Quantifying UAV self-interference patterns on its GNSS positioning equipment

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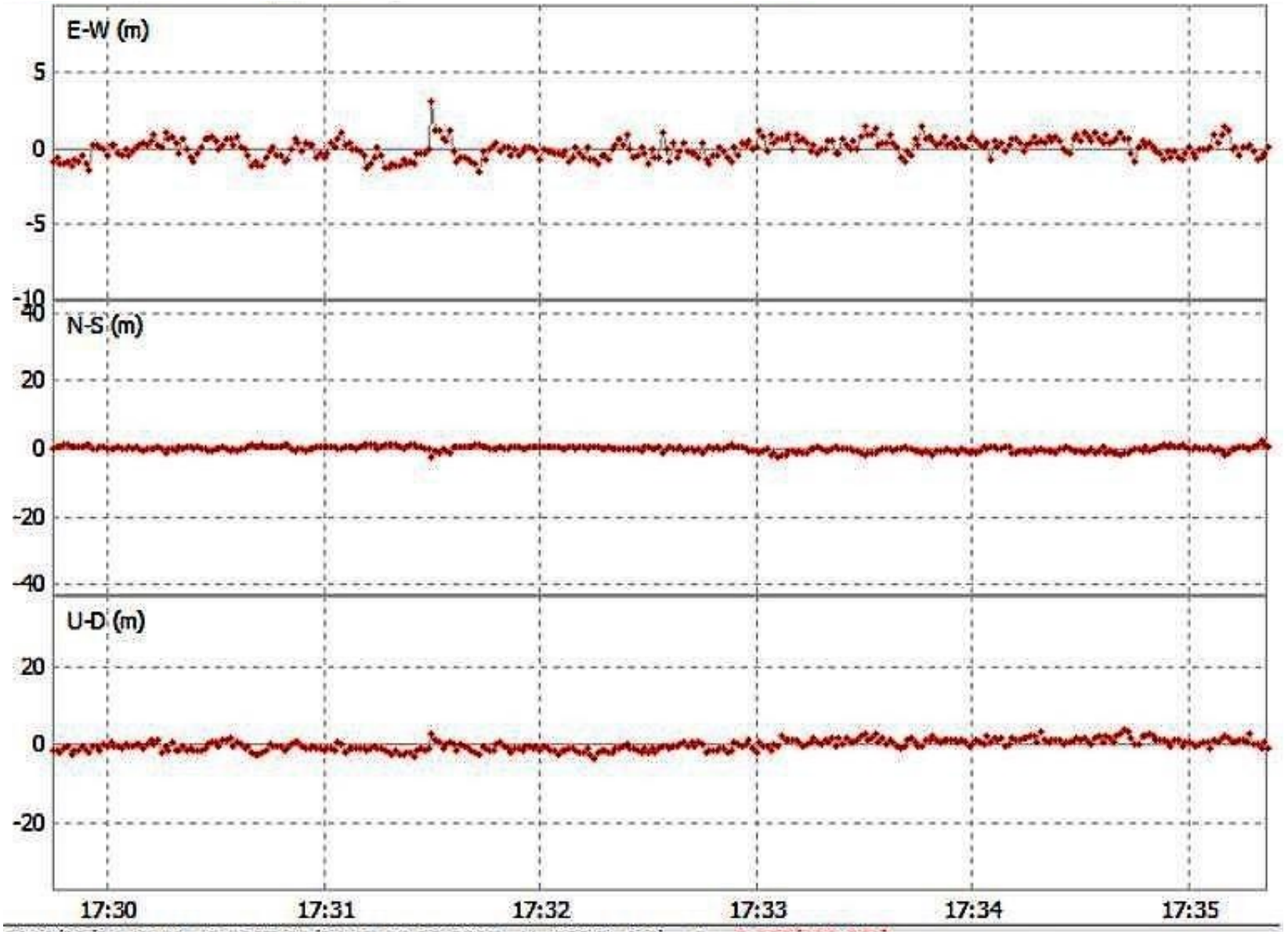
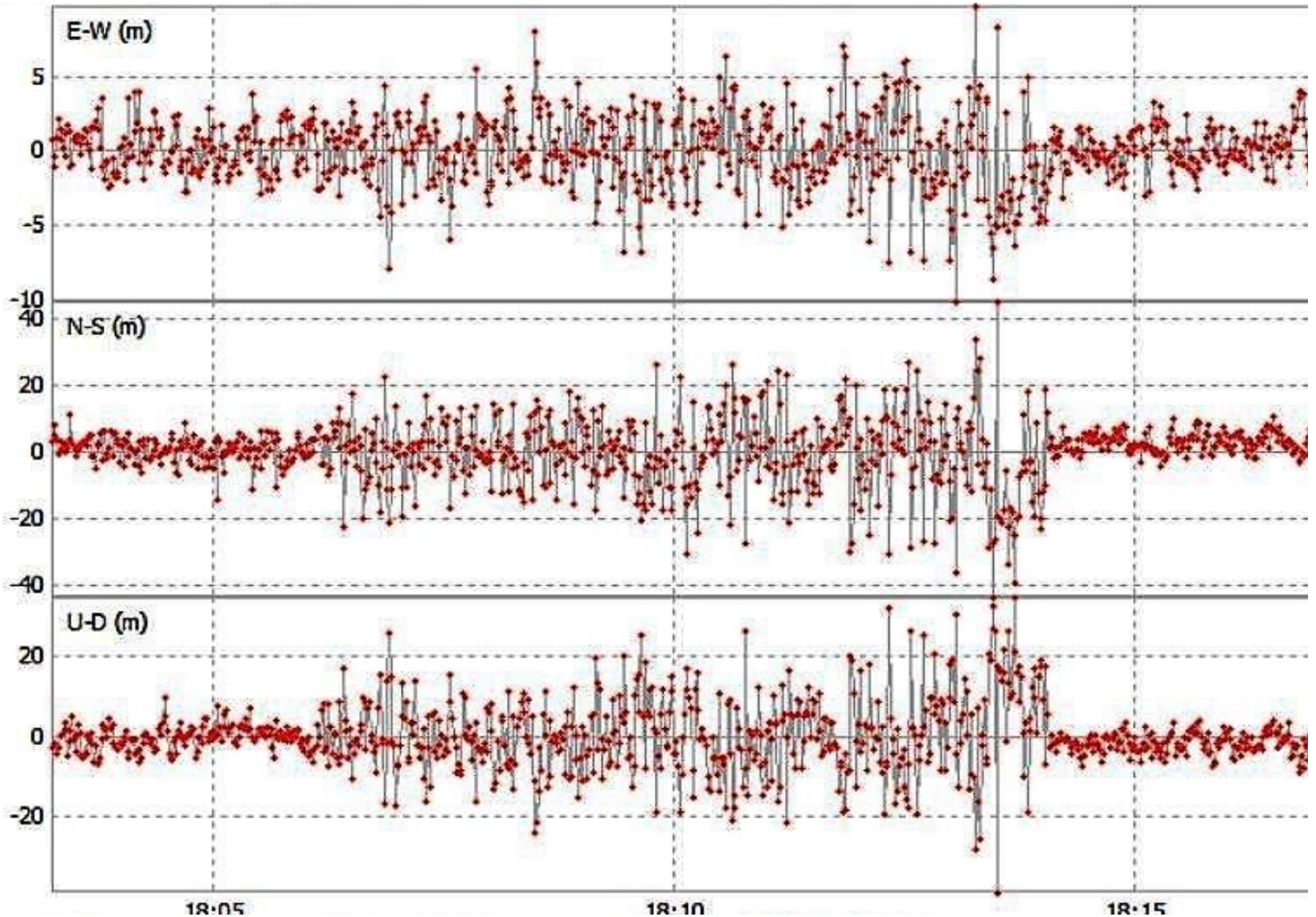
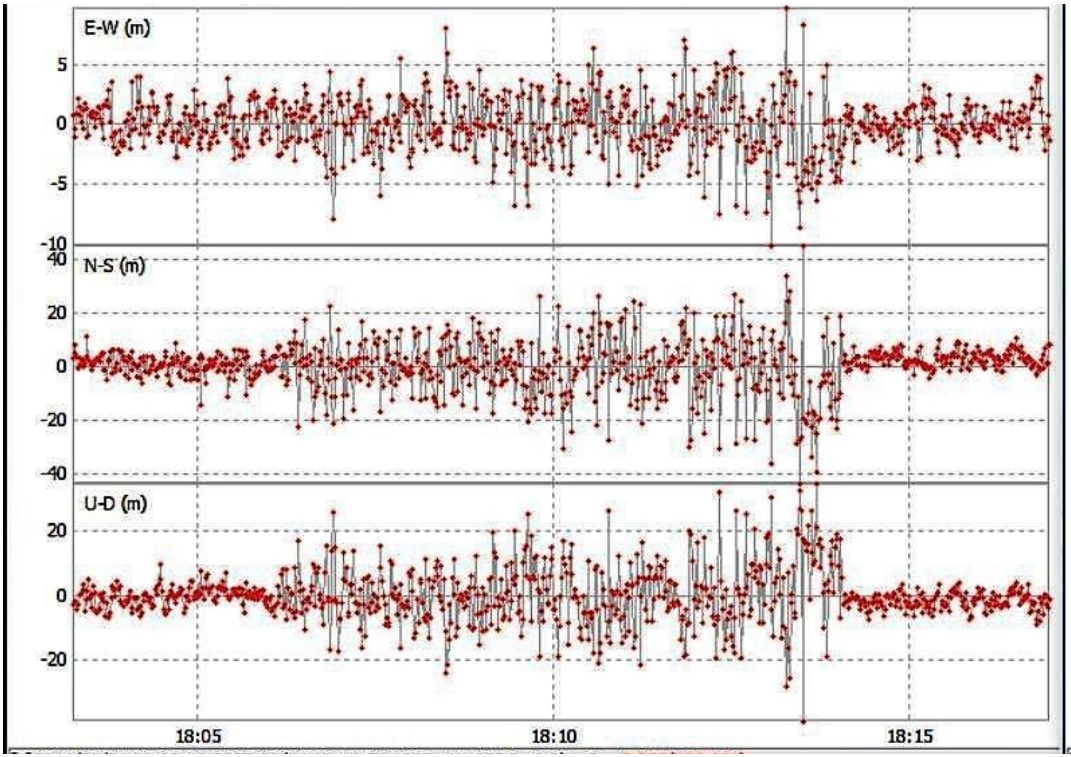
Position output – UAV OFF

