

GNSS Interference Detection and Characterisation using a Software Receiver

The DETECTOR Project



ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA



Black Holes B.V.



The Problem



- RF Interference
 - Unintentional
 - Intentional
 - PPD “innocent” reasons but nasty side-effects?
 - Deliberate disruption to RUC and PAYDI, fleet tracking
- Impacts?
 - Receiver
 - Degraded positioning
 - No positioning
 - Services
 - Small nuisance
 - Economic impact
 - Safety impact

Jammer Counter-measures



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

Jammer Counter-measures



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 - Direct or indirect
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 - Receiver
 - Hybridisation
- Procedure/process

**All dependent on
understanding the threat**

DETECTOR System

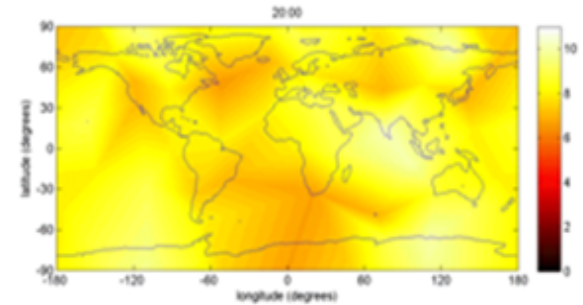


Back-office

2

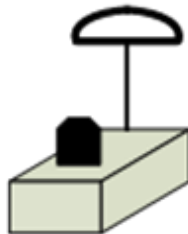


Detection with larger datasets including network logic (multiple nodes).
Interference Characterisation
Ionospheric monitoring
Trending



1

Roadside

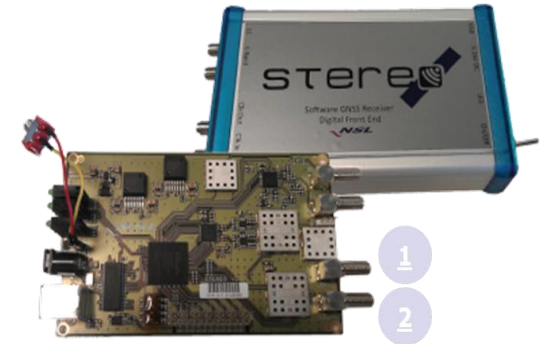


Bespoke RF FE (Stereo) + Processor (SBC) hosting SW
IF data buffered ~ store if detection triggered, if not overwrite

Probe



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

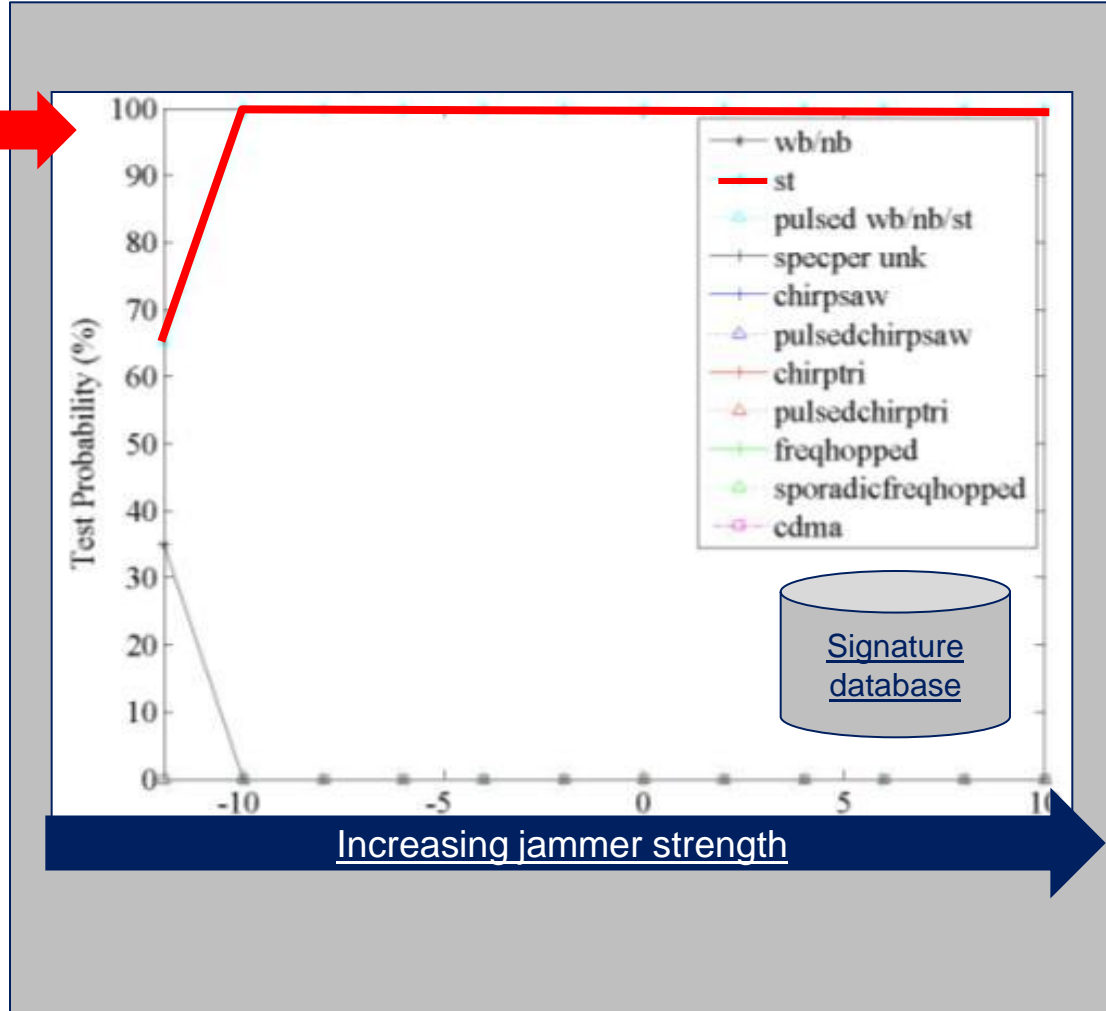
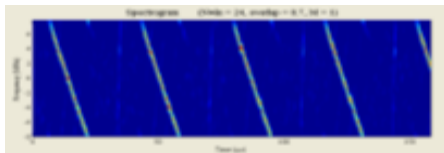
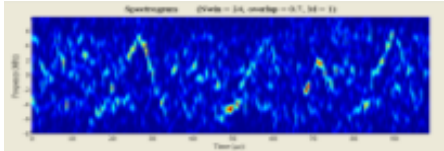
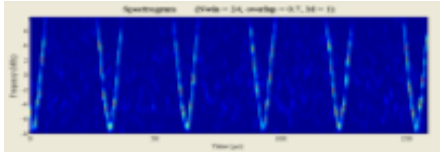
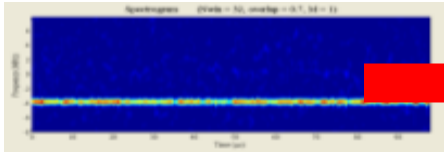


Detection and Characterisation



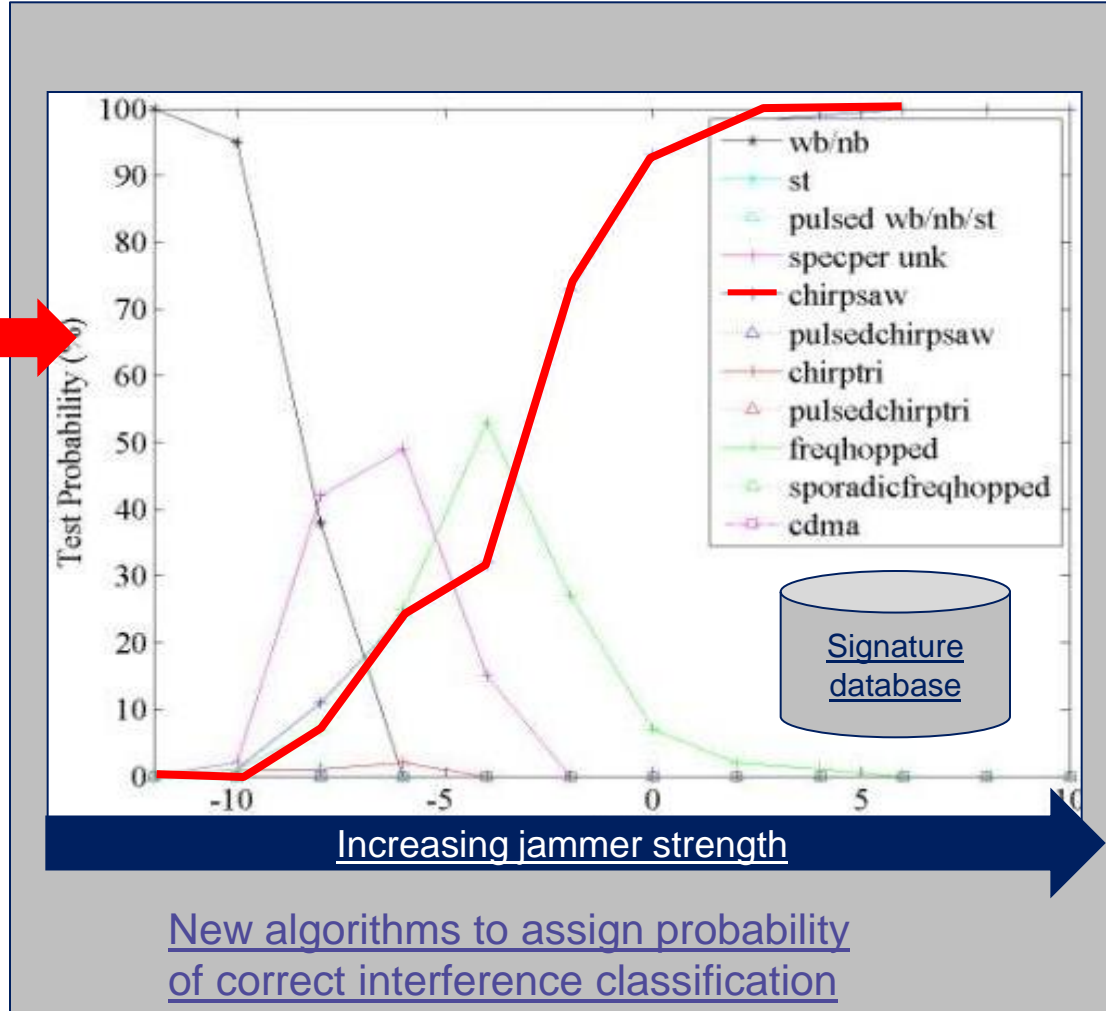
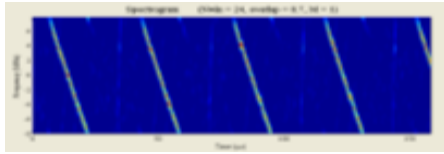
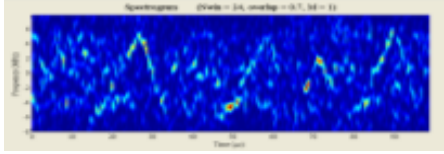
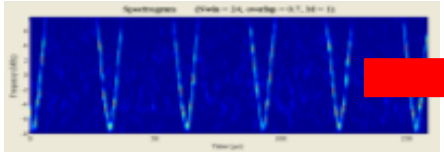
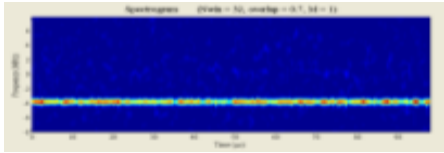
- SNR
 - Relative and absolute drops, number of signals affected
- Pre-correlation
 - Received power vs threshold
 - Spectrogram – power vs frequency (following fft)
- Characterisation
 - Classification (WN, NB, WB, CDMA, chirp, etc + confidence level)
 - Parameterisation
 - Evidential
 - Mitigation
 - Active signal cancellation

Classification



Output:
Single tone
offset
Wide area

Classification



Output:
Chirpsaw
PPD?
Local issue?

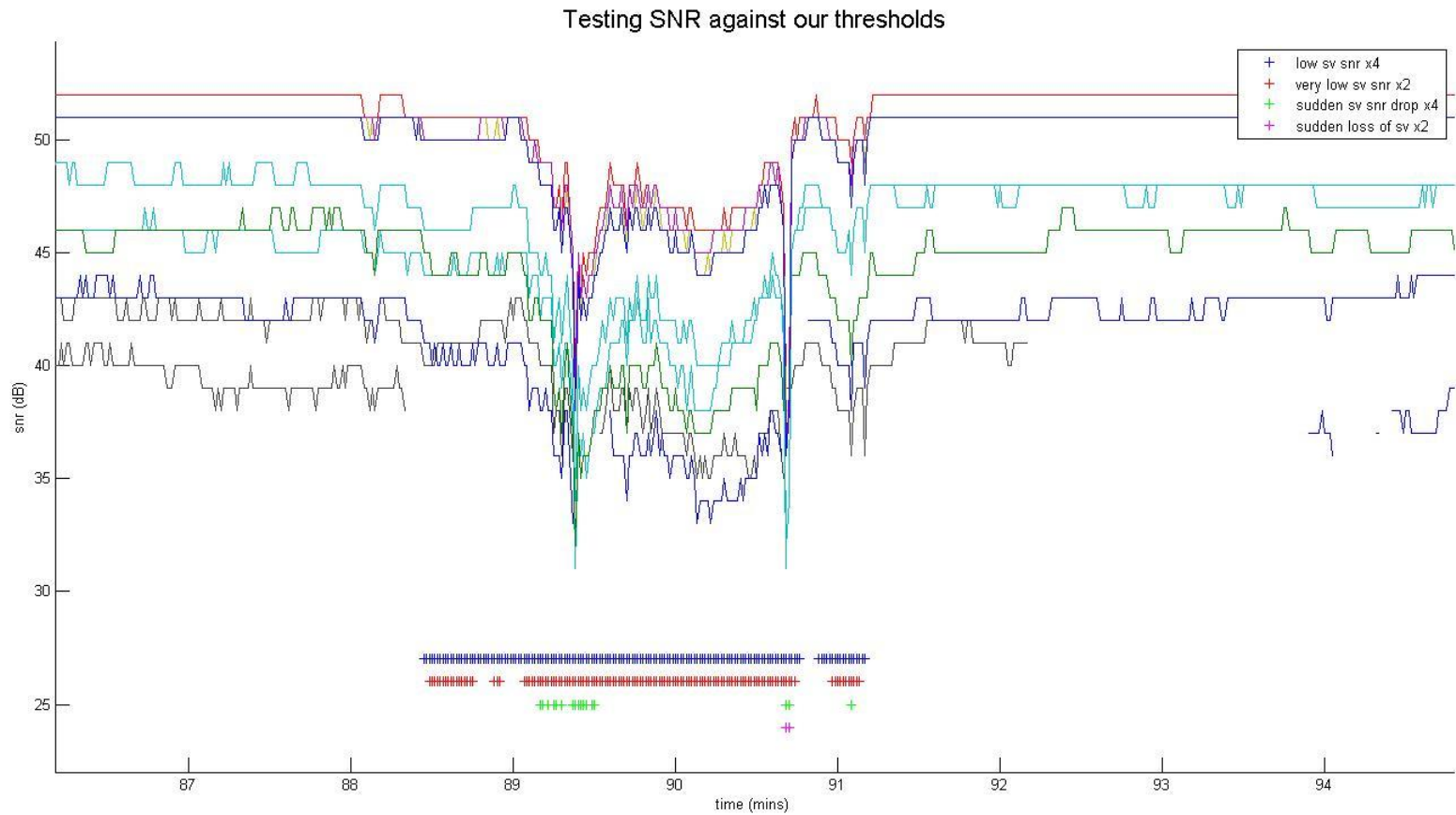
New algorithms to assign probability of correct interference classification



