

TEC-ES Navigation Laboratory (NavLab)



THIRD PARTY ACTIVITY SERVICE

OFFERED BY THE ESTEC NAVIGATION LABORATORY (TEC-ES)

The ESTEC Navigation Laboratory (NavLab) supports test campaigns for navigation and telecommunications services for both ESA and non-ESA projects based on a contract. It manages the laboratory where there are all the required tools and equipment to test GNSS systems and applications.



THE RIGHT TECHNOLOGY AT THE RIGHT TIME

The Technology Directorate at ESA owns a number of laboratories covering a wide range of expertise. The laboratories not only provide specific support to ESA programmes by

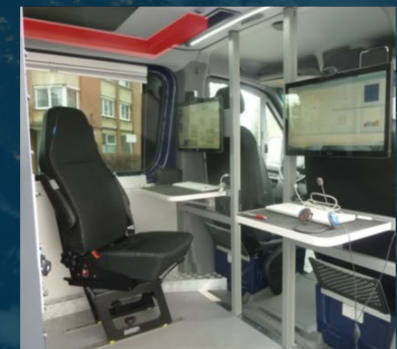
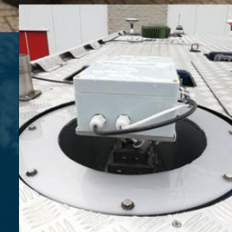
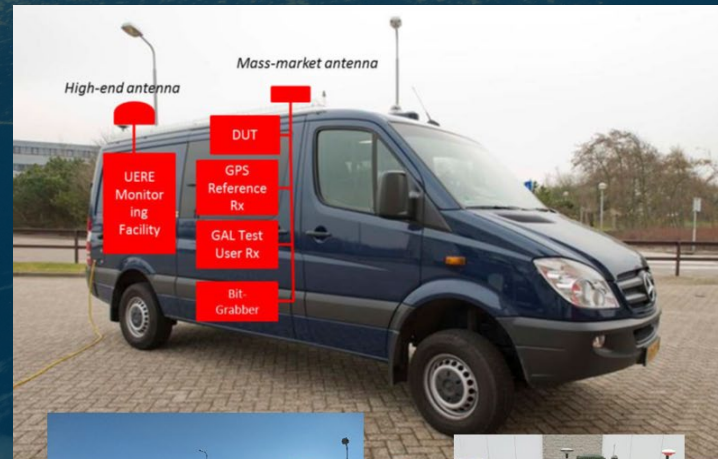
developing new experimental tools and analysis techniques, but also contribute to a larger ESA goal: the diffusion of space technology and knowledge into the wider economy.



SIMPLIFIED ACCESS TO LABORATORIES

ESA has the mandate to maintain unique facilities and expertise when not commercially viable and needed for ESA missions. The simplified access to Laboratories allows SME's, Start-ups, Mid-Caps, Research Institutes,

Universities, etc. to have quick, secure and affordable access to ESA laboratories when client organisations are able to perform their own tests using TEC facilities.



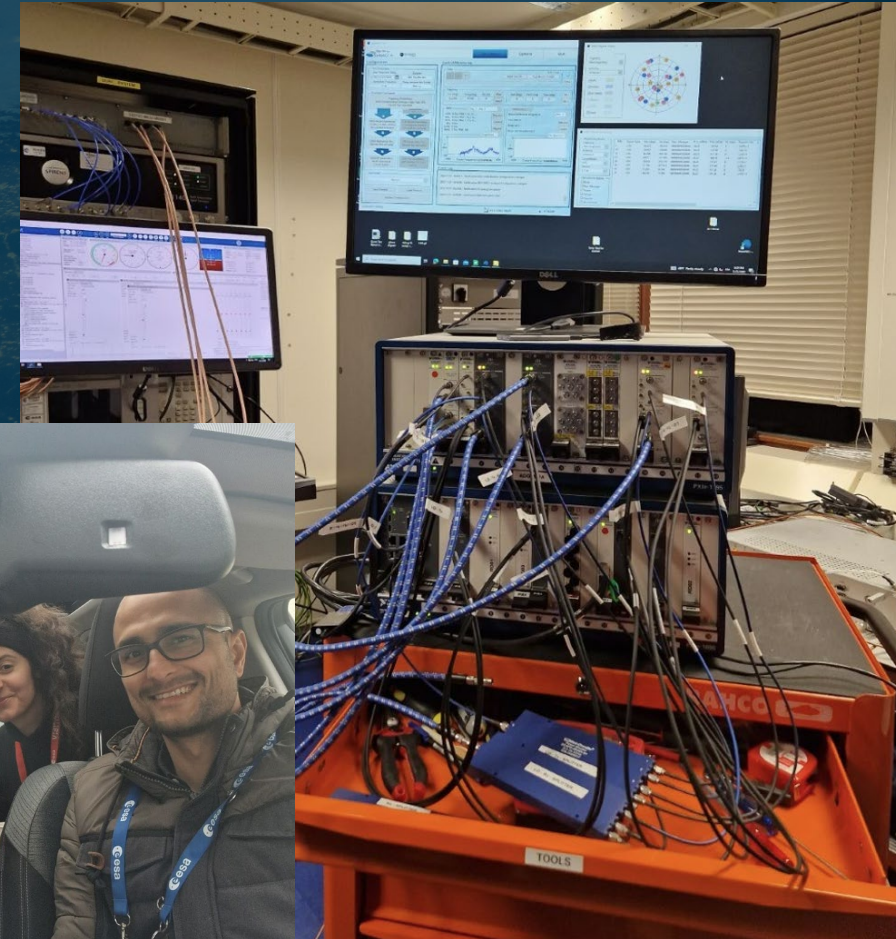
ADGIL Test Campaign

NavLab

Noori BniLam, 11/06/ 2024

Open Innovation Lab (OIL) setup test

- Two test campaigns have been performed to validate the system capability.
- 42 TB of data has been collected!



Open Innovation Laboratory opened in Debrecen, Hungary to redefine Space System testing 🧠🚀🔧

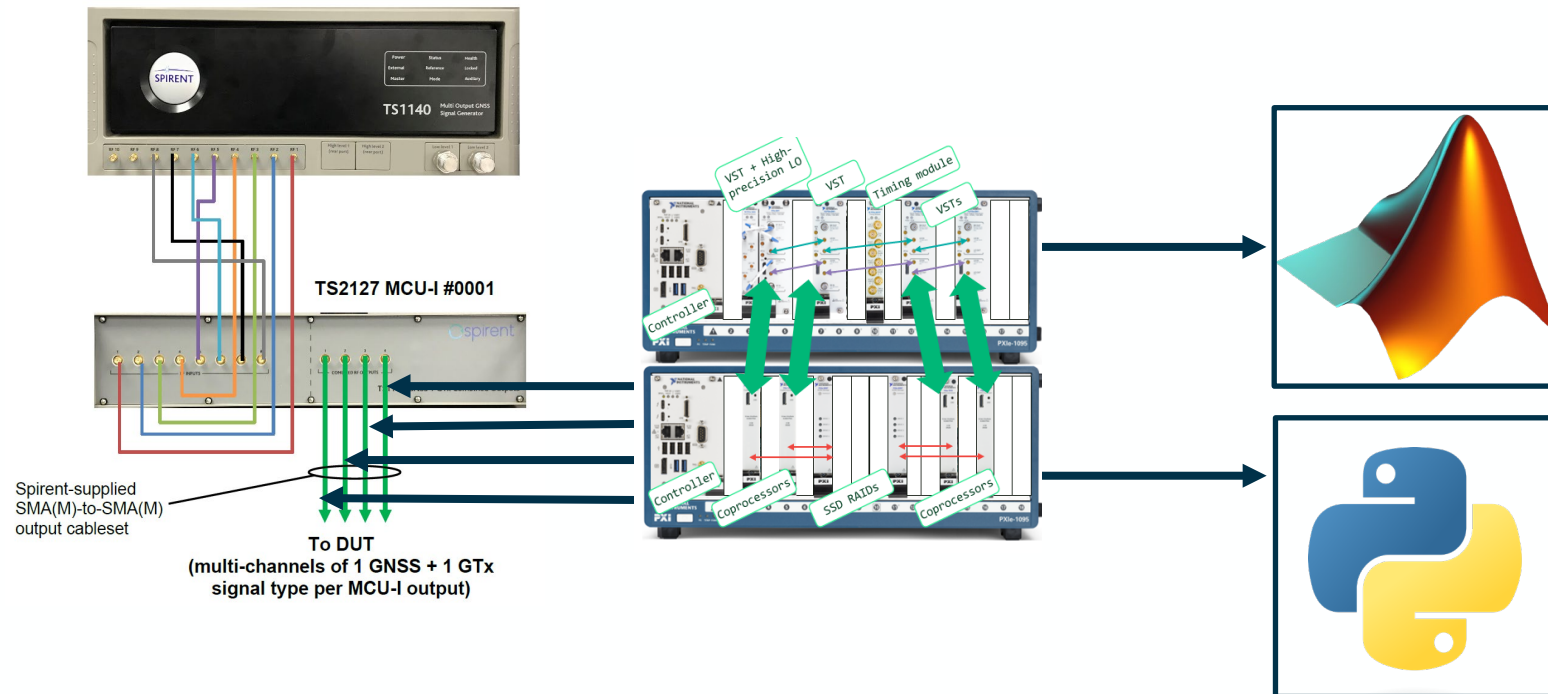
On March 20th 2024, [Emerson's](#) Test and Measurement Business Group (formerly [NI \(National Instruments\)](#)) in collaboration with the [ESA NAVISP](#) declared the grand opening of the Open Innovation Laboratory in Debrecen, Hungary. This facility will help redefine space system development and deployment by introducing advanced test strategies aimed at reducing costs and mitigating risks.



