Official sponsor or EUREF 2017 Symposium

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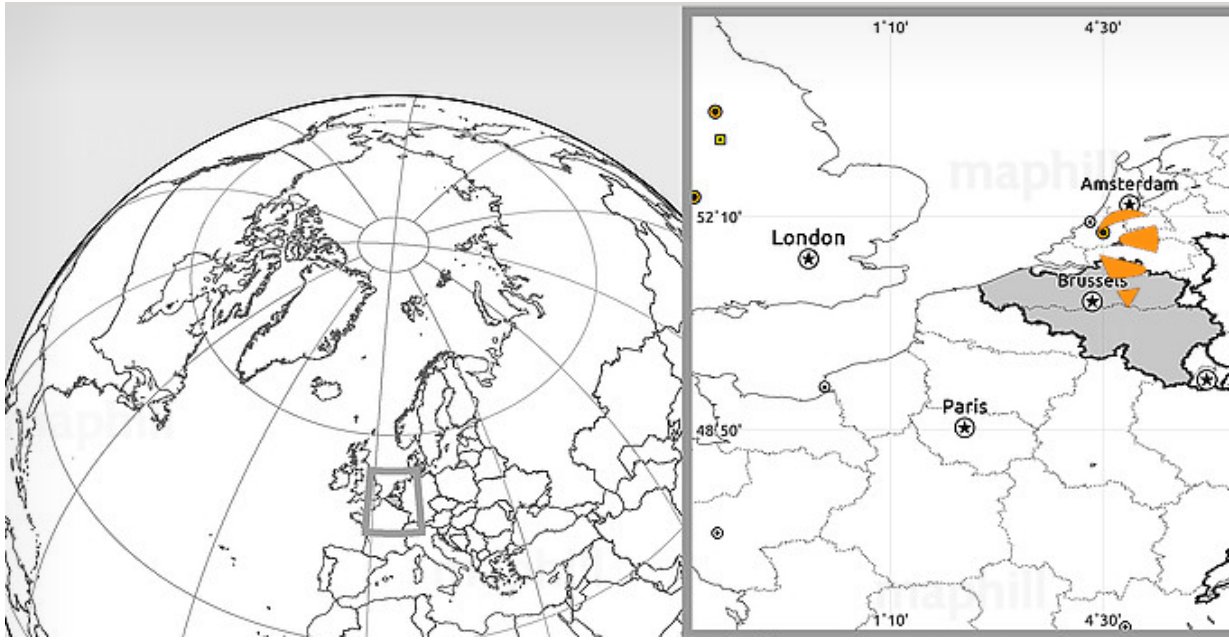
designs, manufactures and sells

highly accurate GNSS receivers

for demanding applications

Mijn thuis is waar mijn Stella staat



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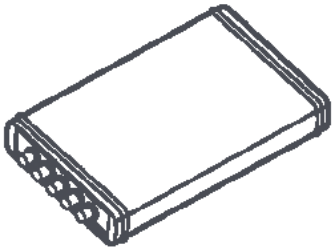
Our Products

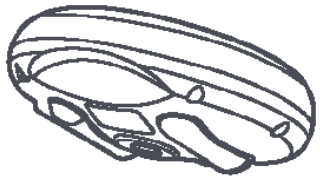
PolaRx

Reference receivers for science and networks



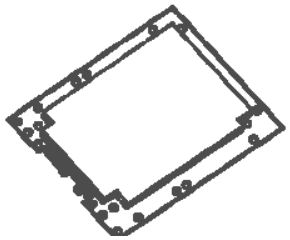
Altus

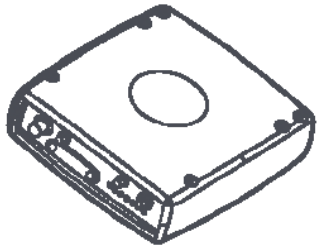
Smart antennas for GIS and survey



AsteRx

Rover Receivers and OEM boards for automation and machine control





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Data Quality: from Tracking to Archiving with no Gaps

F. Clemente, S. Dean, J.M. Sleewaegen, W. De Wilde

EUREF 2017 Symposium

WROCŁAW May 17-19, 2017

GNSS RFI vulnerability: interference is everywhere

GNSS signals as received on the ground : very low power

Sharing of radio spectrum with other services, some operating at high power (Ligado/Docomo LTE , DME, Iridium, Inmarsat)

Narrowband
Wideband (> 1 MHz)

Pulsed
Non-pulsed (continuous)

Unintentional
Intentional (jamming)

In-band
Out of band

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Interference impact on application

Depends on frequency and duration of the offending transmissions

Daily processing: exclusion of arcs with less than a specified amount of continuous slip free observations.

Accuracy effected.

Kinematic processing: most impacted is real-time PPP (re-convergence), risk of missing out on events.

Ambiguity resolutions difficult to impossible depending on interruptions.

What if a 10mW jammer was on the roof of the Mercure hotel?

No mitigation

Reference station → no supply of differential corrections

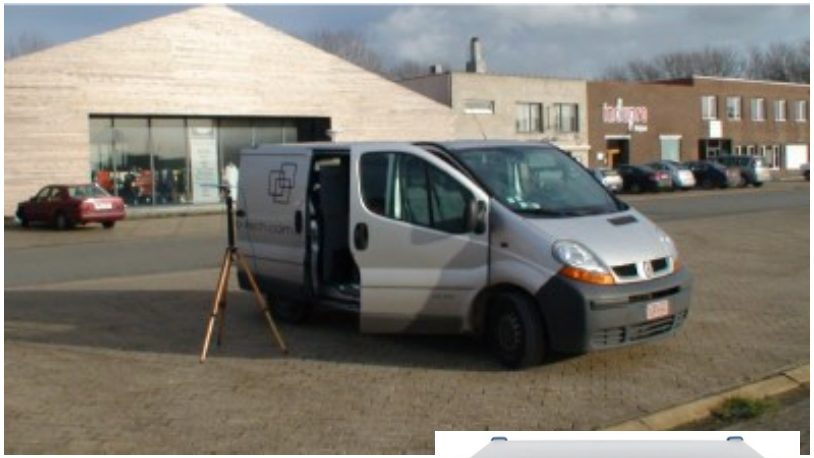
Rover → No RTK in a radius of 400 m from the emitter

Old school troubleshooting

Specialized personnel & dedicated hardware (spectrum analyzer)

Long field campaign

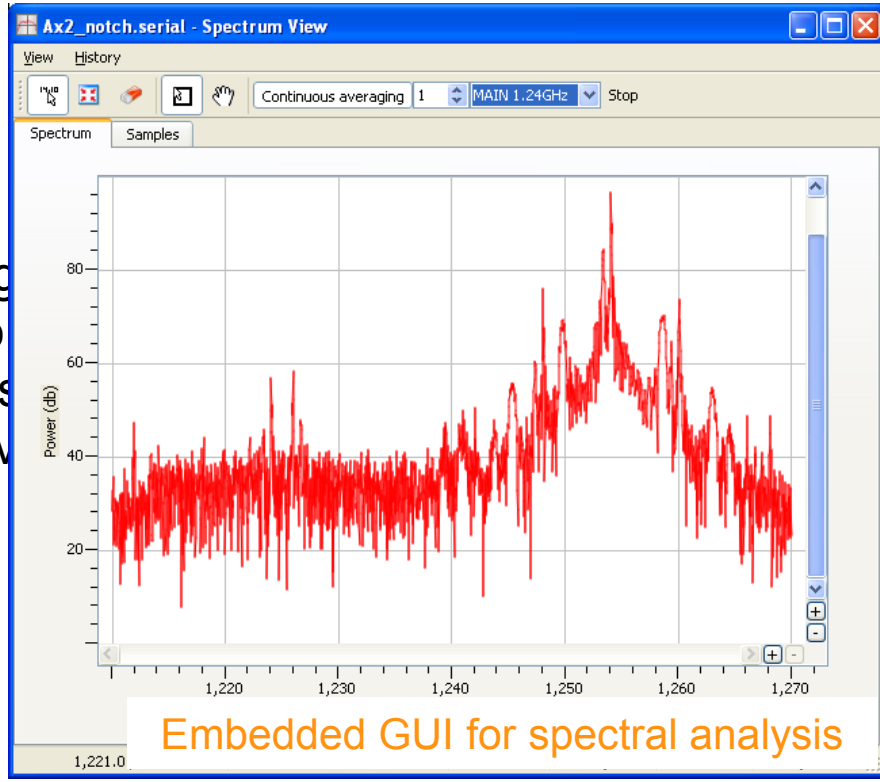
Intermittent interference hardest to detect