Testing - London

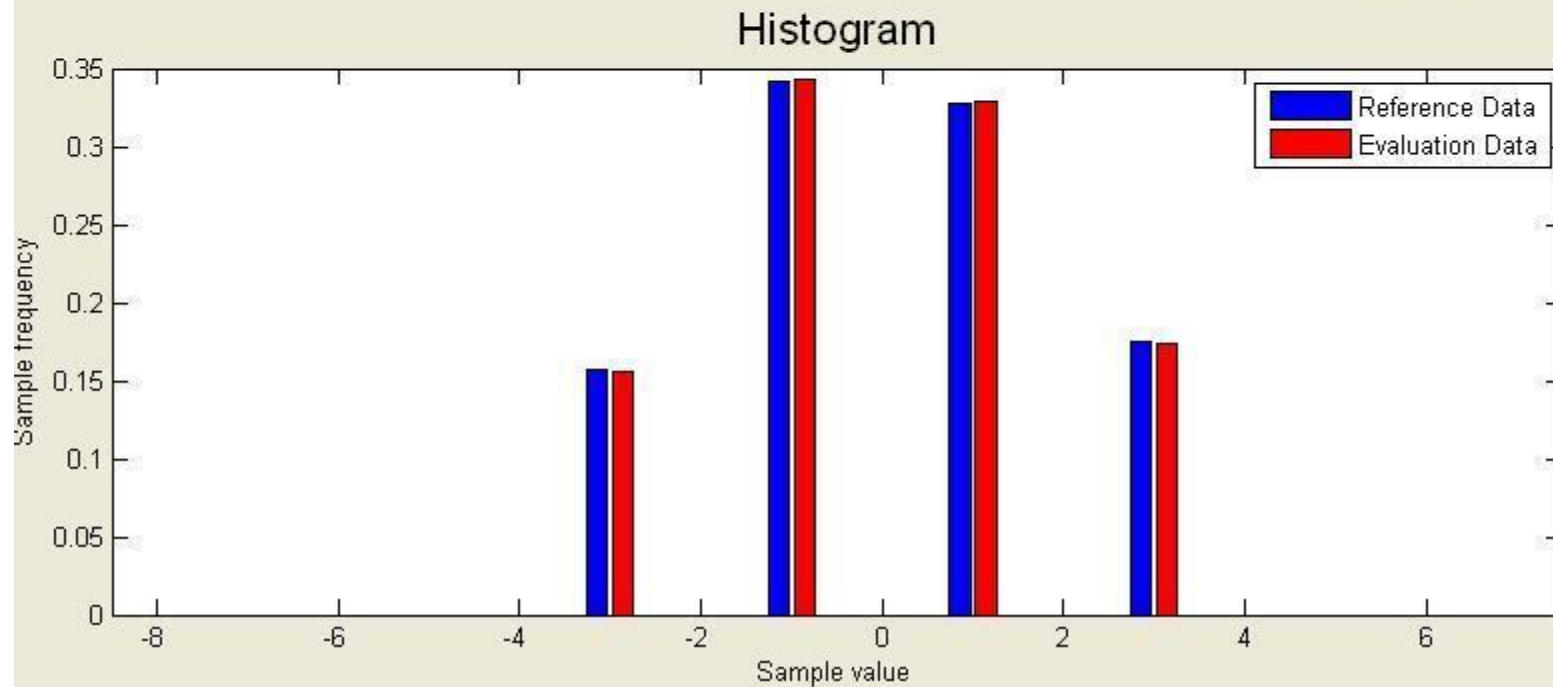
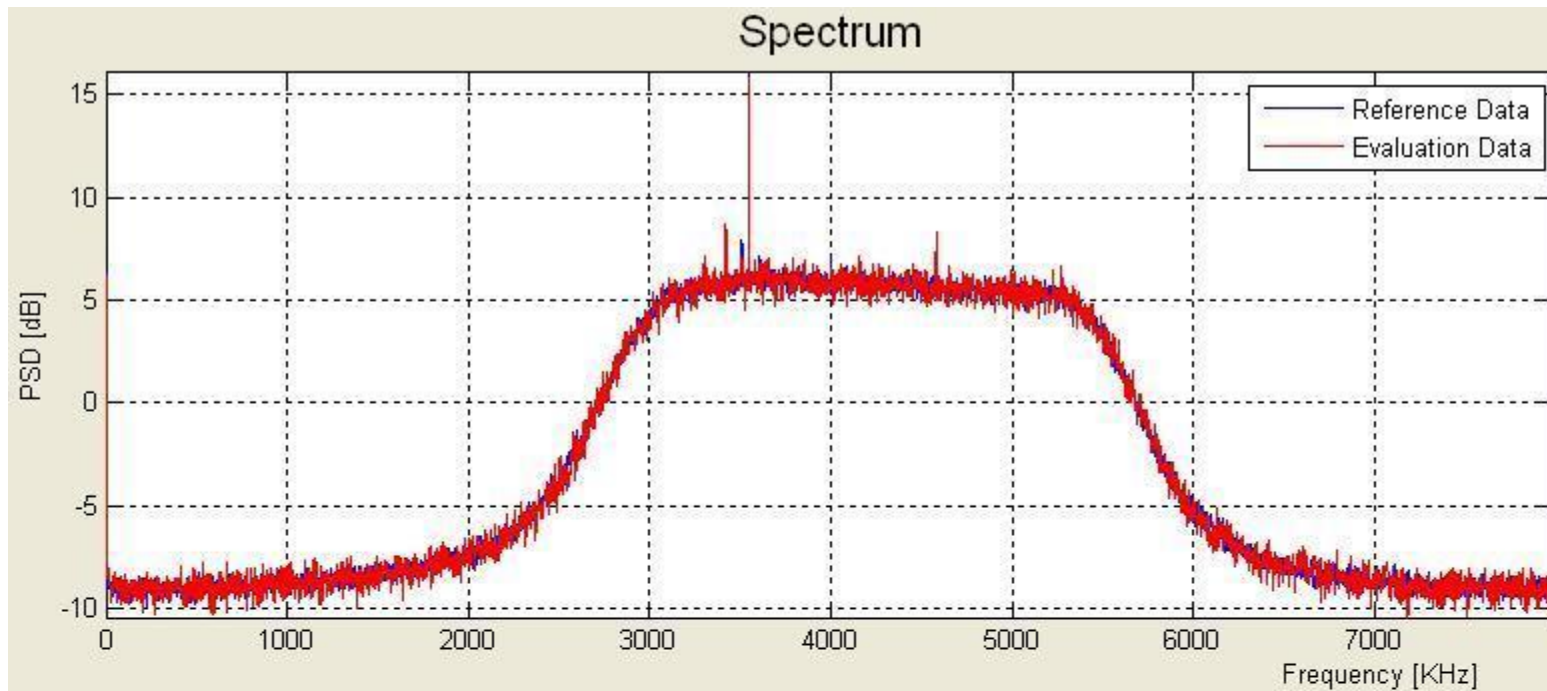
- Identified area of interest through SNR & PVT from existing reference station
- Collected data nearby
 - Stereo FE (RF/IF)
 - COTS Rx (SNR)
- Process with candidate algorithms
- Helps trade-off approaches and set thresholds

Urban RFI capture



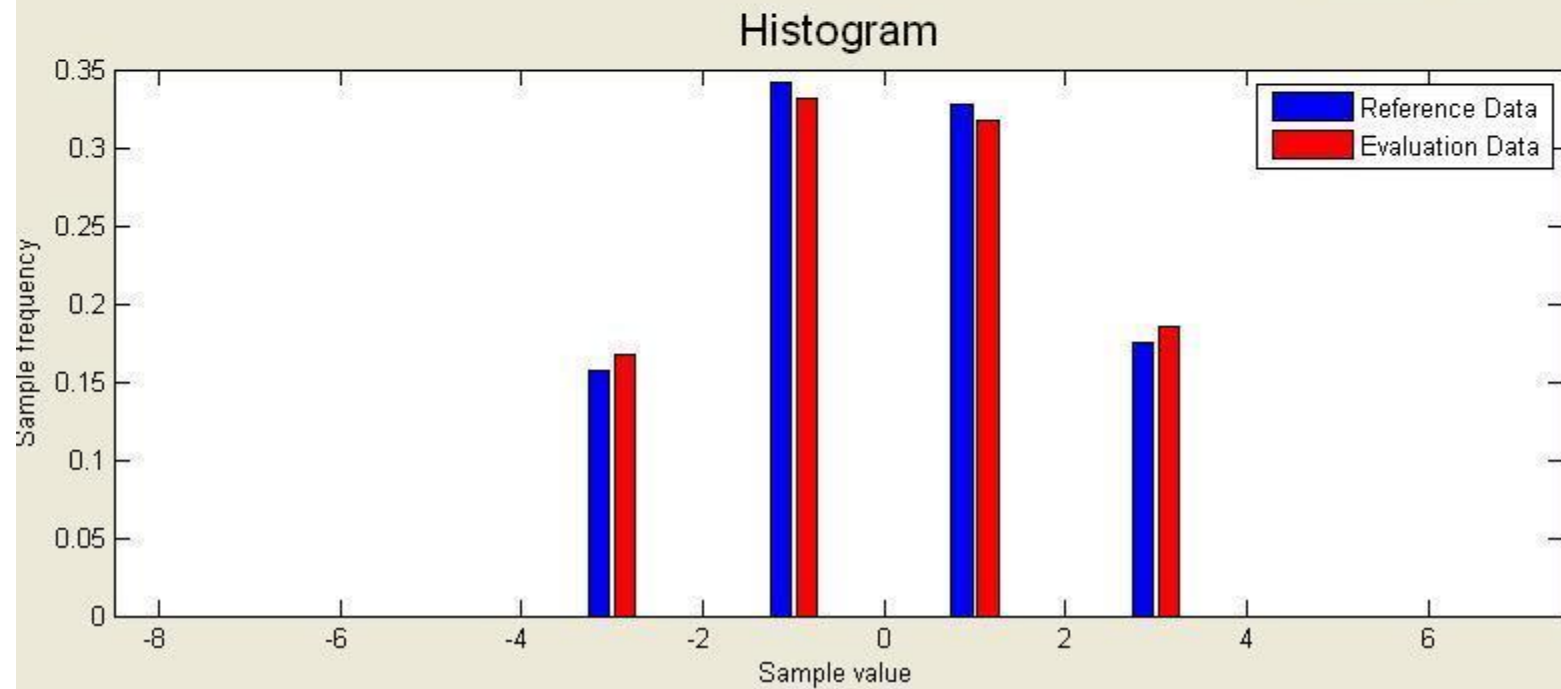
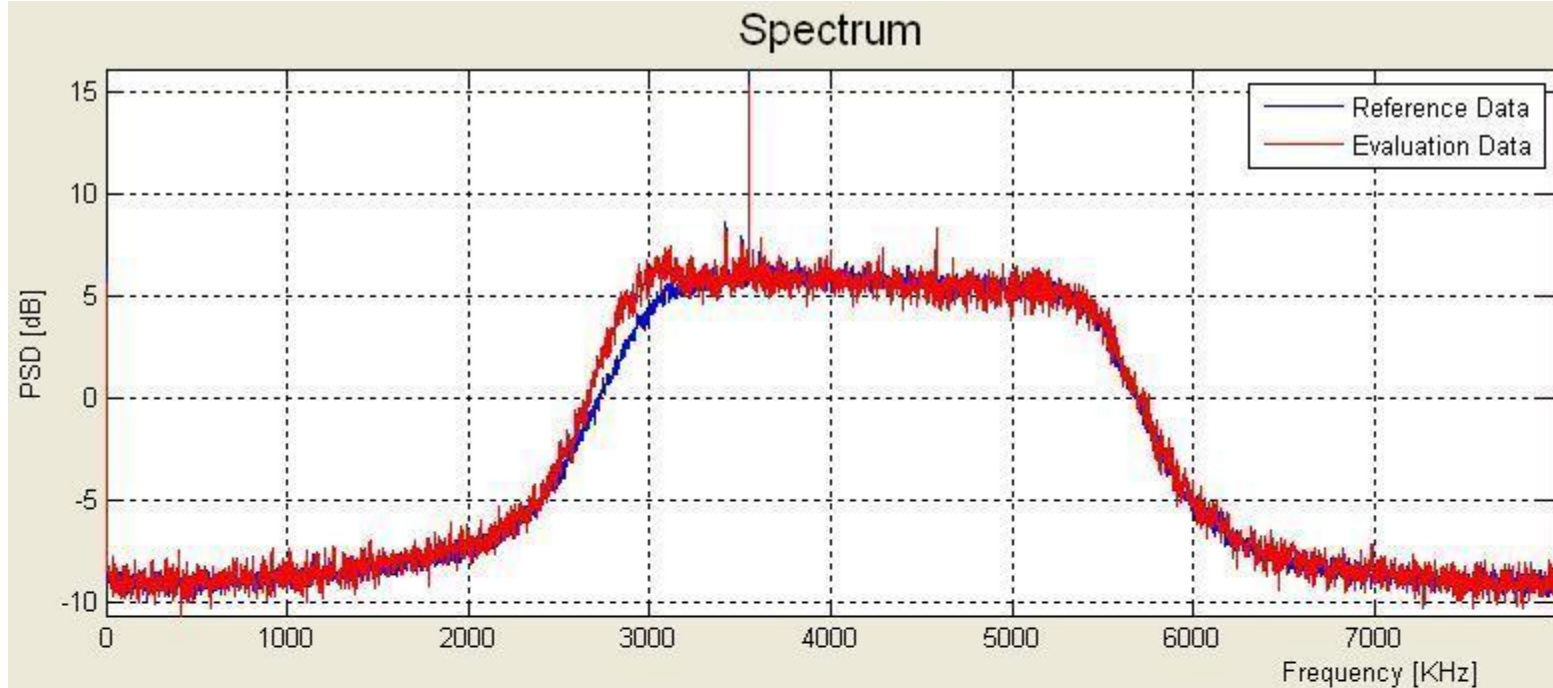