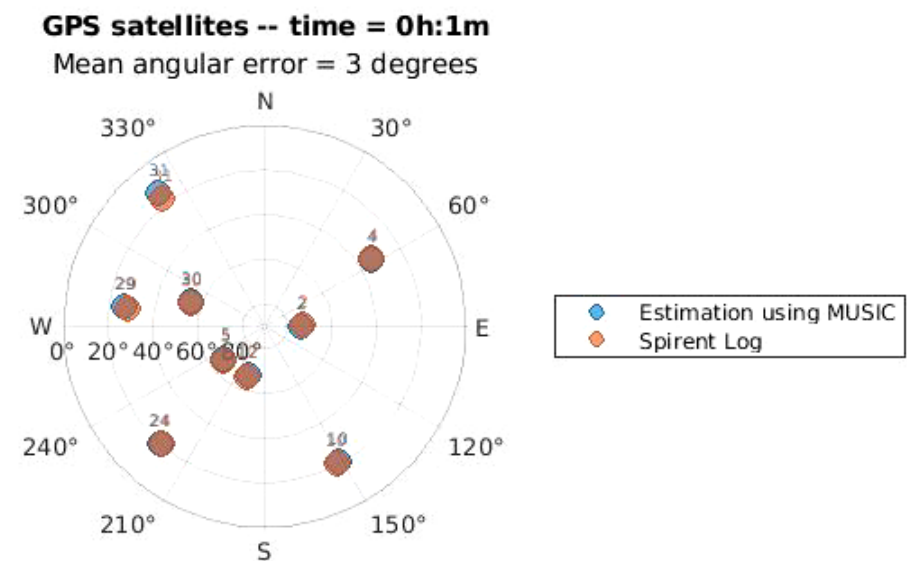
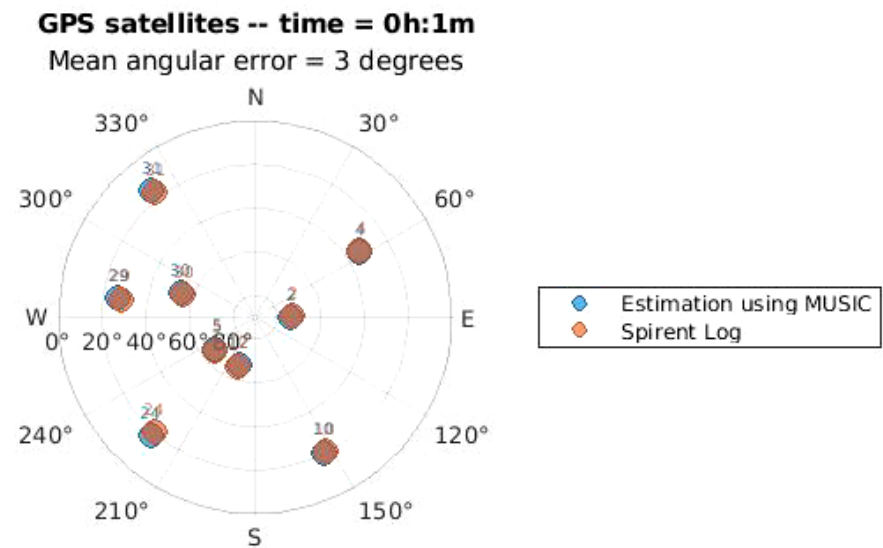
Test 1: RF ports Phase Stability

Simulation Results

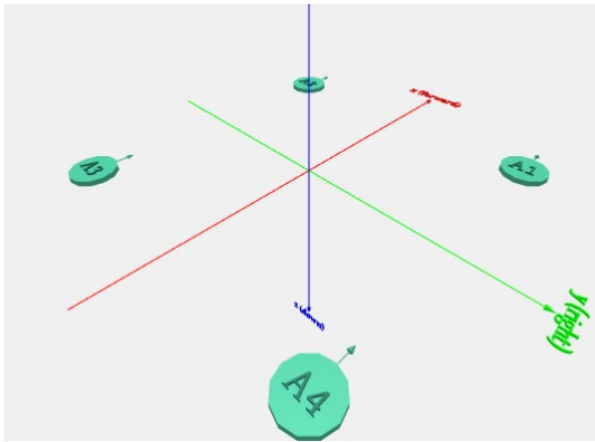
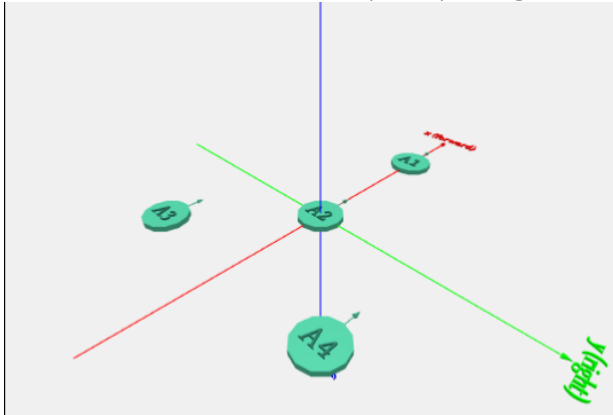
- Multiple RF ports simulator has been used to simulate the GNSS satellites.
- Two array antennas have been investigated 1) Rectangular Array; 2) Y-shaped array.
- The IQ samples of 4 RF port have been collected using the ADGIL system.



AoA Estimation : MUSIC algorithm

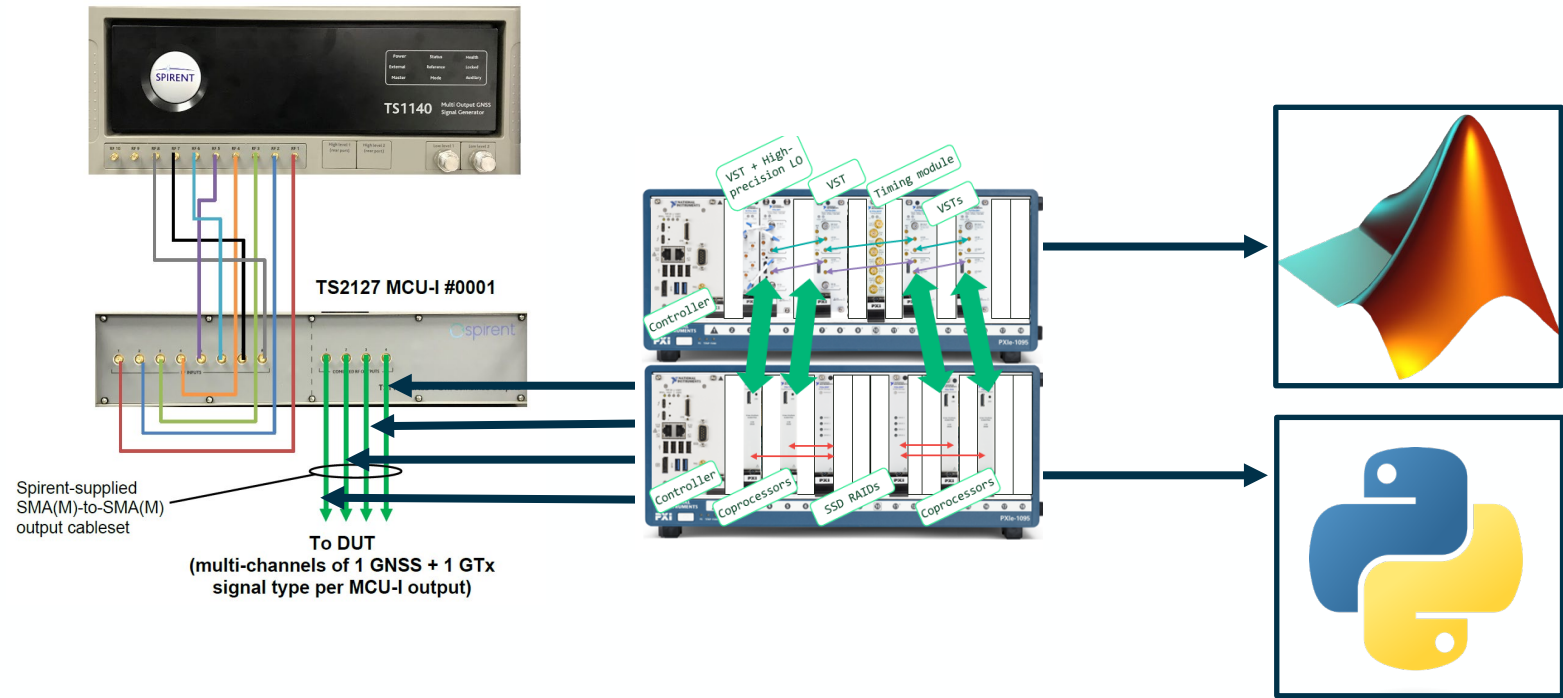
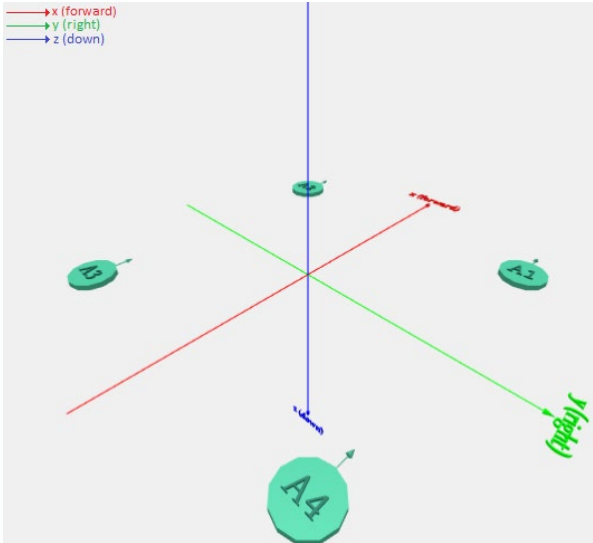


