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IN ASSOCIATION WITH eu2013.ie

Radio Frequency Interference Detection to Support the Use of Global Navigation Satellite Systems (GNSS) in ITS

Kevin Sheridan

NSL

Organised by:

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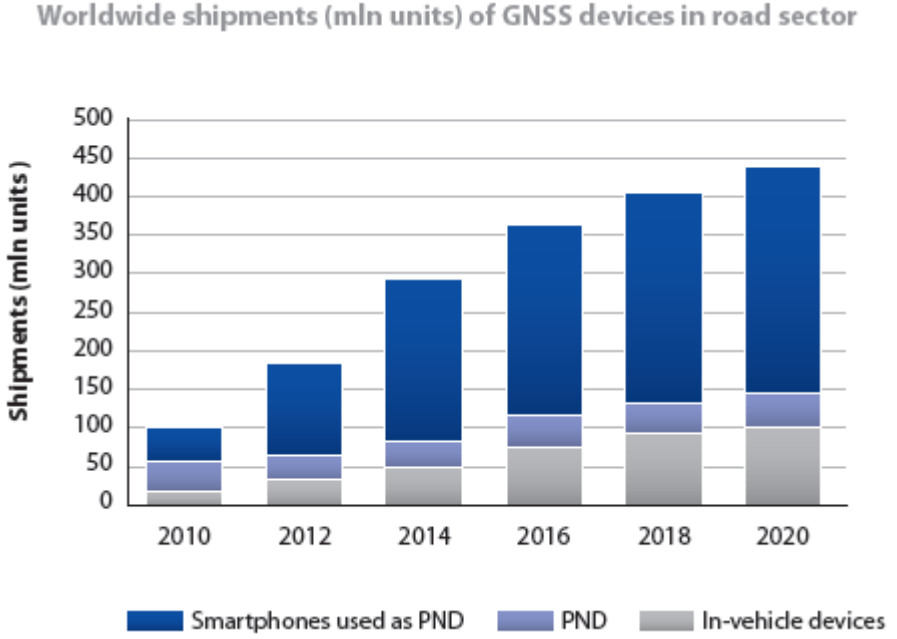
intelligent transport systems its Ireland

Dublin City Council
Comhairle Cathrach Bhaile Átha Cliath

An Roinn Iompair Turasóireachta agus Spóirt
Department of Transport, Tourism and Sport

GNSS Applications

- Used in wide range of domains and industries
  - Consumer
  - Commercial
  - Safety
  - Security
  - Transactions
  - Liability
  - Governmental



Road transport estimated to be valued at 100bn€ by 2020
Source: European GNSS Agency

Radio Frequency Interference

- Unintentional
  - Miss-tuned or faulty equipment, Space Weather
- Intentional
    - **Jamming**, Spoofing, Meaconing
- Impacts of Jamming
  - Receiver
    - Degraded positioning
    - No positioning
  - Services
    - Small nuisance
    - Economic impact
    - Safety impact

Counter-measures

- Legislation (Supply, Possession, Use)
- Education
- Enforcement
  - Detect and remove
  - Direct or indirect
- Equipment
  - Antenna
  - Receiver
  - Hybridisation
- Procedure/process

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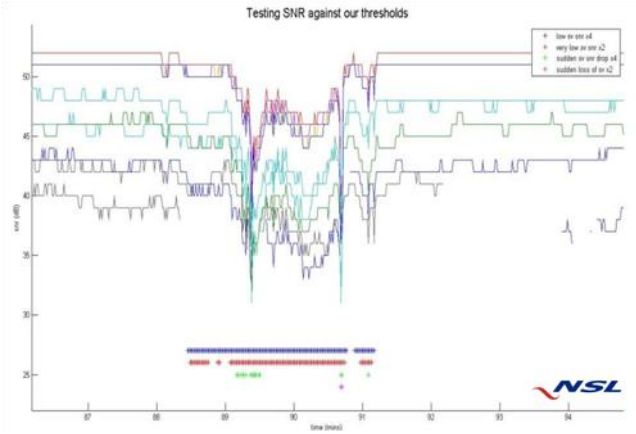
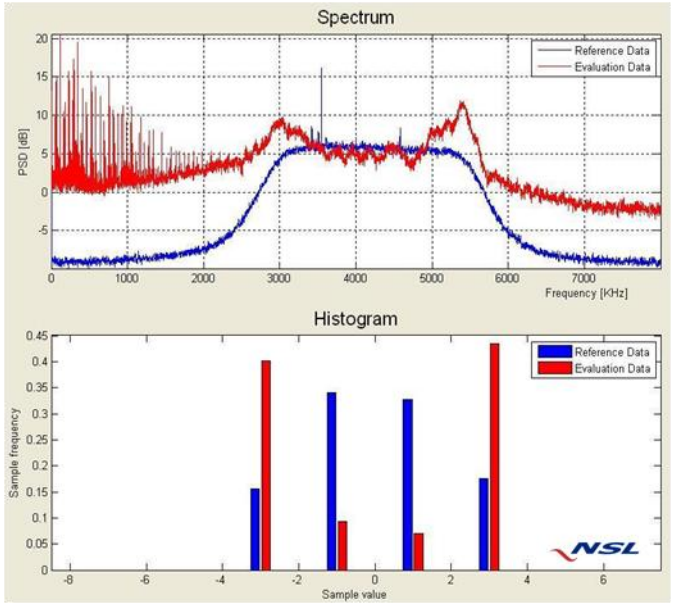
All dependent on understanding the threat