T0





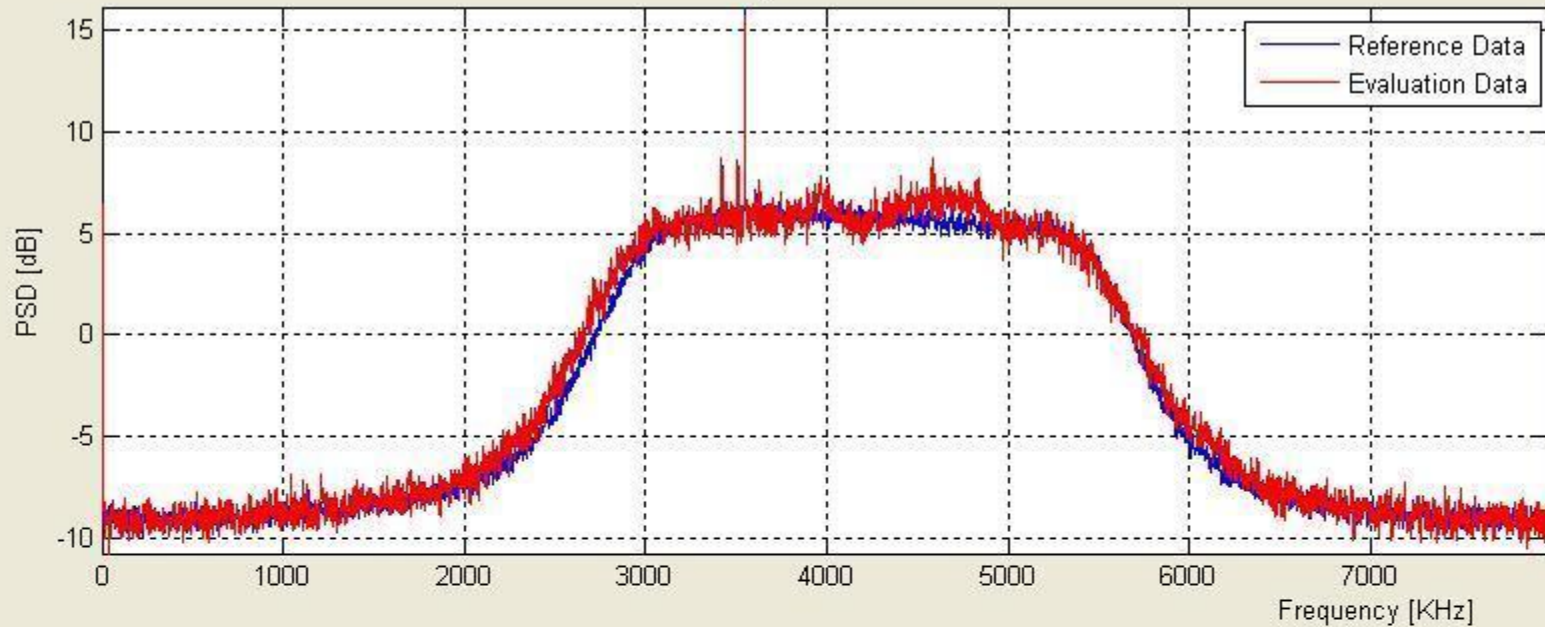
T0 + 10s



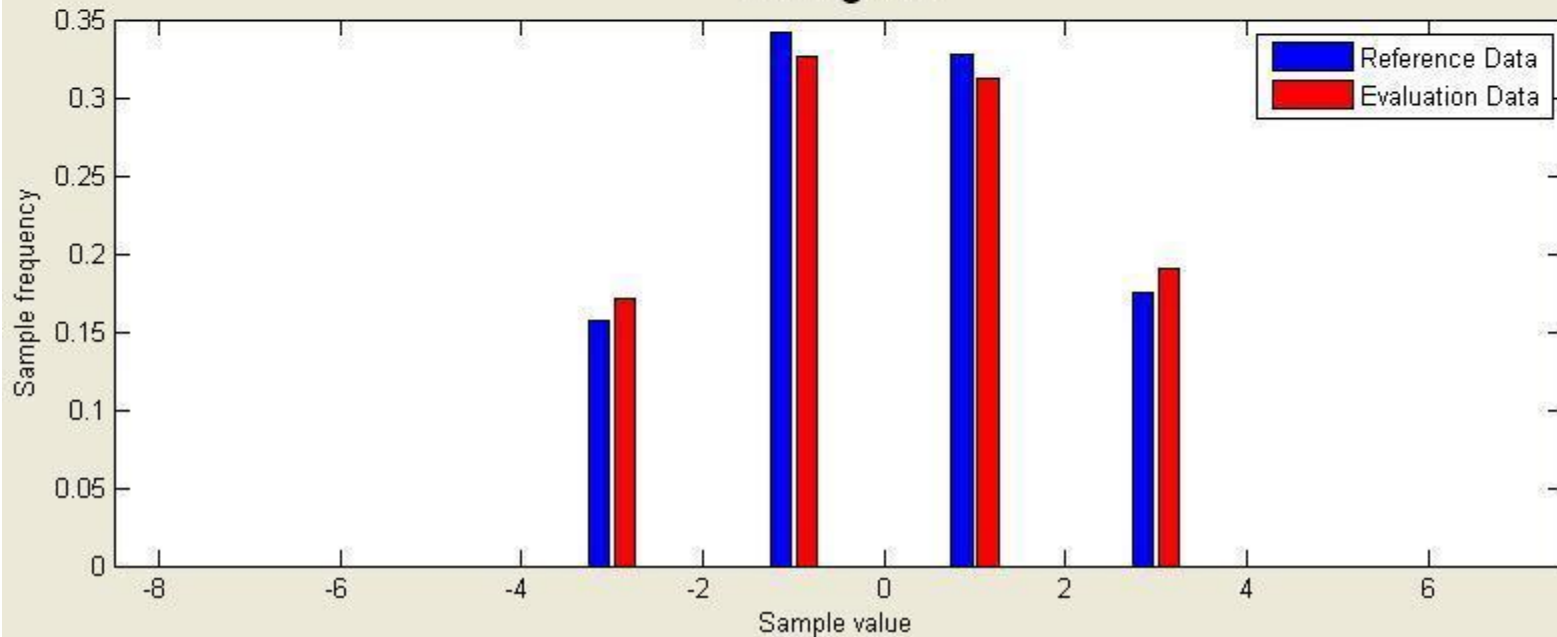


T0 + 20s

Spectrum

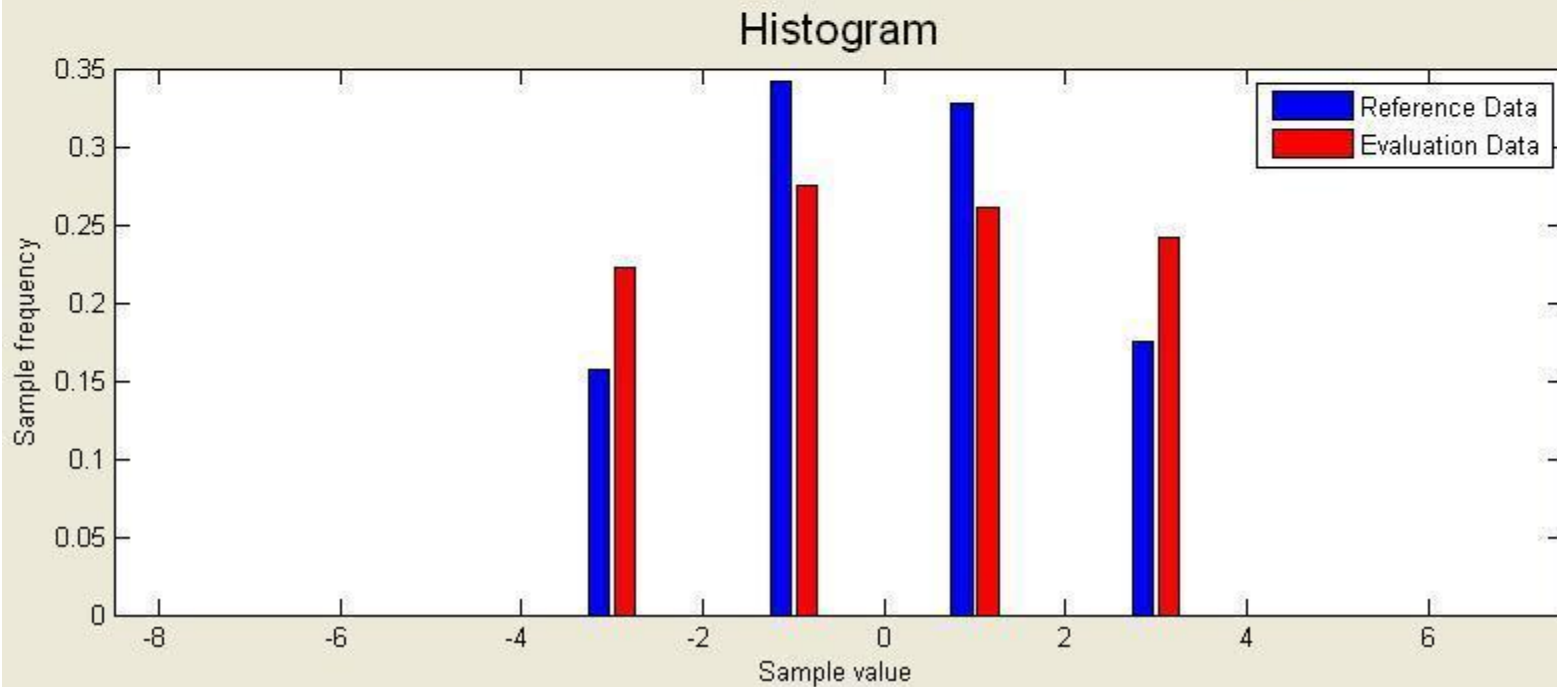
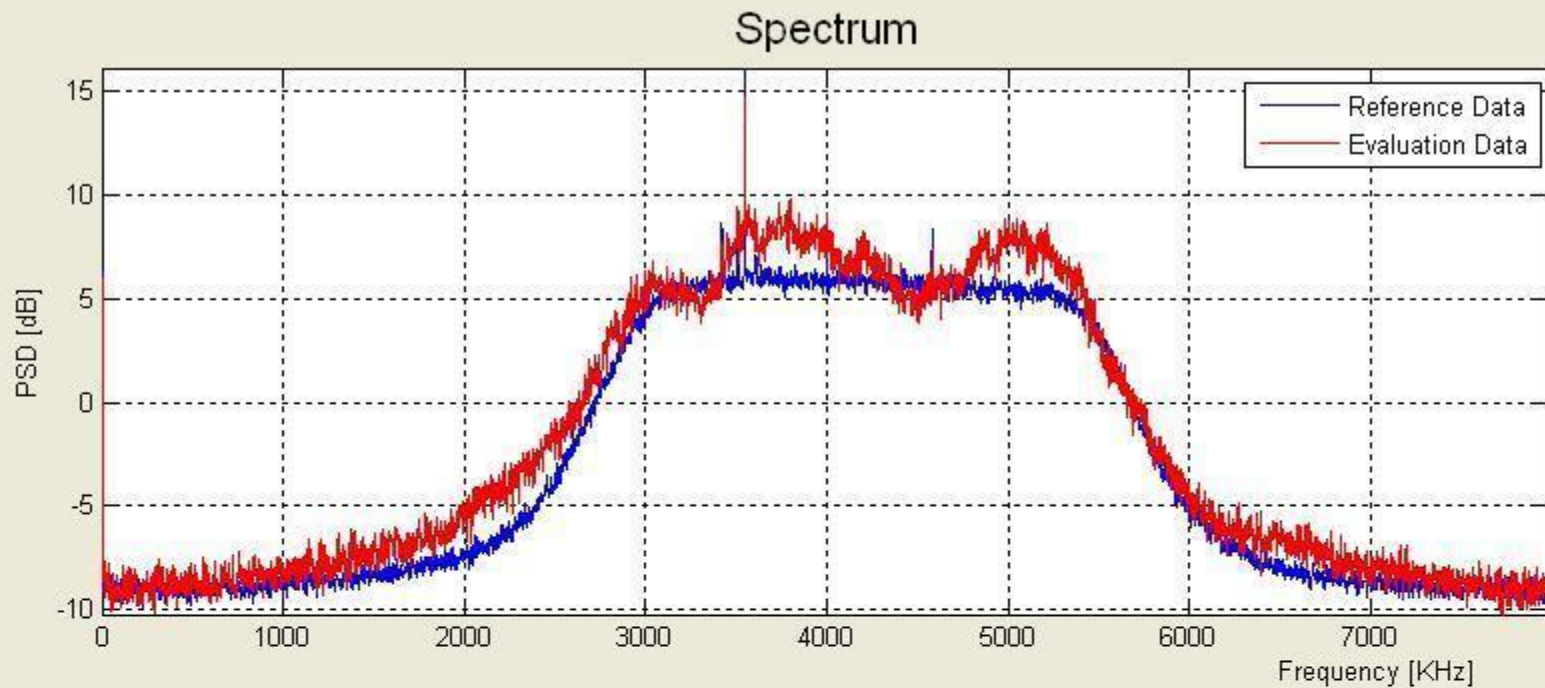