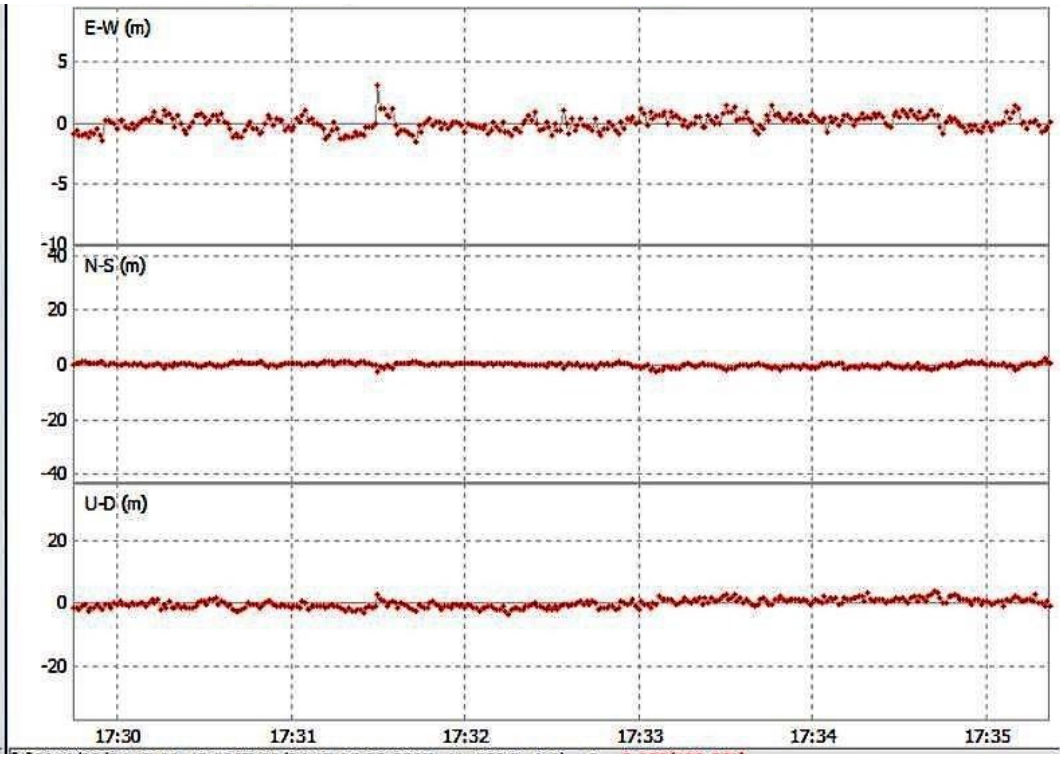


Position output – UAV ON



Position output





Why is this happening?

How can it be avoided?

UAV parts

- 8 motors,
- 3 batteries (6.2 Ah each),
- Pixhawk flight controller,
- Telemetry radio (915 MHz),
- Controller radio (2.4 Ghz).

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Performed tests

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- Test #1 - Inside anechoic chamber with UAV powered off and on

