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

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

UNIVERSITY OF BATH

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

Seized Jammer   **Stolen Cars**   **Hot-Wired Jammer**   **Land Rover Theft**

Previous System (SENTINEL) sentinel CHRONOS TECHNOLOGY

- 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) :**

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

- 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.
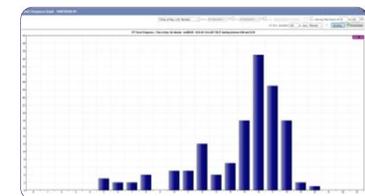
Automated Detection & Identification

- 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
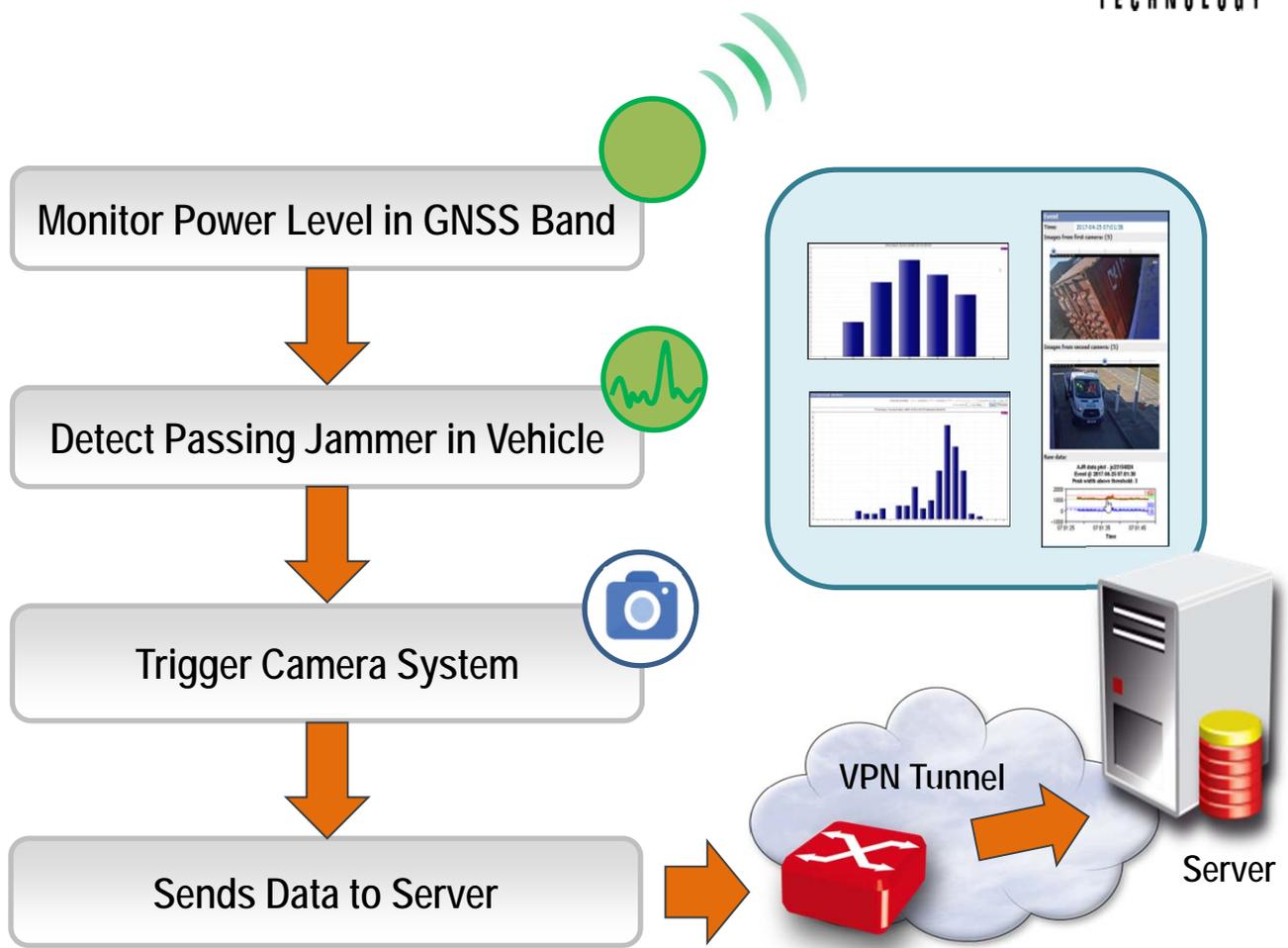
- Potential to develop commercially available system