Histogram



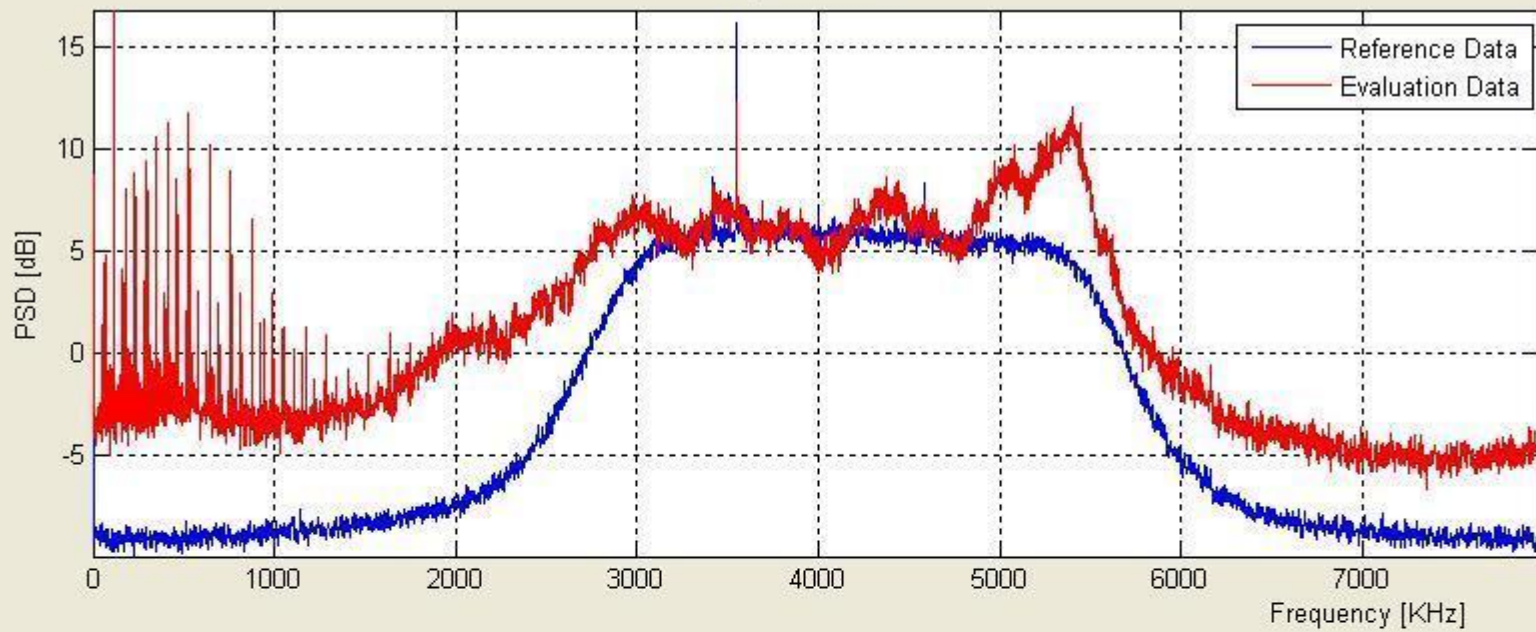


T0 + 50s



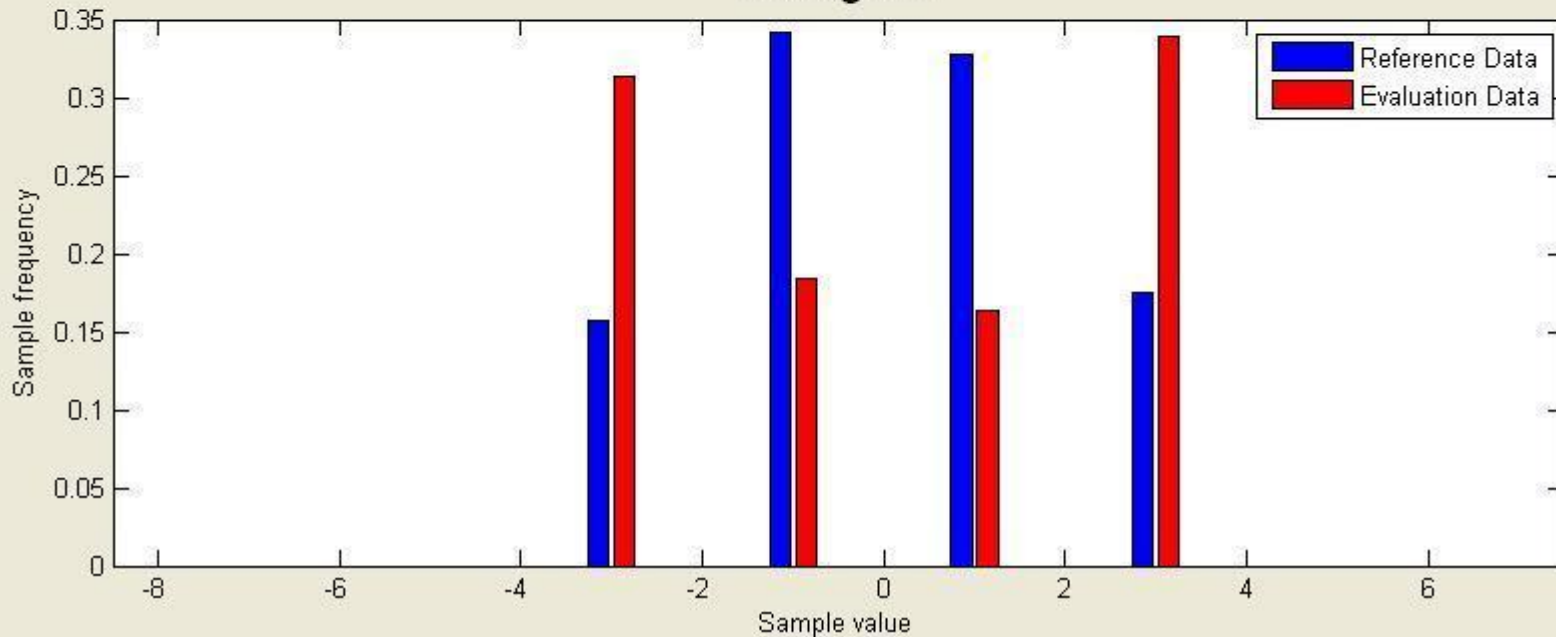


Spectrum



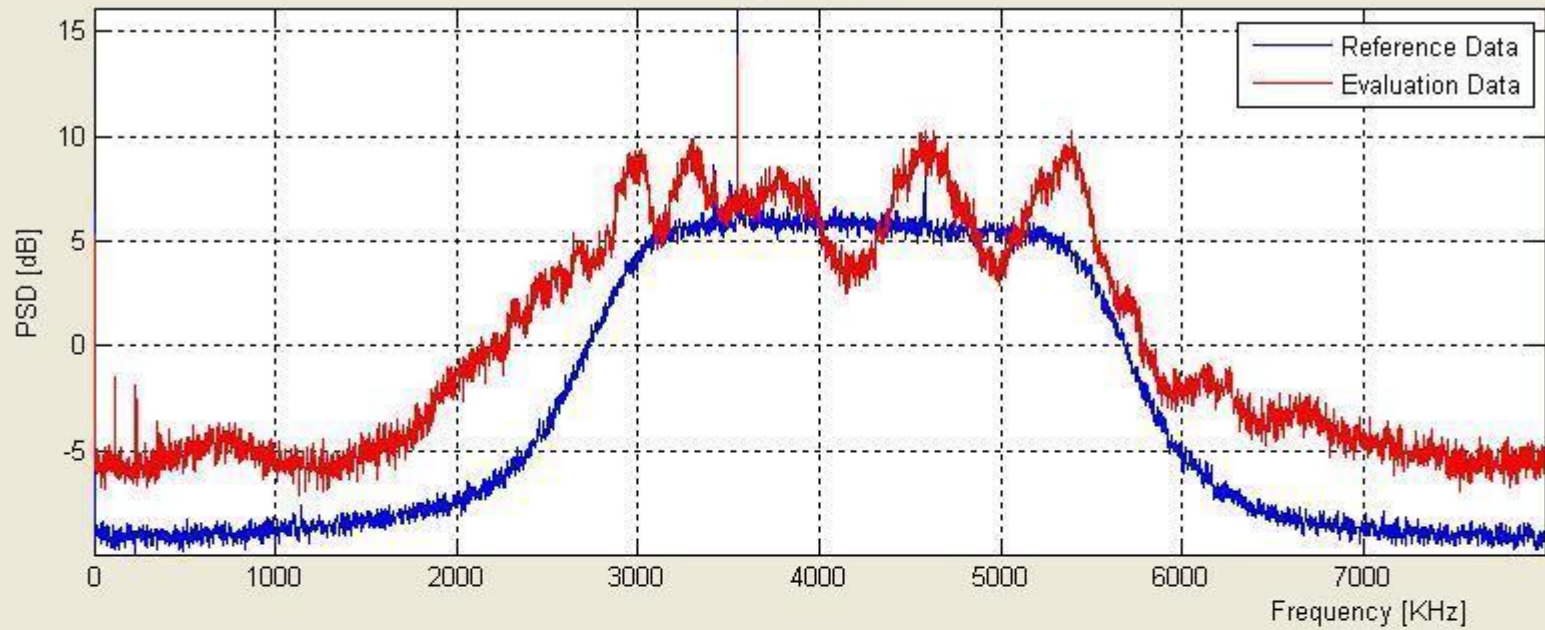
T0 + 70s

Histogram



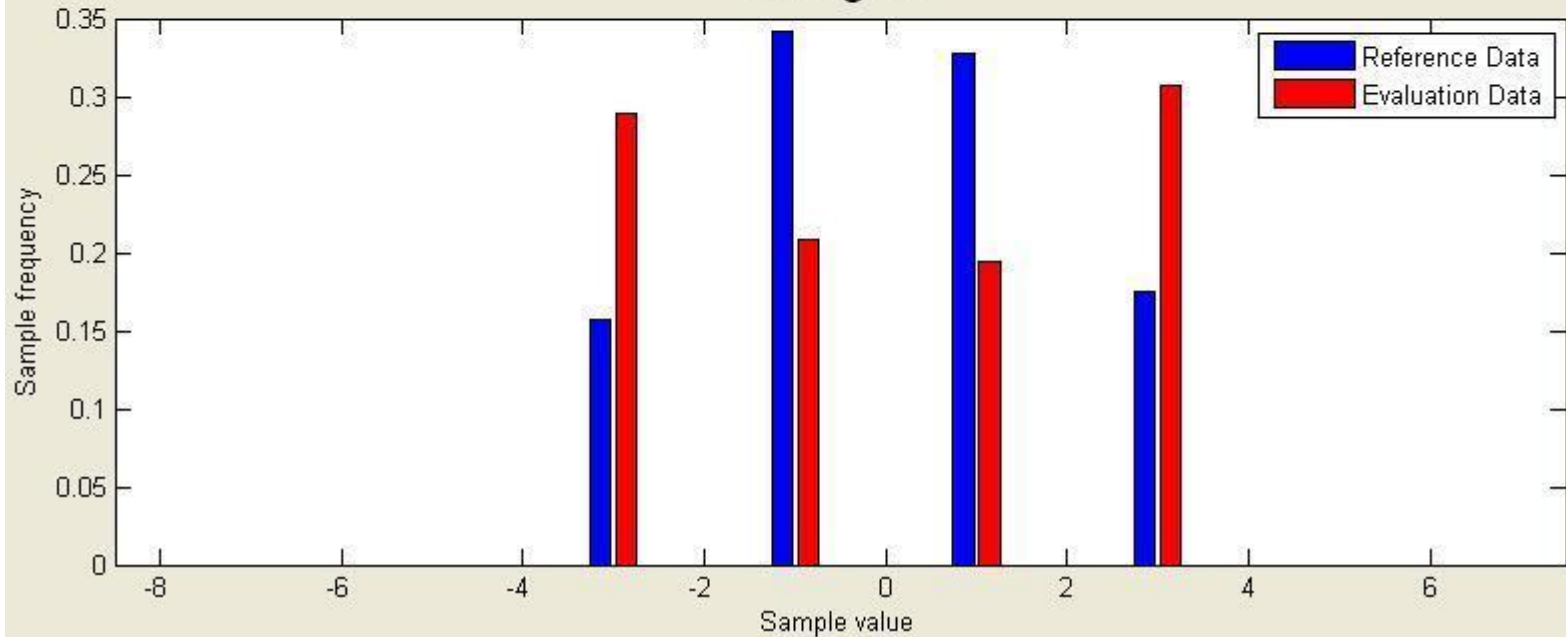


Spectrum



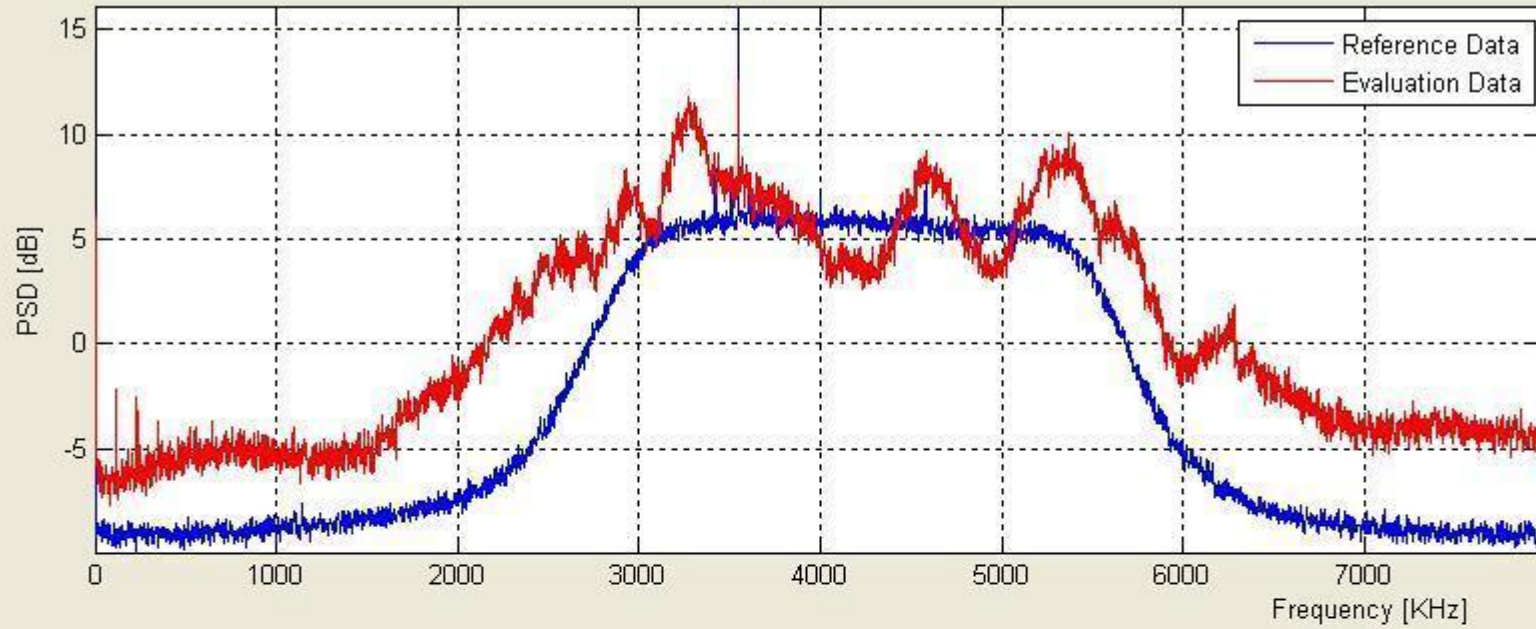
T0 + 80s

Histogram



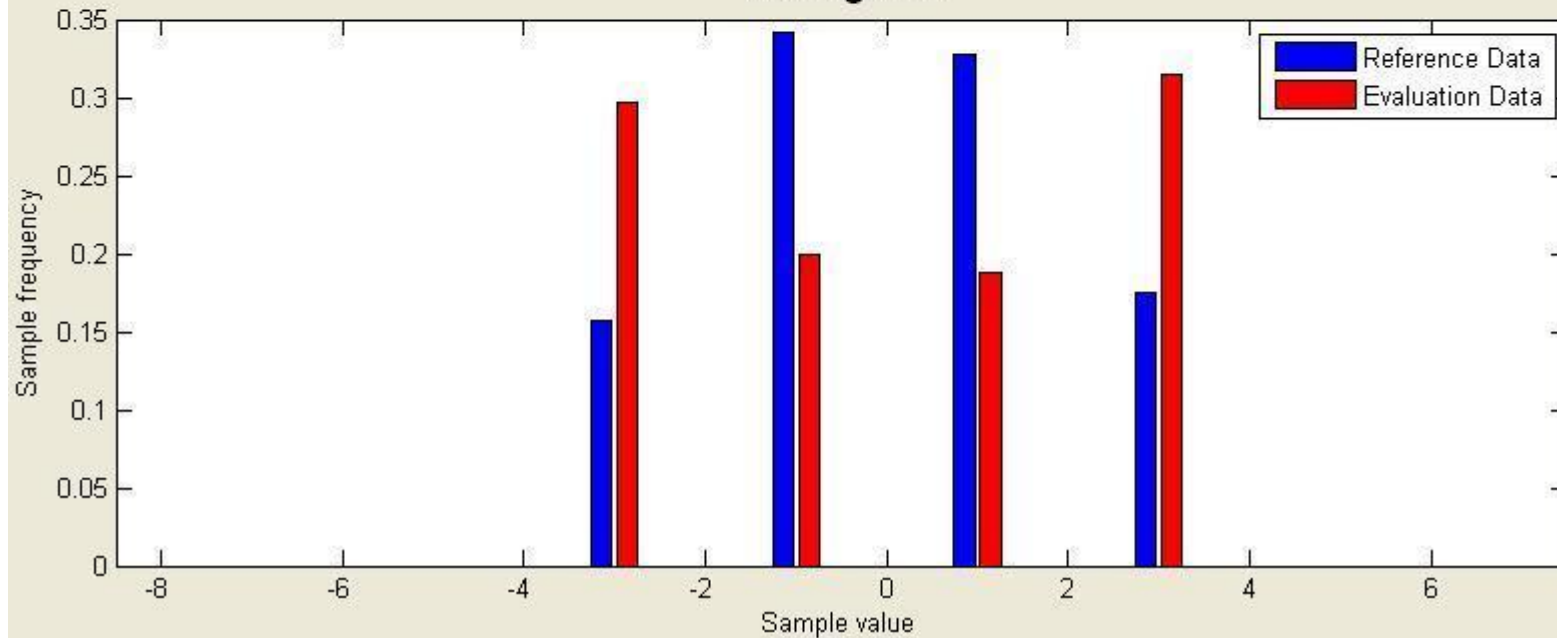


Spectrum



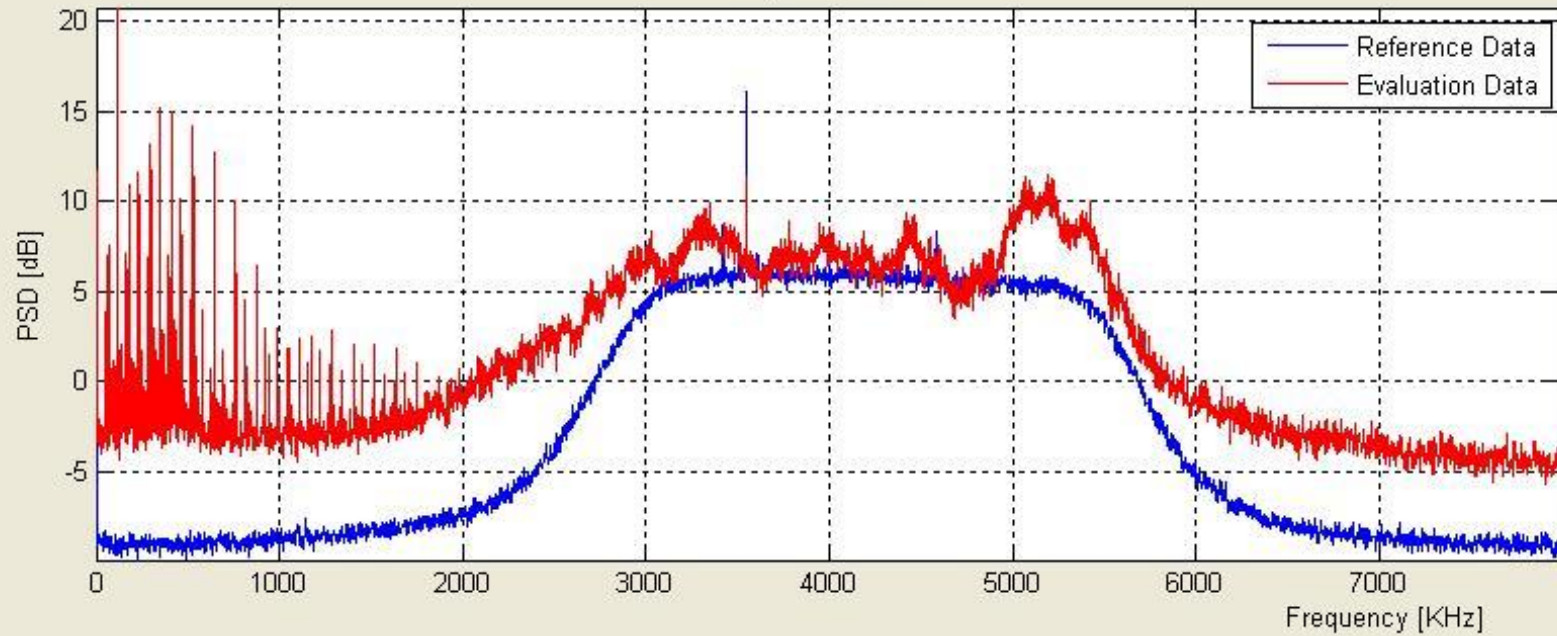
T0 + 90s

Histogram



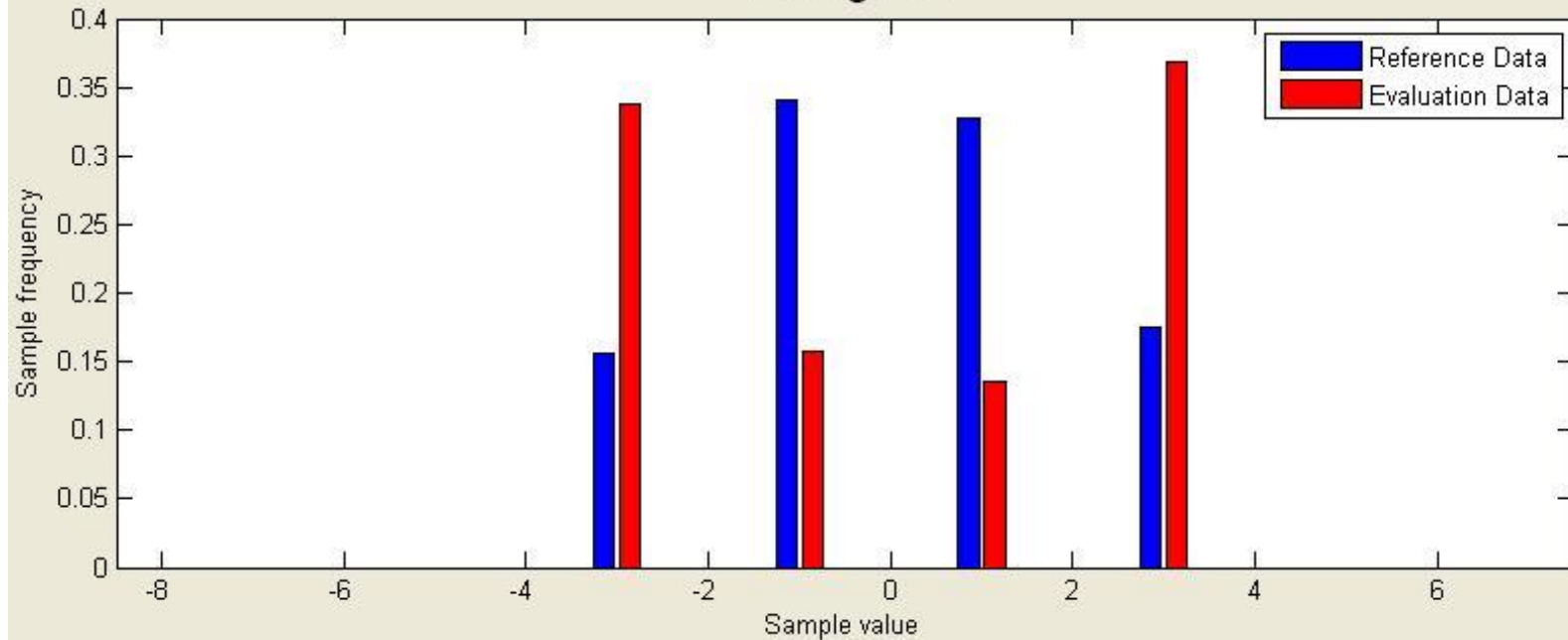


Spectrum



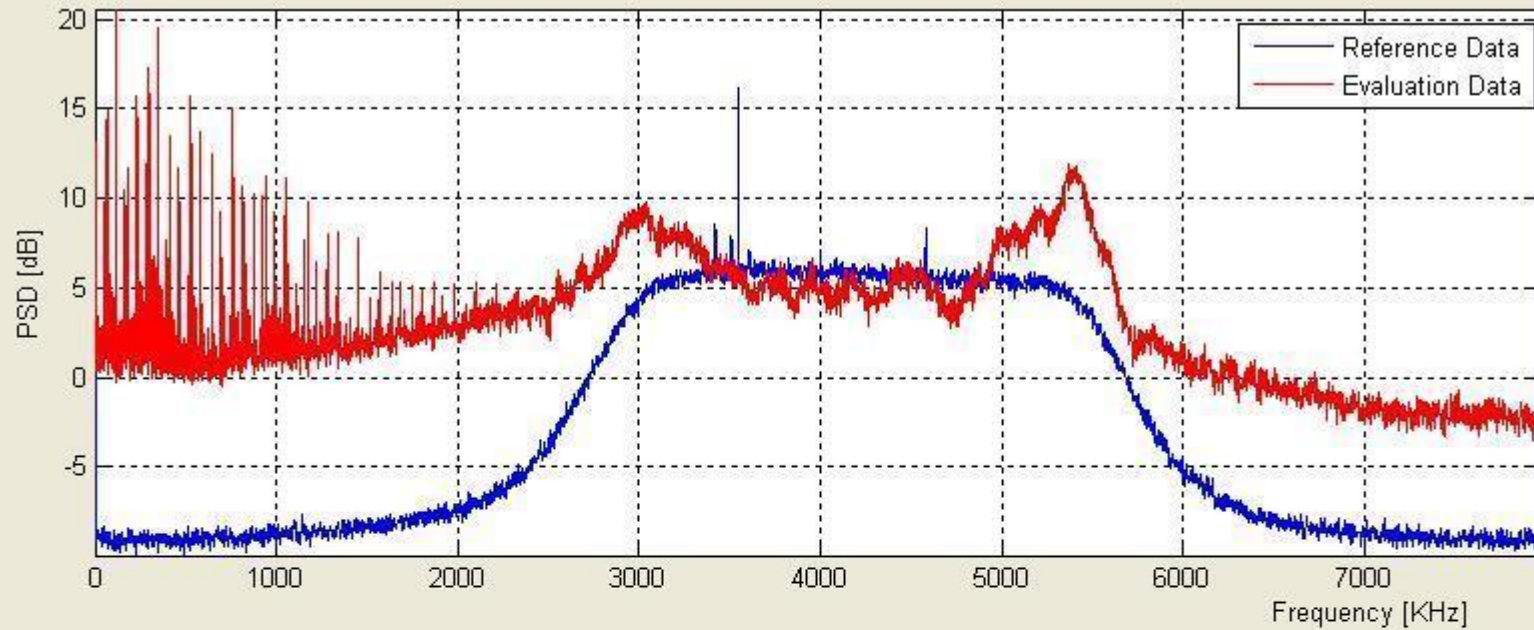
T0 + 100s

Histogram



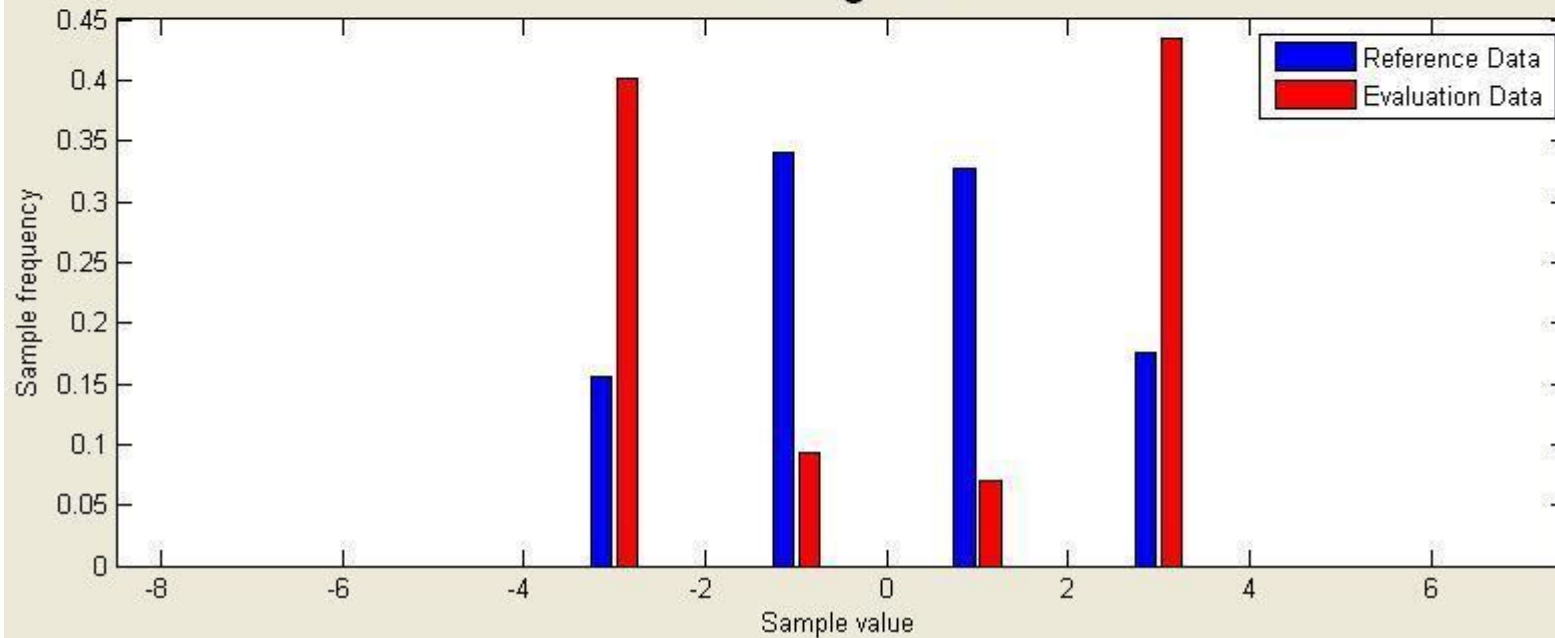


Spectrum



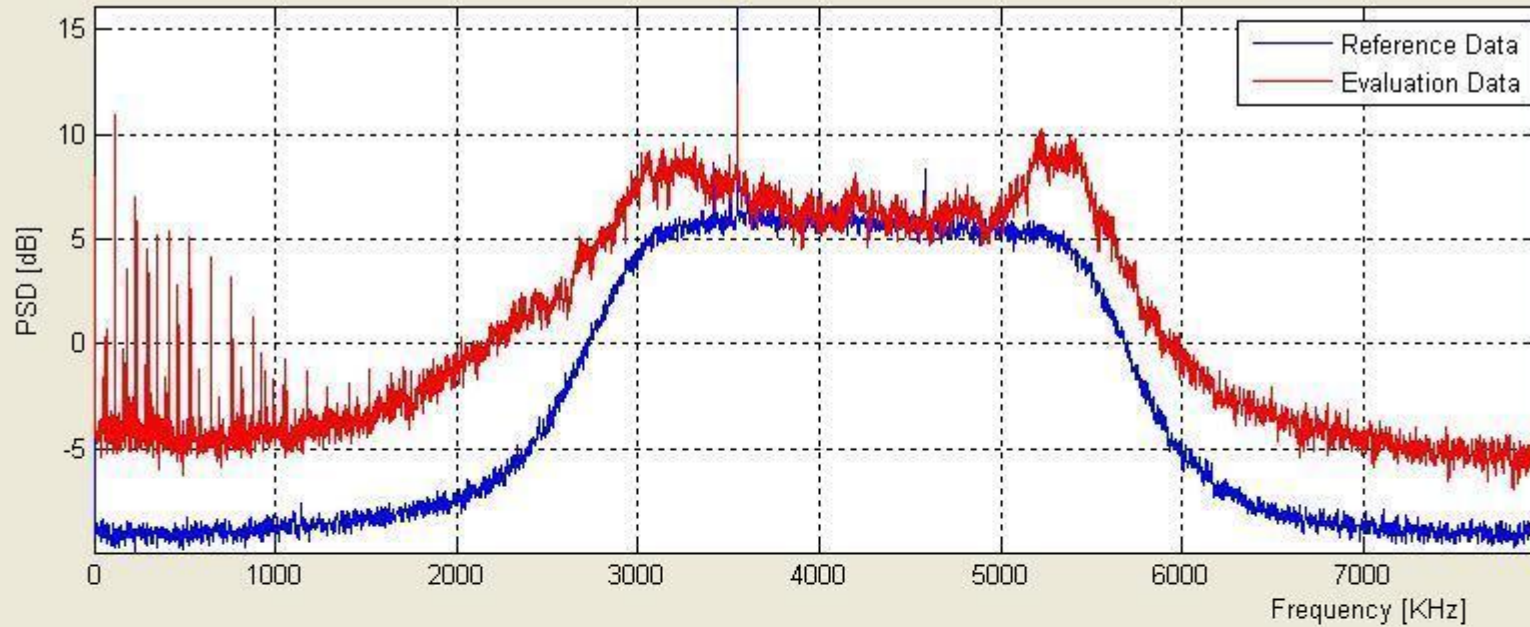
T0 + 110s

Histogram



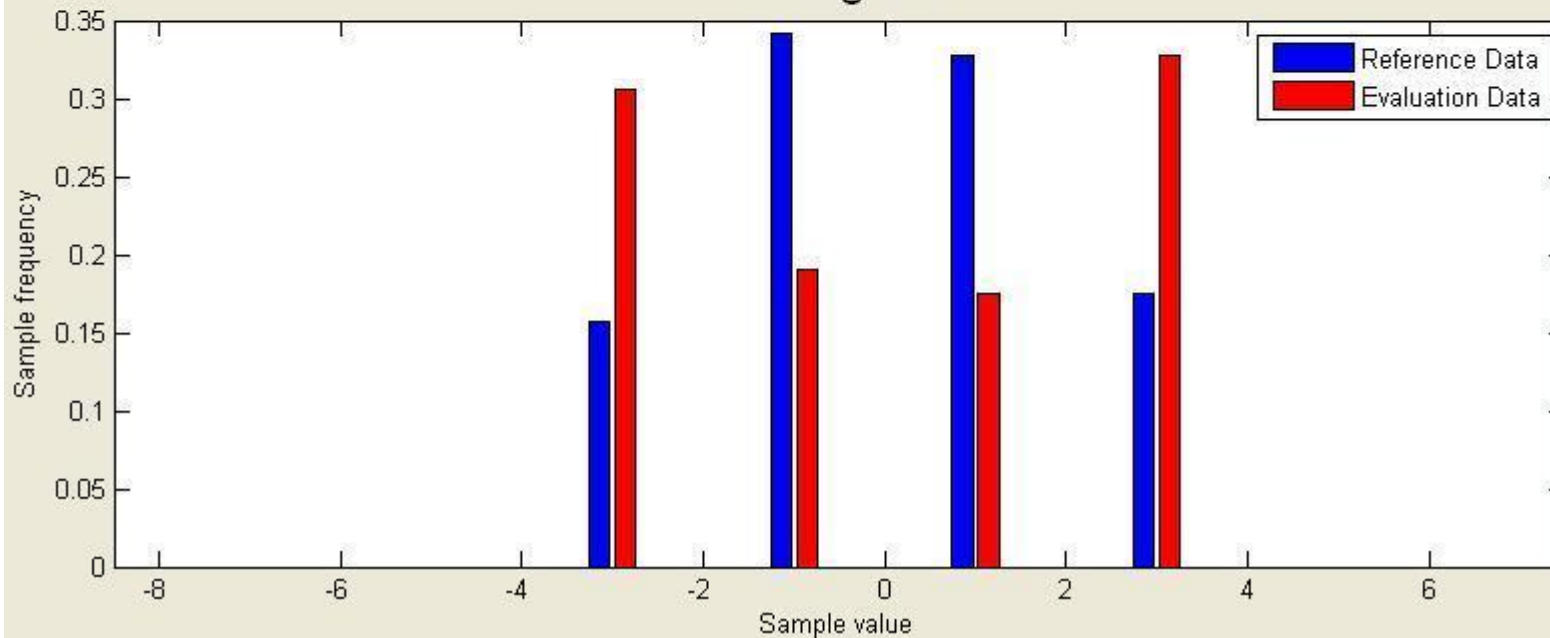