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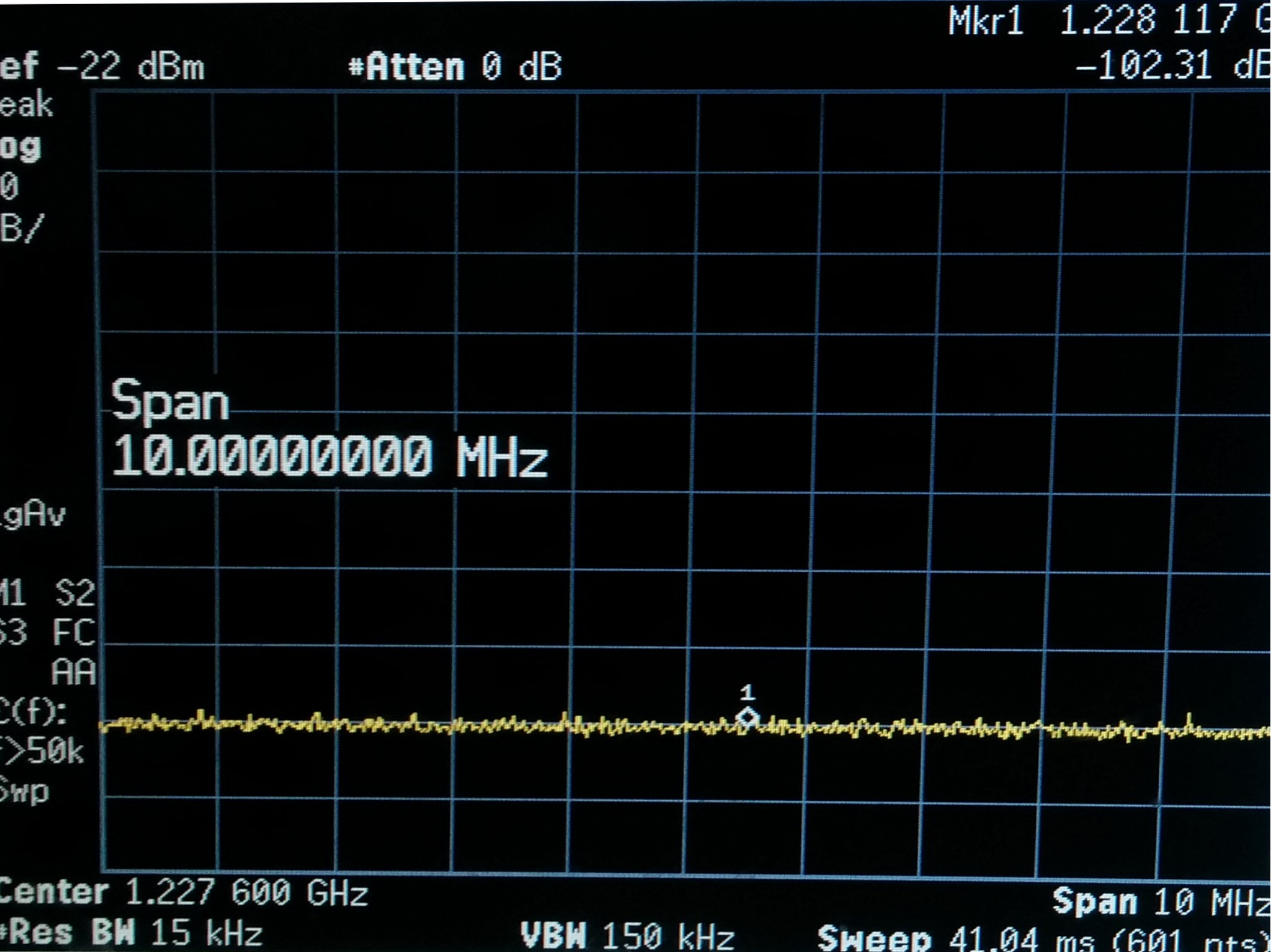
- Test #2 – Open-sky with UAV powered off and on