Septentrio
GNSS receiver

SBF
Protocol

Analog
Video
Transmiss
@ 1254 M



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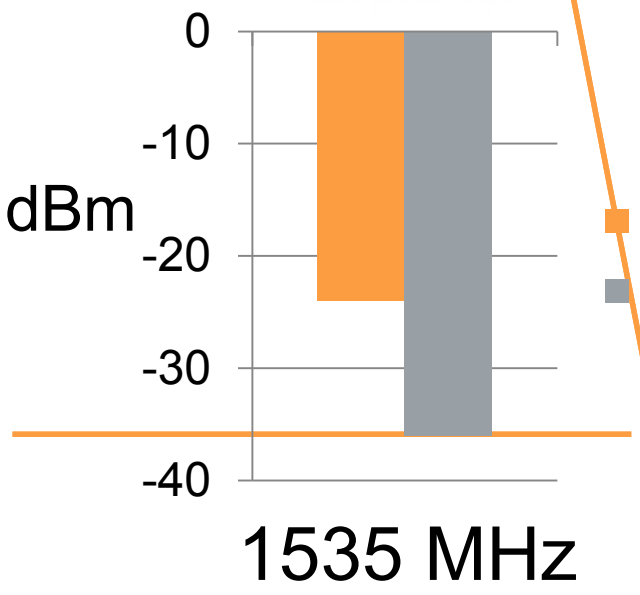
Much more than detection

AIM+ @ inteference

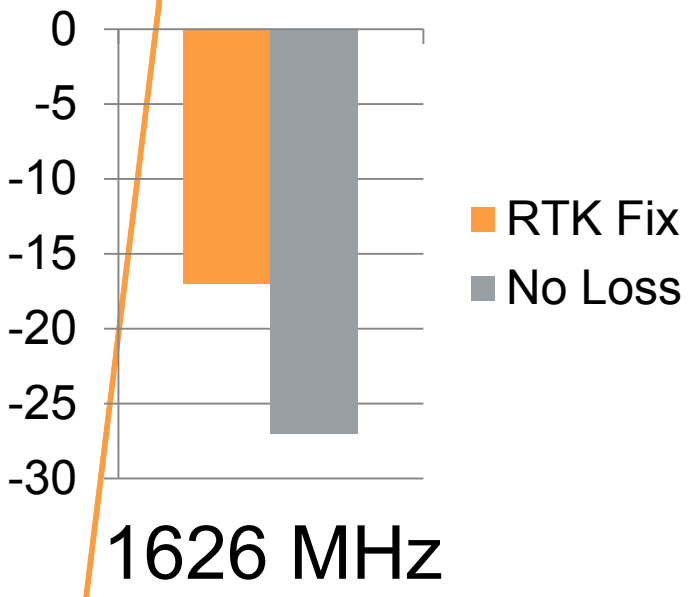
Out of band and adjecent bands rejection

docomo LTE Xi クロッシィ

ligado NETWORKS



inmarsat



GNSS L1

No Need Sharp Antenna Filters

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AIM+ Interference Mitigation