Spectrum



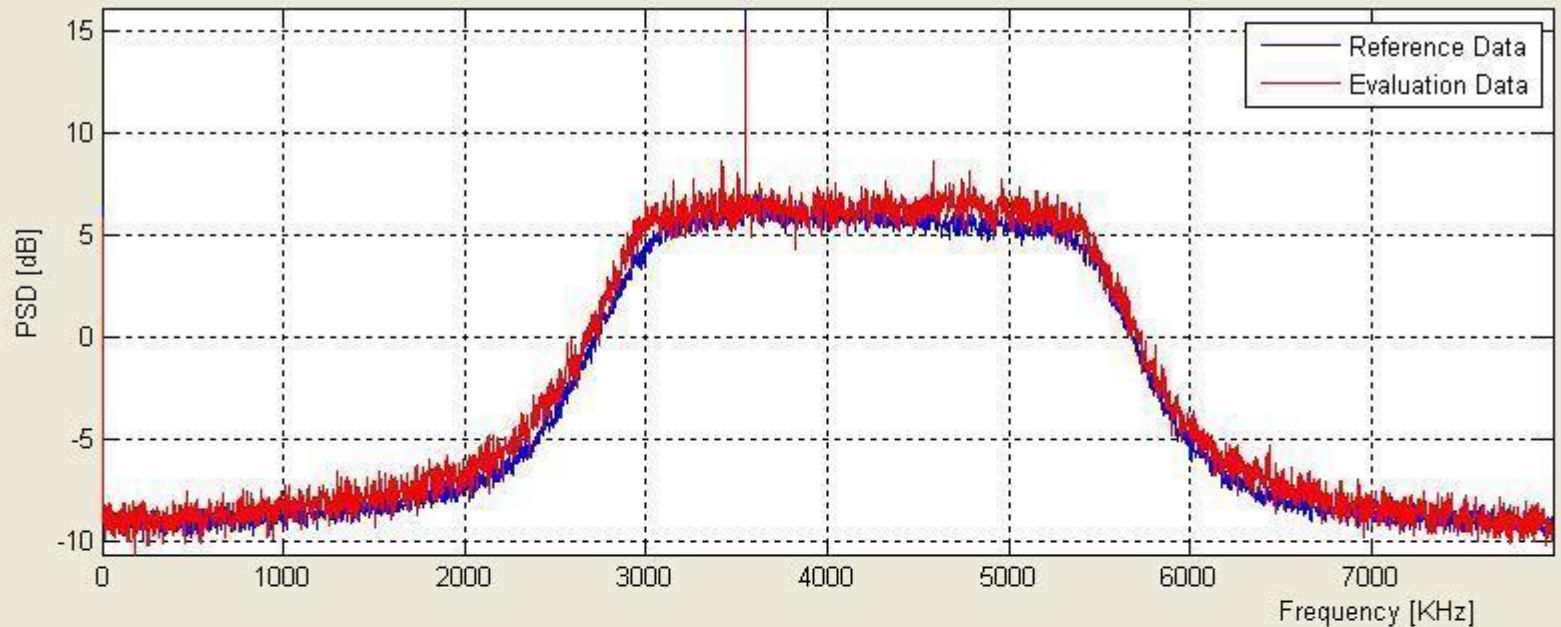
T0 + 120s

Histogram



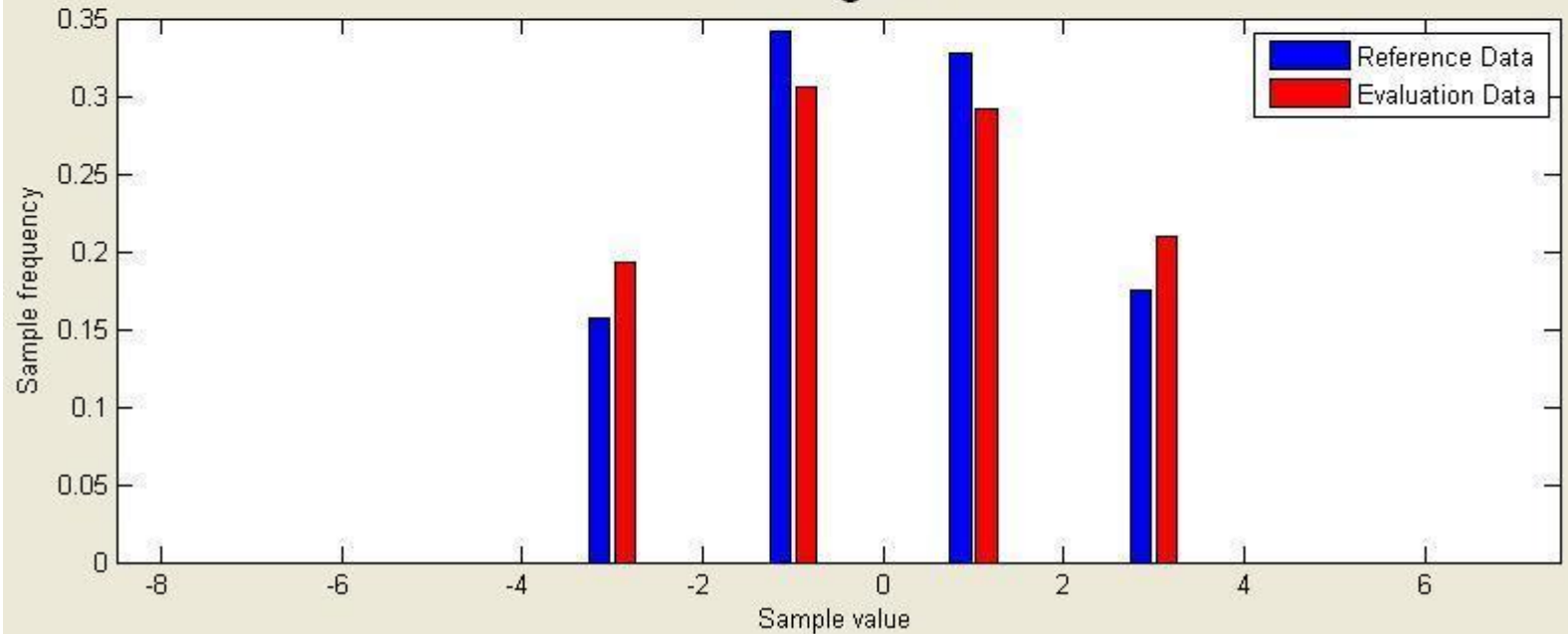


Spectrum



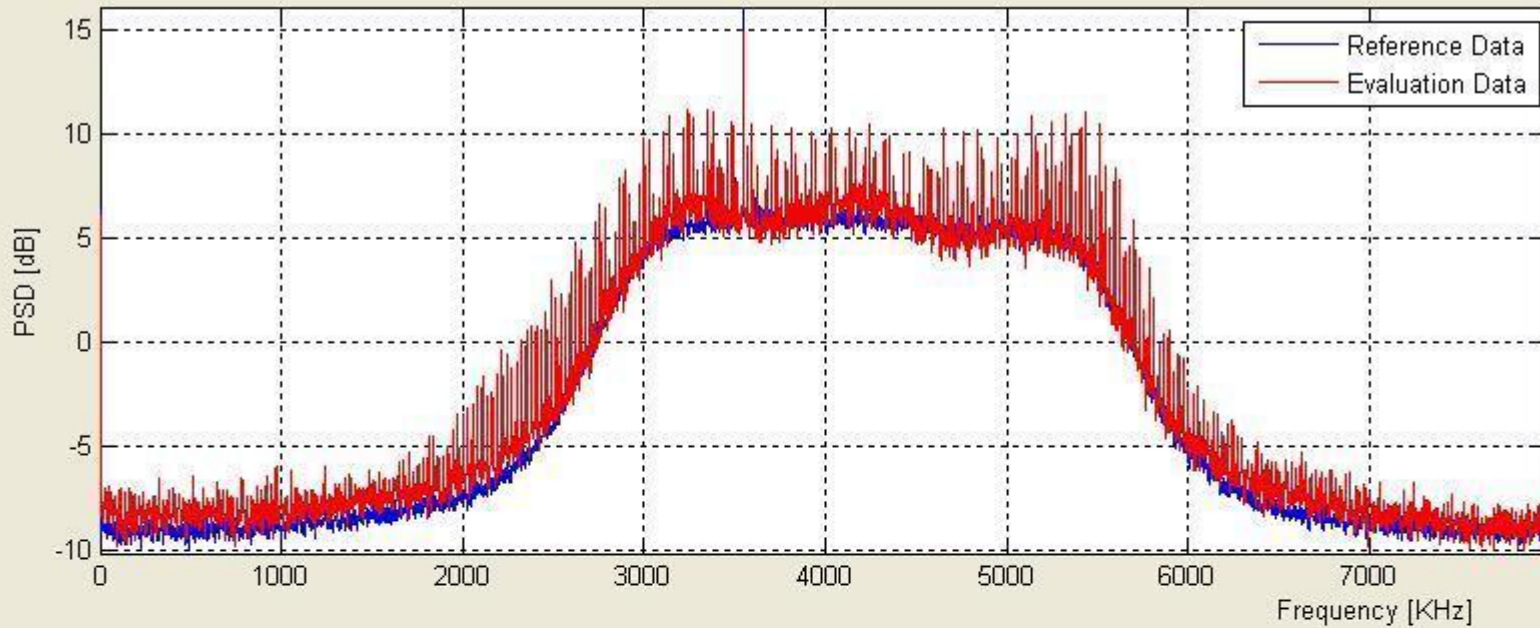
T0 + 130s

Histogram



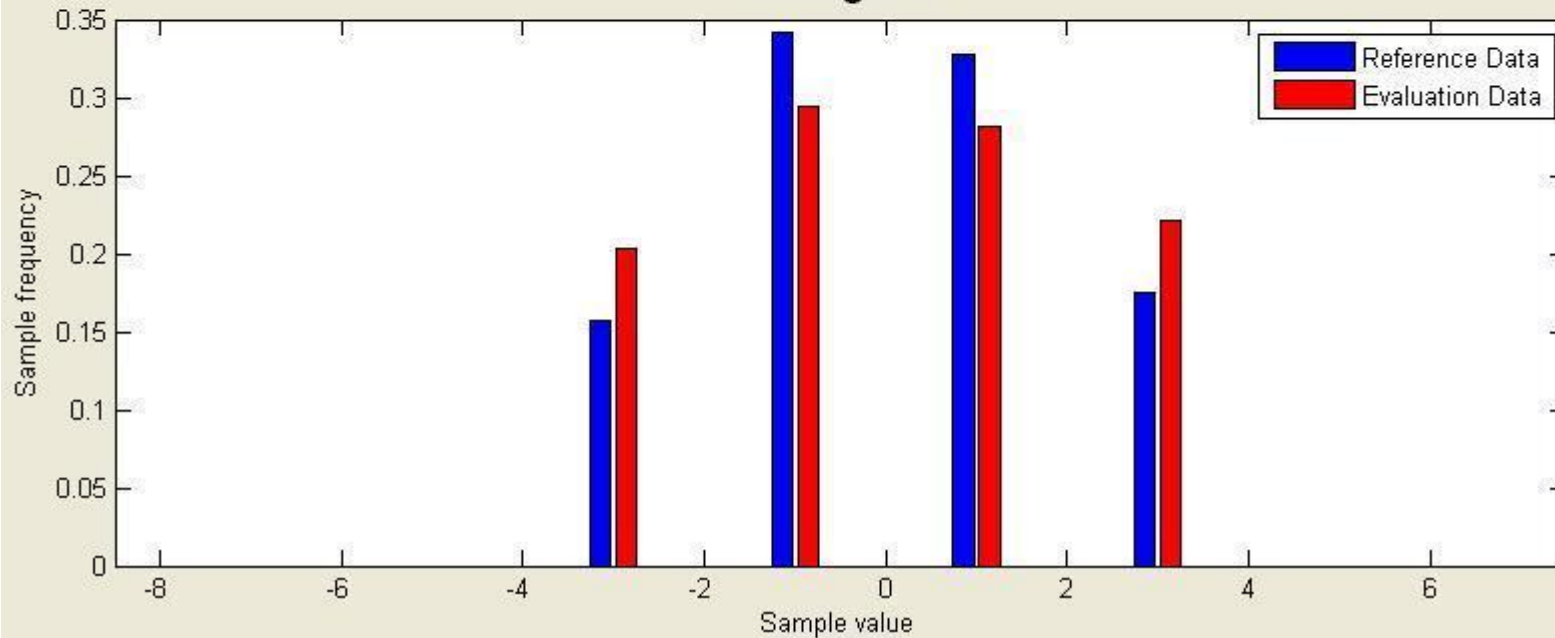


Spectrum



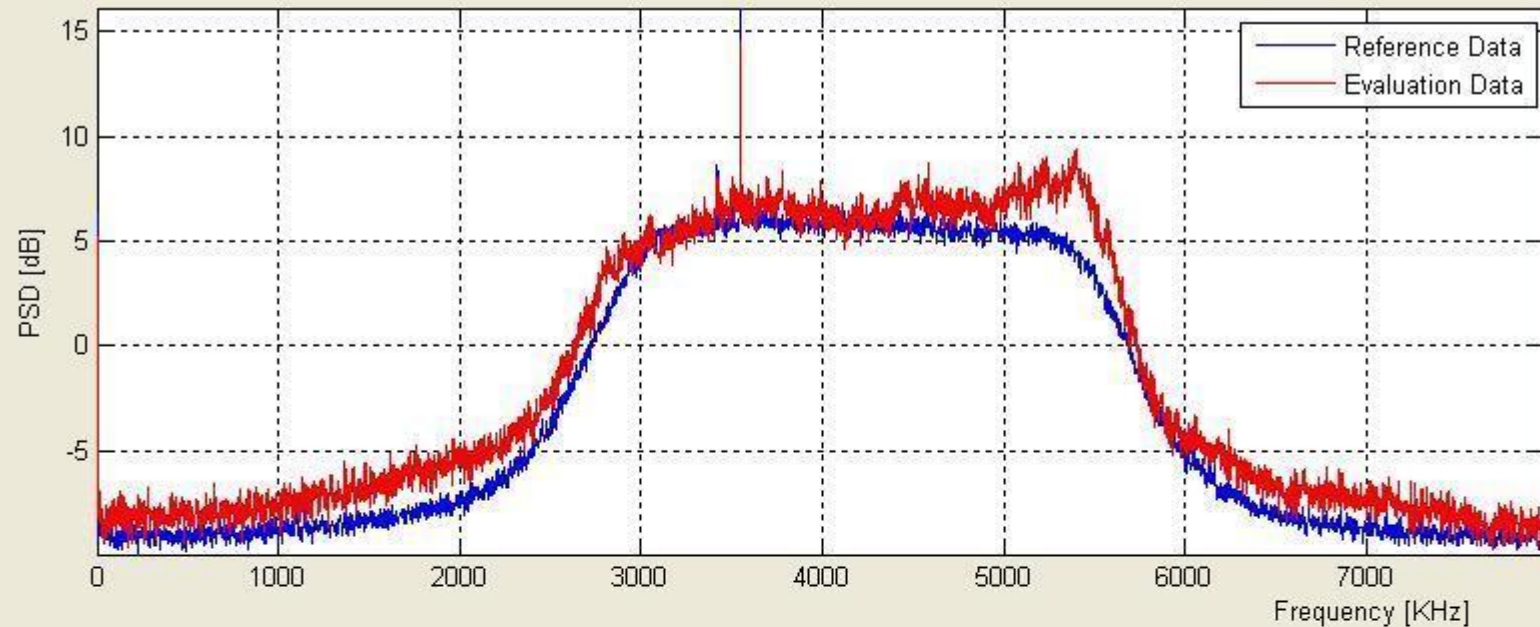
T0 + 170s

Histogram



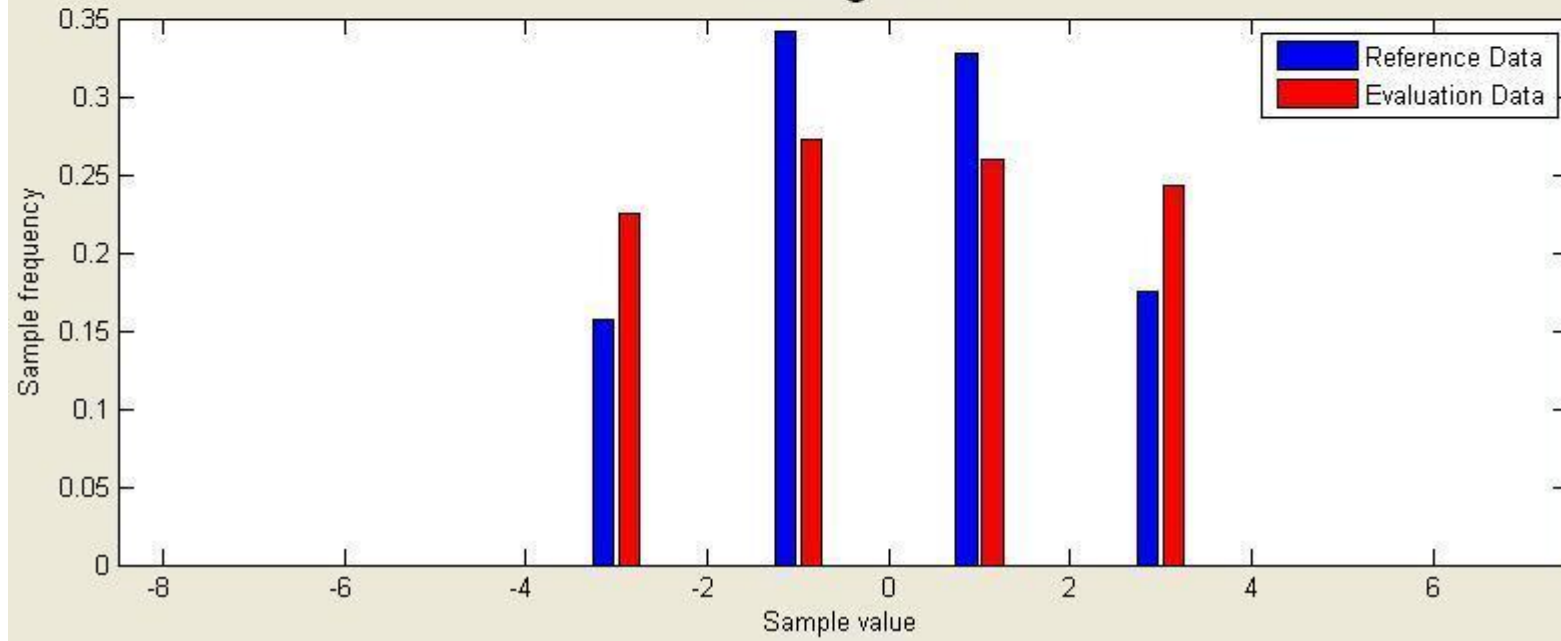


Spectrum

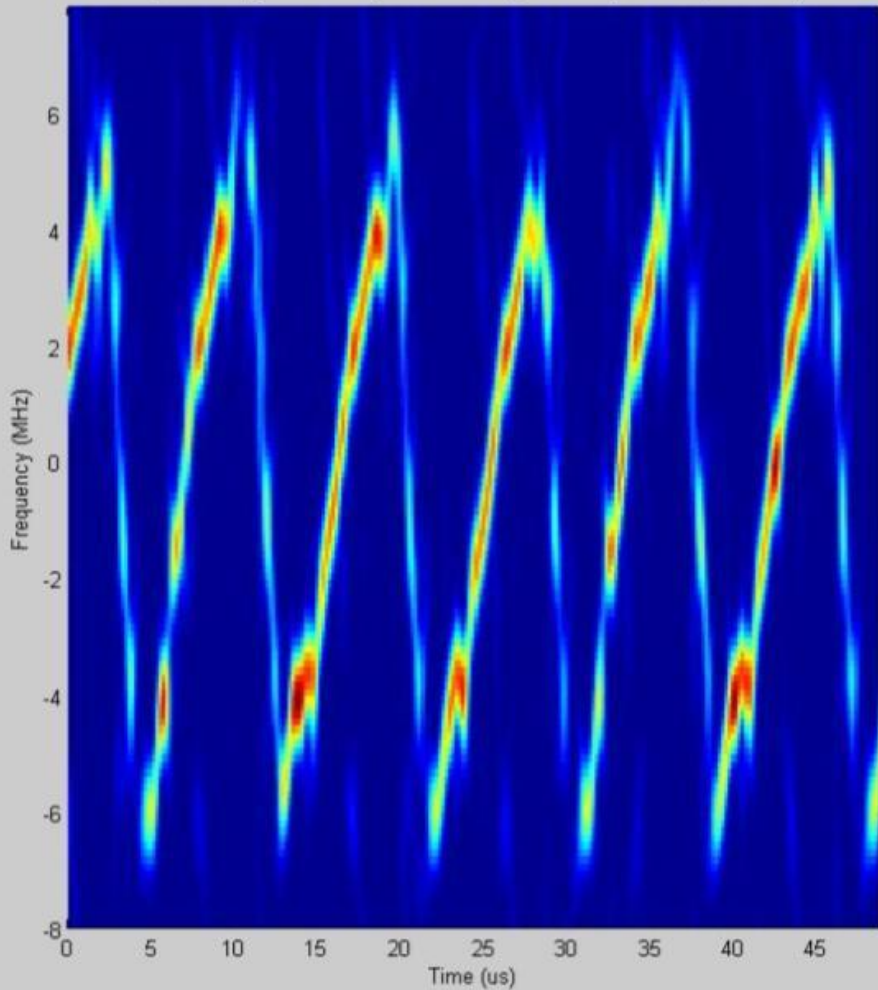


T0 + 200s

Histogram



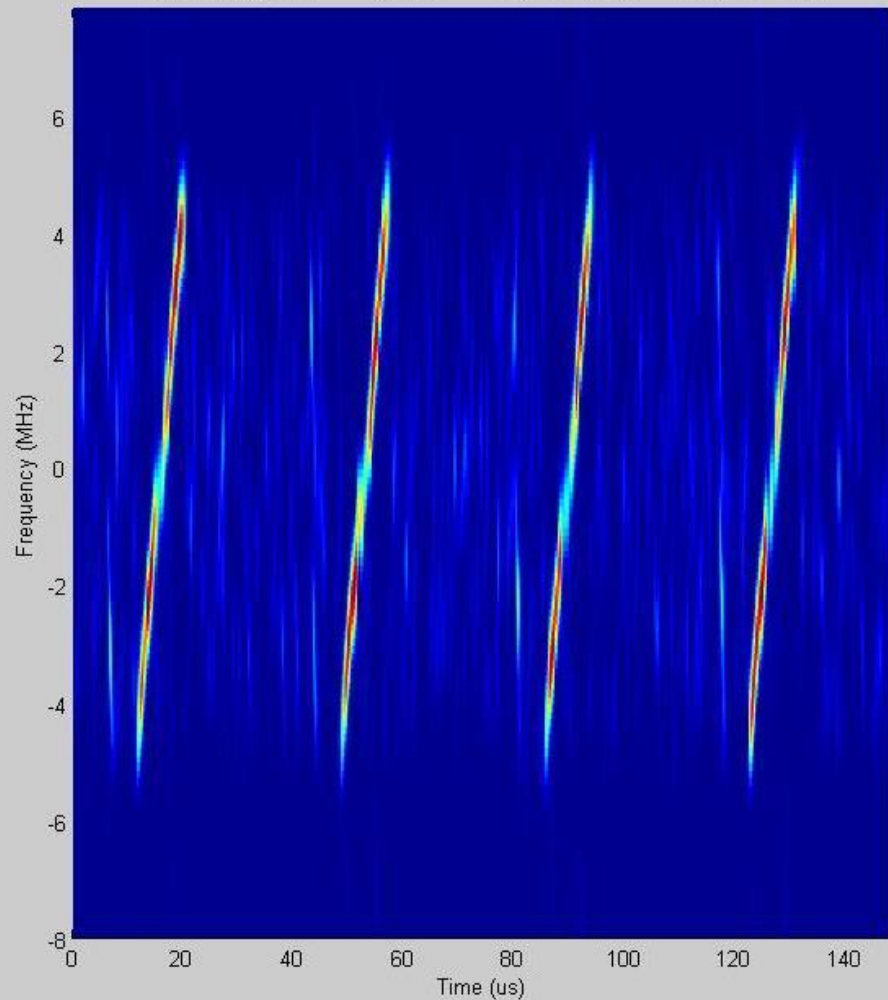
Spectrogram (Nwin = 16, overlap = 0.8, M = 2)

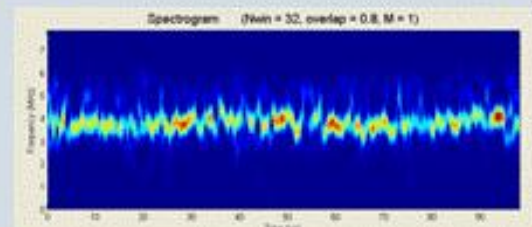
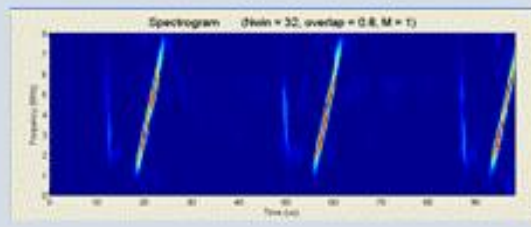
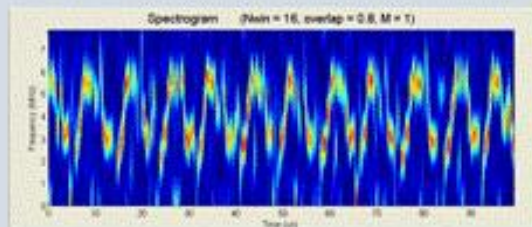
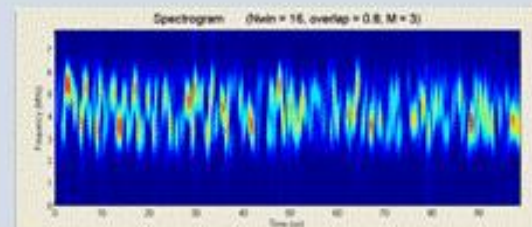