Detector

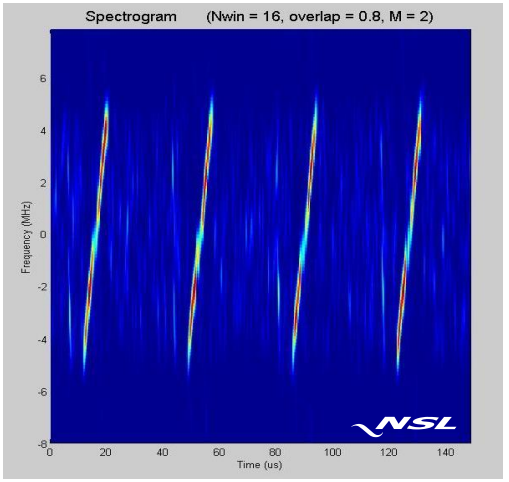
Fingerprinting GNSS Threats

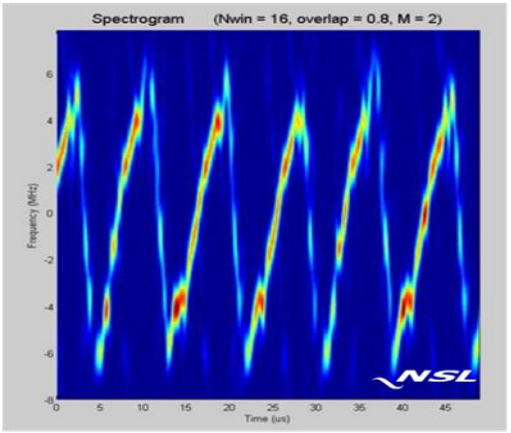


Drop in Signal/Noise of GNSS signals

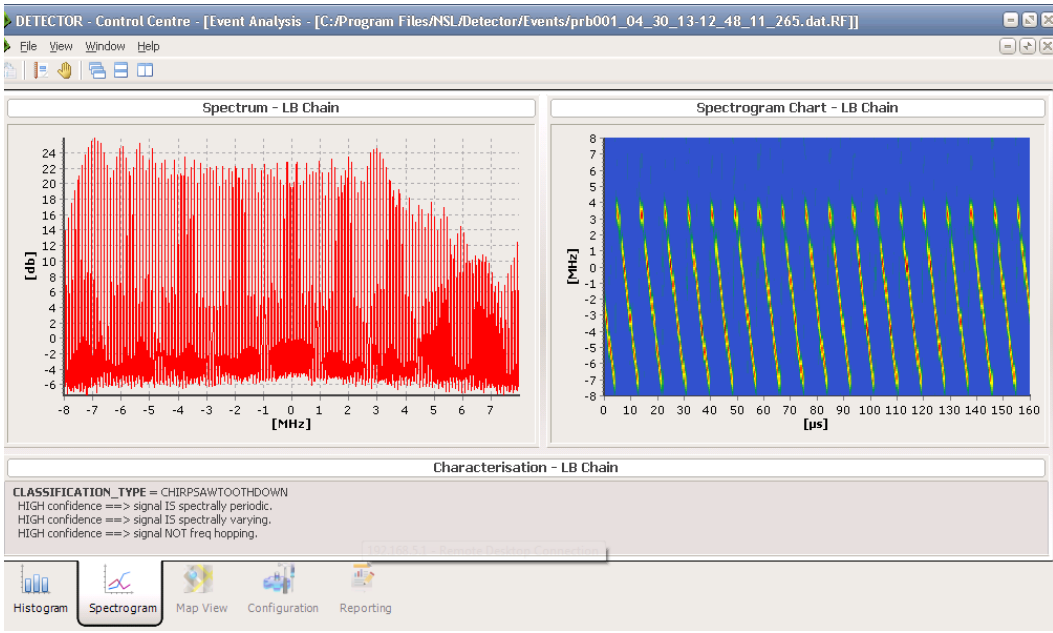


Disturbed RF Power

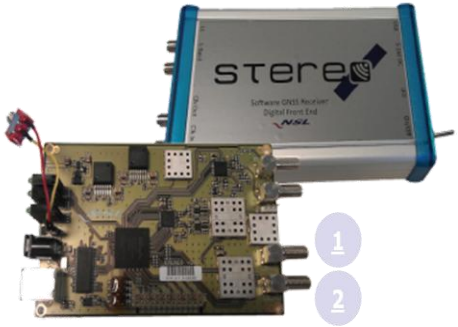




Deploy → **Detect** → **Characterise**



Frequency	Channel 1	Channel 2
GPS L1	X	X
GPS L2		X
GPS L5		X
Galileo E1	X	X
Galileo E5		X
Galileo E6		X
Glonass L1	X	X
Glonass L2		X
GSM		X
Satcom		X



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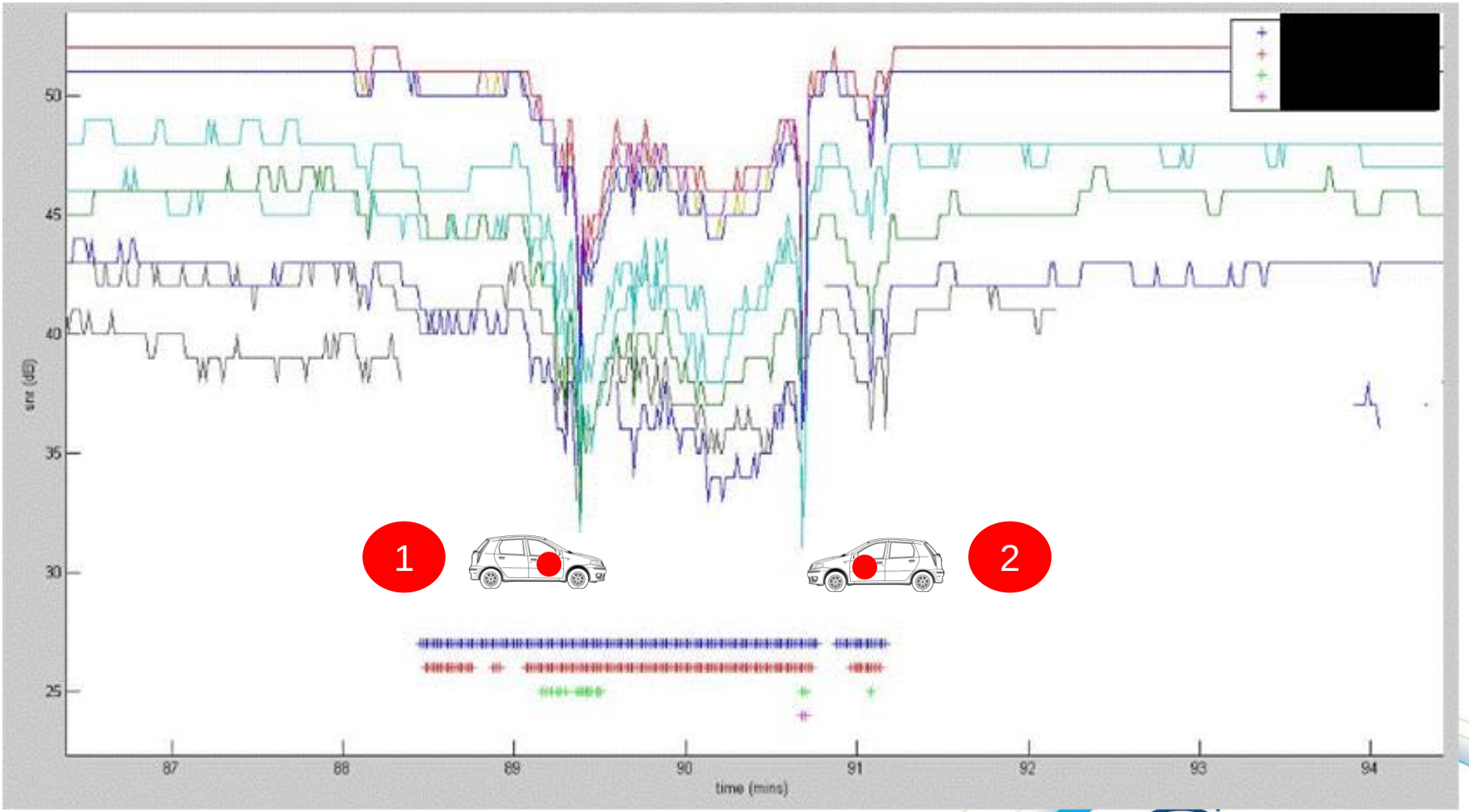
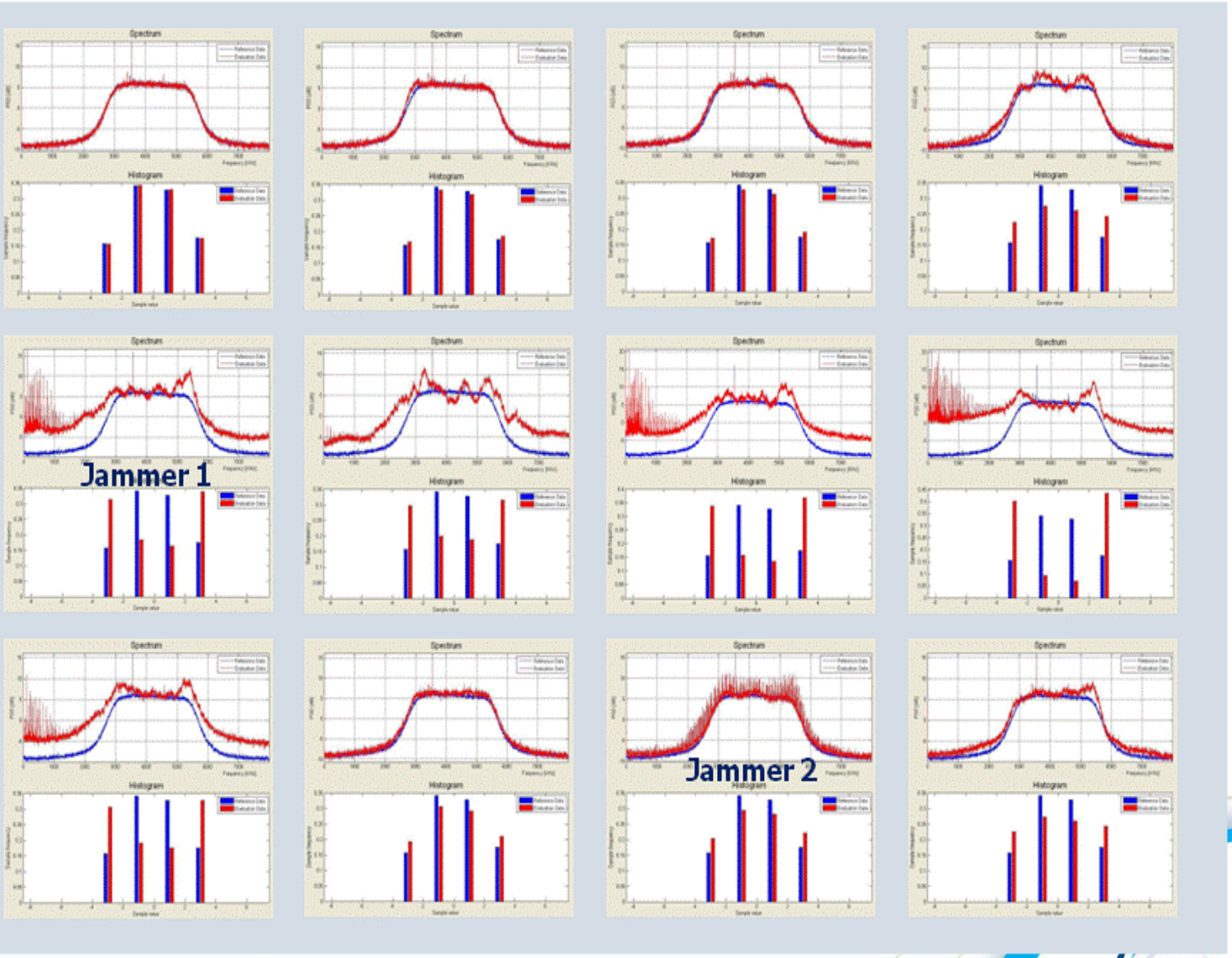
Testing