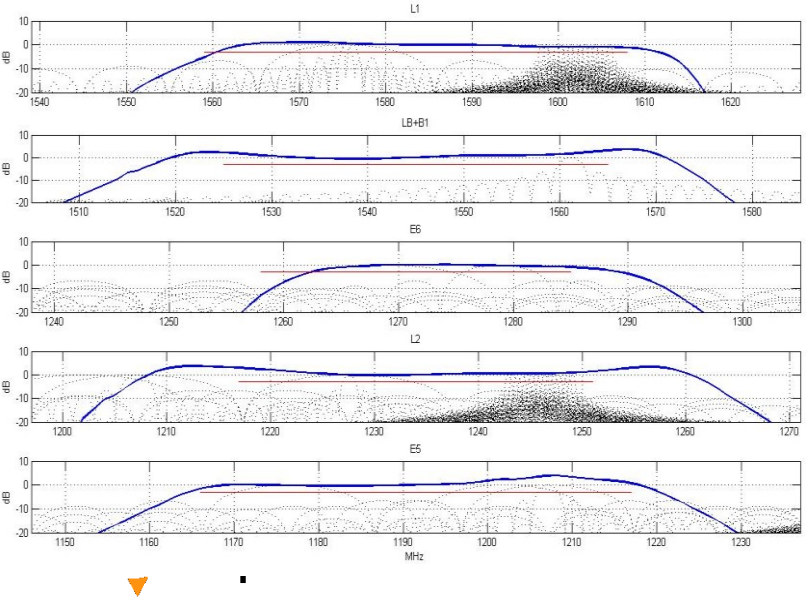
Out-of-band

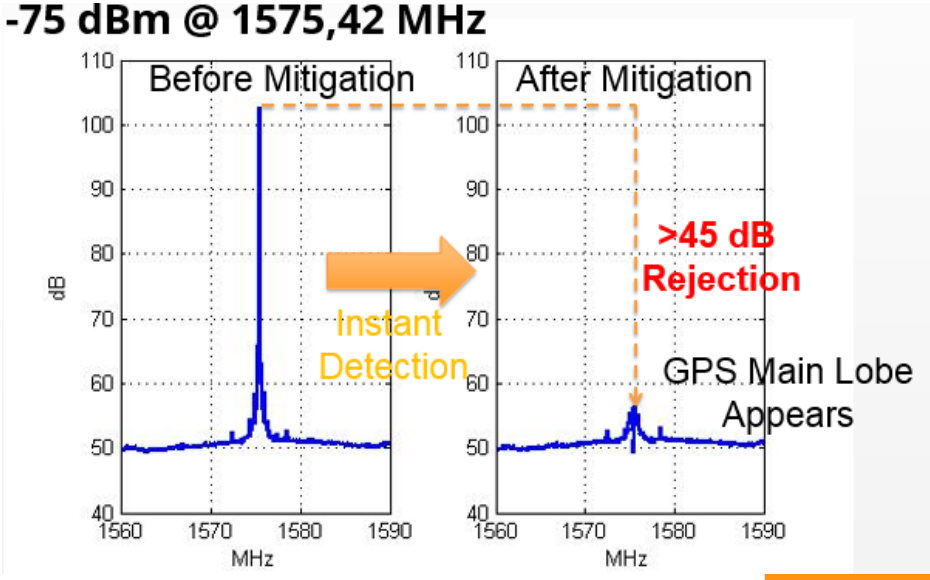
4 demodulators

Separated filtering for all bands

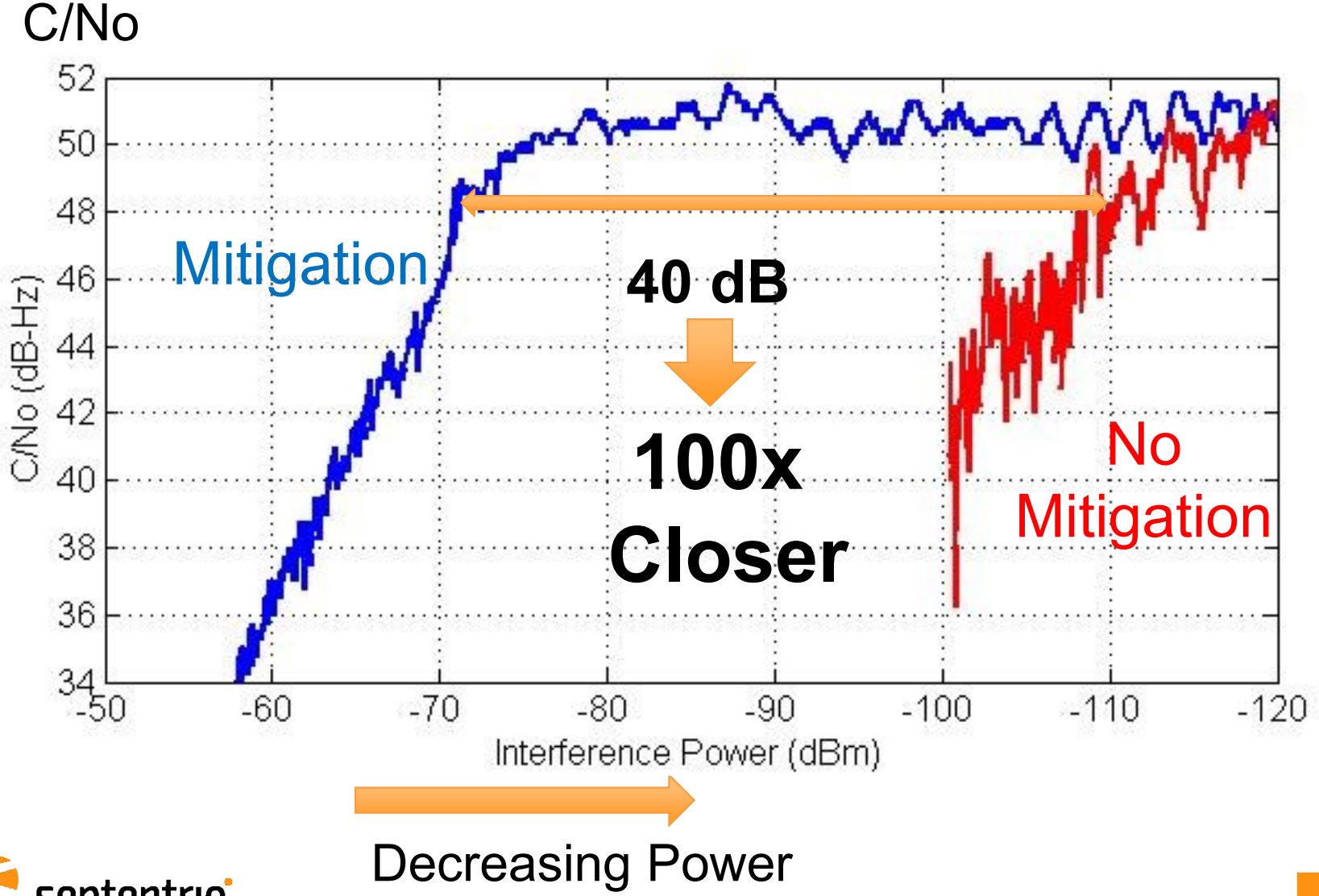
In-band

3 notch filters
Wide band mitigation unit
Pulse-blanking





Jamming GPS L1 Main Lobe



Hilversum, The Netherlands

Radio Amateur digipeater

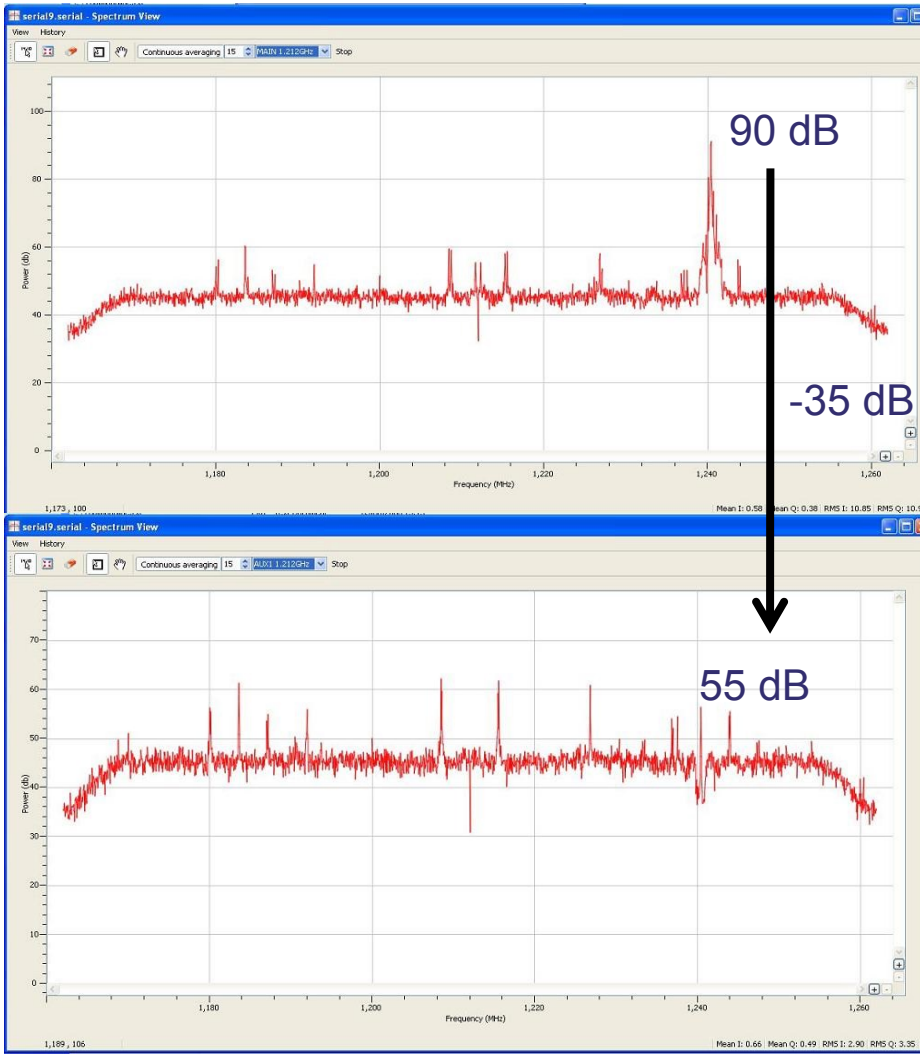
1240.4 MHz (GLO L2)