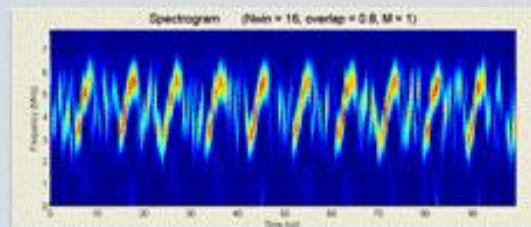
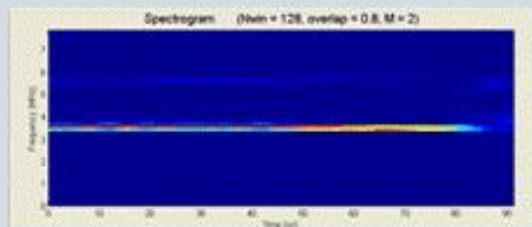
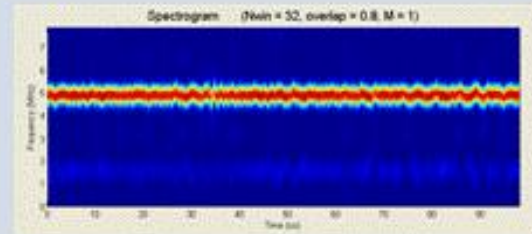
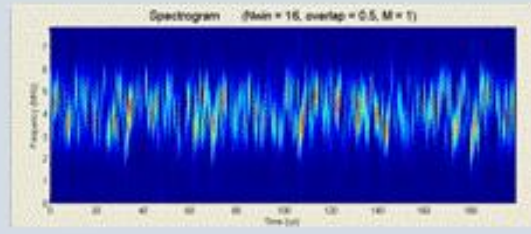
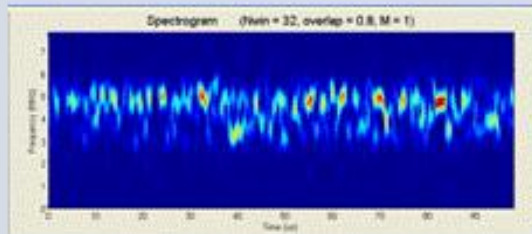
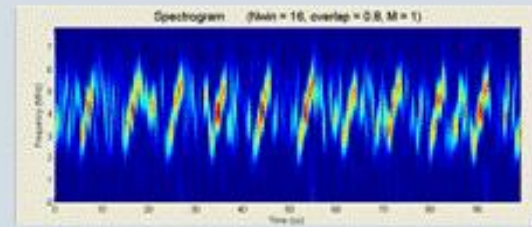
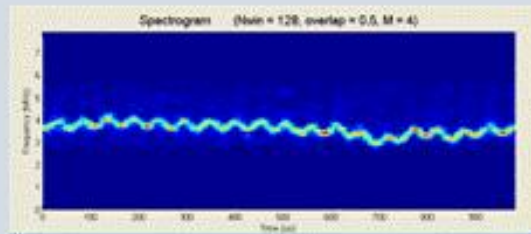
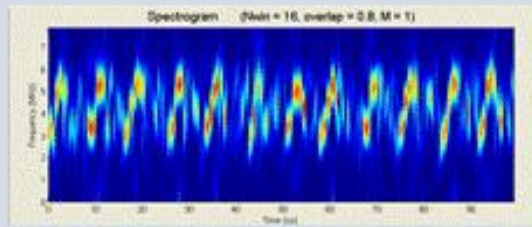


Characterisation

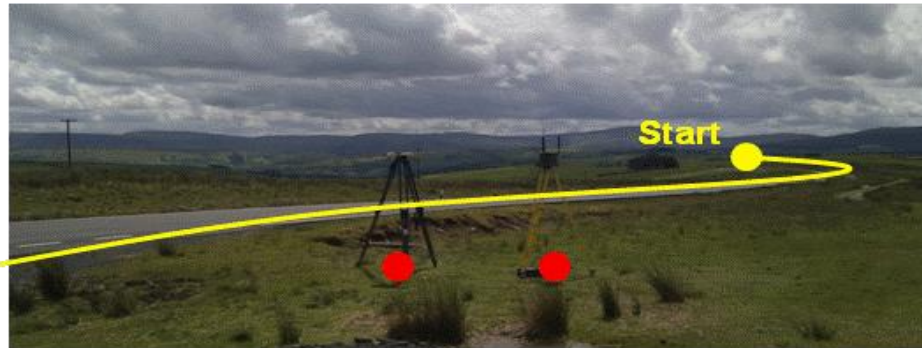


Spectrogram (Nwin = 16, overlap = 0.8, M = 2)

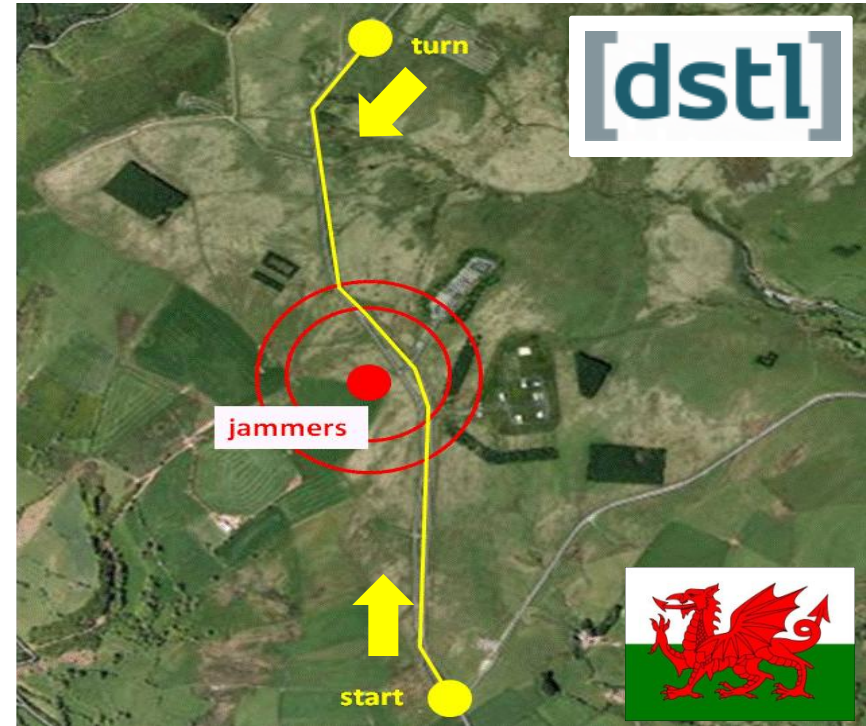




Field Trials



- Opportunity to refine performances using “real” jammers in open-air conditions
- Different jammer “types”
- Different jammer “powers”
- Different distances, geometries, speeds
- Multiple Jammers*