- Real-world data samples
- Simulations
- Lab Tests
- Tests of end-to-end solution

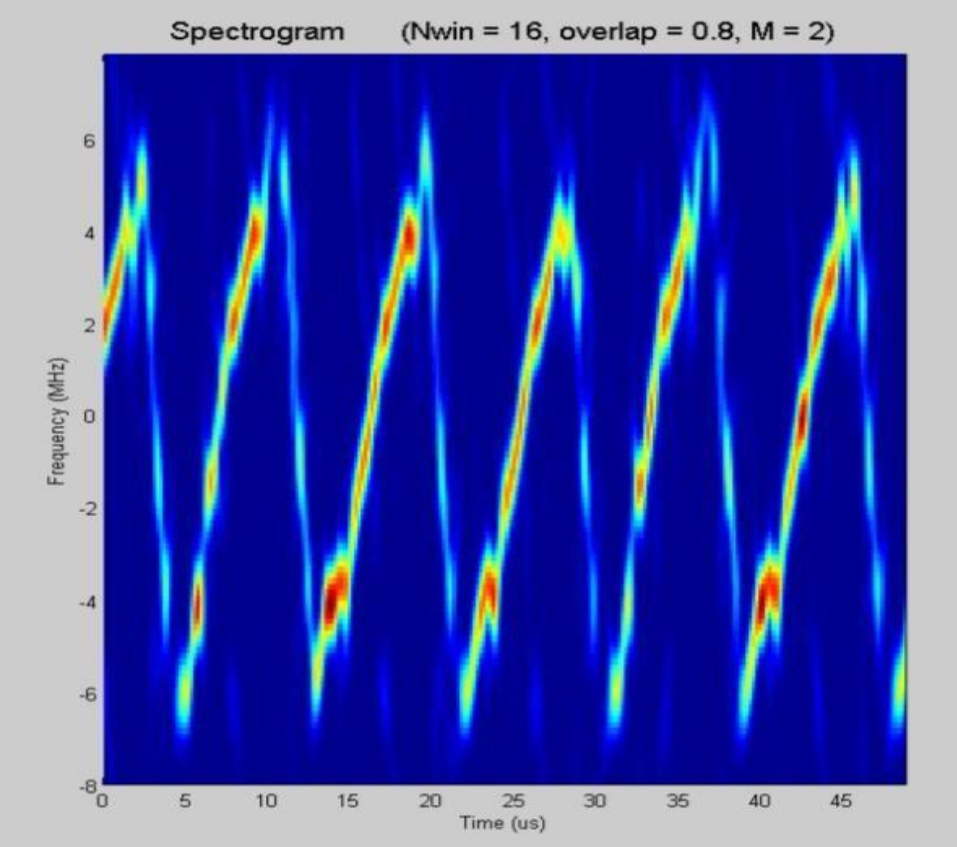
Post-Correlation Detection Events

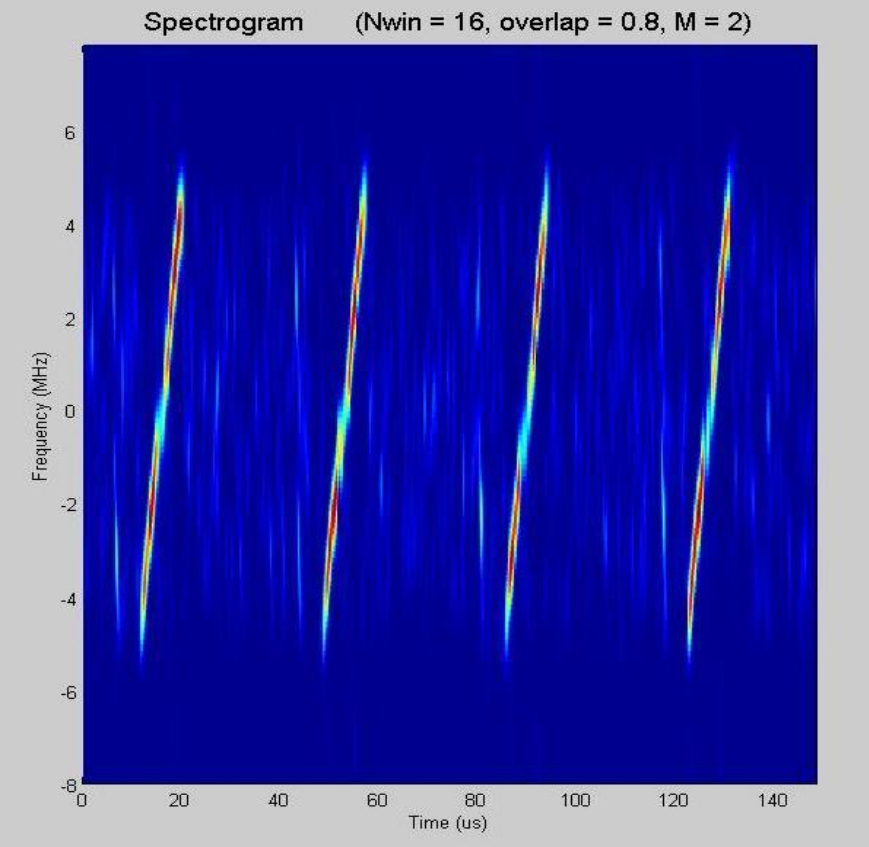


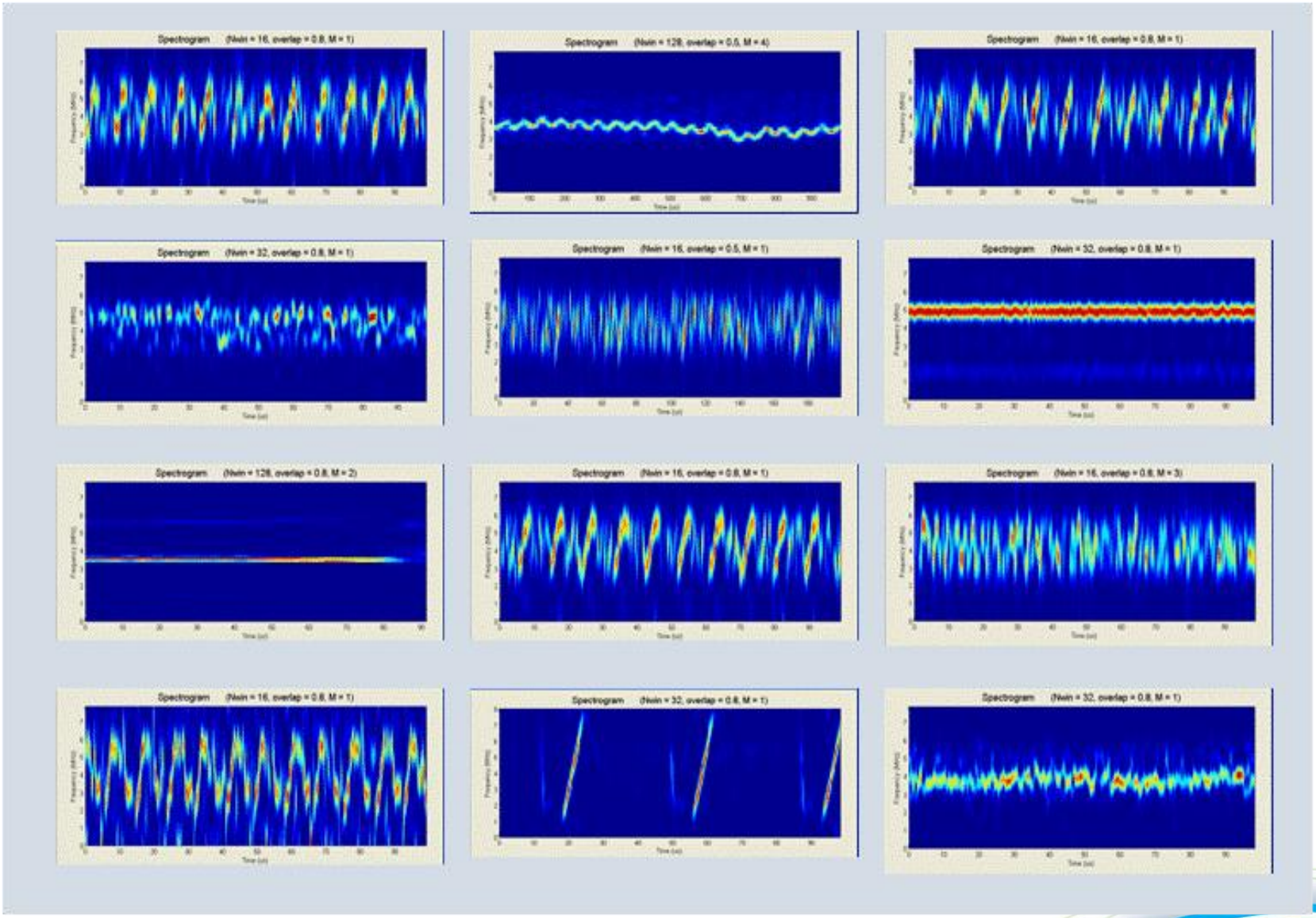
Pre-Correlation Detection Events



Characterisation