Test #1

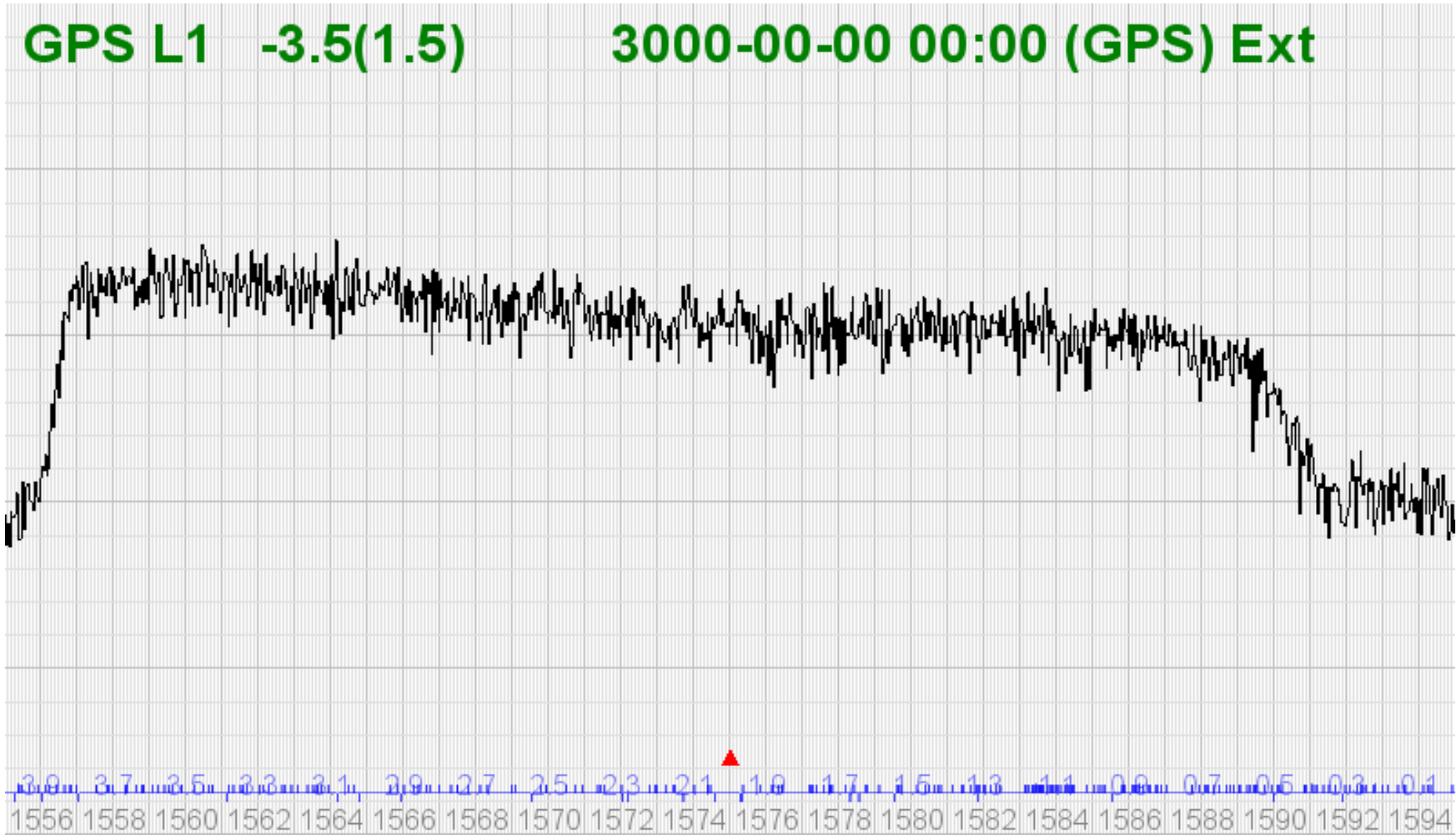
Test #1

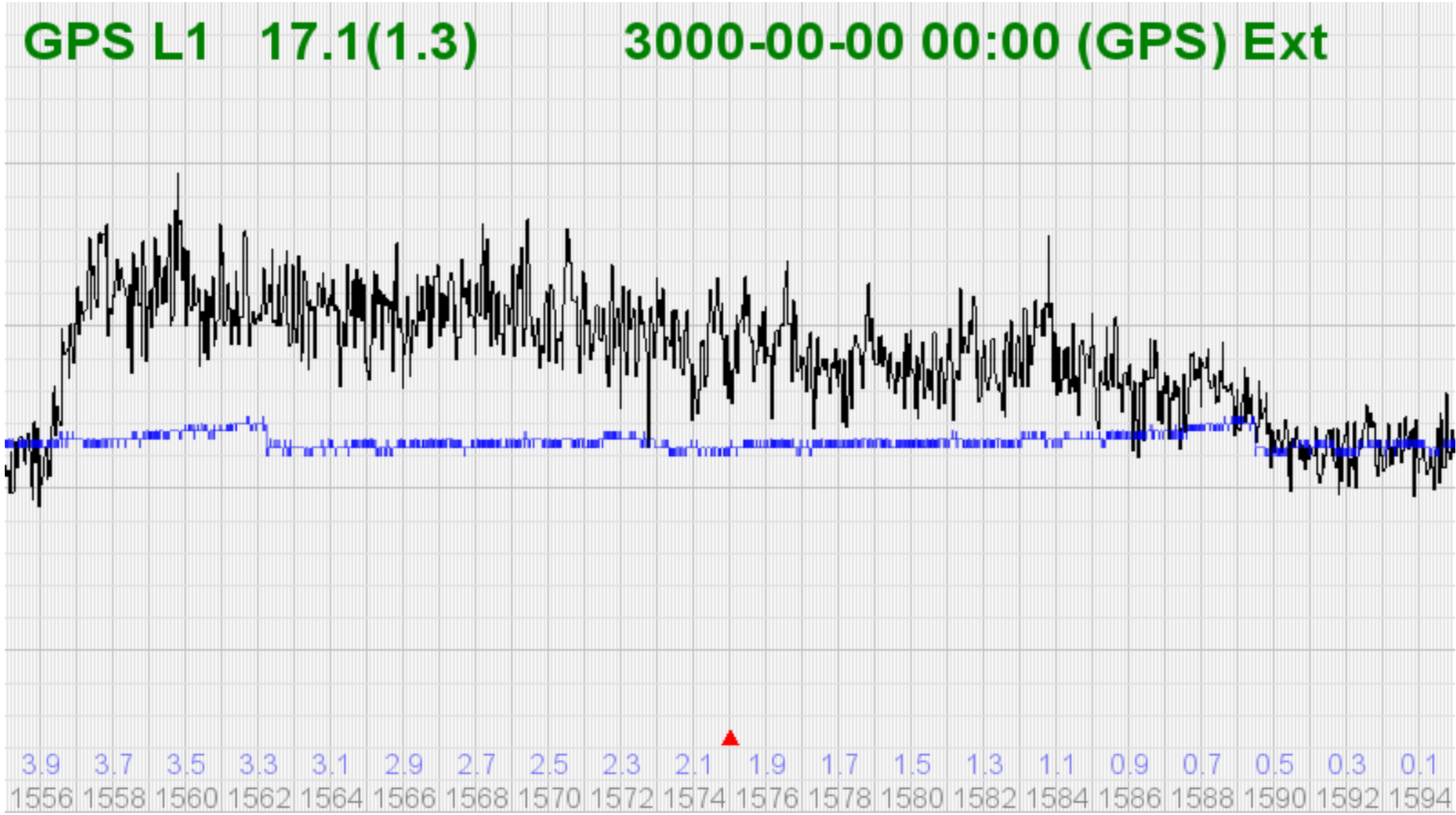
- Agilent E4440a spectrum analyzer
- Anechoic chamber
- UAV off and on


Mkr1 1.228 117 G
ef -22 dBm
#Atten 0 dB
-102.31 dB
eak
og
0
B/
Span
10.00000000 MHz
gAv
M1 S2
S3 FC
AA
C(f):
>50k
Swp
1
Center 1.227 600 GHz
Span 10 MHz
#Res BW 15 kHz
VBW 150 kHz
Sweep 41.04 ms (601 pts)