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

System Overview

Installation location

JammerCam Hardware

Monitor Power Level in GNSS Band

Detect Passing Jammer in Vehicle

Trigger Camera System

Sends Data to Server

VPN Tunnel

Server

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] (y-axis, range -40 to 40)

Time [s] (negative approaching) (x-axis, range -10 to 10)
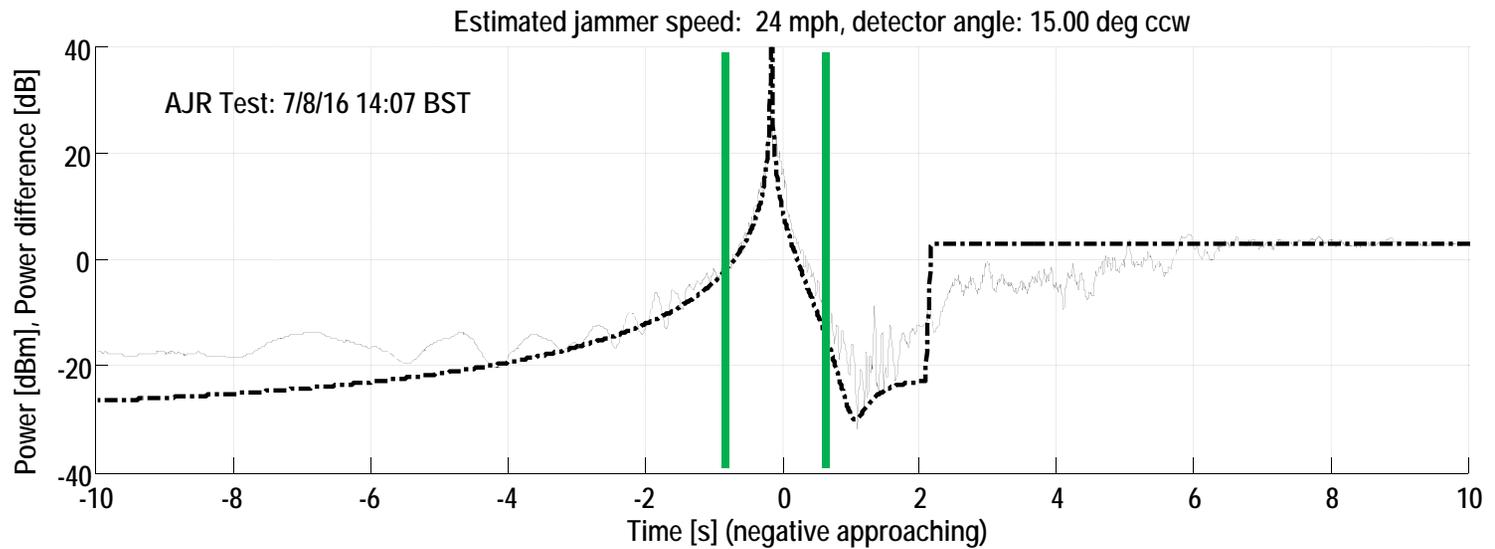
HD Camera