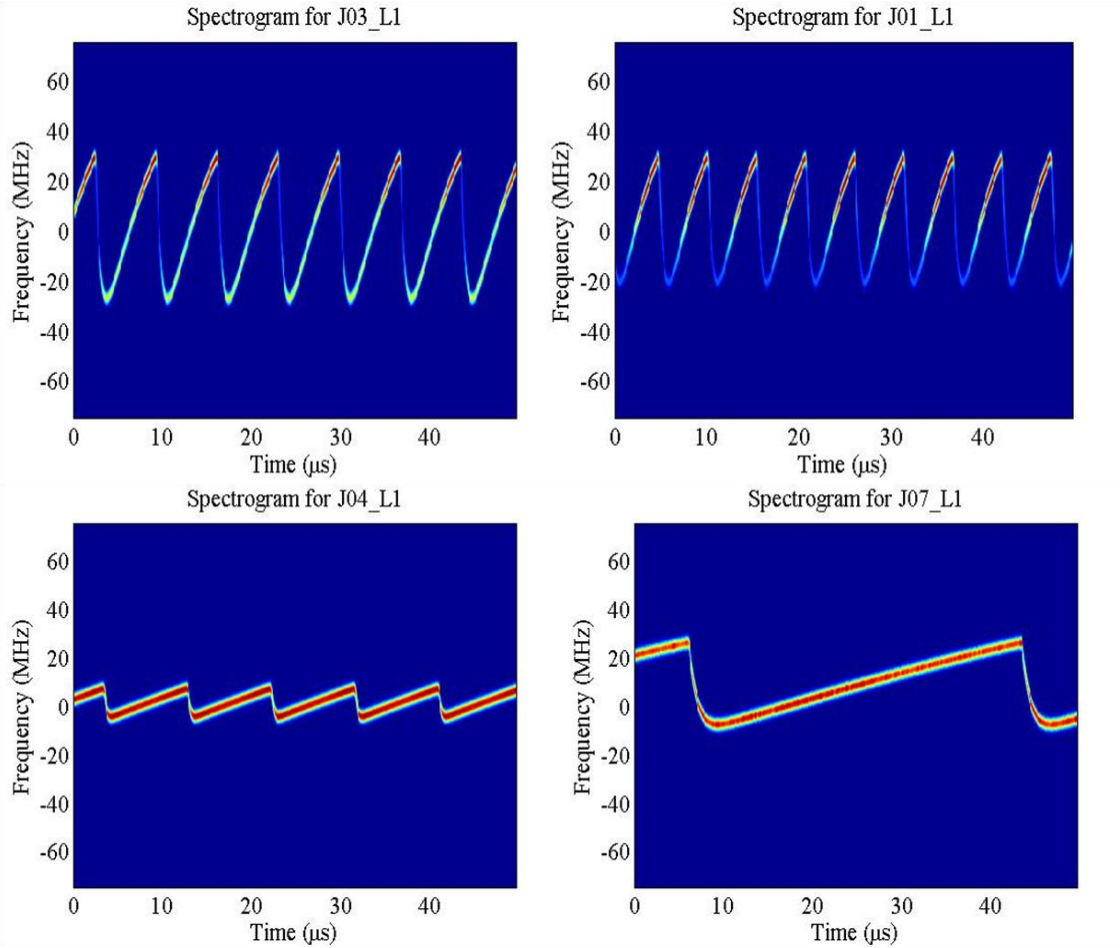




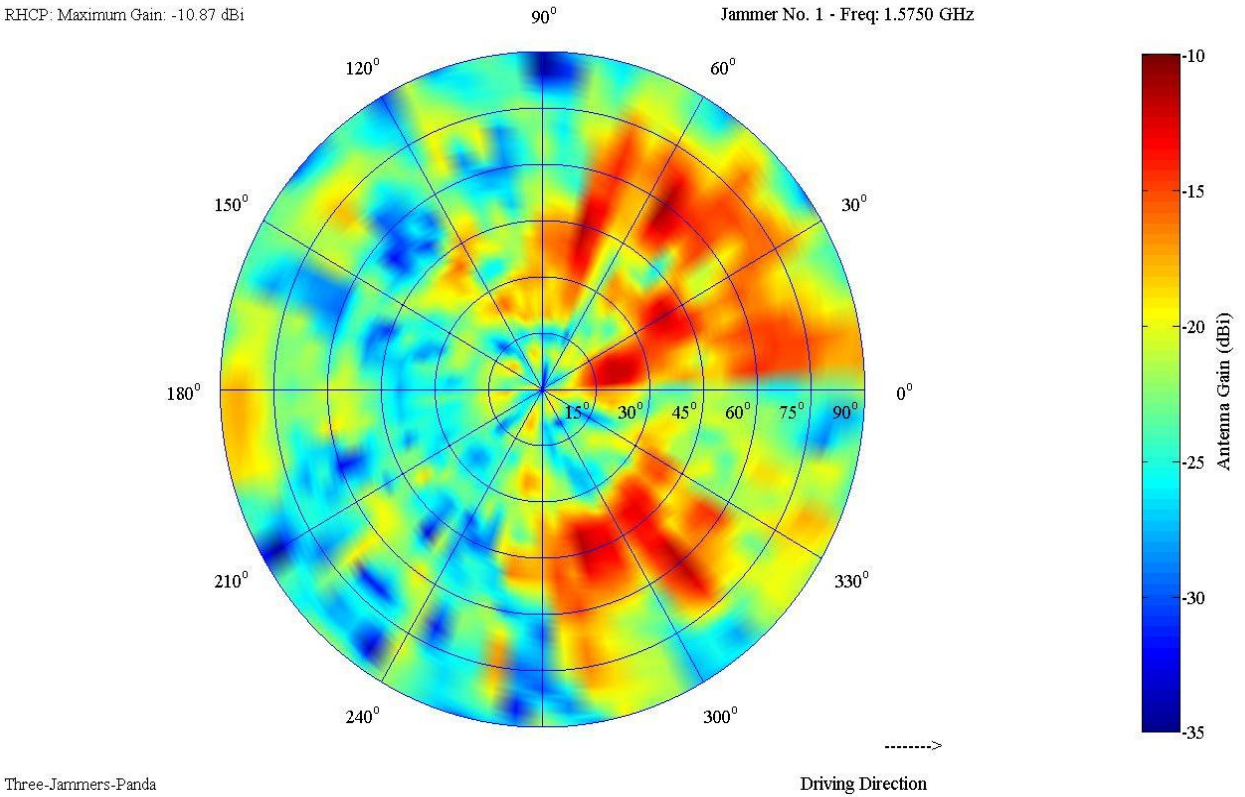


41 Hours SNR detect 5 or 6 possible interference events
Pre-correlation – detects and characterises 20

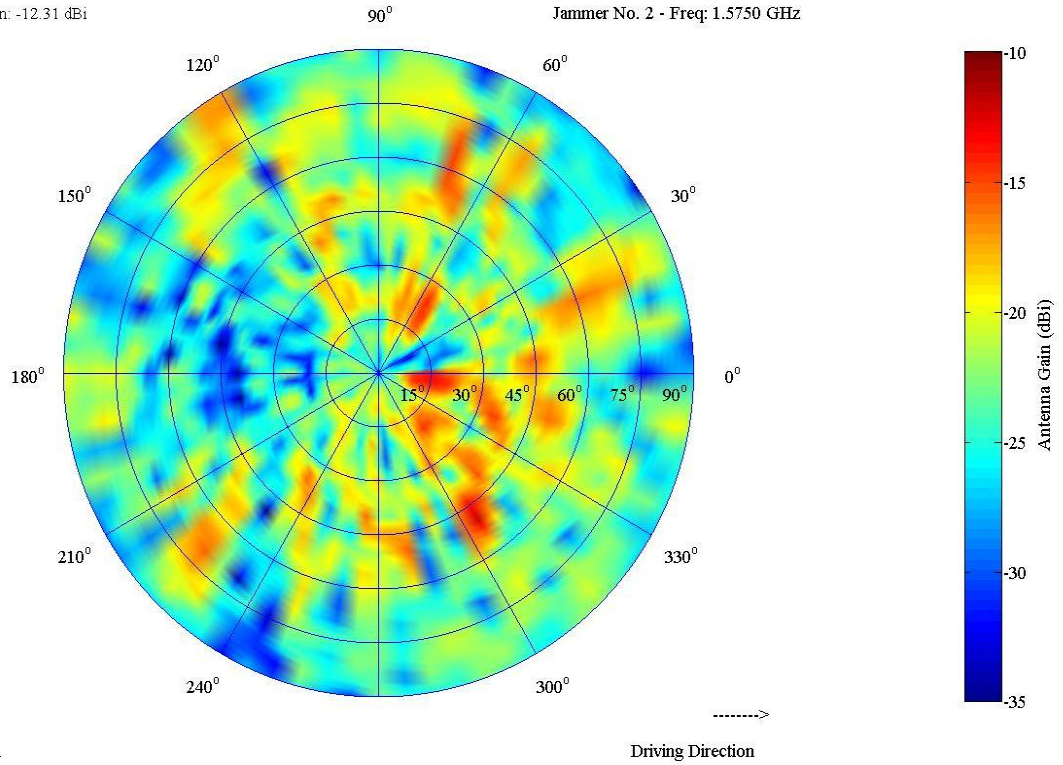
Institute for the Protection and Security of the Citizen, EC Joint Research Centre