Test #1 (second try)

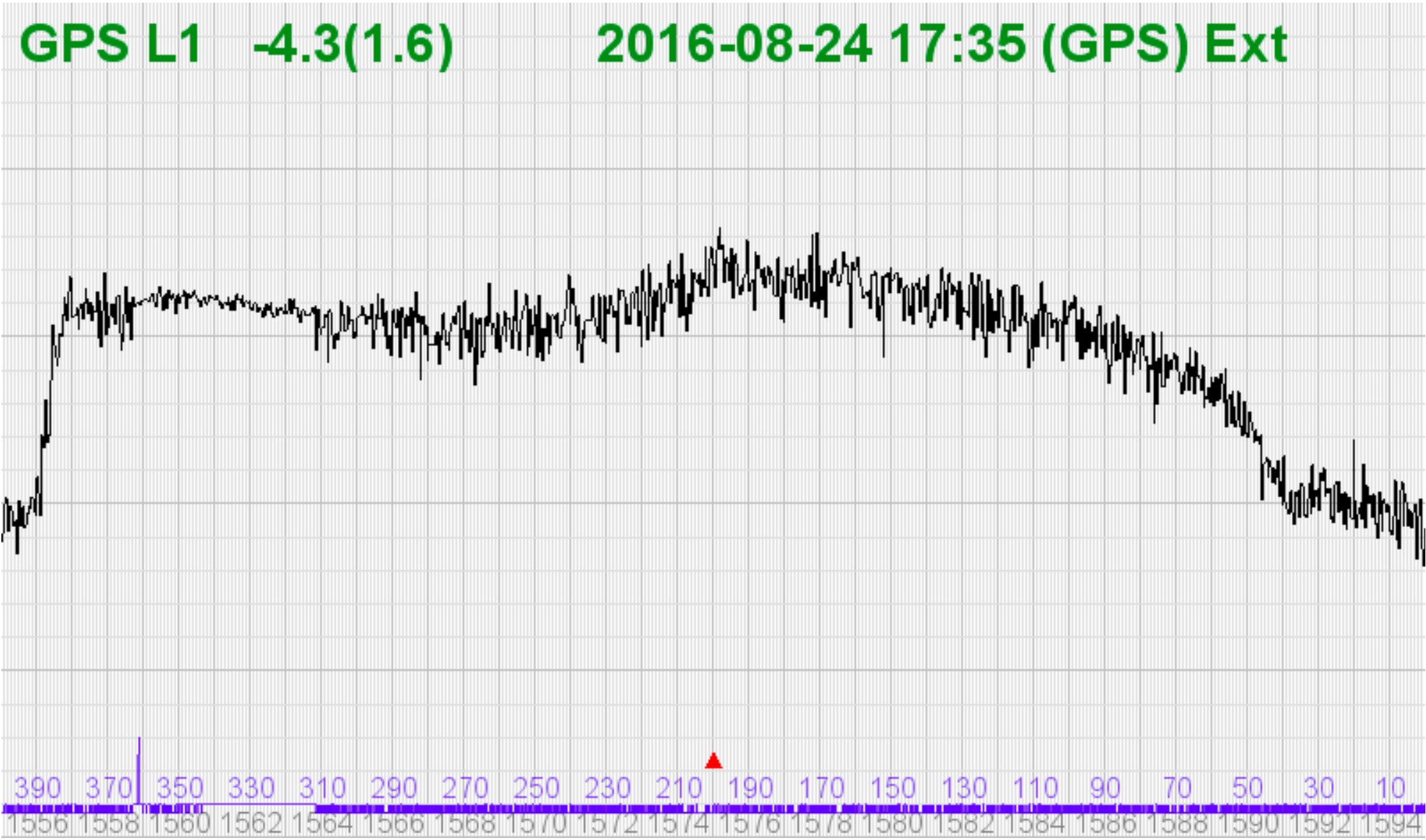
- Javad Triumph LS spectrum analyzer
- Anechoic chamber
- UAV off and on