Narrowband interference

Transmits in bursts

2 second on / 8 seconds off

Mitigated with notch filter



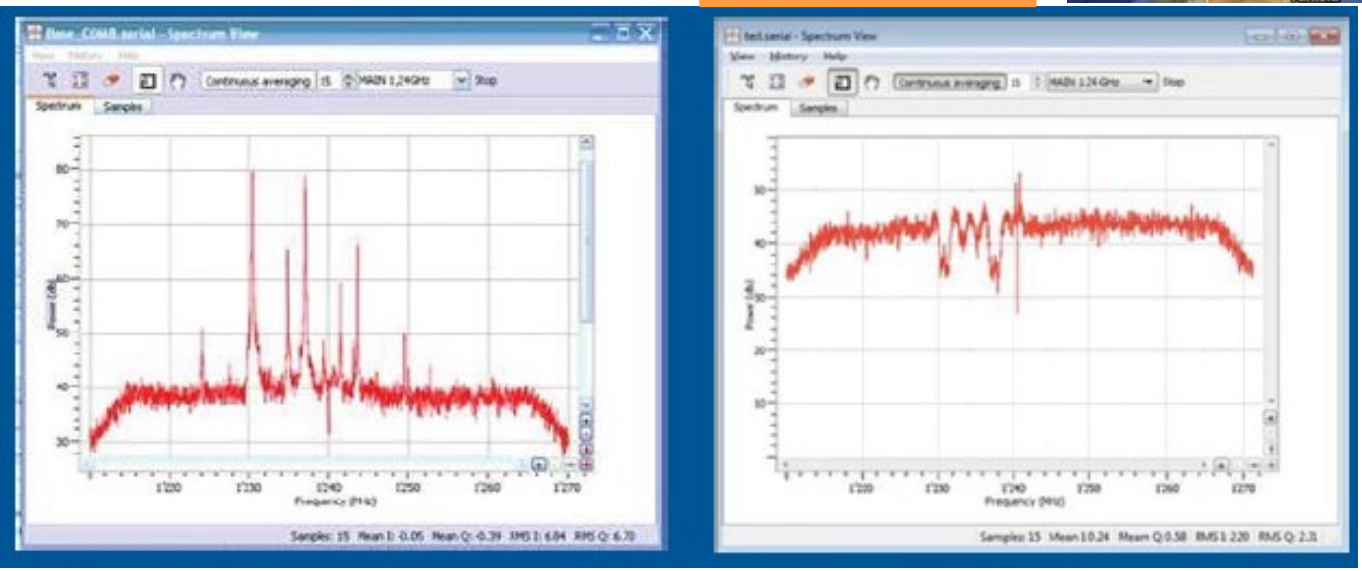
Tuymen, Russia

In-Band interference

Unknown source

GPS & GLO L2-Band

Mitigated with notch filter

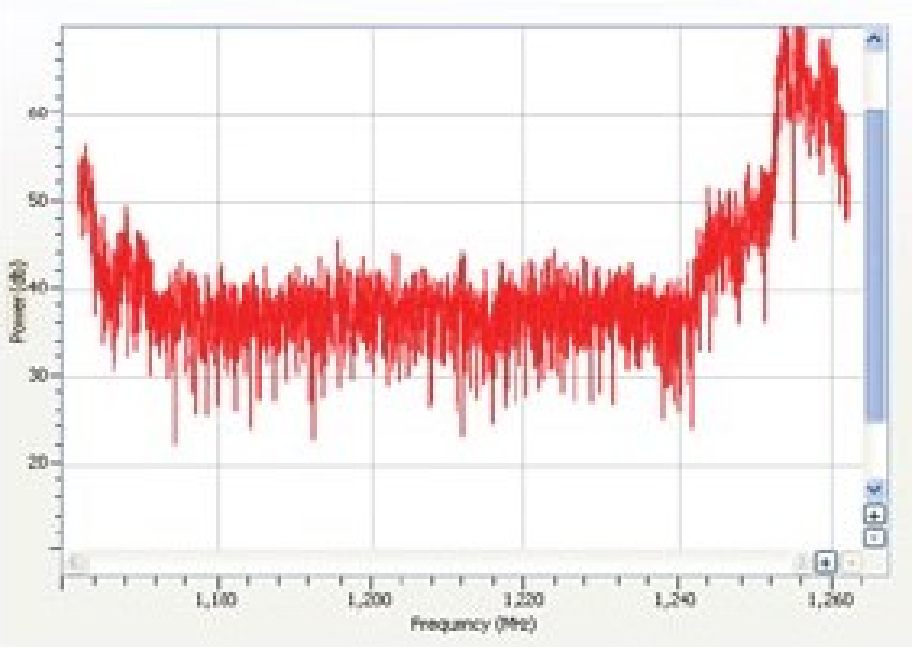


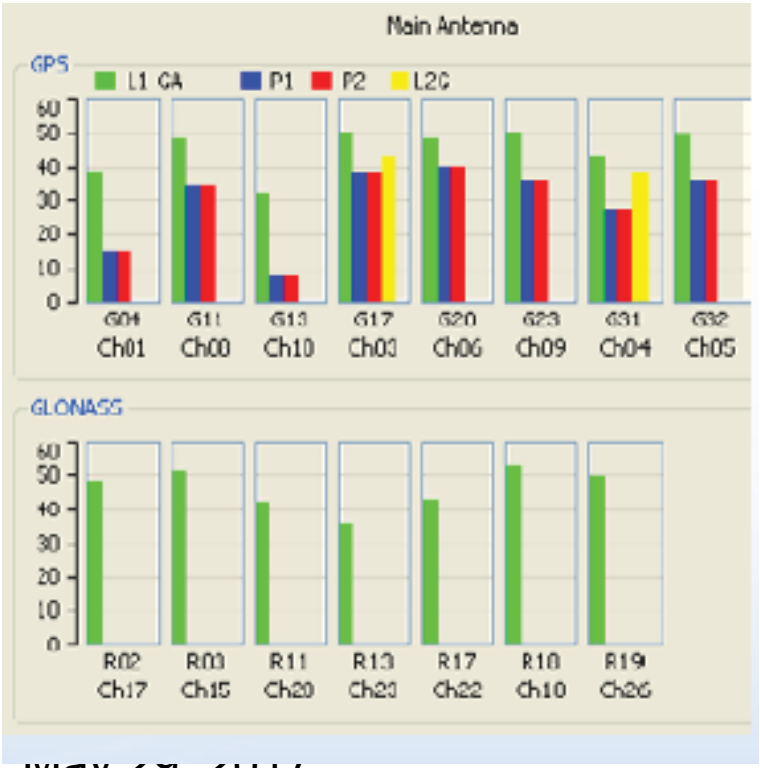
Ostende, Belgium

Broadband Amateur TV

1250MHz GLO L2

Spill over in GPS L2





In-Band interference – DME

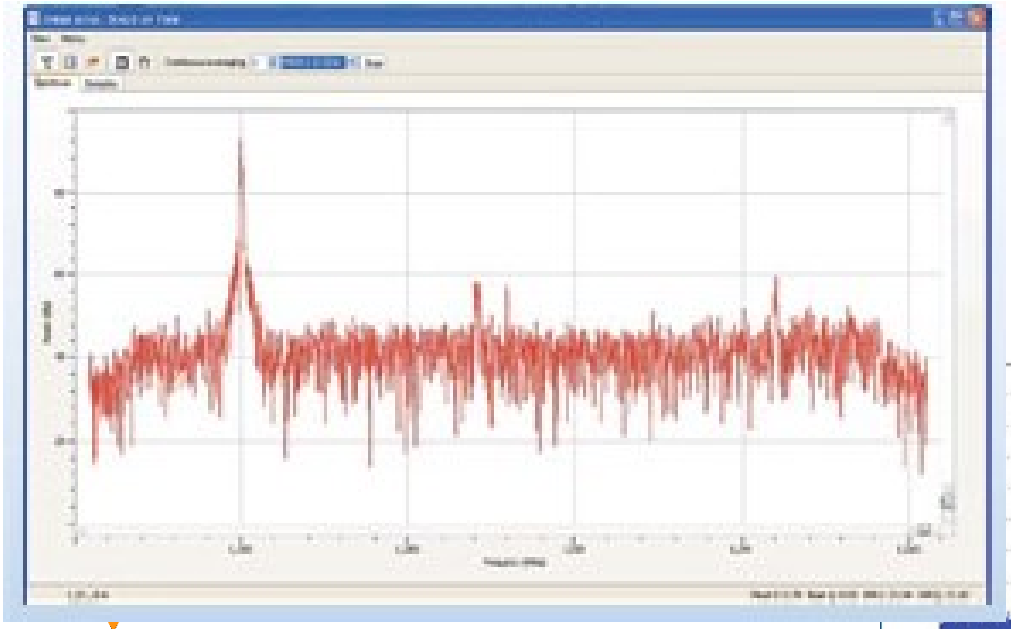
Distance Measurment Equipment (DME)

Tactical Air Navigation (TACAN)