5 images

Server and Database
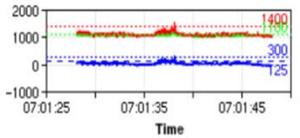
- Automated alerts

- 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
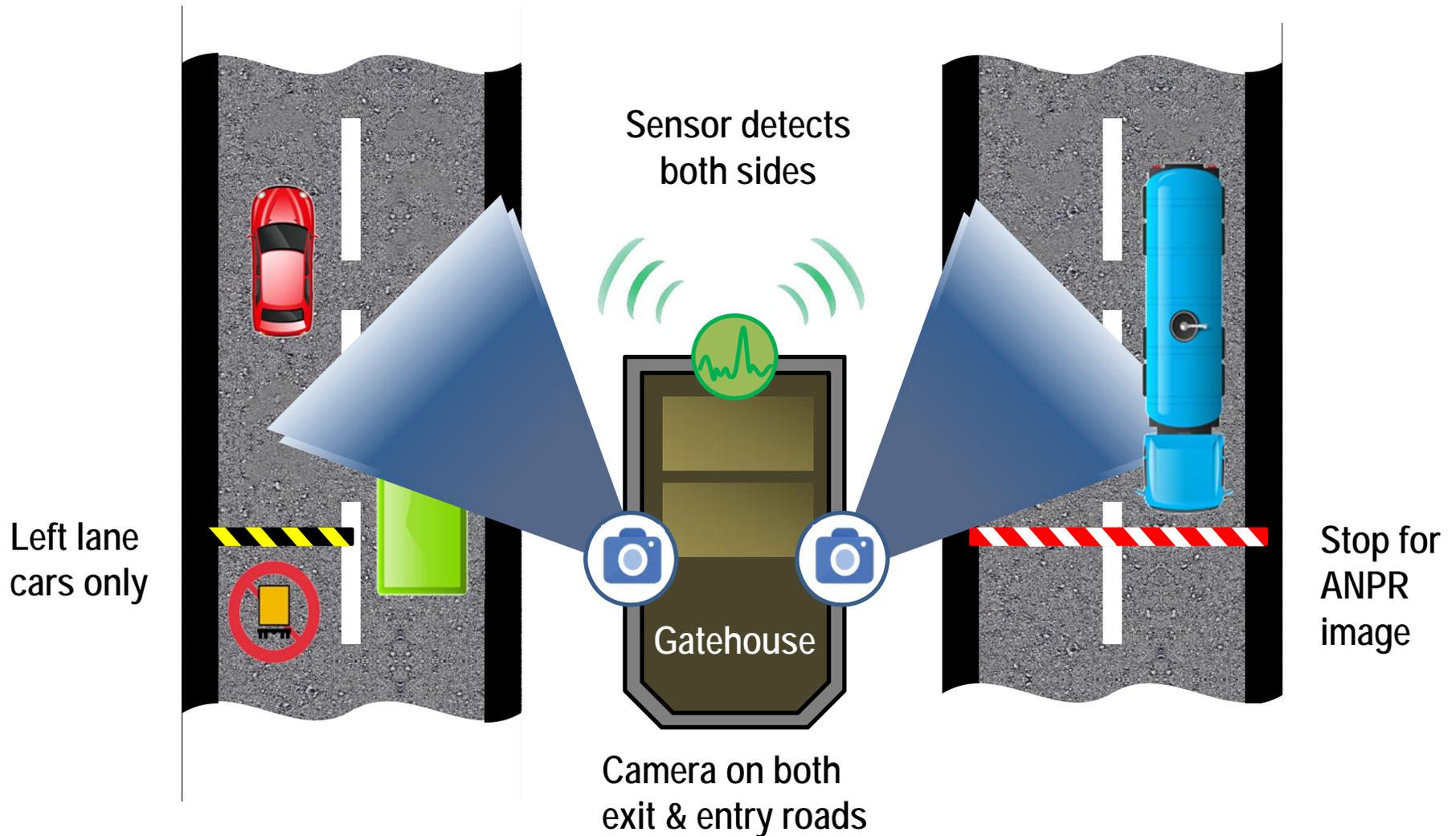 - Raw data views of interference profile - enables visibility of 'near misses' or non-triggering events

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
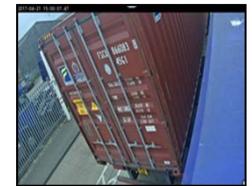
Sensor Location