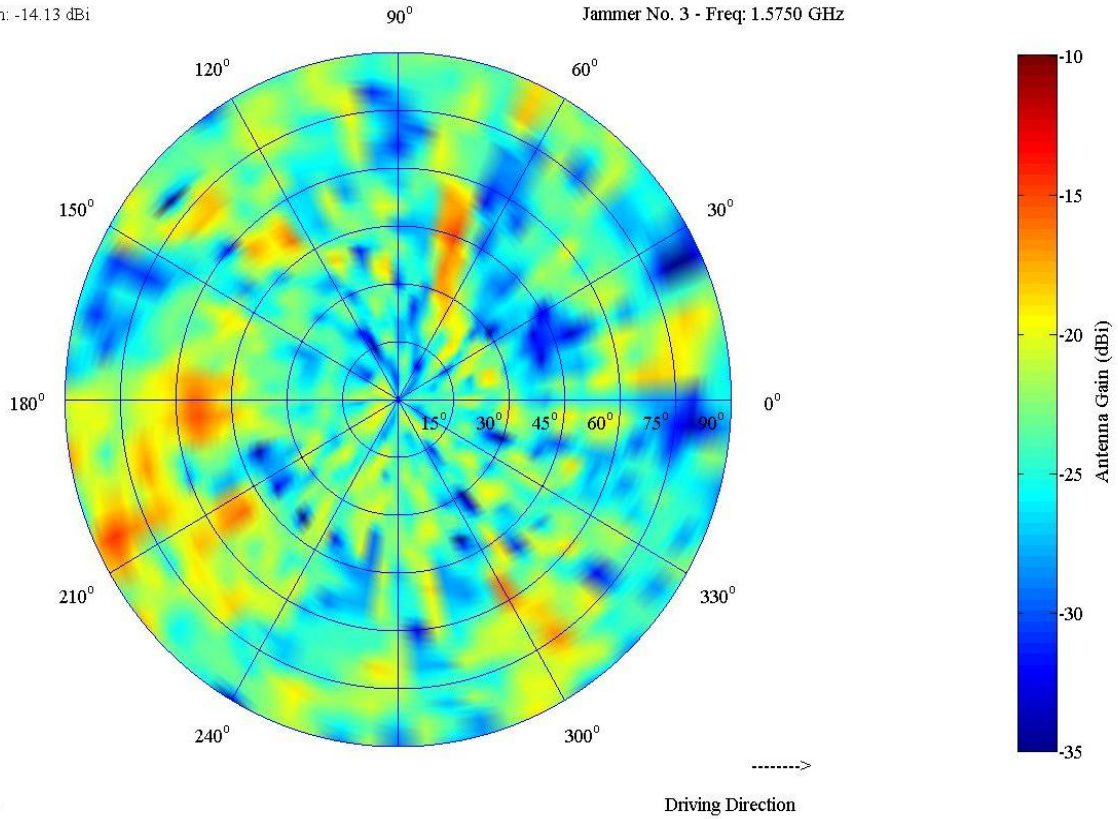
Dashboard Jammer

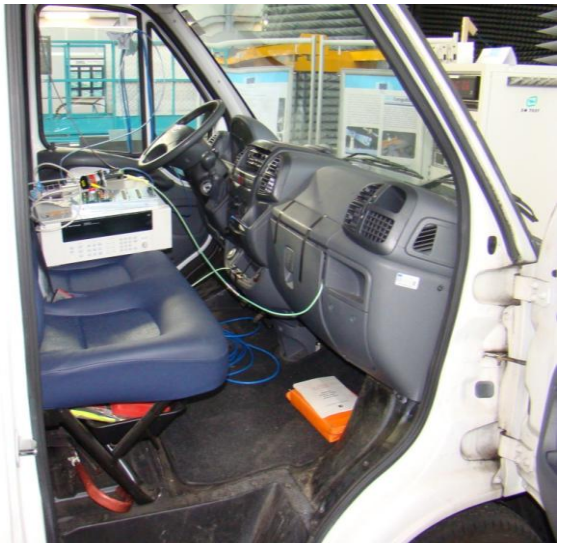


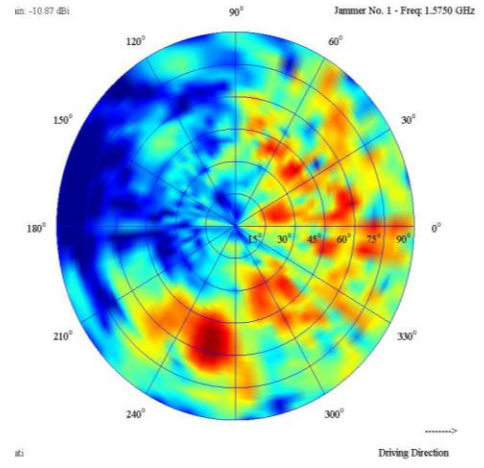
Glovebox Jammer

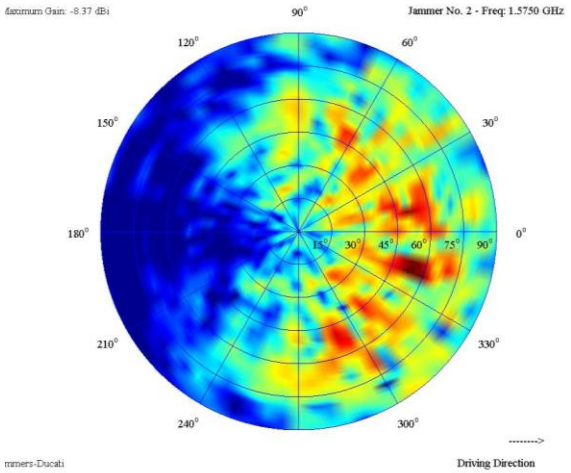


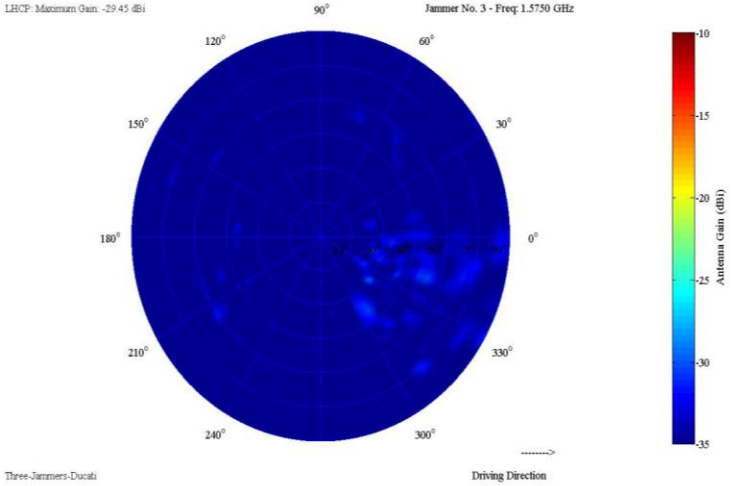
Boot Jammer


RHCP: Maximum Gain: -14.13 dBi
Jammer No. 3 - Freq: 1.5750 GHz
90°
120°
60°
150°
30°
180°
0°
210°
330°
240°
300°
15°
30°
45°
60°
75°
90°
-10
-15
-20
-25
-30
-35
Antenna Gain (dBi)
-------->
Driving Direction



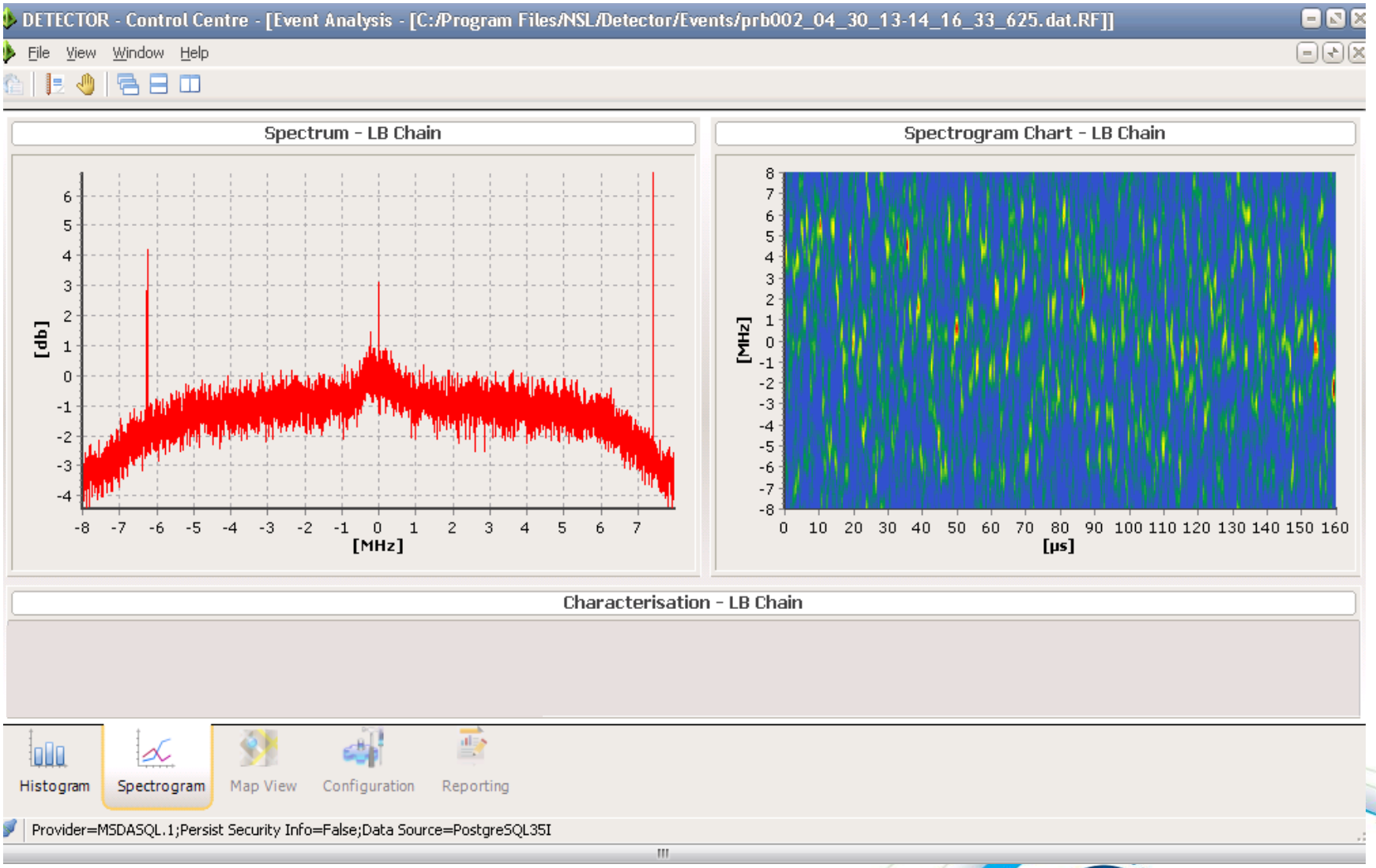

Jammer No. 1 - Freq: 1.5750 GHz
90°
120°
60°
150°
30°
180°
0°
210°
330°
240°
300°
15°
30°
45°
60°
75°
90°
Driving Direction


Jammer No. 2 - Freq: 1.5750 GHz
90°
120°
60°
150°
30°
180°
0°
210°
330°
240°
300°
15°
30°
45°
60°
75°
90°
Driving Direction