Share band with GPS L5 and GALILEO E5

2700 high-power pulse pairs sent per second

Mitigated with notch filter
&
Pulse blanking



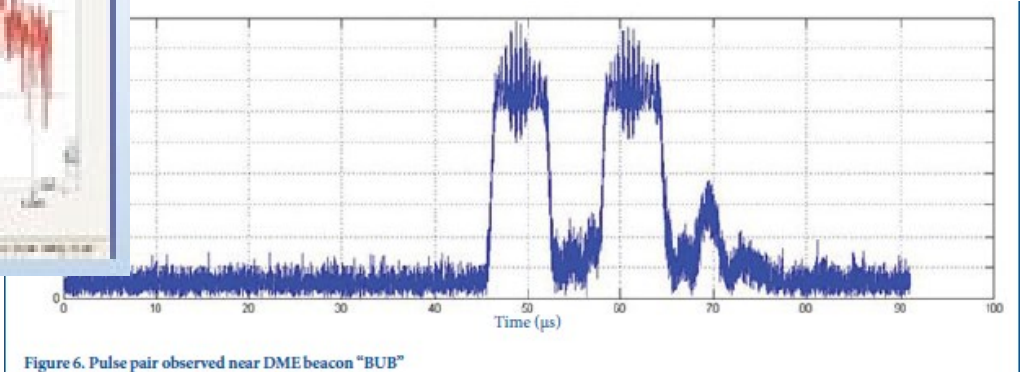
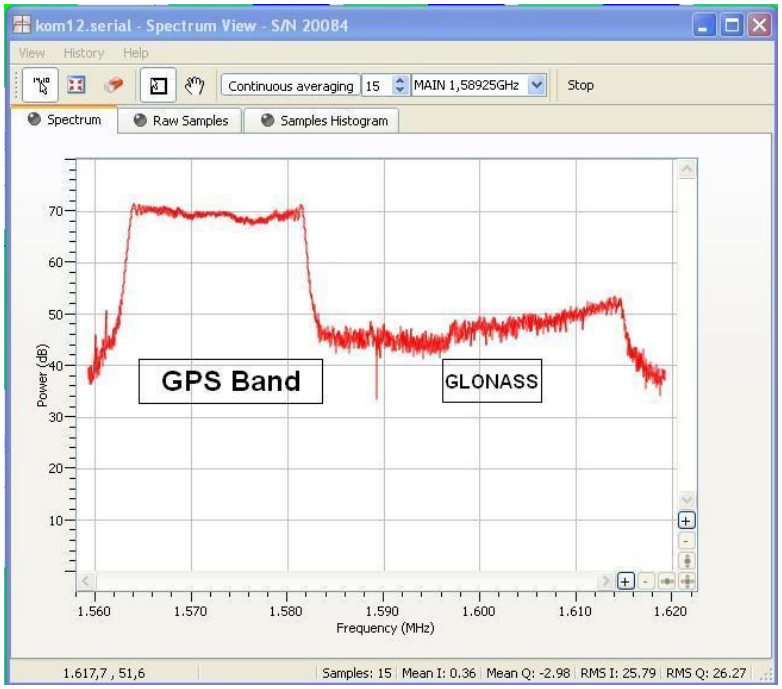


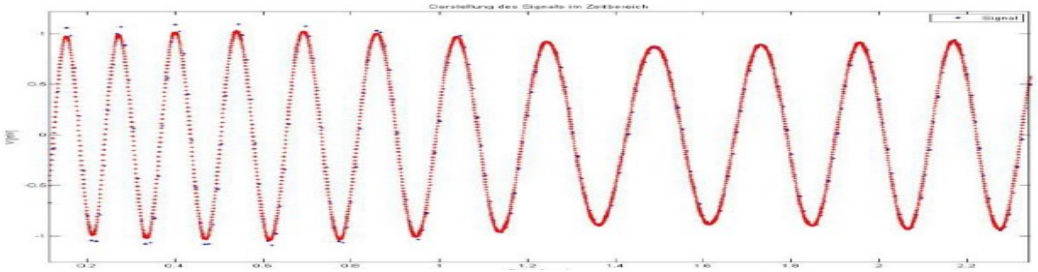
Figure 6. Pulse pair observed near DME beacon "BUB"

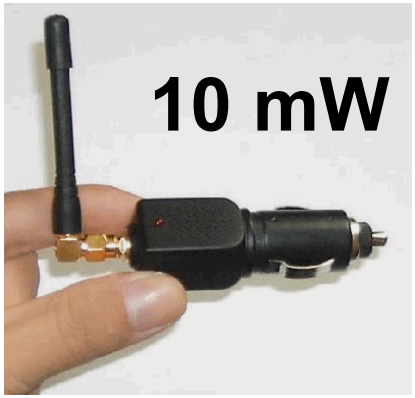
Chirp Jammer

Spectrum:



Time Domain:





4x 300 mW

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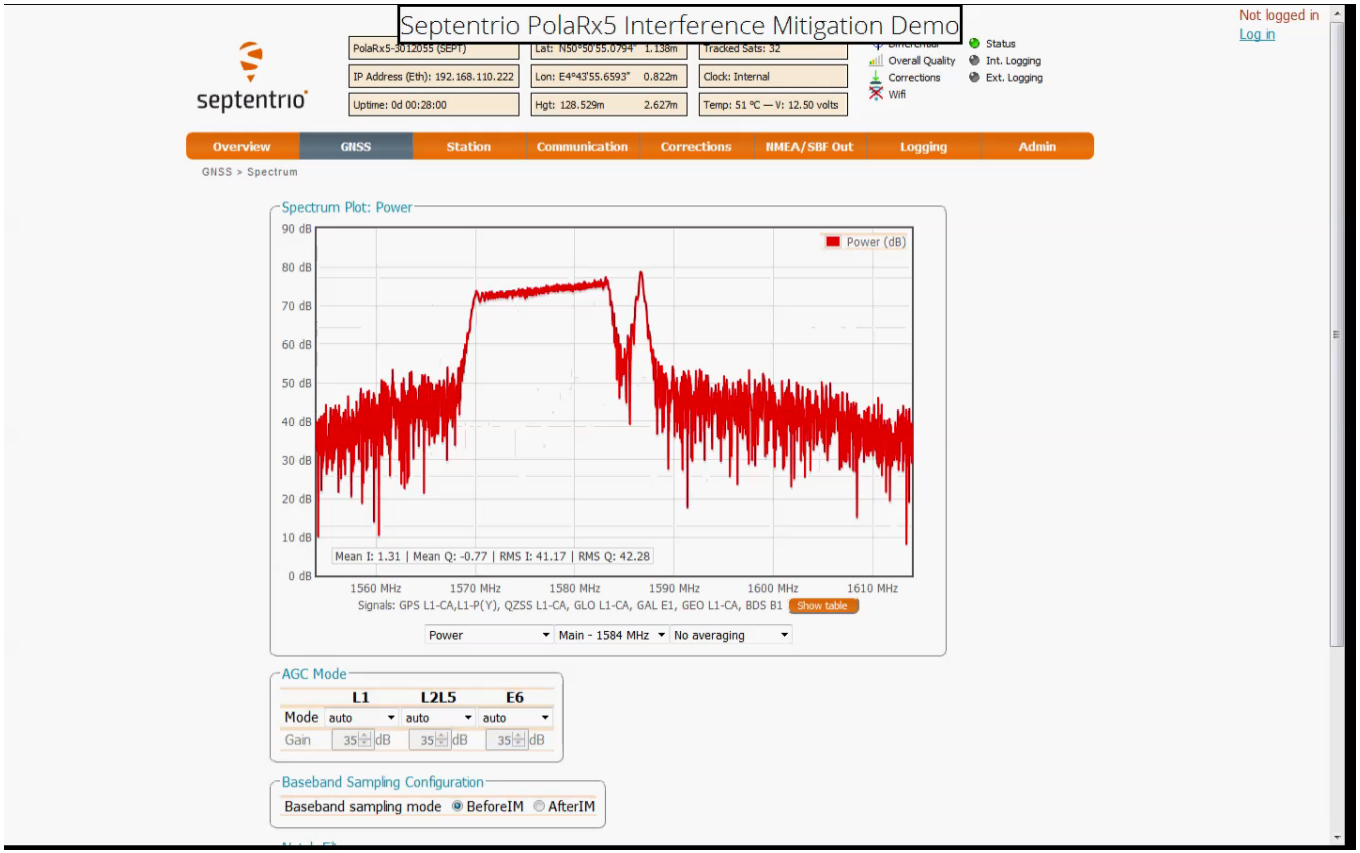
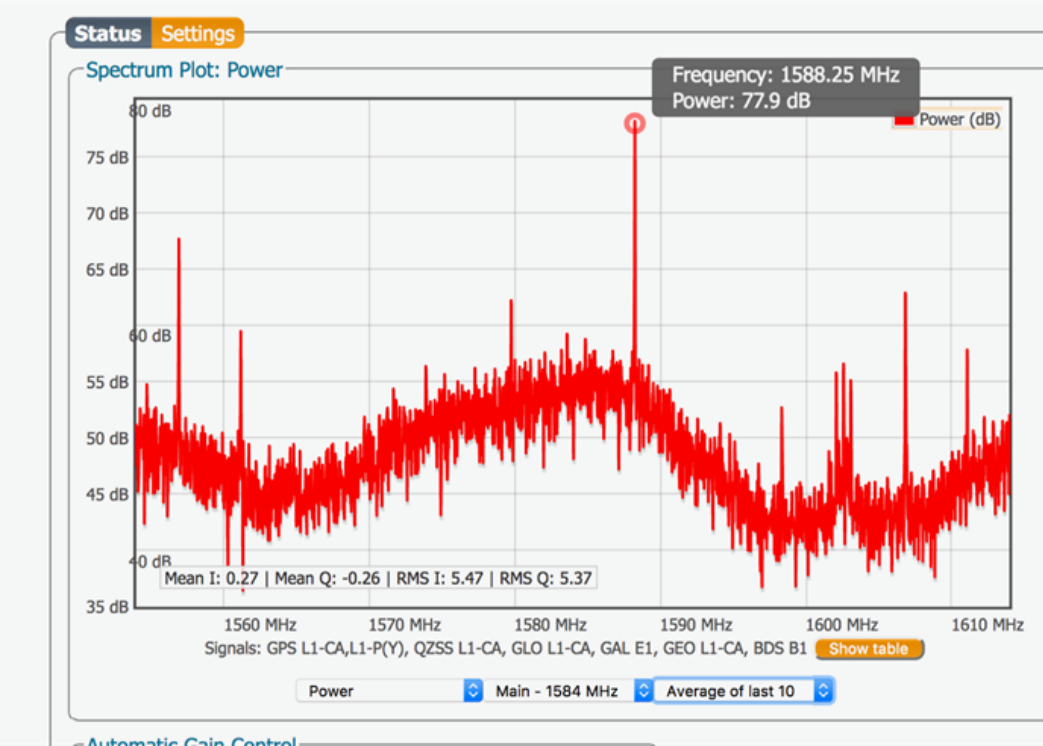