BniLam, N., Principe, F., & Crosta, P. (2023). **Large Array Antenna Aperture for GNSS Applications.** *IEEE Transactions on Aerospace and Electronic Systems.*

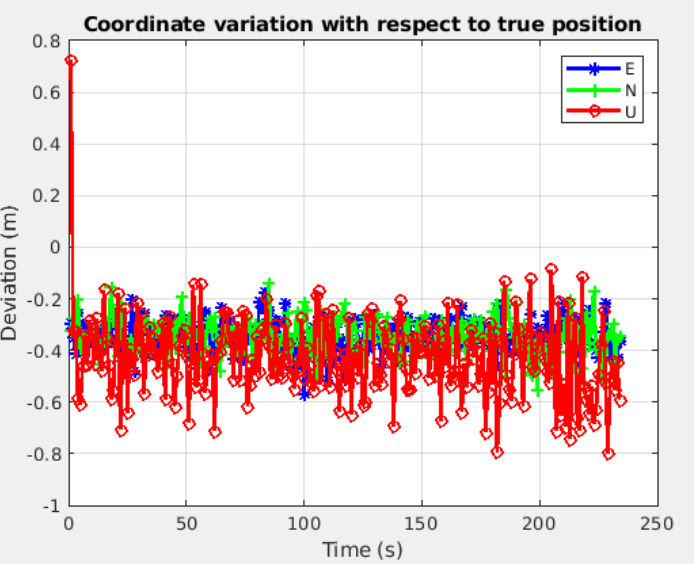
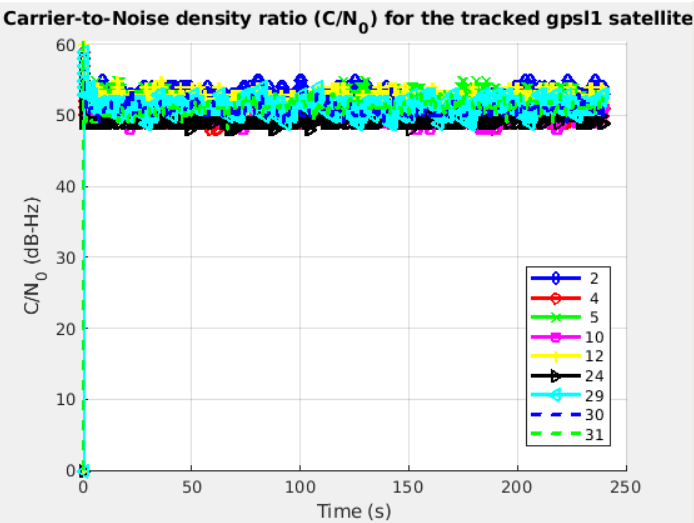


Test 2: Interference Mitigation Capability

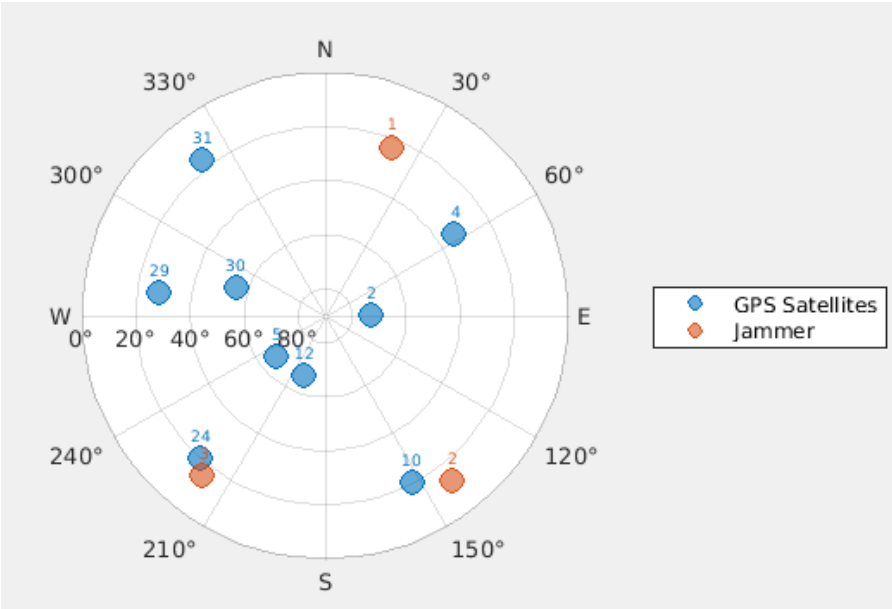
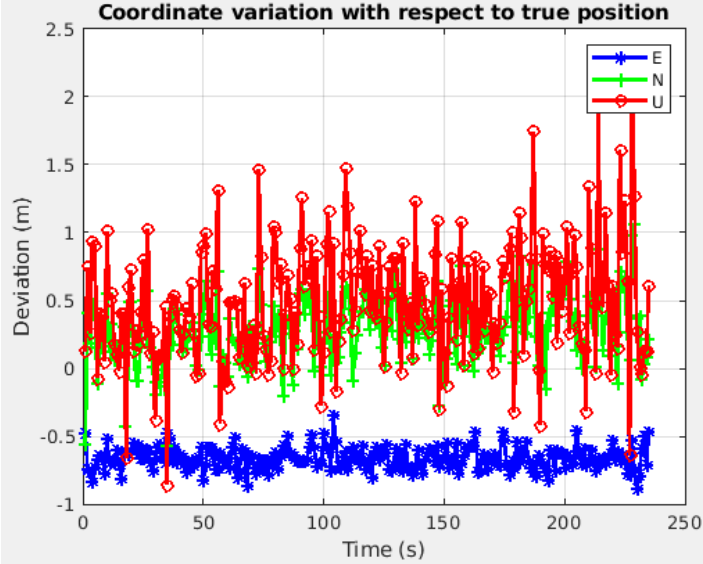
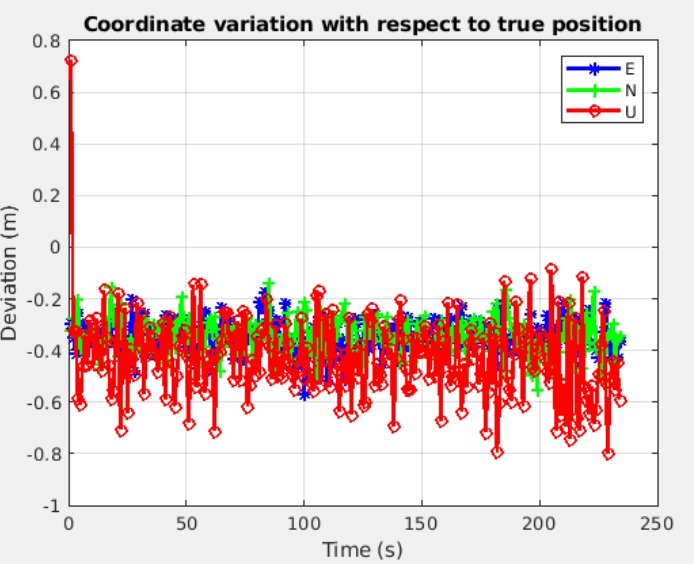
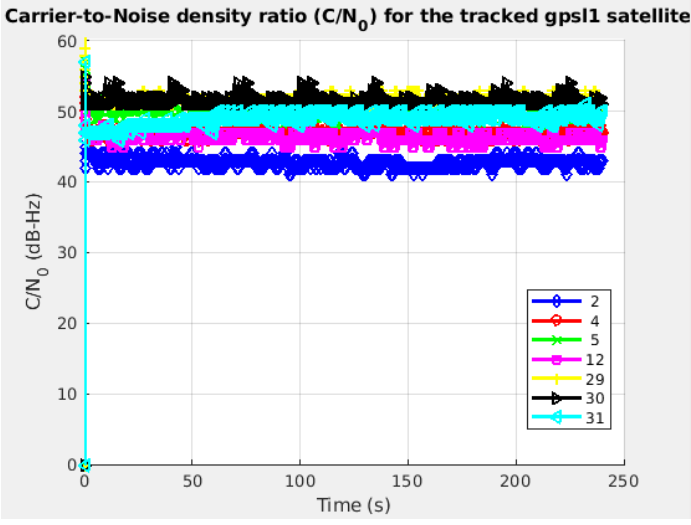
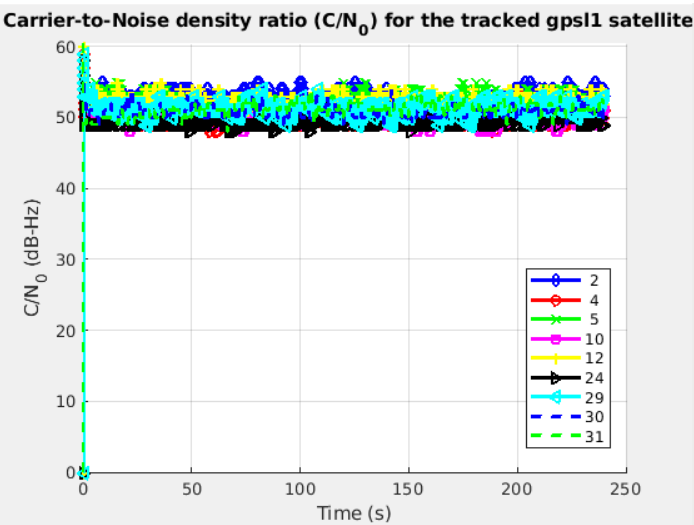
Rectangular Array



