
- Tail off during night-time
Serial Offenders...

- Identified instances of the same vehicle causing multiple detections
- The flatbed truck in the photos is captured every 1-2 days
- Stopped in May 2017 – has on-board company-fitted GPS tracker but no obvious jammer, driver did not seem ‘aware’ of jammers
- Suspected faulty tracker installation, causing antenna to broadcast amplified ‘noise’ on GNSS bands
  - Has been advised to have installation inspected, to be continued...
- Possibility of ‘serial offences’ by articulated lorries, however analysis is currently complicated by cab/container combinations
Considerations & Issues

- Gate has 2 lanes for both entry and exit if image captures multiple vehicles it’s currently unknown which is causing interference
  - Directional shielding and algorithm research on-going

- Articulated lorry container/cab expected to have different jamming profile
  - Possibility container is lower power due to metallic structure

- Profiles currently unknown to distinguish between a ‘low power’ interference close to sensor or ‘high power’ further away

- Currently vehicles are required to be moving to generate a defined interference ‘peak’ to trigger camera

- Installation required to be a perpendicular to the road as possible for optimal RF ‘peak’ generation
JammerCam Future Developments

- Testing at Idaho Jamming Trials – Summer 2017
- Outbound automatic trigger or correlation with other systems
  - ANPR system to automatically log number-plates
  - Traffic data to correlate fluctuations in detections with traffic
- Pre-loaded interference signatures to identify different causes and device types, position in vehicle, non-intentional, etc.
- Directional shielding to refine accuracy of incident location
- Further testing in various traffic environments - Speed, volume, purpose
  - New installation planned at major UK motorway service station – Q3 2017
- Night vision/low light camera
Conclusions & The Future

- Jamming/Interference incidents and are being detected and source vehicles identified...
  - Current question is around how best to use this information to best effect
- Implemented use of hand-held detection devices to confirm and isolate sources of interference once they are within the terminal
- Port Police currently developing framework for dealing with incidents:
  - May require co-ordination with other agencies
  - Developing process for searching of cab or container of lorries for illegal activity
  - Some containers opened already, no jammers found, thinking must be in the cabs
  - Considerations of how to deal with simple ‘personal privacy’ incidents, i.e. no other intention than operating the jammer
Thanks for your attention!

www.chronos.co.uk
www.gps-world.biz