Sensor detects
both sides

Left lane
cars only

Gatehouse

Stop for
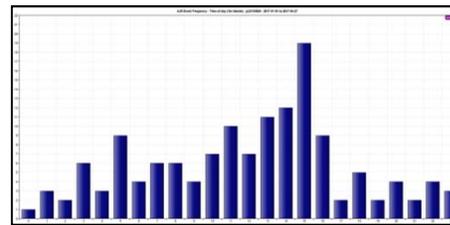ANPR
image

Camera on both
exit & entry roads

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
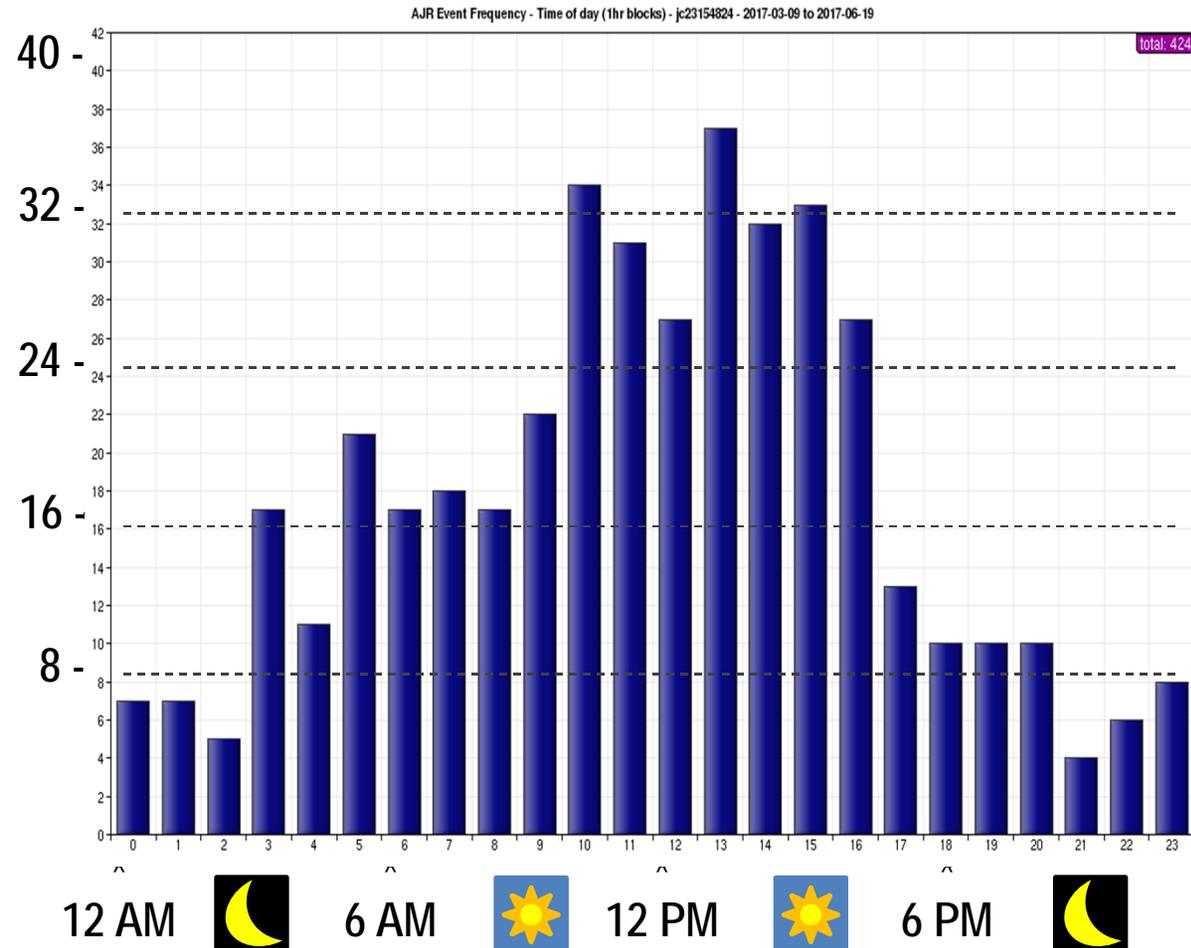
Overall Detections