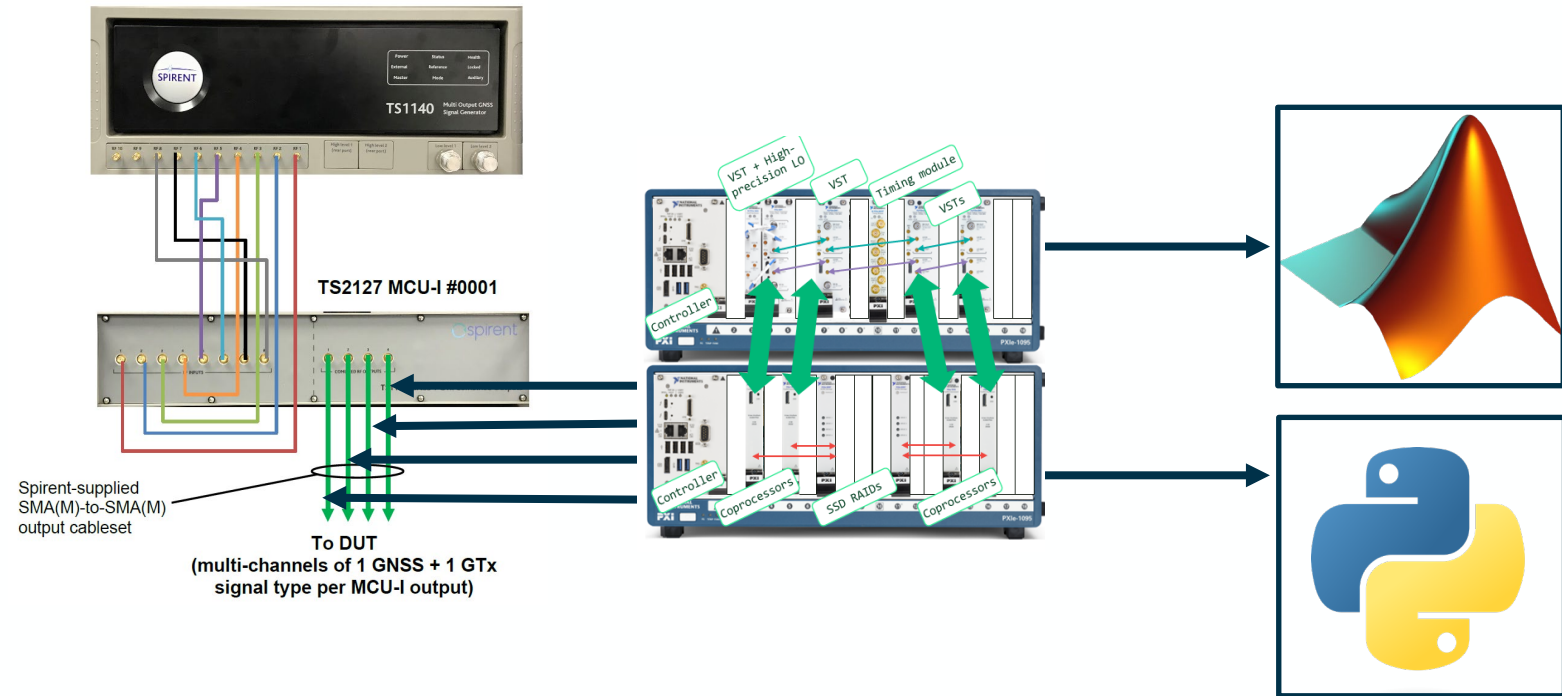
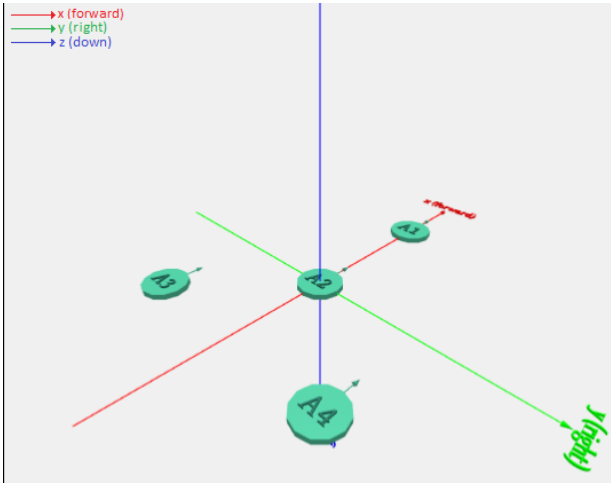
Simulation – 1CW + NBPSK + AWGN jamming signals



Simulation – 1CW + NBPSK + AWGN jamming signals



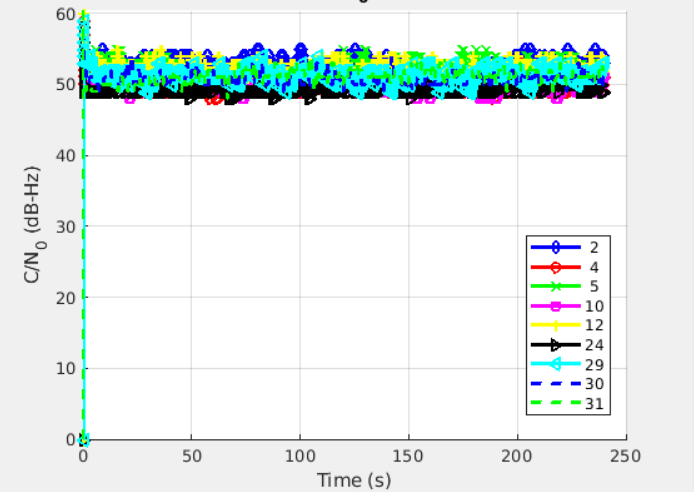
Y-shaped Array



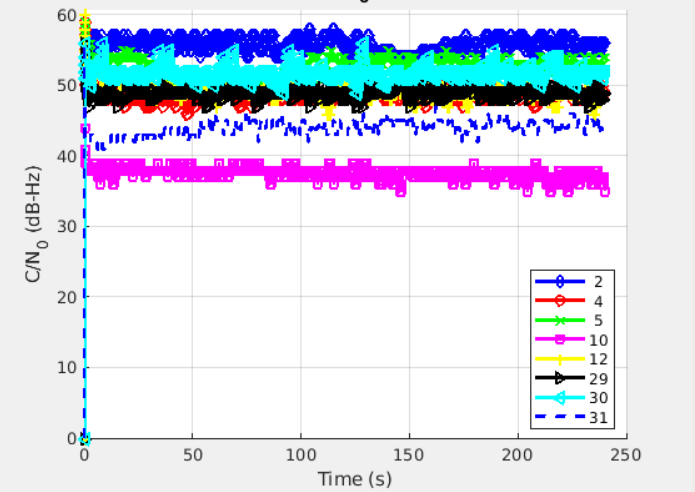
Simulation – 1CW + NBPSK + AWGN jamming signals



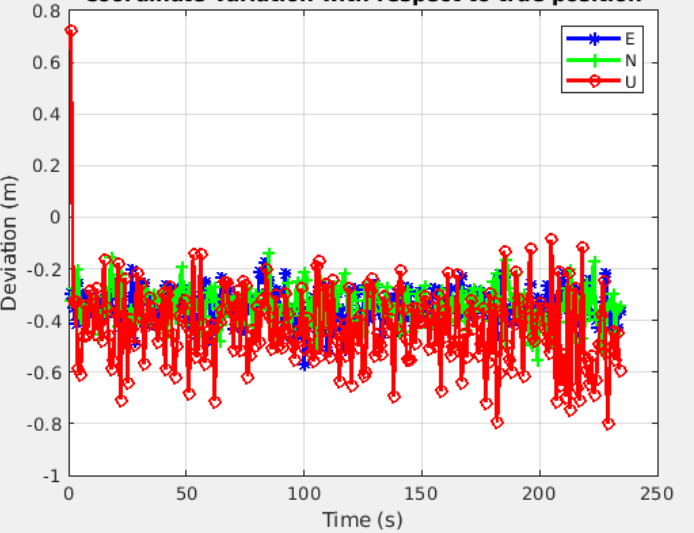
Carrier-to-Noise density ratio (C/N_0) for the tracked gps11 satellite