Septentrio PolaRx5 Interference Mitigation Demo
septentrio
PolaRx5-3012055 (SEPT)
IP Address (Eth): 192.168.110.222
Uptime: 0d 00:28:00
Lat: N50°50'55.0794" 1.138m
Lon: E4°43'55.6593" 0.822m
Hgt: 128.529m 2.627m
Tracked Sats: 32
Clock: Internal
Temp: 51 °C — V: 12.50 volts
Status
Overall Quality
Int. Logging
Corrections
Ext. Logging
Wifi
Not logged in
Log in
Overview
GNSS
Station
Communication
Corrections
NMEA/SBF Out
Logging
Admin
GNSS > Spectrum
Spectrum Plot: Power
Power (dB)
90 dB
80 dB
70 dB
60 dB
50 dB
40 dB
30 dB
20 dB
10 dB
0 dB
Mean I: 1.31 | Mean Q: -0.77 | RMS I: 41.17 | RMS Q: 42.28
1560 MHz
1570 MHz
1580 MHz
1590 MHz
1600 MHz
1610 MHz
Signals: GPS L1-CA,L1-P(Y), QZSS L1-CA, GLO L1-CA, GAL E1, GEO L1-CA, BDS B1
Show table
Power
Main - 1584 MHz
No averaging
AGC Mode
L1
L2L5
E6
Mode
auto
Gain
35 dB
Baseband Sampling Configuration
Baseband sampling mode
BeforeIM
AfterIM

When it looks like Interference…but it is a broken LNA…

- Change in amplitude – T dependent
- Gradual and very significant frequency drift
- From one modus to another
- Loss on other frequency bands

Conditional stability



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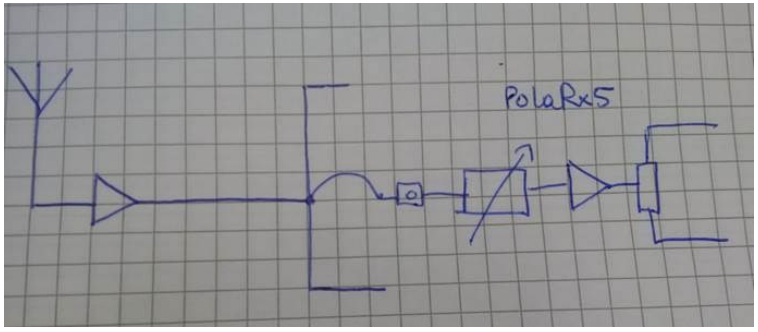
Explanation on the impedance

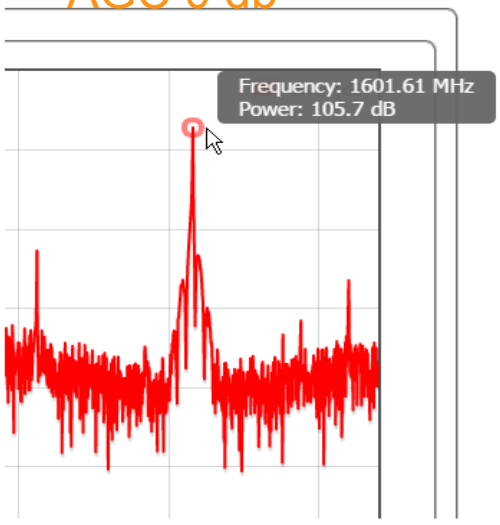
Minimalistic schematic of the set-up with for the antenna & receiver:



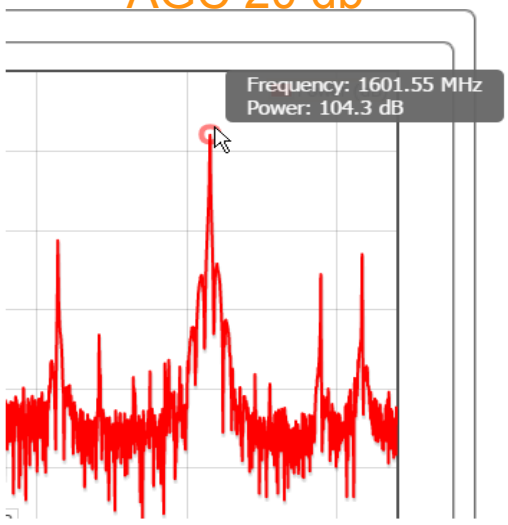
If the interference is external/environmental → changing AGC = no impact on IF

Resonating antenna LNA → change AGC = IF frequency shift.

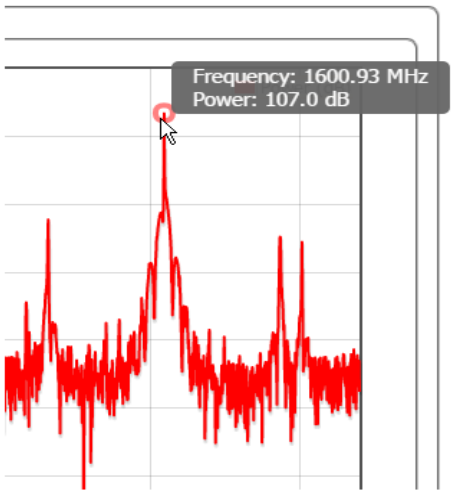
AGC 0 db



AGC 20 db



AGC 50 db



Data storage integrity

Storage integrity

Data collected by GNSS receivers are typically either streamed or FTP pushed to a server.

During telemetry it can happen that data packages are lost and that the files at the server side differ from what logged on the receiver.

So far, to recover the missing information, retransmitting the complete file was required.