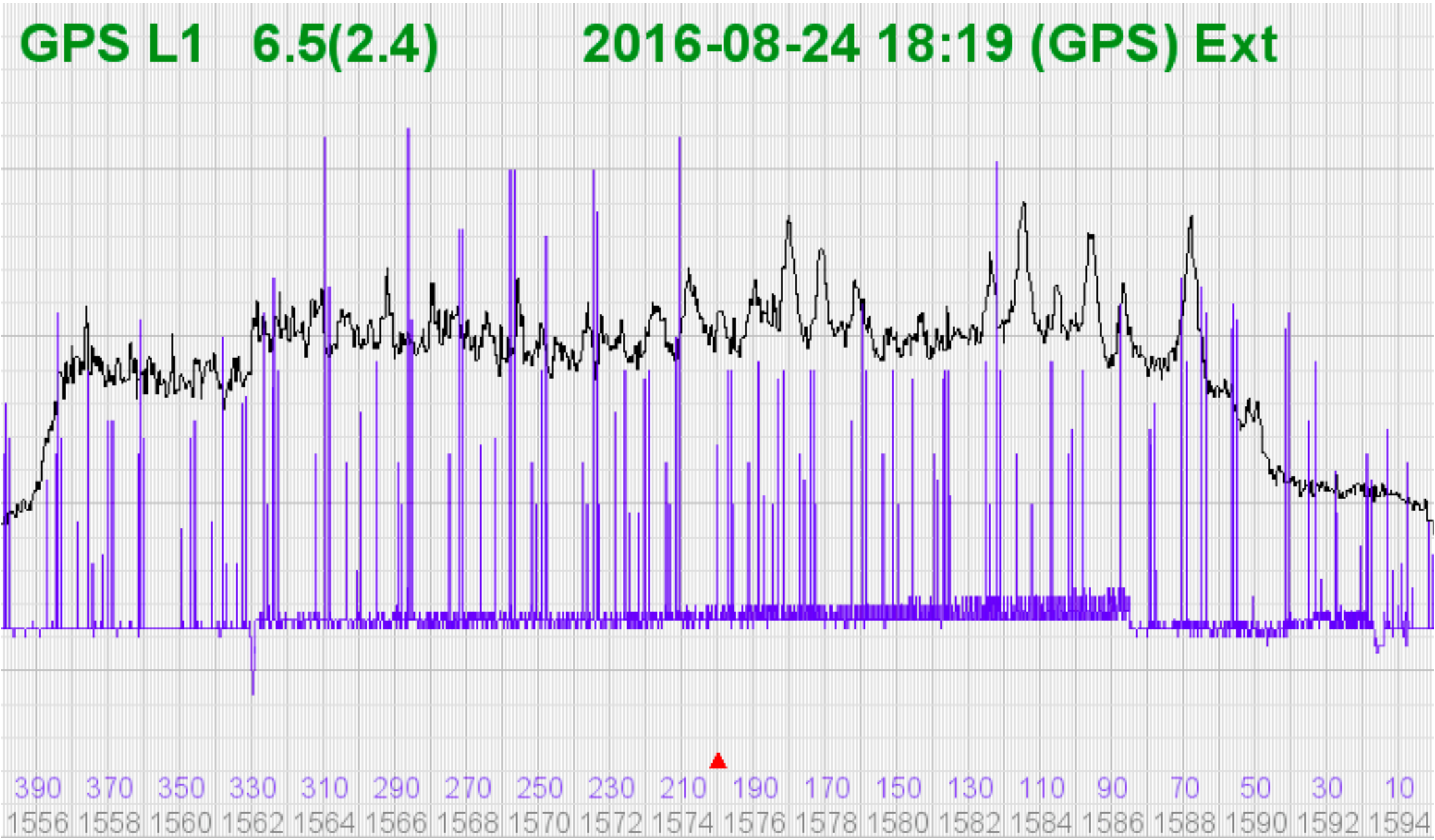

GPS L1 -3.5(1.5) 3000-00-00 00:00 (GPS) Ext
1556 1558 1560 1562 1564 1566 1568 1570 1572 1574 1576 1578 1580 1582 1584 1586 1588 1590 1592 1594


GPS L1 17.1(1.3)
3000-00-00 00:00 (GPS) Ext
3.9 3.7 3.5 3.3 3.1 2.9 2.7 2.5 2.3 2.1 1.9 1.7 1.5 1.3 1.1 0.9 0.7 0.5 0.3 0.1
1556 1558 1560 1562 1564 1566 1568 1570 1572 1574 1576 1578 1580 1582 1584 1586 1588 1590 1592 1594