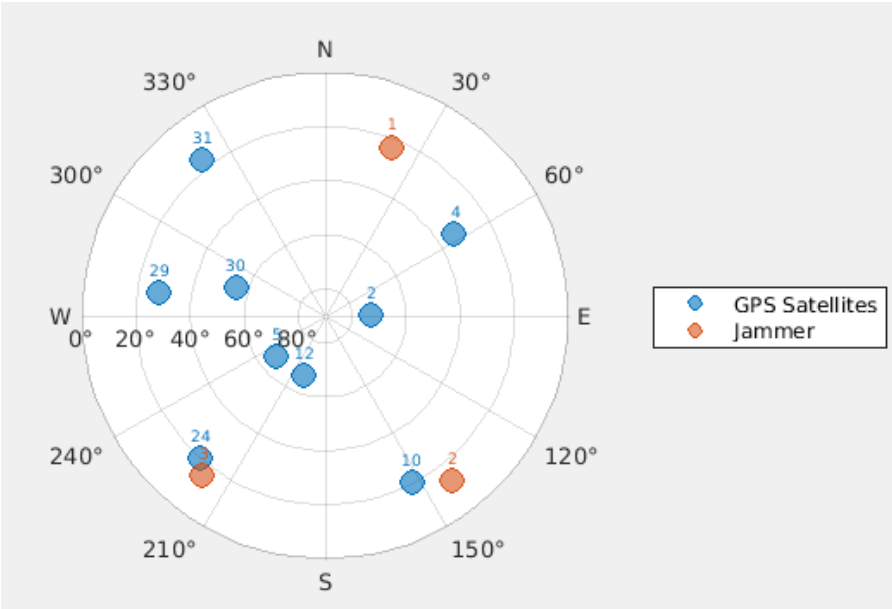
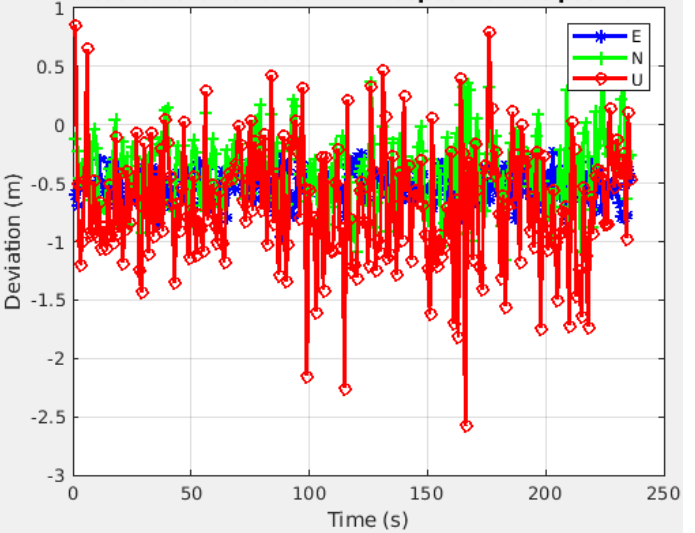
Carrier-to-Noise density ratio (C/N_0) for the tracked gps11 satellite



Coordinate variation with respect to true position



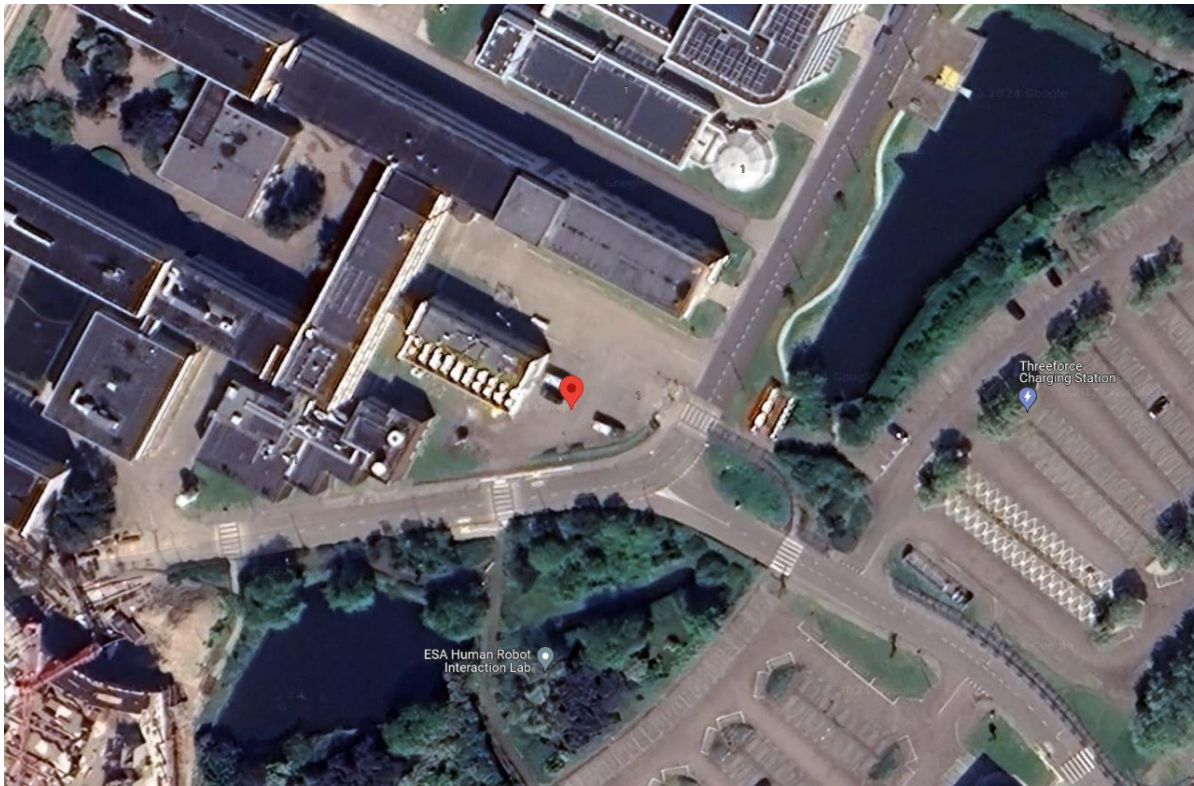
Coordinate variation with respect to true position



Test 3: Live Signal Beamforming Capability

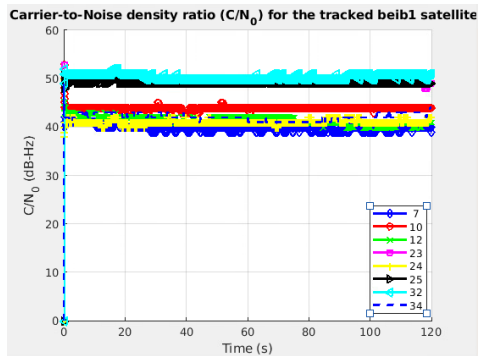
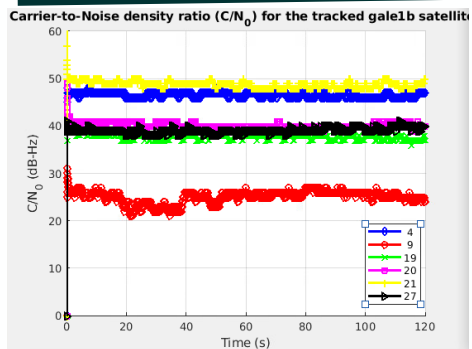
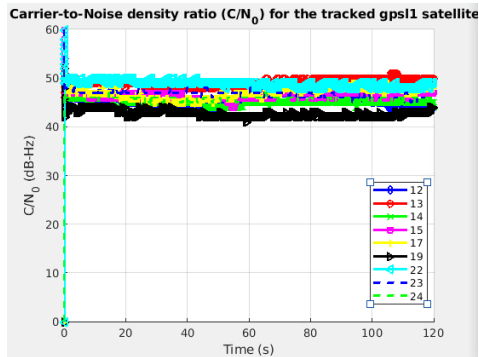
Open Sky Array Antenna

- Measurements of L1 frequency band (BW = 50 MHz for 15 minutes)
- Measurements of L frequency band (BW = 500 MHz for 5 minutes)