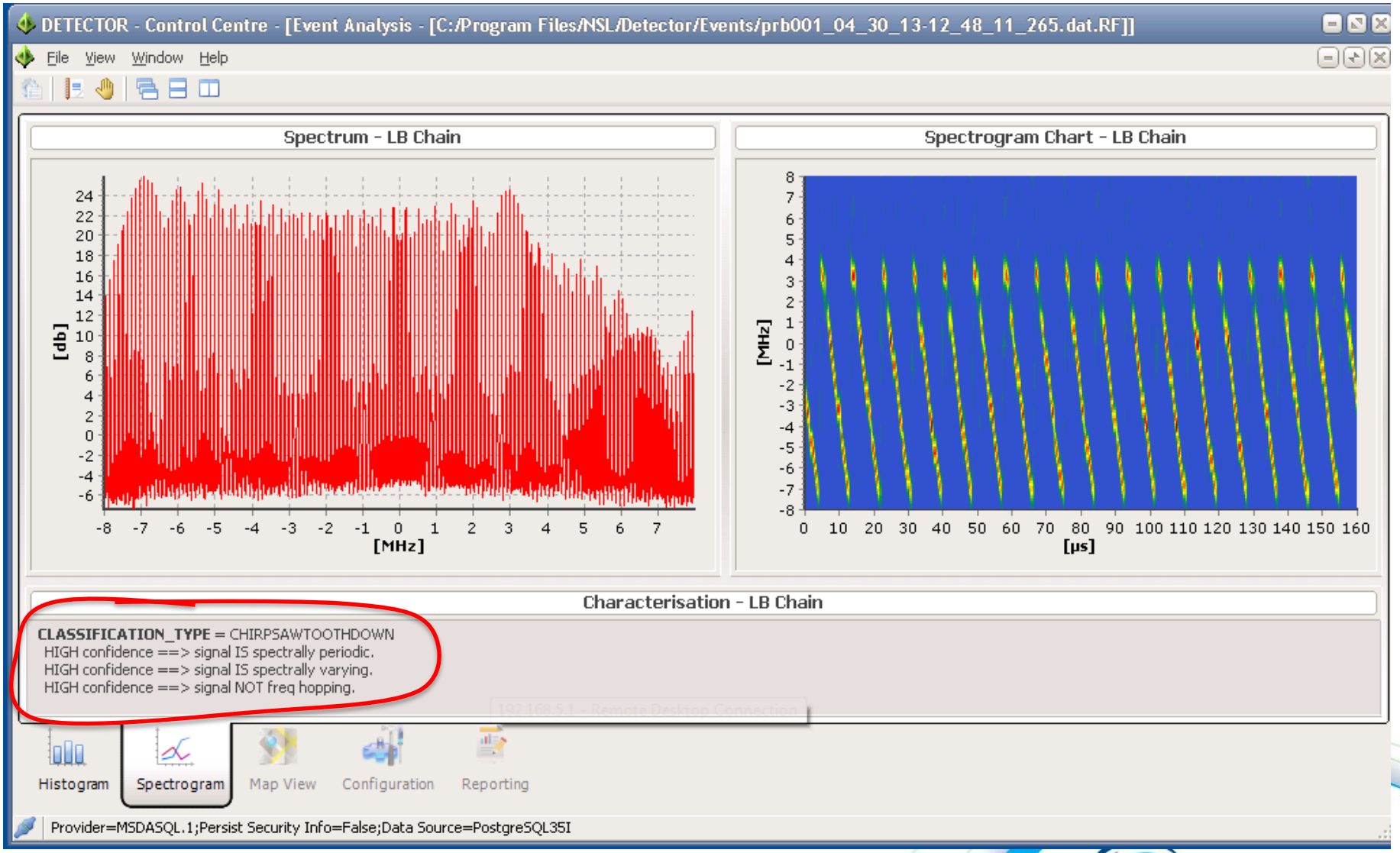

Jammer No. 3 - Freq: 1.5750 GHz
90°
120°
60°
150°
30°
180°
0°
210°
330°
240°
300°
Driving Direction
-10
-15
-20
-25
-30
-35
Antenna Gain (dBi)

