Vehicle borne GPS jamming incidents detected in the SENTINEL project

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CGSIC
17th Sept 2012
Nashville
The SENTINEL Project

- GNSS SErvices Neeedng Trust In Navigation, Electronics, Location & timing

- UK Government Funded R&D Project, 2 years, ~£1.5m
  - through Technology Strategy Board
  - “Trusted Services” Call

- Research service to establish extent to which GNSS and eLoran PNT signals can be trusted
  - at point of use, 24x7x365
  - In specific user-community applications
  - Built on the GAARDIAN project which researched “Detection”
  - adding “Location” of interference source
The SENTINEL Partners

- ACPO-ITS – Association of Chief Police Officers
  - User Community – Law Enforcement
  - Brings other Government agencies into the collaboration

- GLA – General Lighthouse Authorities
  - User Community - Maritime
  - eLoran

- University of Bath - Dept. of Electrical & Electronics
  - GPS & Space Weather

- Ordnance Survey
  - User Community – Land Geolocation

- NPL – National Physical Laboratory
  - Time, UTC Traceability

- Thatcham Vehicle Security
  - Certification of safety critical services

- Chronos Technology Ltd
  - GAARDIAN Research
  - SENTINEL Project Leader
Real time detection & location of GNSS interference for the protection of critical infrastructure facilities and services
The Deliverables

- Joins User Community with Technology Innovators
- Deploy Clusters of GAARDIAN probes into “SENTINEL” networks
- Planned Phased Approach
  - GAARDIAN probe redeployment
  - New probe development
  - Tactical Deployment & Testing to prove technology
  - Different scenario deployments
  - Multimodal deployments e.g. Port, Motorway, Airport
Tactical Deployments

- GAARDIAN proved “Detection” of short events
- Vehicle passing with cigarette lighter jammer!
- SENTINEL confirmed capability at Jamming trials June 2011 & 2012 – Summer!
Data Analysis from Around the UK

- SENTINEL Phase 1 Results
- Redeployment of GAARDIAN probes
- OS Differential GPS Reference Station Sites
- Reason – Intermittent Loss of Service
- Selected various locations
- Will present results from 4 locations…..
Location “A” – 12 Months of Data

Small Town - Urban A
0/1/2 events per day – 36 Total

Can we detect a pattern?
Location “A” – Hour Bins

Hour Bins Throughout the Day
Location “A” – Day Bins

Day Bins Throughout the Week

- Monday: 10
- Other Days: 5
Location “A” – 11am-2pm

Day Bins Throughout the Week

- Monday: 10 events
- E vents

- Fri: 5 events
Sit and Wait!

Hand Held GPS Jammer Detector

Along comes “White Van man”

Investigations lead to device confiscation
Location “A” – 12 Months of Data

When was the device confiscated?

1 Feb 2011

1

2

Time

Now
Location “B” – 6 Months of Data

City & Docks 2 lane link Motorway.
0/1/2 events per day – 67 Total

Aug 2011

Now
Location “B” – Hour Bins

Hour Bins Throughout the Day

Midnight

15:00
Location “B” – Day Bins

Day Bins Throughout the Week

Monday

Day Bins Through the Week
Location “C” – 2 Months of Data

City 2 lane link Motorway
0/1/2 events per day – 10 Total

Dec 2011
Now
Location “C” – Hour Bins

Hour Bins Throughout the Day
Location “C” – Day Bins

Day Bins Throughout the Week

Monday

Events

5
Location “D” – 1 Month of Data

City - Urban A
0/1/2 events per day – 18 Total

Jan 2012
Location “D” – Hour Bins

Hour Bins Throughout the Day

Midnight

12:00
Location “D” – Day Bins

Day Bins Throughout the Week

Monday

Day Bins Throughout the Week
Who are the culprits?

- Evasion of Company Vehicle Tracking
- Evasion of Road User Charging
- Spoofing the Tachograph
- Stealing High Value Cars or Vans
- Stealing High Value Loads
- Stealing High Value Assets
- Evasion of Covert Tracking
- Securing Off-Site Meetings
- Any Other Ideas?
# Location “A” – 4 Event Sequence

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>Duration</th>
<th>Sat PRNs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-02-19 21:58:48</td>
<td>00:12</td>
<td>9, 12, 14, 15, 17, 18, 22, 25, 27</td>
</tr>
<tr>
<td>2011-02-19 21:56:38</td>
<td>00:18</td>
<td>9, 12, 14, 15, 17, 18, 22, 25, 27</td>
</tr>
<tr>
<td>2011-02-18 18:30:35</td>
<td>00:15</td>
<td>5, 7, 8, 15, 21, 26, 27, 28</td>
</tr>
<tr>
<td>2011-02-17 18:42:58</td>
<td>00:18</td>
<td>5, 8, 15, 21, 26, 28</td>
</tr>
</tbody>
</table>