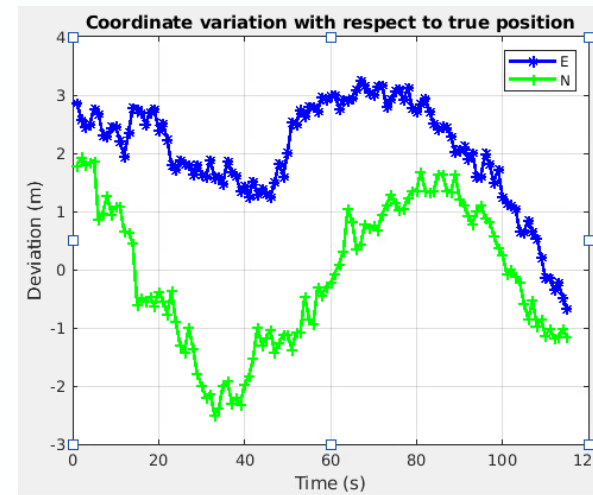


Open Sky Array Antenna

Single Antenna



Single Antenna

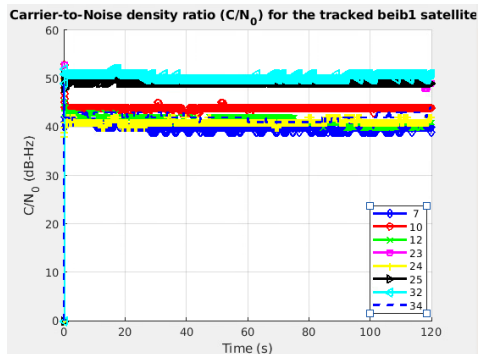
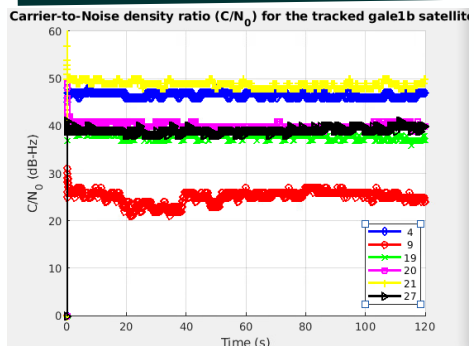
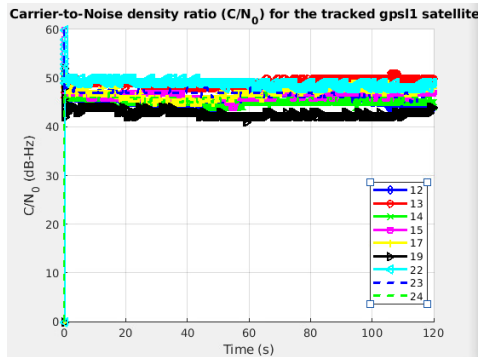


```
Error50: 2.6466476578414
Error95: 3.28423004033822
Max: 3.37687336658967
stdDev: 0.701468673781962
RMS: 29.5149061691682
mean: 2.44011046788721
nr: 115
```

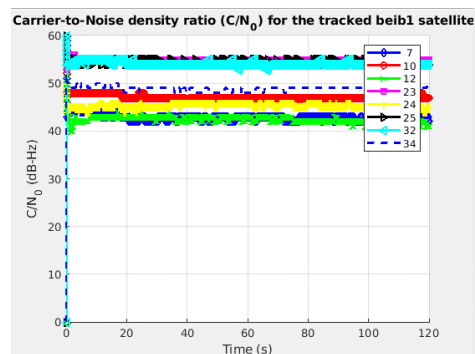
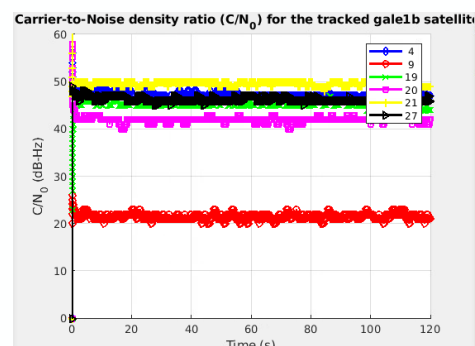
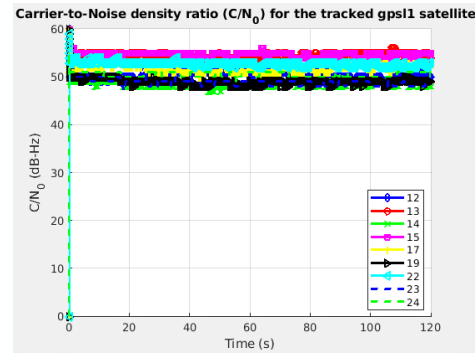
```
gdop: 1.86794144660586
pdop: 1.4584677089214
hdop: 1.01214656036196
vdop: 1.05008582513228
tdop: 0.833734672285351
```

Open Sky Array Antenna

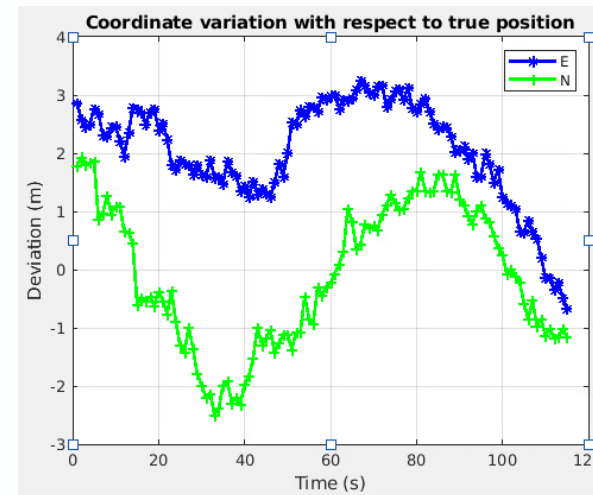
Single Antenna



Beamforming



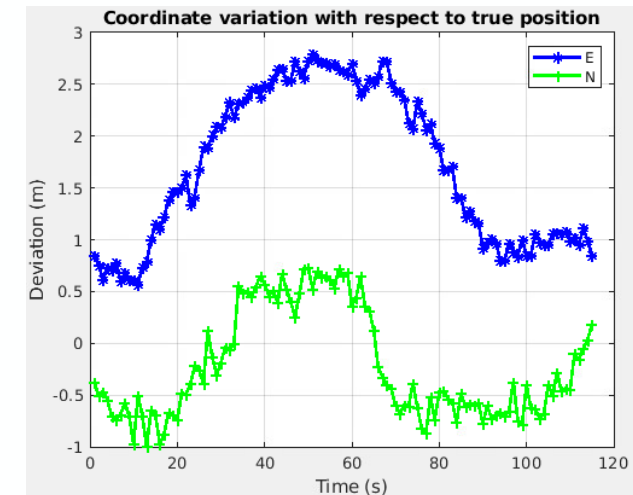
Single Antenna



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 pdop: 1.4584677089214
 hdop: 1.01214656036196
 vdop: 1.05008582513228
 tdop: 0.833734672285351

Beamforming



Error50: 1.74146887723649
 Error95: 2.757992871161
 Max: 2.84303044635562
 stdDev: 0.685372376459151
 RMS: 28.8173901840456
 mean: 1.82283001309765
 nr: 115

gdop: 1.89909574905363
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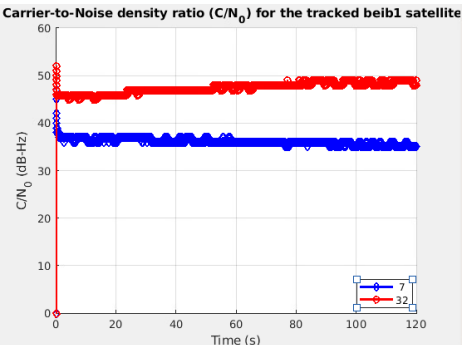
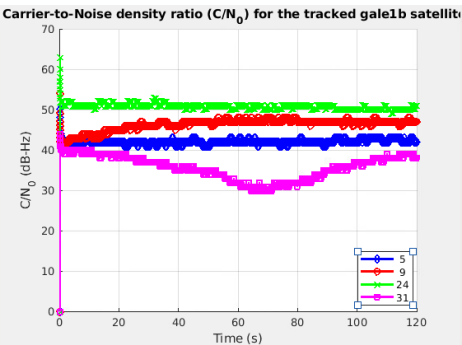
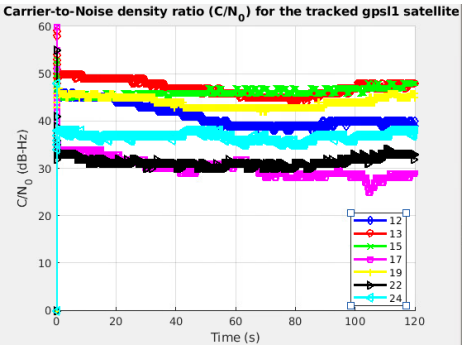
Canyon-like Environment

- Measurements of L1 frequency band (BW = 50 MHz for 15 minutes)
- Measurements of L frequency band (BW = 500 MHz for 5 minutes)