Automotive Testing Center, Aldenhoven

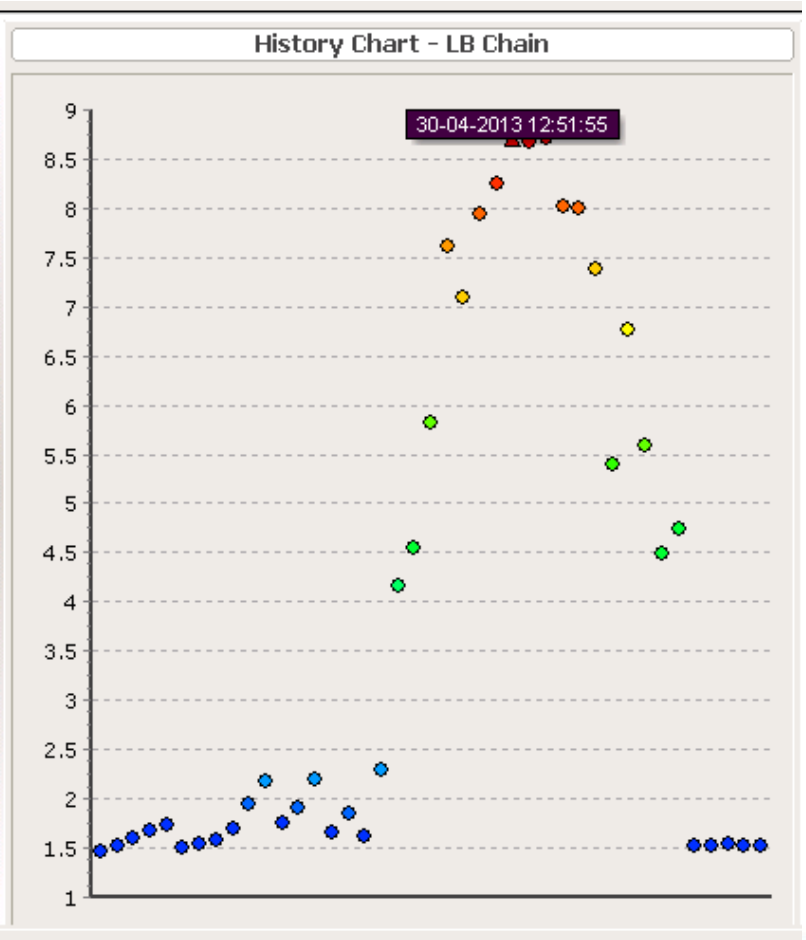
Check End-to-End Solution

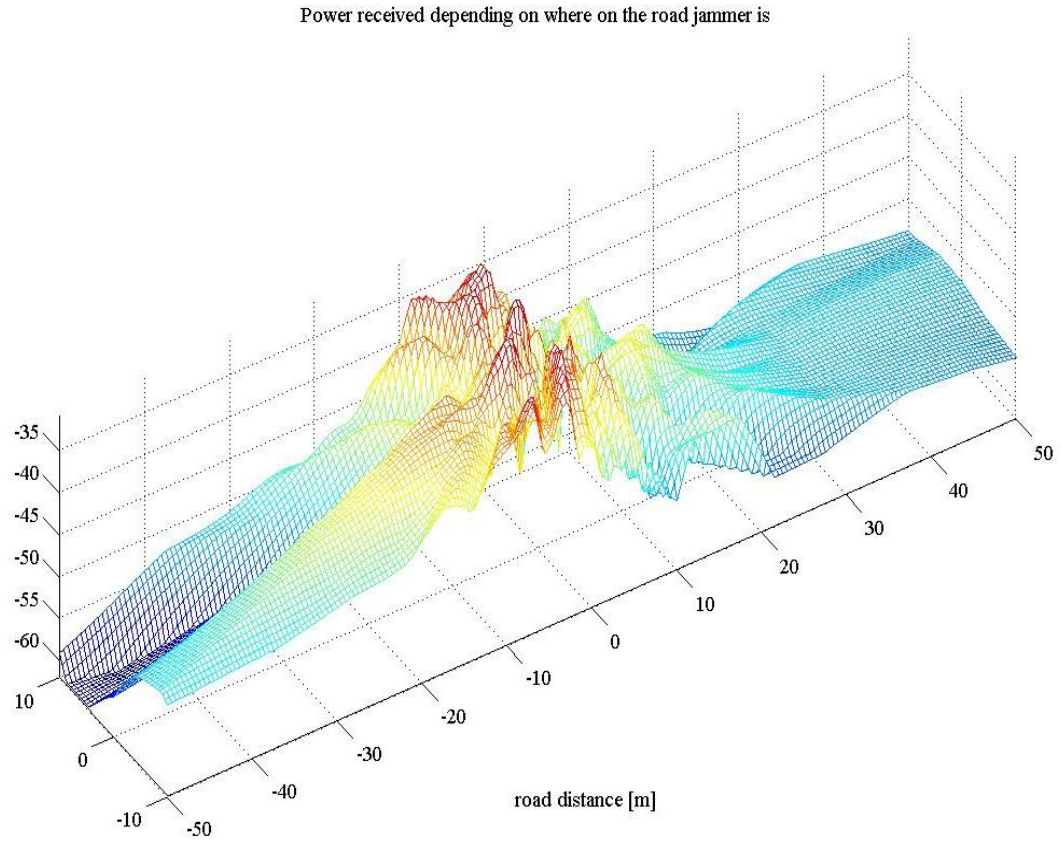


Check End-to-End Solution



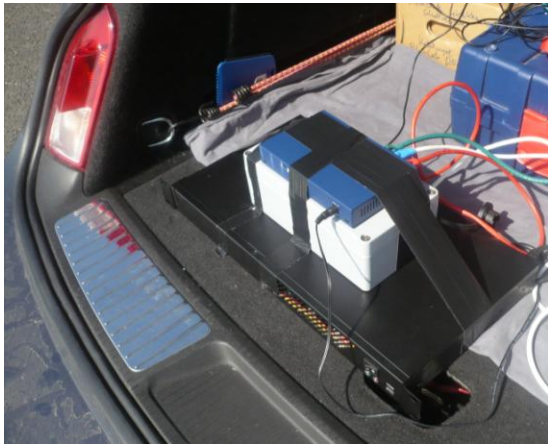
Power Received on Gantry

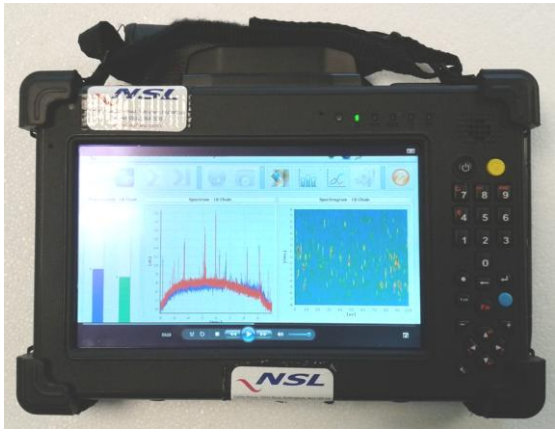




Testing Included:

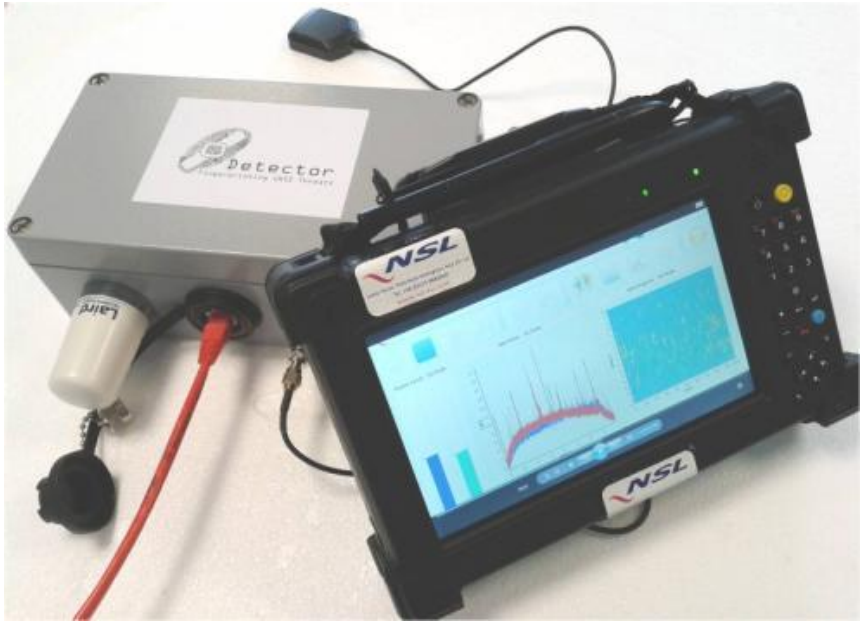
- Automated detection & classification
- Range of speeds
- Different antenna placement
- Different jammers
- Different gain settings
- Obstruction conditions
- Moving probe
- Tablet PC





Detection and Classification Successful in all Scenarios

Deployment



DETECTOR Interference Workshop

- 26 & 27 September 2013
- Automotive Test Centre, Aachen, Germany
- Demonstrations
  - Impacts of Jammers