Transmitting data can be expensive, especially when using Iridium telemetry and creates an unnecessary overhead.

Storage integrity

Fast differencing algorithm → delta encoding to minimize network usage

Only transfer the deltas
Reduce number of bytes
Lower the bill

Errors during transmission could be present →
Data gap in any part of the file

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Workflow

- Users configure data recording on an external computer
- Users configure the exact same recording on the internal disk of the receiver
- Synchronization scheduled on regular basis on the external computer to fetch data which would have been lost in the communication
- File names must be the same on both sides
- Requires disk access privileges (*setDefaultAccessLevel* and *setUserAccessLevel* commands)
- Storage integrity is usable with an SSH key (to avoid being prompt for password)

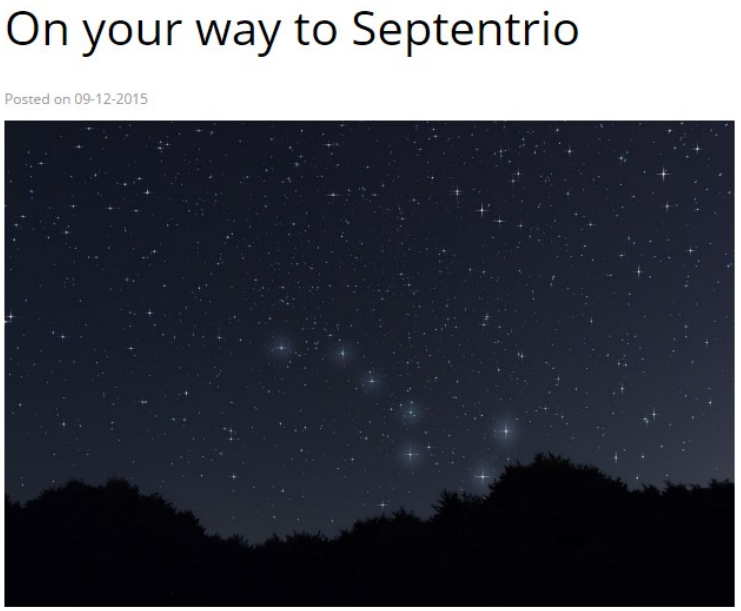
3 take away

Septentrio is a Belgian manufacturer of high end GNSS receiver

Interference is a real threat and is widely diffused. Septentrio has effective ways to monitor and mitigate it.

Optimize synchronization achieving data integrity by only transferring the deltas

Much more @ the booth



Laurent, Guy and I will be happy

to answer more questions offline and talk further about Septentrio technology

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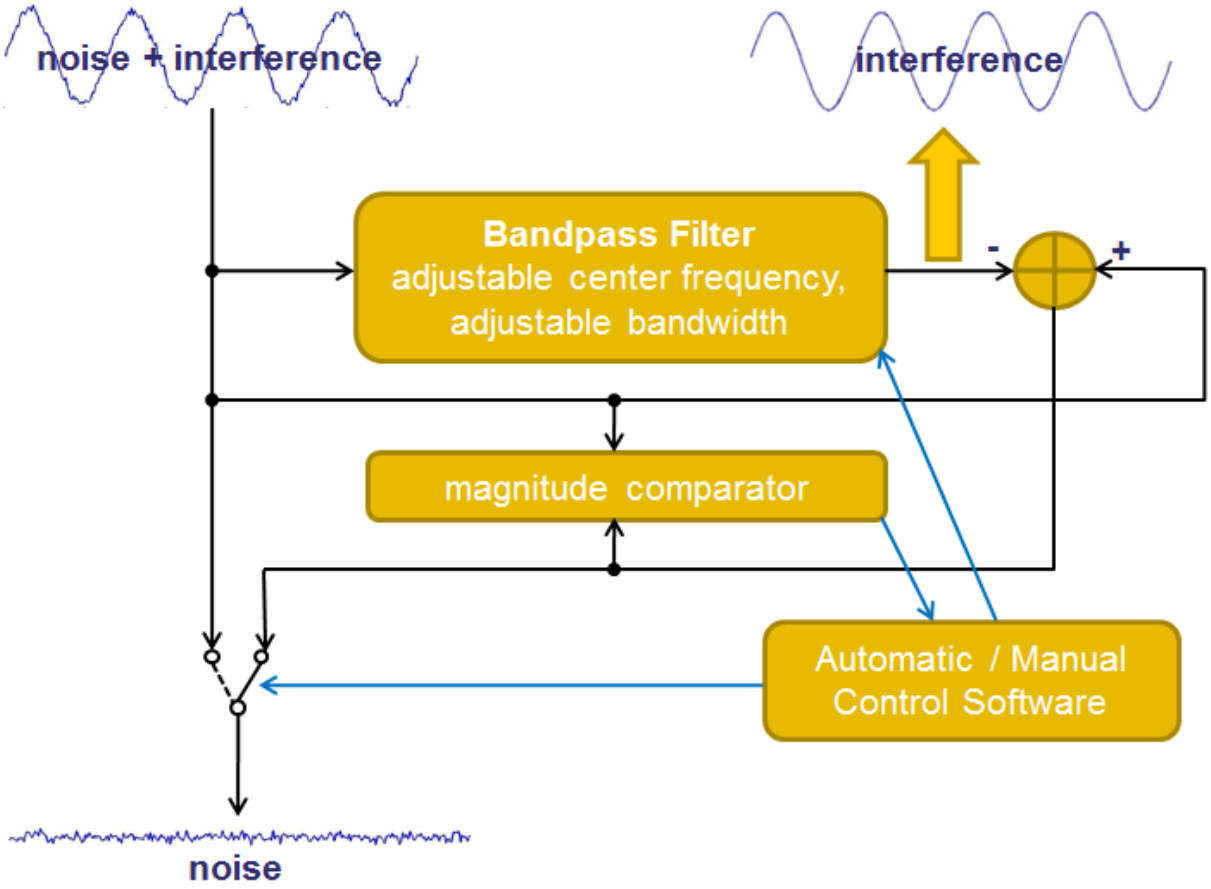
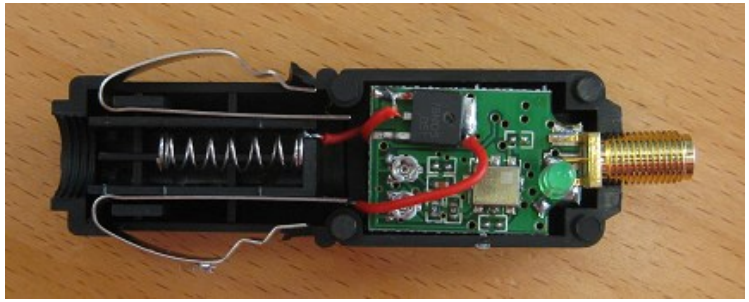
Back-up slides

Interference



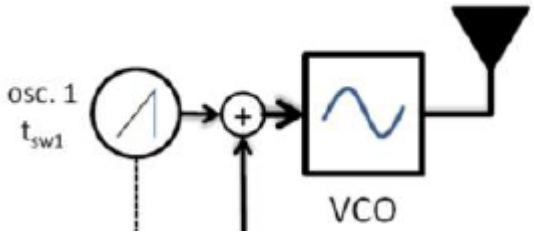
Jammer Operating Principles

Cheap circuit

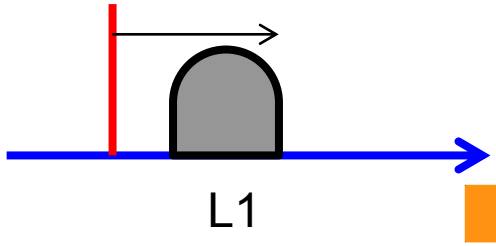


Two types:

- Pure sine-wave (CW)
  - VCO + manual tuning
  - Significant drift over temperature
  - Effective for narrowband
  - Can be mitigated by AIM+



- Chirp type
  - Frequency sweep sine wave
  - Sweep makes sure to hit L1
  - Less impact on narrowband
  - Septentrio has technology available to mitigate