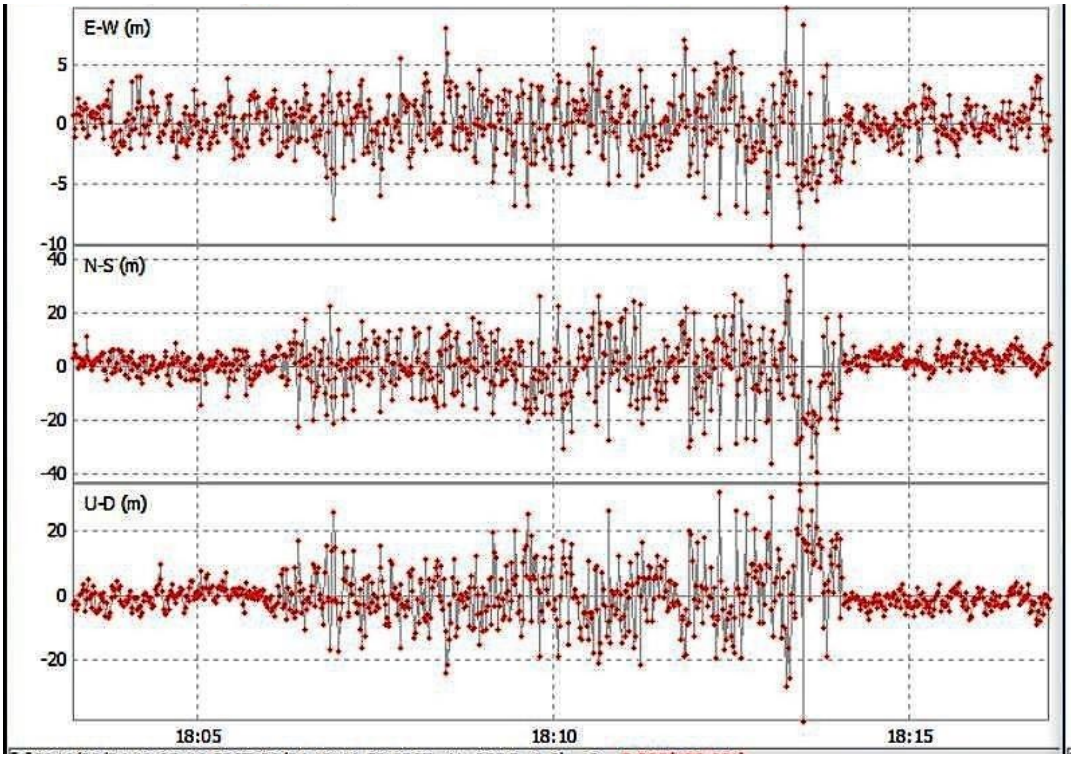
Test #2

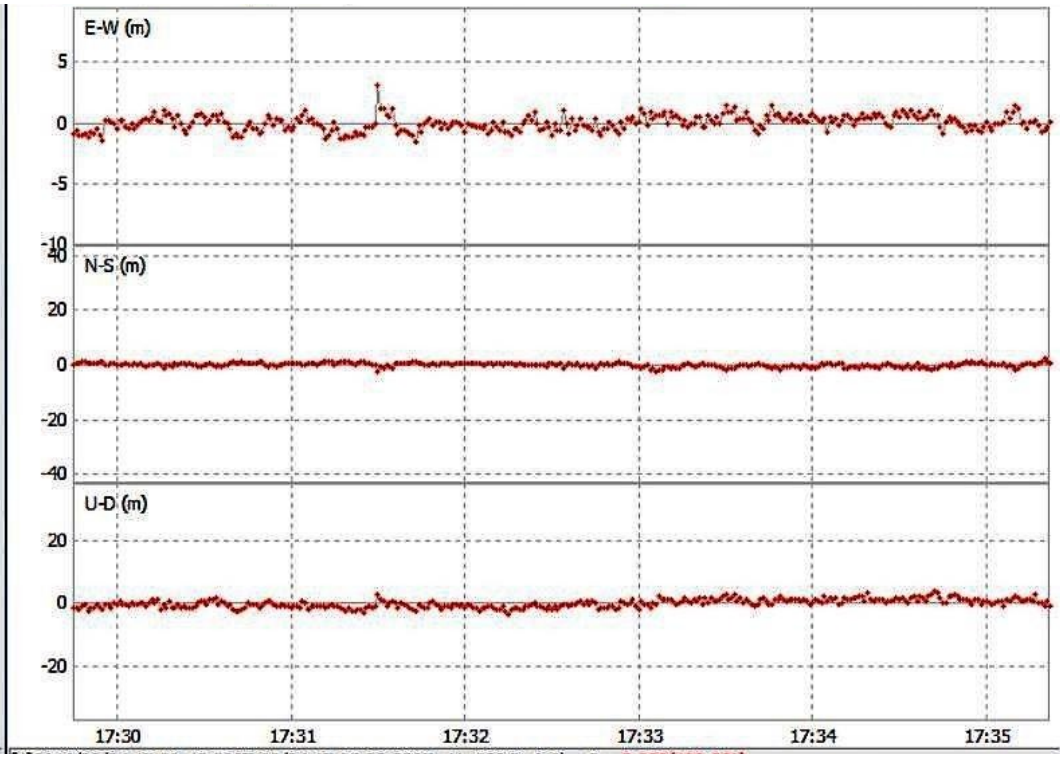
- Javad Triumph LS spectrum analyzer
- Open-sky environment
- UAV off and on


GPS L1 -4.3(1.6) 2016-08-24 17:35 (GPS) Ext
390 370 350 330 310 290 270 250 230 210 190 170 150 130 110 90 70 50 30 10
1556 1558 1560 1562 1564 1566 1568 1570 1572 1574 1576 1578 1580 1582 1584 1586 1588 1590 1592 1594


GPS L1 6.5(2.4) 2016-08-24 18:19 (GPS) Ext
390 370 350 330 310 290 270 250 230 210 190 170 150 130 110 90 70 50 30 10
1556 1558 1560 1562 1564 1566 1568 1570 1572 1574 1576 1578 1580 1582 1584 1586 1588 1590 1592 1594

Position output





On the practical aspect...

- Solution was degradated by a factor of 10.
- Intensity of motor rotation does not play a role in the amount of interference.
- “Cheap” electronics – voltage regulators, transmitters...
- Cheap antennas and receivers are more prone to accept interference – processing capabilities.
- Interference tracking is not a deterministic problem and can be expanded to other scopes.

Conclusions

- Why is this happening?
  - Since receiver and UAV circuits were separated during the tests, it is concluded that the interference comes through the air into the antenna.
  - Most likely because residual out-of-band noise from surrounding electronics (GNSS -130dBm v. Cellphone 30dBm or 10^-15W v. 2W).
- How can it be avoided?
  - Better antenna/receiver set.
  - Better radio equipment for telemetry and communication.
  - Isolating GNSS equipment from the electronics.

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