  - Detection Solutions
- Presentations
  - Applications
  - Technology
  - User Needs
- Further details to follow at:

  http://www.gnss-detector.eu

Thank you for your attention!

The work presented in this paper has been co-funded under the EC FP7 programme through the European GNSS Agency (GSA)

www.gnss-detector.eu

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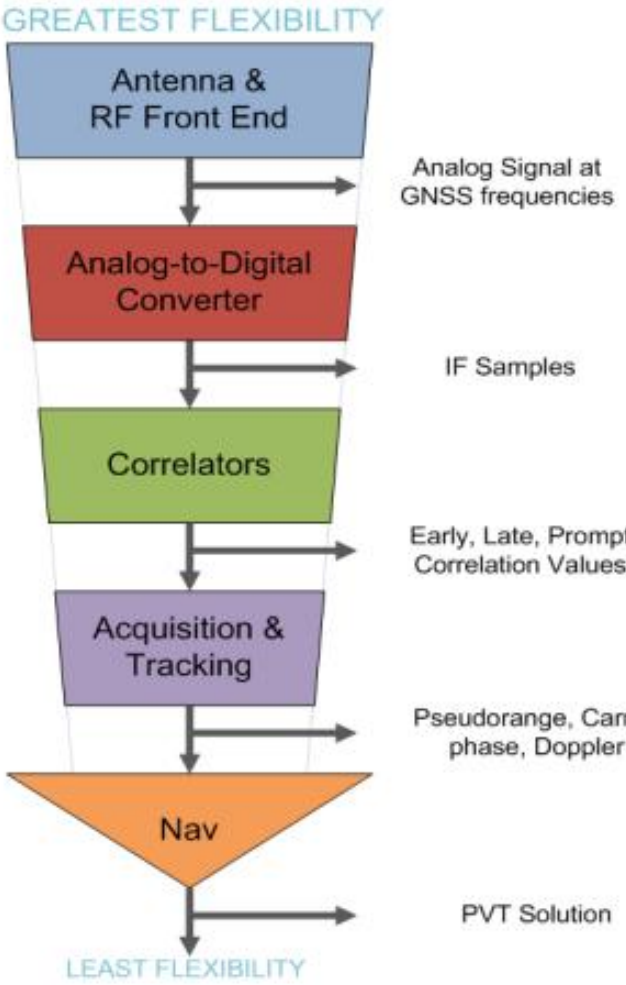
AGIT
Gründen. Ansiedeln. Fördern.

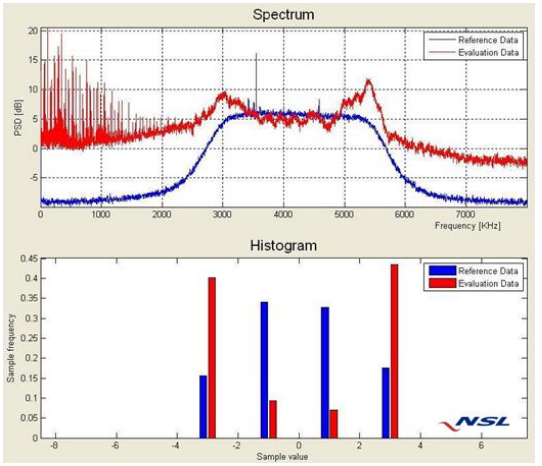
ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Black Holes B.V.

Pre & Post Correlation Techniques

Pre-correlation
Detect effect of interference on raw RF signal





Post-correlation
Detect effect of interference on processed measurements