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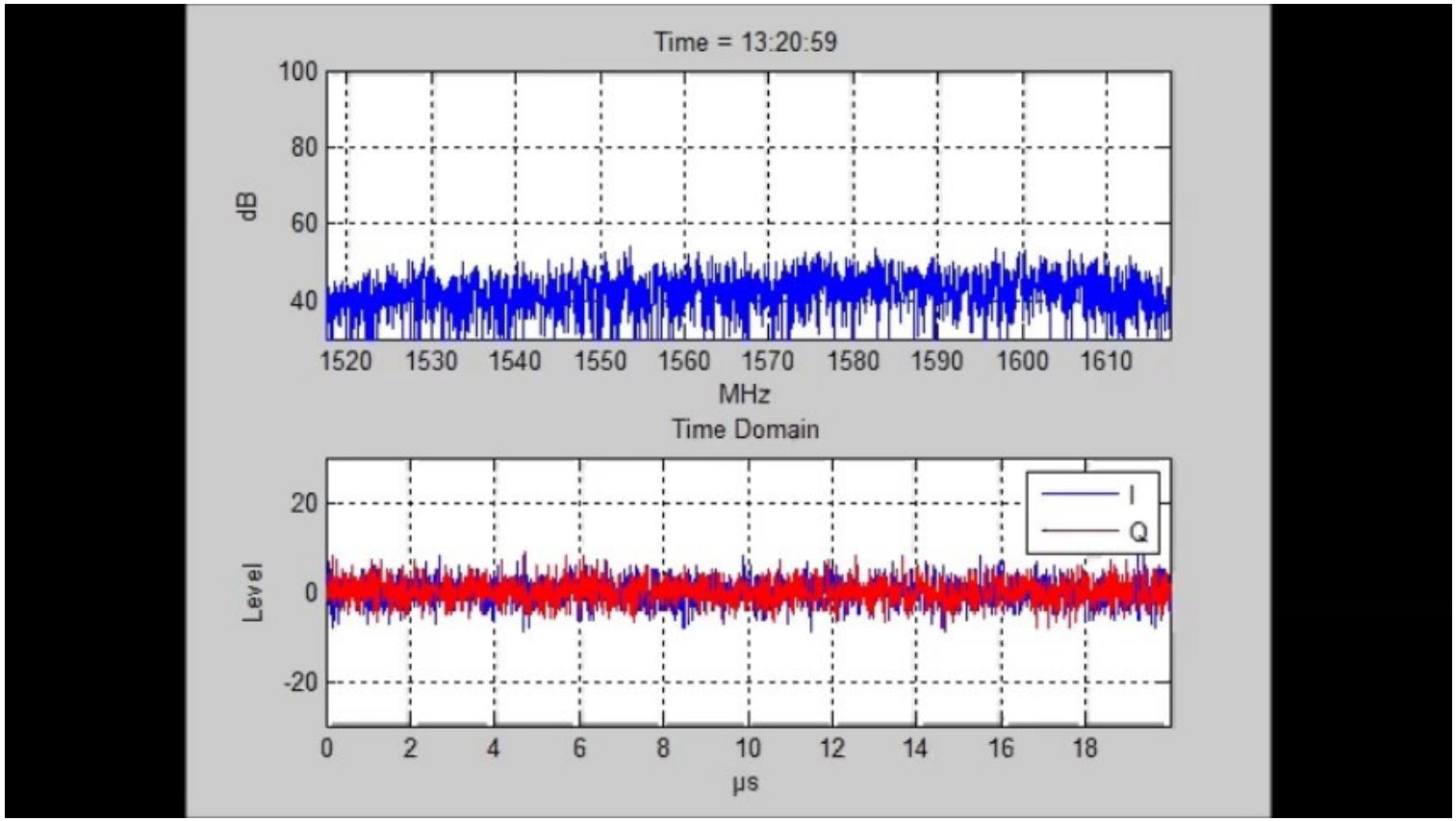
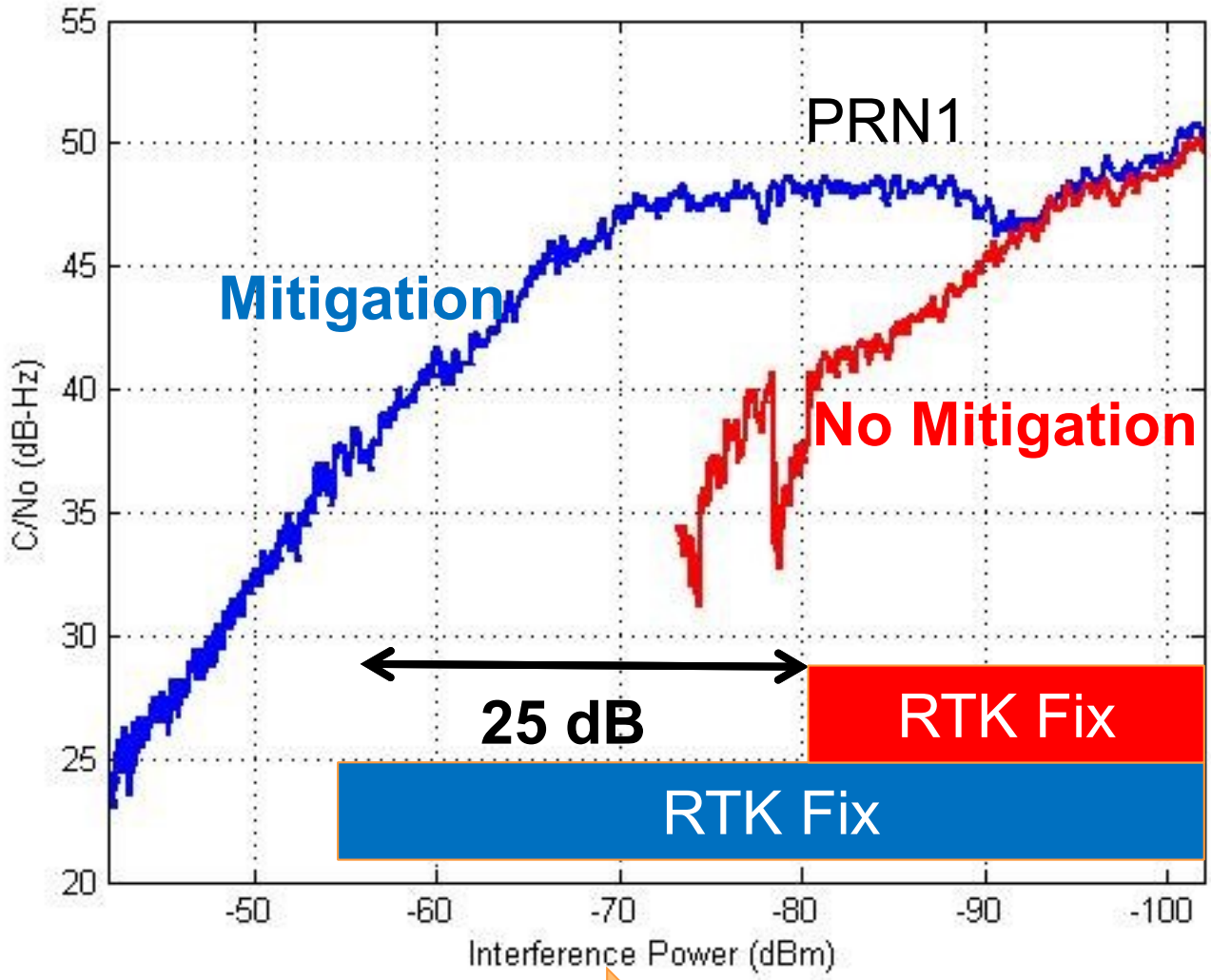
Chirp jammer in action



With AIM…Rejection



Decreasing Power

Jammer Detection

C/No

- One band much worse than others

Histogram

- Normal signal (noise): Gaussian distribution
- Jammer: sine-wave distribution