- '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

AJR Event Frequency - Overall distribution (1day blocks) - jc23154824 - 2017-03-09 to 2017-06-19

total: 423

March   April   May   June

Algorithm Improvements
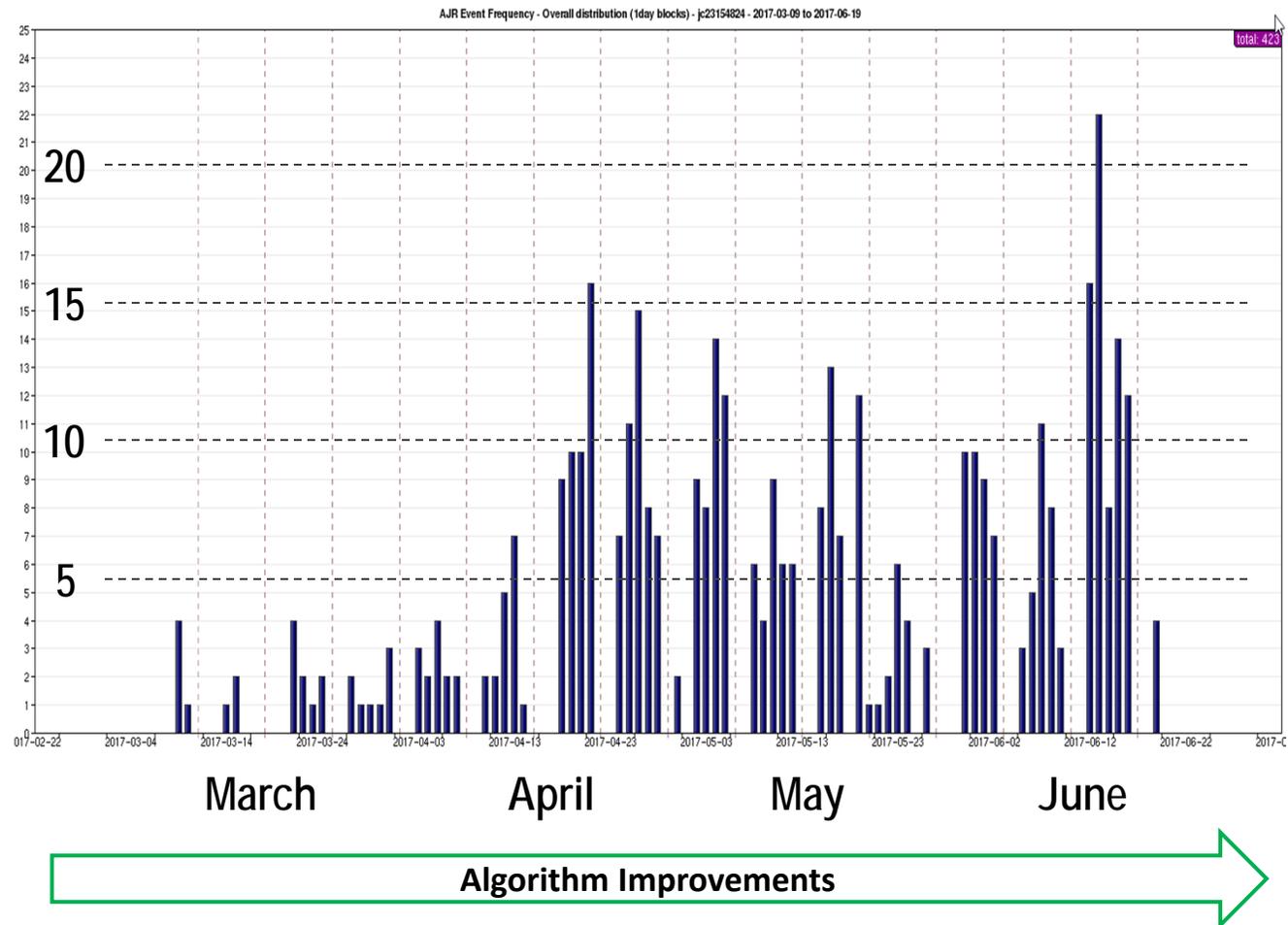
Time of Day Analysis