17-19th Feb 2011
## Early Data Events Summary

<table>
<thead>
<tr>
<th>Location</th>
<th>Months</th>
<th>Events</th>
<th>Events/Month</th>
<th>Road</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location A</td>
<td>12</td>
<td>36</td>
<td>3</td>
<td>Town Urban A</td>
<td>Total</td>
</tr>
<tr>
<td>Location A</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>Town Urban A</td>
<td>Since Confiscation</td>
</tr>
<tr>
<td>Location B</td>
<td>6</td>
<td>67</td>
<td>11</td>
<td>City Urban Motorway</td>
<td></td>
</tr>
<tr>
<td>Location C</td>
<td>2</td>
<td>10</td>
<td>5</td>
<td>City Urban Motorway</td>
<td></td>
</tr>
<tr>
<td>Location D</td>
<td>1</td>
<td>16</td>
<td>16</td>
<td>City Urban A</td>
<td></td>
</tr>
</tbody>
</table>
Build a Model

- Based on data from a growing network of Sensors
  - With additional features
- By expanding SENTINEL network
- With proposals to other private organisations
- Build a Model - Feel a Spreadsheet coming on!
- Validation over coming months as more data comes in
  - and more sensors are deployed
Road Length Stats?

Road lengths statistics – Dept. for Transport


<table>
<thead>
<tr>
<th>Total Miles</th>
<th>Principal Single</th>
<th>Principal Dual</th>
<th>Trunk Single</th>
<th>Trunk Dual</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorway</td>
<td></td>
<td>26</td>
<td></td>
<td>2185</td>
<td>2211</td>
</tr>
<tr>
<td>Urban A</td>
<td>5001</td>
<td>1645</td>
<td>96</td>
<td>162</td>
<td>6904</td>
</tr>
<tr>
<td>Rural A</td>
<td>15942</td>
<td>1160</td>
<td>3045</td>
<td>1971</td>
<td>22118</td>
</tr>
</tbody>
</table>

31233
## Average Journey Length?

<table>
<thead>
<tr>
<th>Average Journey Length</th>
<th>Principal Single</th>
<th>Principal Dual</th>
<th>Trunk Single</th>
<th>Trunk Dual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorway</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>Urban A</td>
<td>10</td>
<td>25</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>Rural A</td>
<td>25</td>
<td>50</td>
<td>50</td>
<td>75</td>
</tr>
</tbody>
</table>
**Journey Factor**

\[
\text{Journey Factor} = \frac{\text{Total Miles}}{\text{Average Journey Length}}
\]

<table>
<thead>
<tr>
<th>Journey Factor</th>
<th>Principal Single</th>
<th>Principal Dual</th>
<th>Trunk Single</th>
<th>Trunk Dual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorway</td>
<td>1.0</td>
<td></td>
<td></td>
<td>29.1</td>
</tr>
<tr>
<td>Urban A</td>
<td>500.1</td>
<td>65.8</td>
<td>3.8</td>
<td>2.2</td>
</tr>
<tr>
<td>Rural A</td>
<td>637.7</td>
<td>23.2</td>
<td>60.9</td>
<td>26.3</td>
</tr>
<tr>
<td>Total</td>
<td>1137.8</td>
<td>90.0</td>
<td>64.7</td>
<td>57.6</td>
</tr>
</tbody>
</table>
## Nearly There!

<table>
<thead>
<tr>
<th>Events per Month</th>
<th>Principal Single</th>
<th>Principal Dual</th>
<th>Trunk Single</th>
<th>Trunk Dual</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Detections</td>
<td>2</td>
<td>8</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

**Rough Approximation from Events Summary Slide**

**Next: Journey Factor x Events per Month**

| Total Events per Month | 2276 | 720 | 259 | 461 |

**Total Events per Month – Approx. 3700 !!!**

**Inject a Pessimism Factor!**

50%

**Events per Day = ~60 around the UK**
Go Large!

<table>
<thead>
<tr>
<th>Events per Month</th>
<th>Principal Single</th>
<th>Principal Dual</th>
<th>Trunk Single</th>
<th>Trunk Dual</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Detections</td>
<td>5</td>
<td>20</td>
<td>10</td>
<td>15</td>
</tr>
</tbody>
</table>

Selecting Higher Rates from Events Summary Slide
Next: Journey Factor x Events per Month

| Total Events per Month | 5689 | 1800 | 647  | 864  |

Total Events per Month – Approx. 9000 !!!
Inject a Optimism Factor!
150%

Events per Day = ~450 around the UK
2012 Latest Deployments

- Roads – Co-Located with ANPR
- Tactical ANPR Vans
- Airport Runway
  - Co-located with ILS
  - Near a Motorway
- Electricity Grid Sub-Station Installations
- UK Port Entry Locations with Europe
- Tunnel Entrance under Thames
- London Financial District
Conclusion

- Deliberate Vehicle borne GPS Jamming is here
- Evidence suggests the small portable type
  - Impact radius 200/300m
- Model constructed for on-going investigation of UK impact
- Estimate between ~50 & 450 Events per day
- SENTINEL continues to monitor 24x7…

www.gaardian.co.uk
Detecting UK GPS Jamming – 24x7