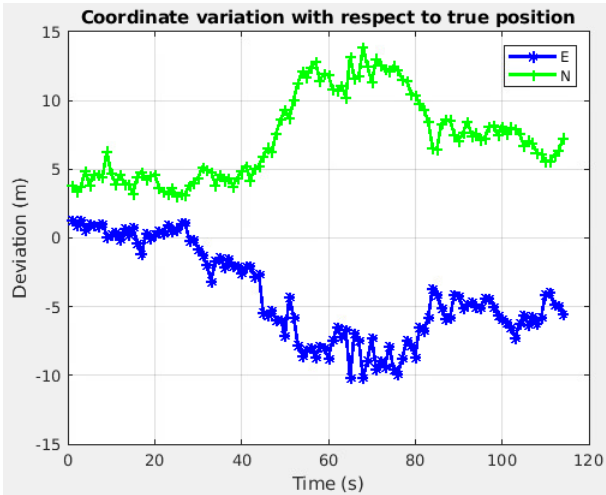


Canyon-like Environment

Single Antenna



Single Antenna

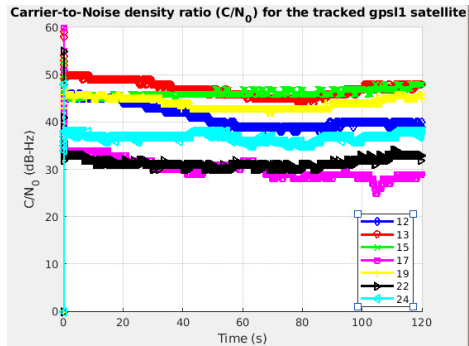


Error50: 8.7698
Error95: 15.5226
Max: 17.2334
stdDev: 4.0638
RMS: 22.1266
mean: 8.6969
nr: 114

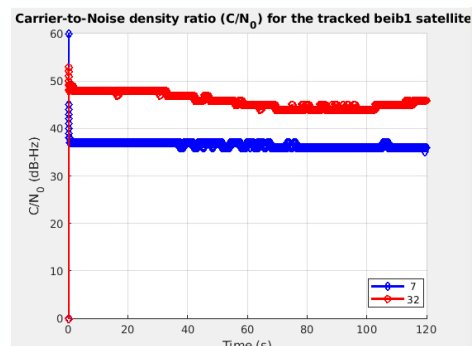
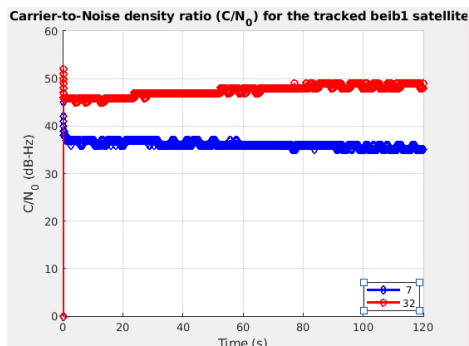
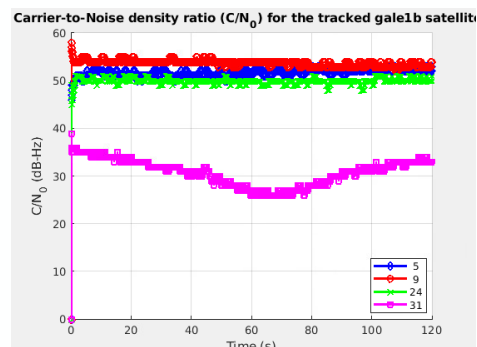
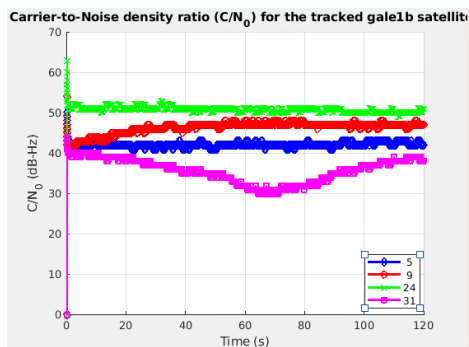
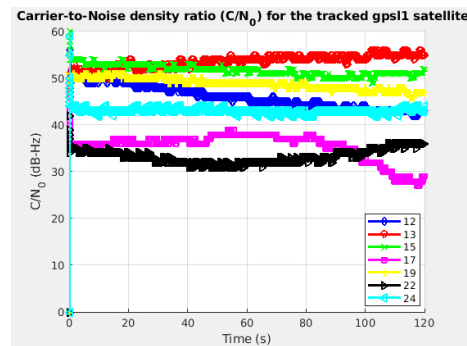
gdop: 4.9670
pdop: 3.2131
hdop: 1.8811
vdop: 2.6048
tdop: 2.2519

Canyon-like Environment

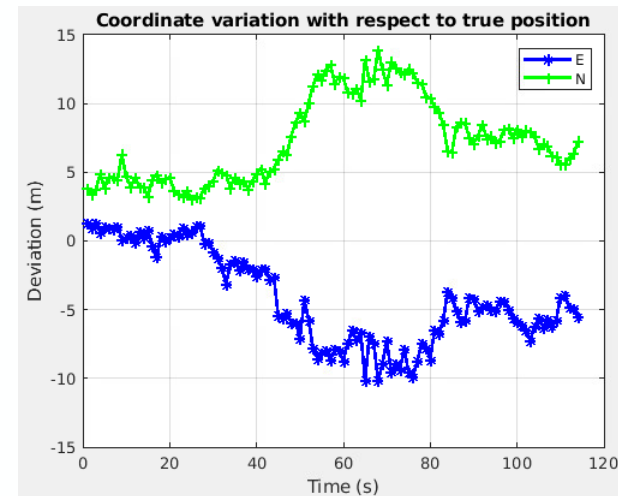
Single Antenna



Beamforming



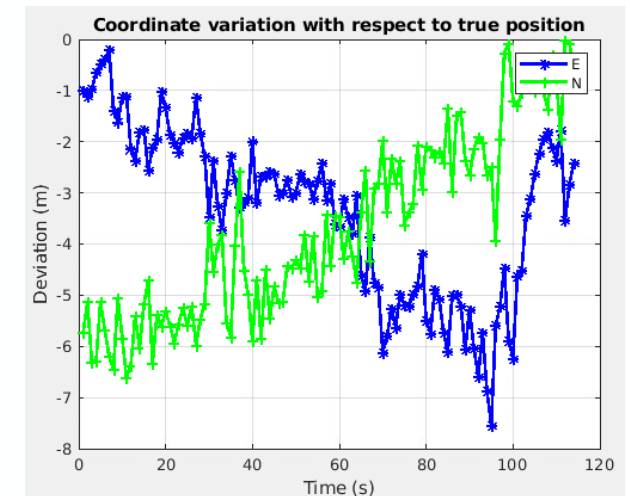
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Beamforming

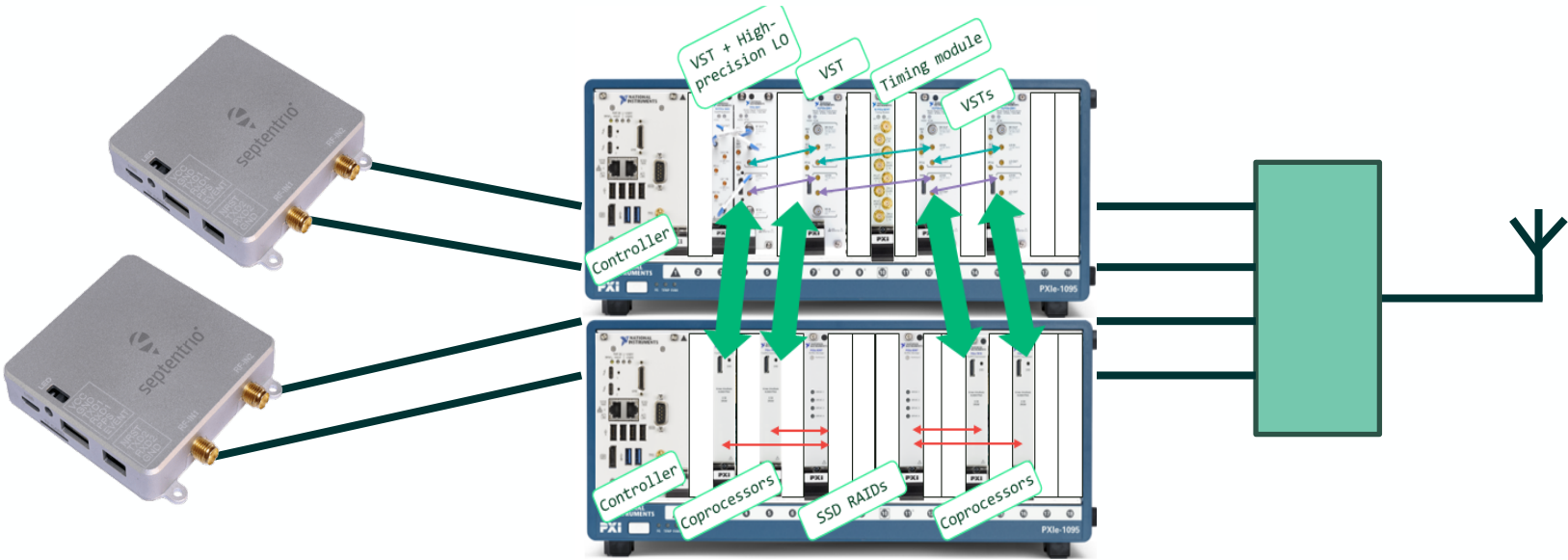


Error50: 5.6363
Error95: 6.7148
Max: 7.9442
stdDev: 1.1167
RMS: 42.2323
mean: 5.4246
nr: 114