- Port is 24 hours so detections span all hours of the day

- Increase with traffic, during normal business hours

- Tail off during night-time

AJR Event Frequency - Time of day (1hr blocks) - jc23154824 - 2017-03-09 to 2017-06-19

total: 424

12 AM 🌙 6 AM ☀️ 12 PM ☀️ 6 PM 🌙

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
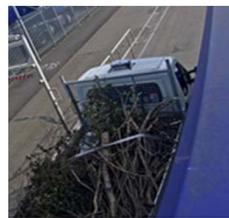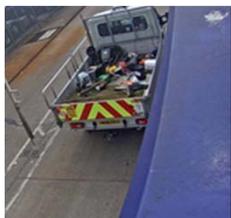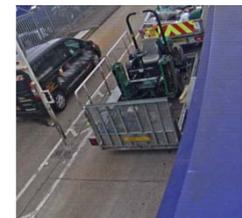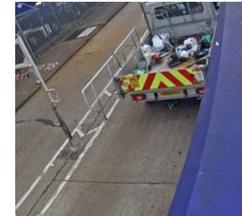
Considerations & Issues

- 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
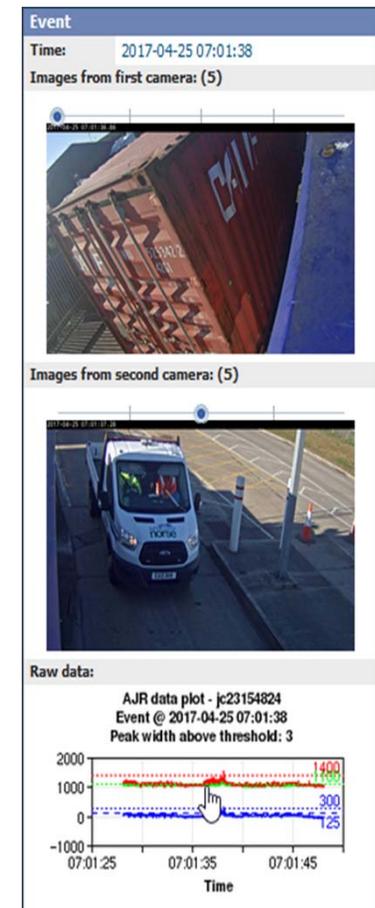
JammerCam Future Developments

- 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
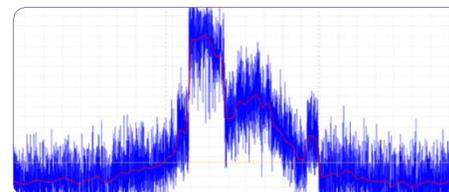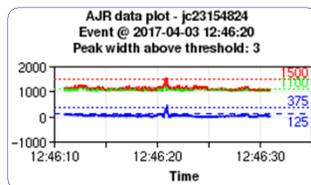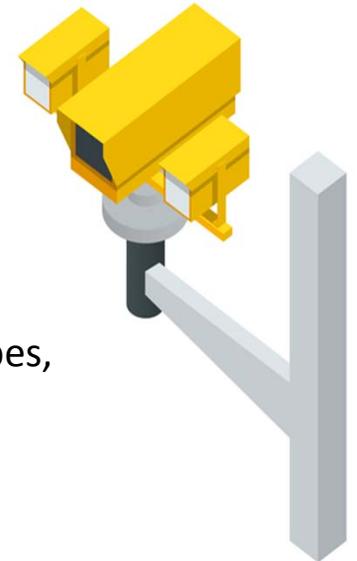
Conclusions & The Future

- **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

Photos: Courtesy Hampshire Constabulary and NaVCIS

www.chronos.co.uk

www.gps-world.biz