DETECTOR controlled Test Scenarios

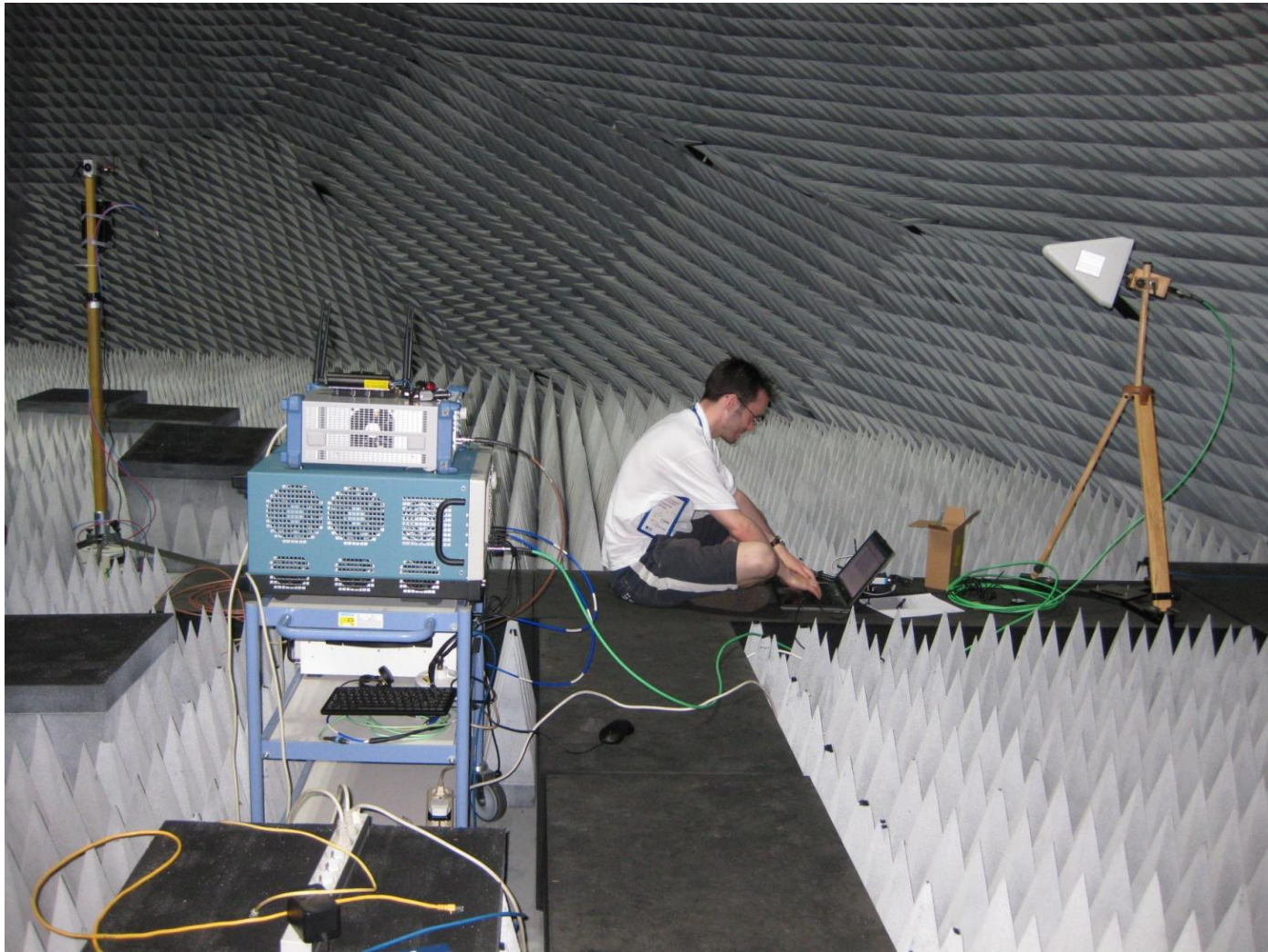
UK MOD GPS jamming trials (June 2012)

IPSC, JRC



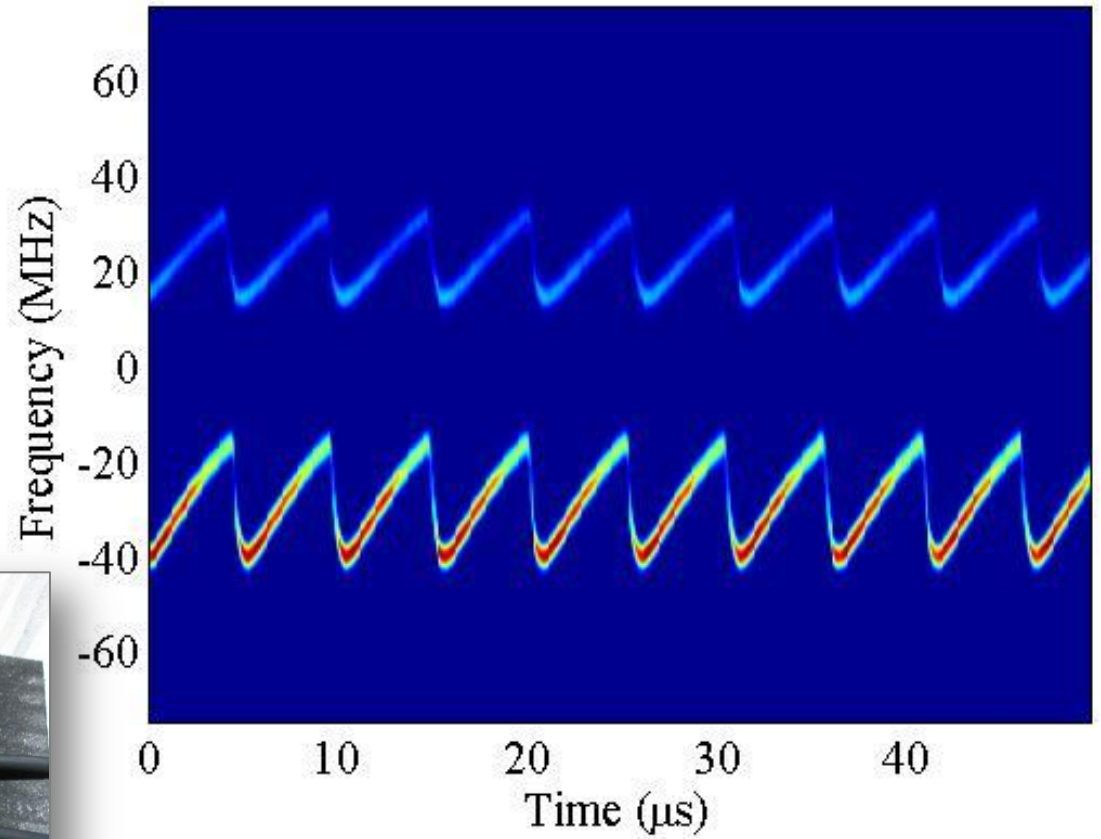
- Characterise a set of typical jammers
- How does power emanate from vehicles?
- Will probe on gantry discriminate vehicle using jammer?
- Is distance to jammer significantly more important than direction?