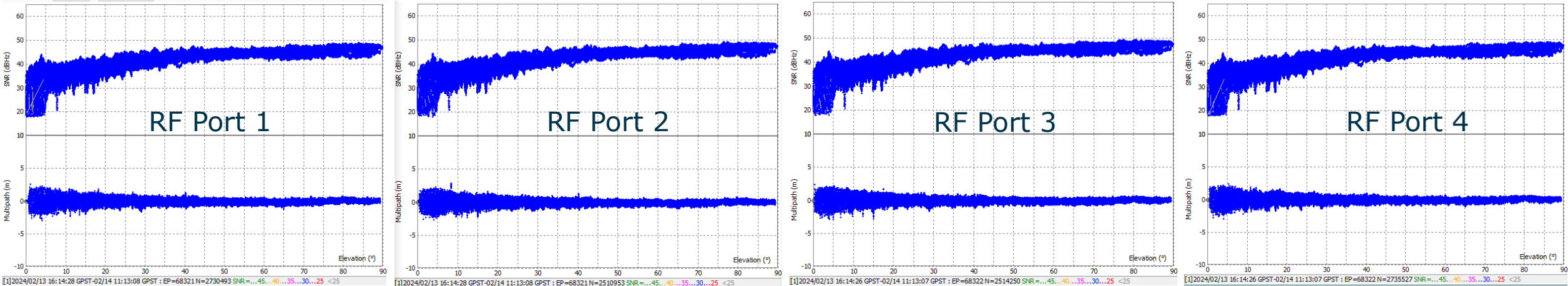
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pdop: 3.1600
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vdop: 2.5966
tdop: 2.1792

Test 4: Playback Capability

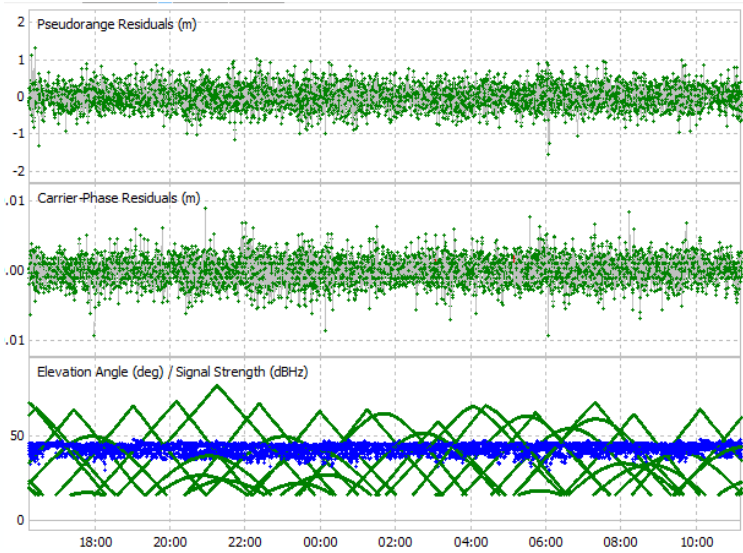
Zero Baseline Test



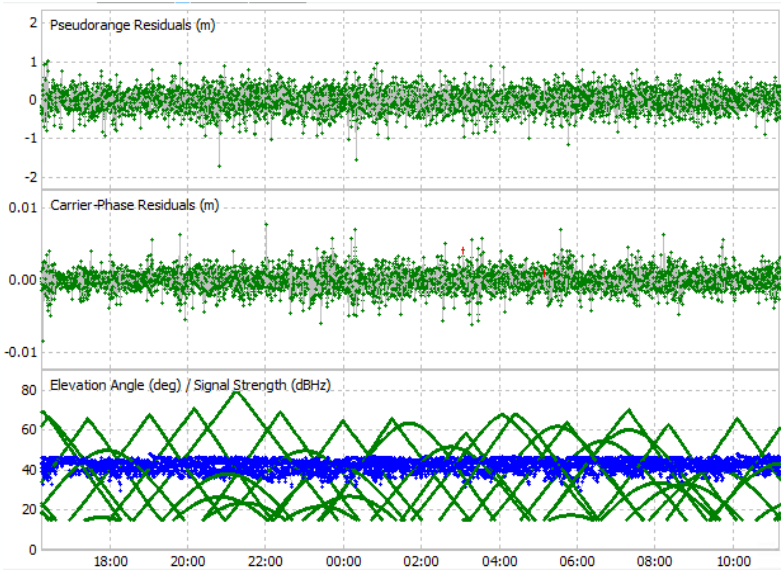
Zero Baseline Test – 500MHz – 15 hours



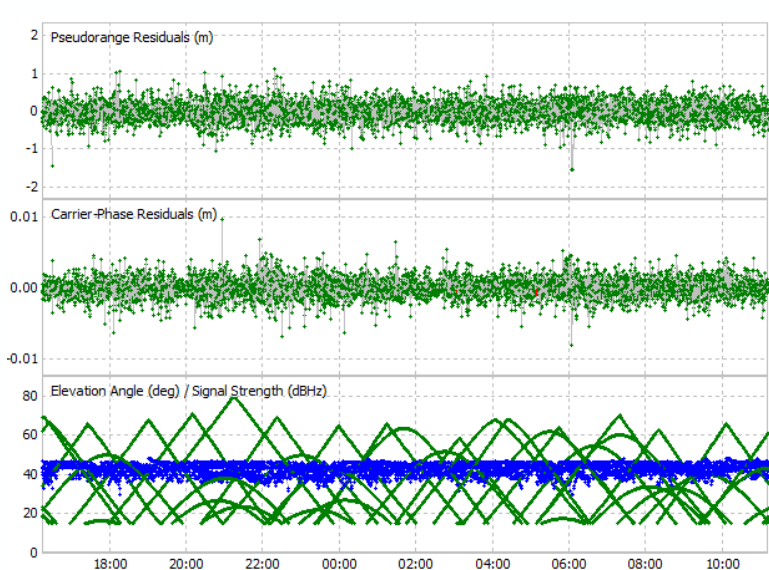
ZBT port1-2



ZBT port1-3



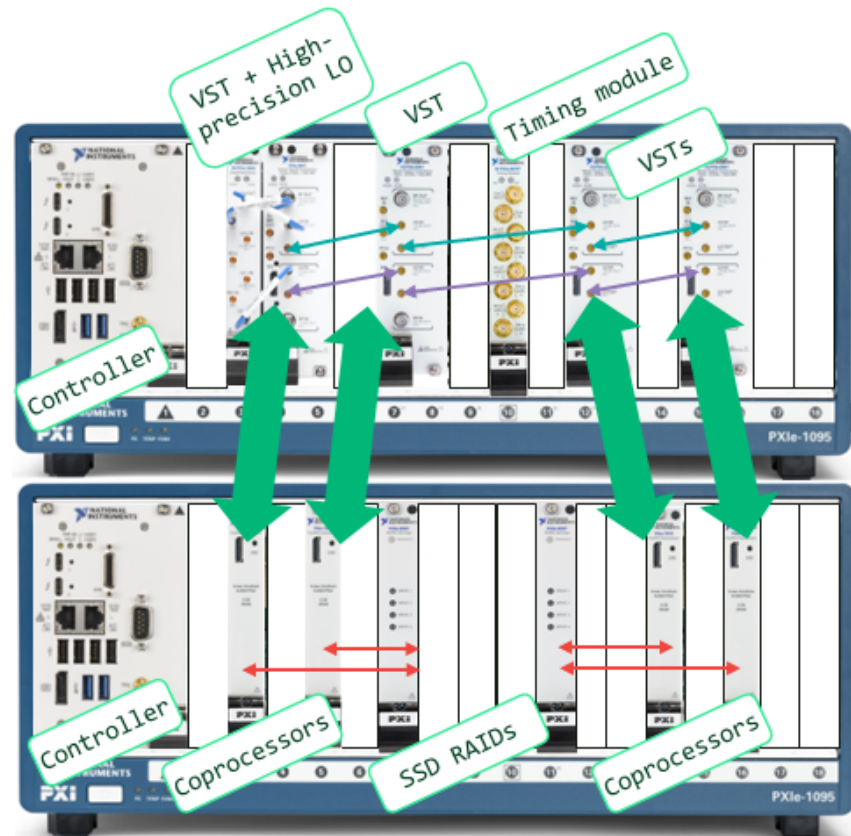
ZBT port1-4



Possible Utilizations

Possible Utilizations

- 1) Record and replay coherent RF ports
→ This feature enables array antenna signal processing, dual polarizations signal processing, and jamming and spoofing testing.
- 2) Four RF channels with a simultaneous bandwidth of 500 MHz
→ This feature enables new technologies testing (such as phased-based ranging) with GNSS signals.



Proposed Solution:

- Daisy-chain OR
- Star-configuration for LO, CLK and TRIG sharing
- HSS data link (MGT) between VST and Coprocessor
- Backplane (PCIe) data transfer between Coprocessor and SSD RAID

Description:

- TX LO sharing
- RX LO sharing
- HSS data streaming
- Backplane data transfer

Thank you

Noori Bni Lam, 20/03/ 2024