IPSC, JRC



IPSC, JRC

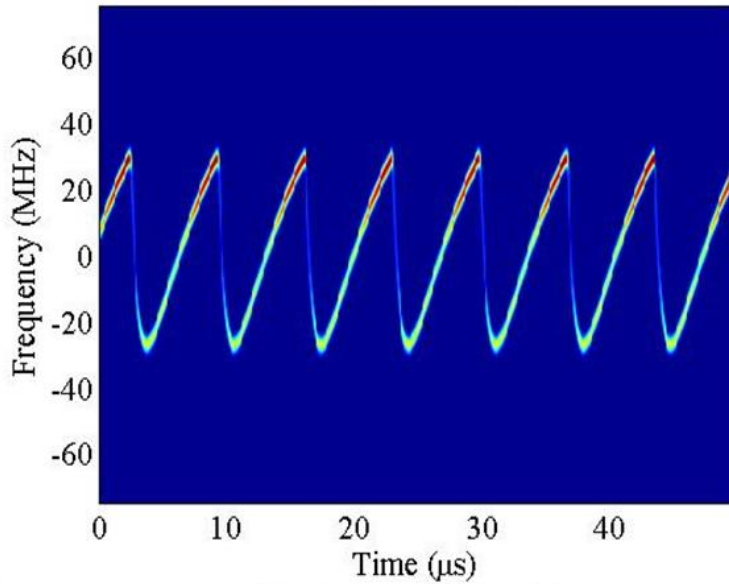
Spectrogram for J02_1205MHz



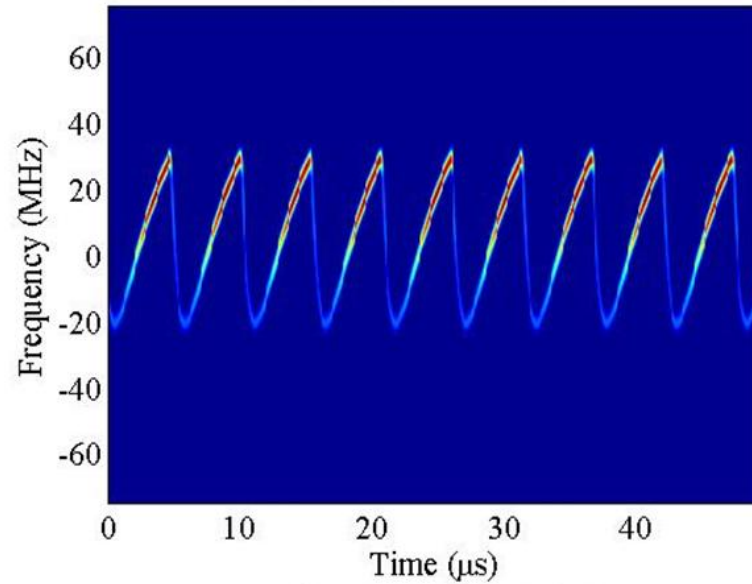
JRC, IPSC



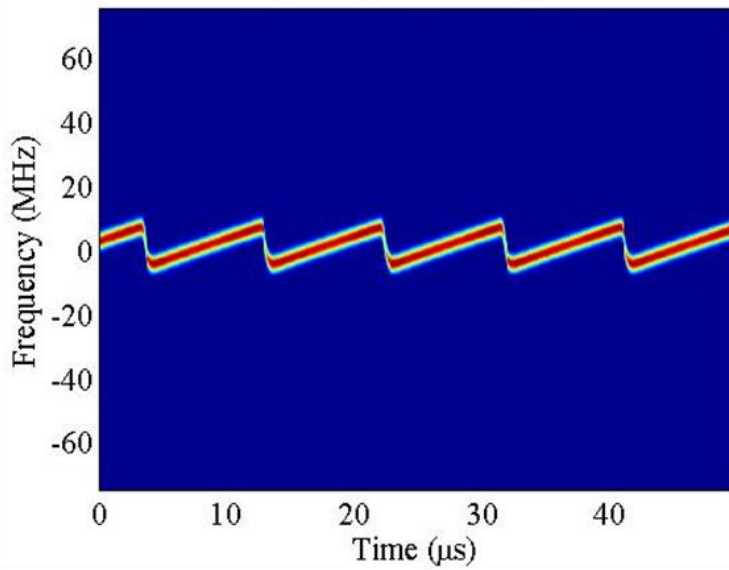
Spectrogram for J03_L1



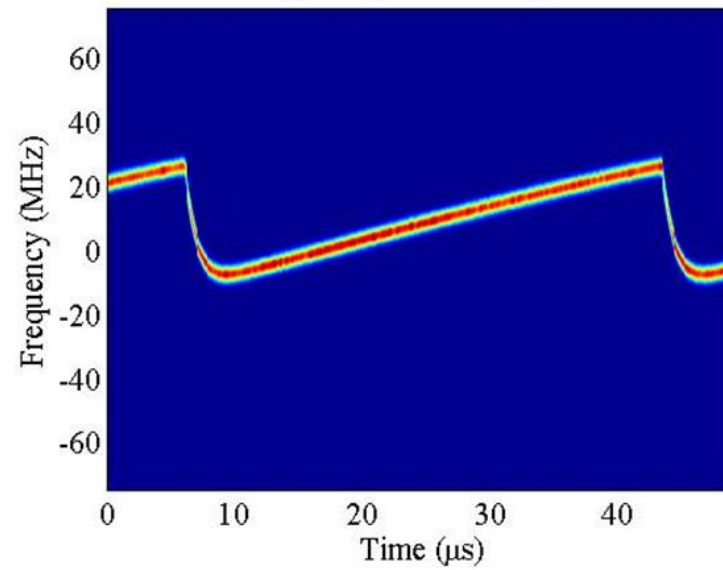
Spectrogram for J01_L1



Spectrogram for J04_L1



Spectrogram for J07_L1

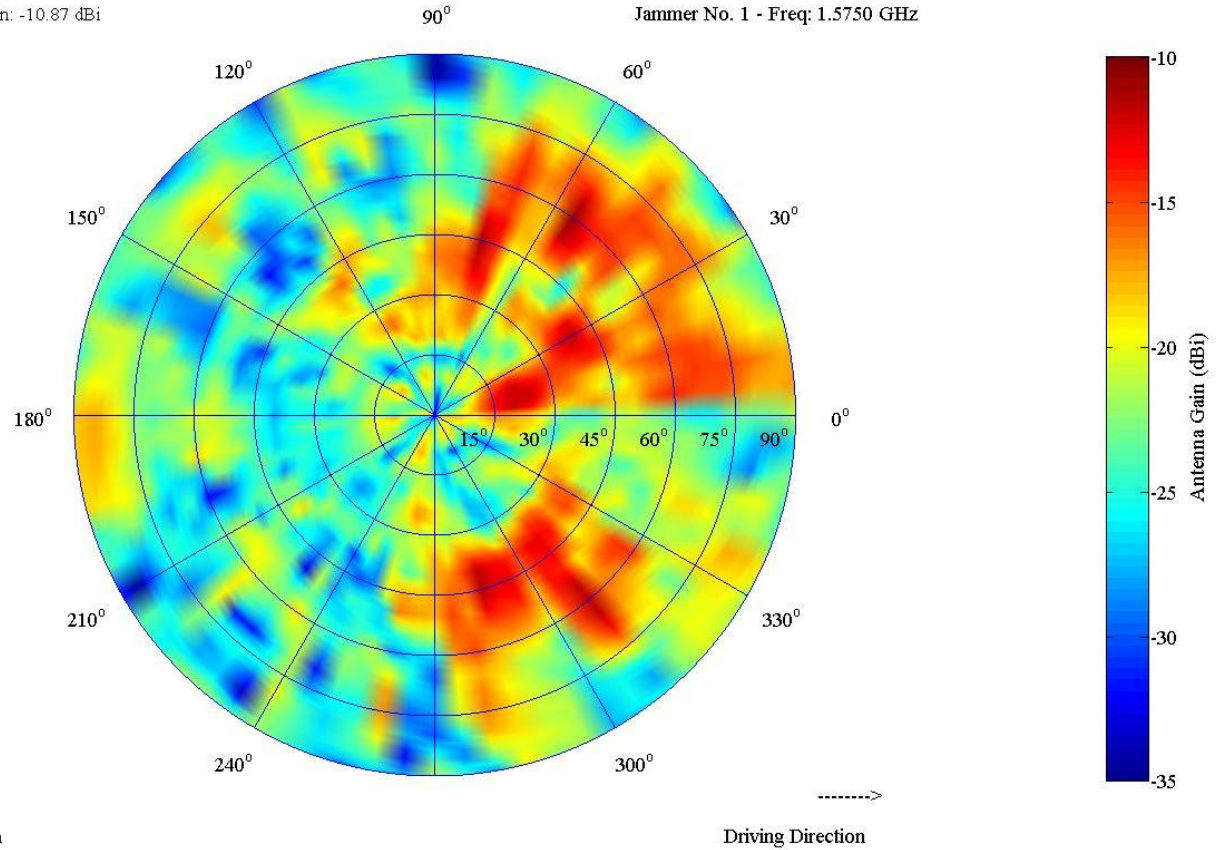


Dashboard Jammer



RHCP: Maximum Gain: -10.87 dBi

Jammer No. 1 - Freq: 1.5750 GHz

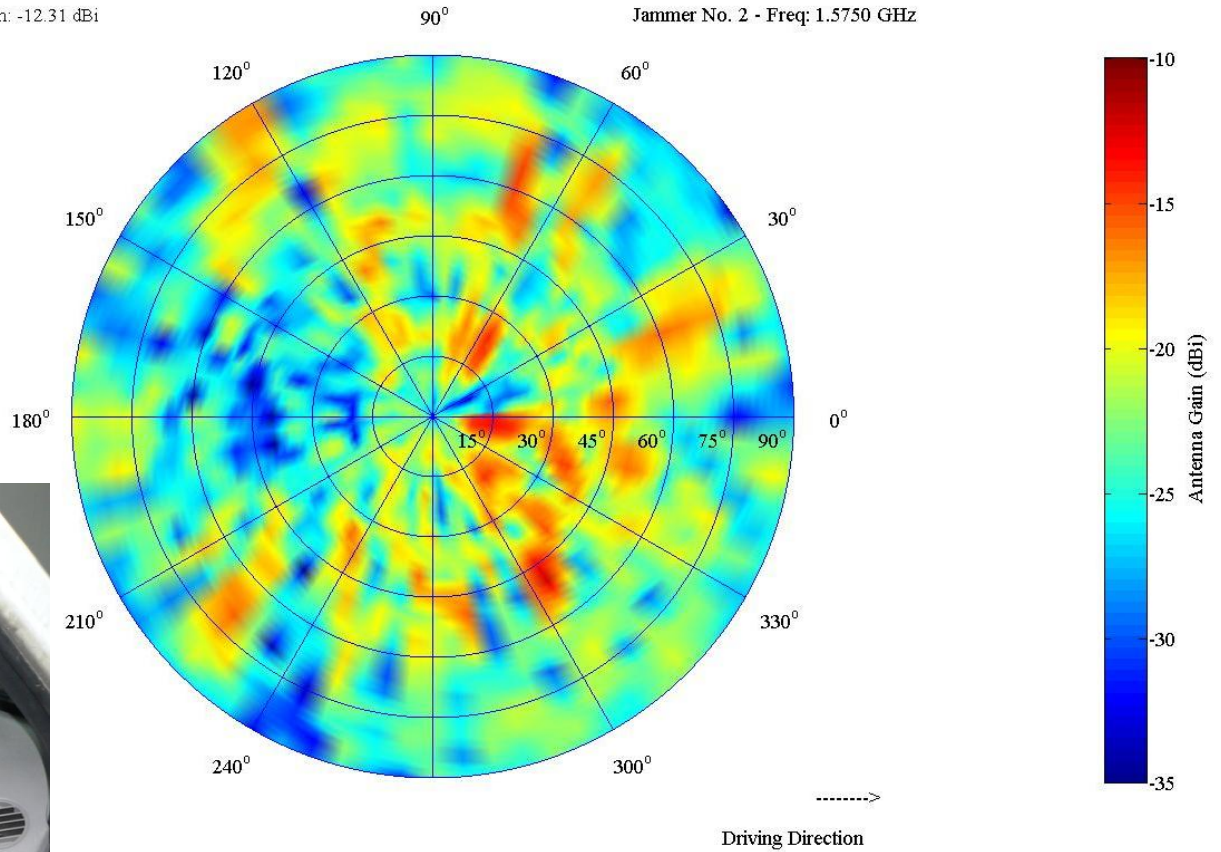


Glovebox Jammer



RHCP: Maximum Gain: -12.31 dBi

Jammer No. 2 - Freq: 1.5750 GHz

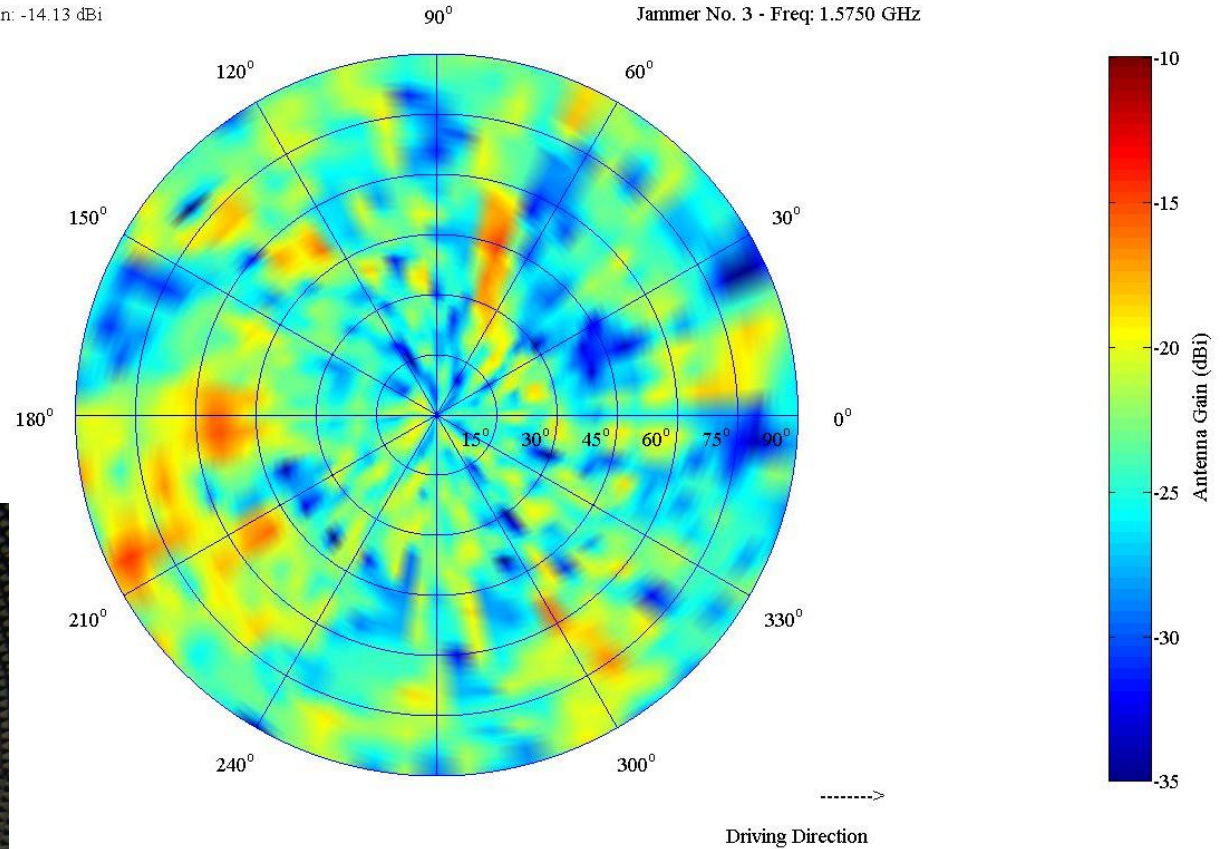


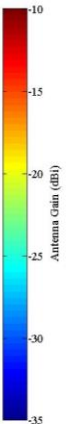
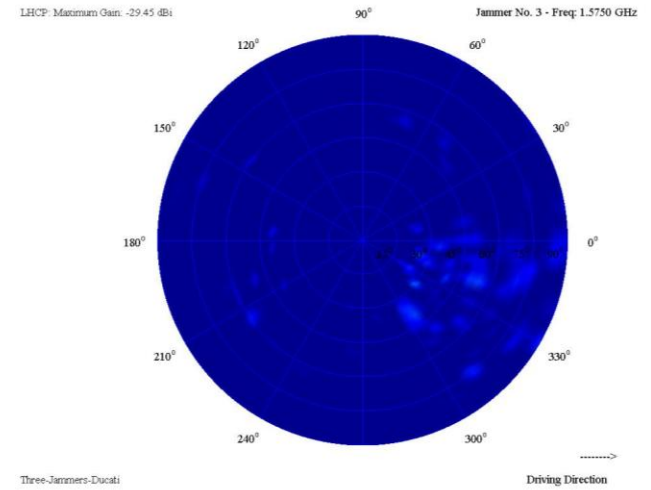
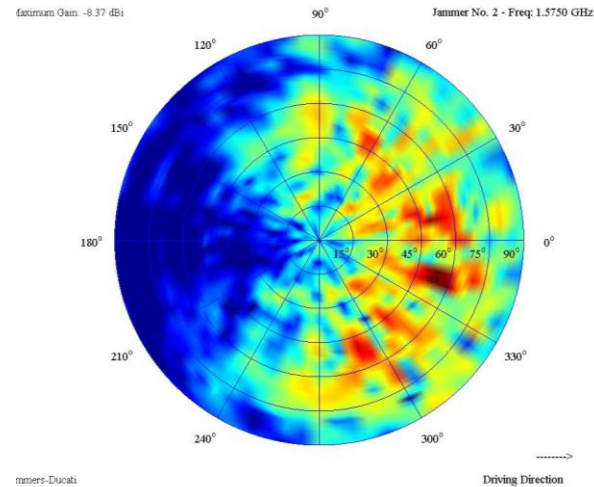
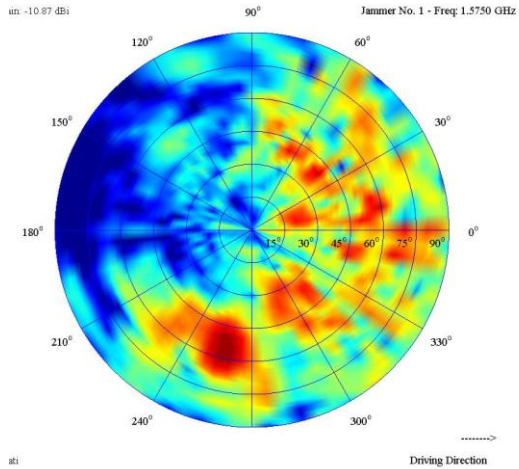
Boot Jammer



RHCP: Maximum Gain: -14.13 dBi

Jammer No. 3 - Freq: 1.5750 GHz

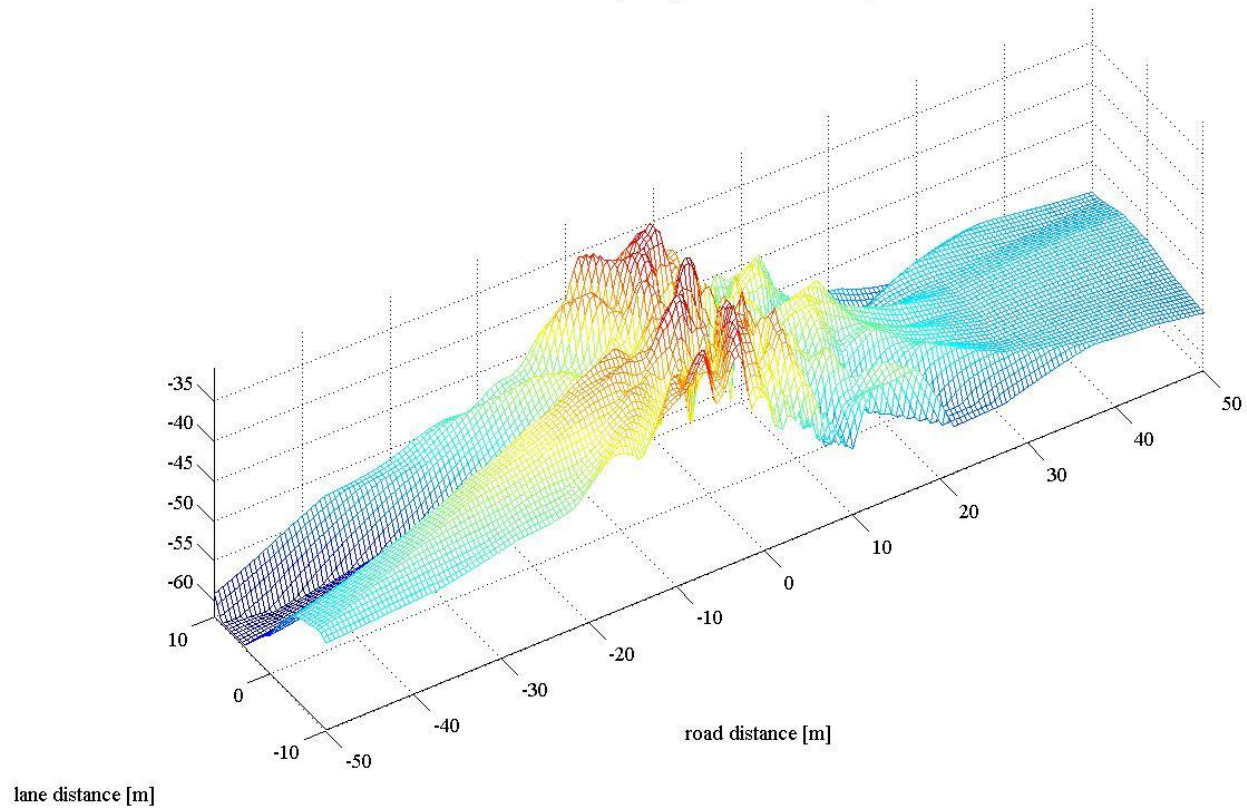




Power Received on Gantry

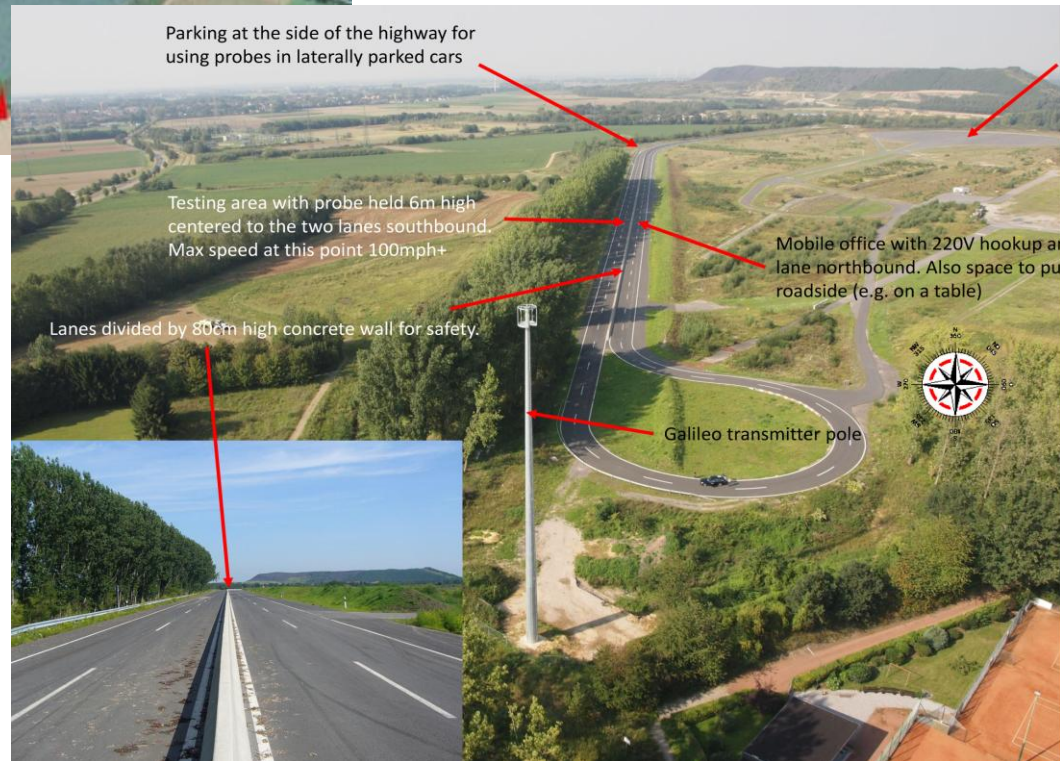
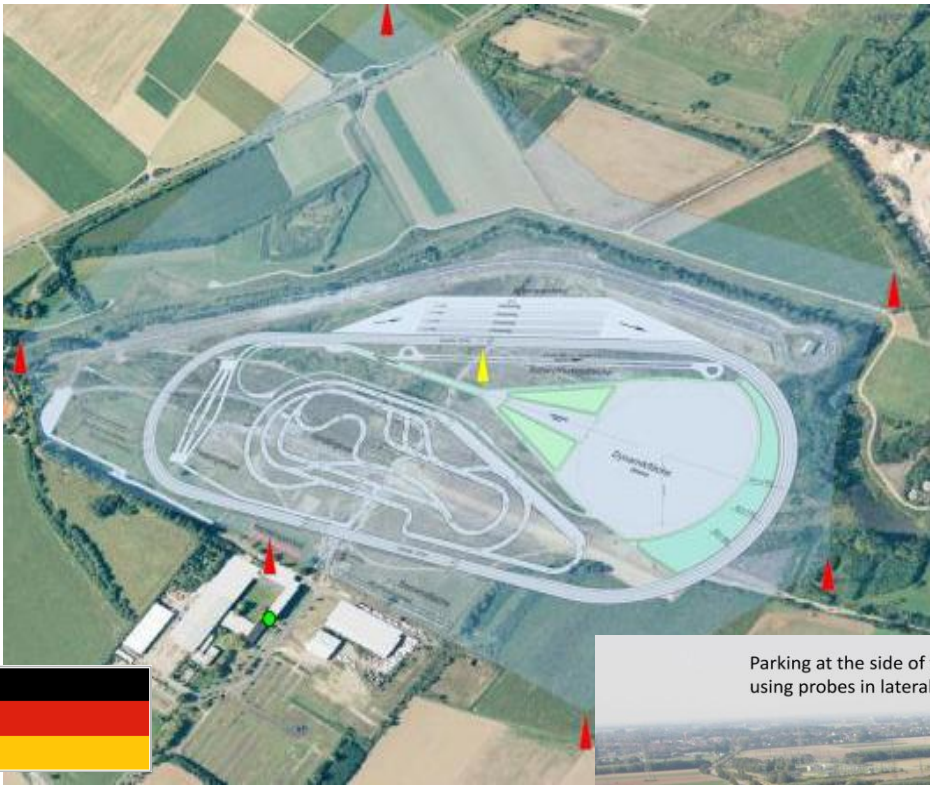


Power received depending on where on the road jammer is





Validation



Parking at the side of the highway for using probes in laterally parked cars

Large surface for drive/walk around tests, crossroad simulation, maybe parking scenario

Testing area with probe held 6m high centered to the two lanes southbound. Max speed at this point 100mph+

Mobile office with 220V hookup and cherrypicker in left lane northbound. Also space to put a probe at the roadside (e.g. on a table)

Lanes divided by 80cm high concrete wall for safety.

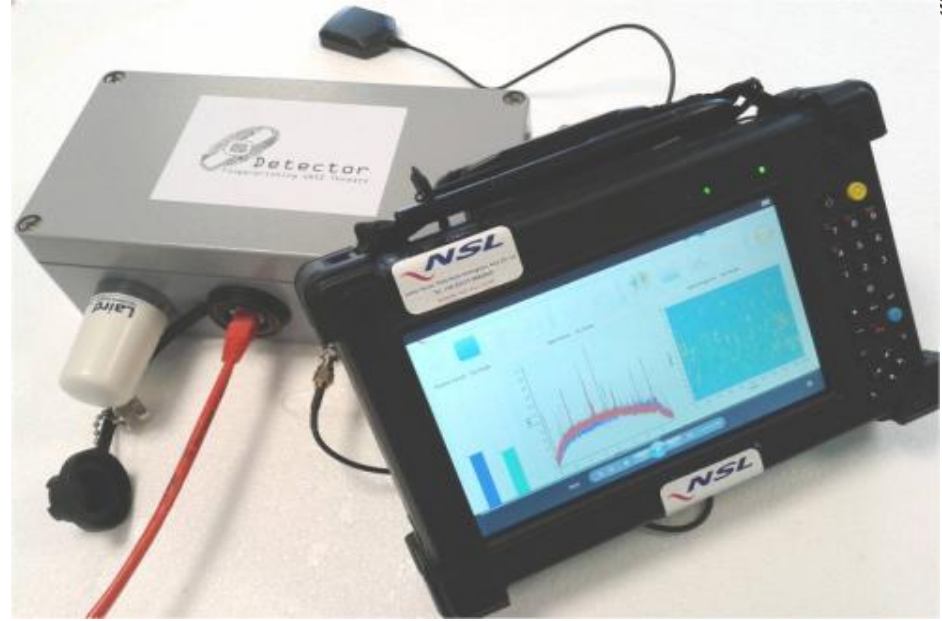
Galileo transmitter pole



AGIT
Gründen. Ansiedeln. Fördern.

Detector
Fingerprinting GNSS Threats

Deployment





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

DETECTOR Consortium



		 <i>Gründen. Ansiedeln. Fördern.</i>
<p><u>GNSS Technology developer</u></p>	<p><u>GNSS Road Toll Operator</u></p>	<p><u>Automotive Test Site</u></p>
 ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA	<p>Black Holes B.V.</p>	  Institute for the Protection and Security of the Citizen
<p><u>GNSS Interference R&D</u></p>	<p><u>Legal Experts</u></p>	<p><u>*EC Joint Research Centre</u></p>