

Bistatic Polarimetric Measurements and Simulations of a Cessna 172 at DVB-T Frequencies

Idar Norheim-Næss^{*}, Kyrre Strøm^{*}, Erlend Finden^{*}, Øystein Lie-Svendsen^{*},
Terje Johnsen^{*}, Diego Cristallini[†], Heiner Kuschel[†], Karl Erik Olsen^{*}

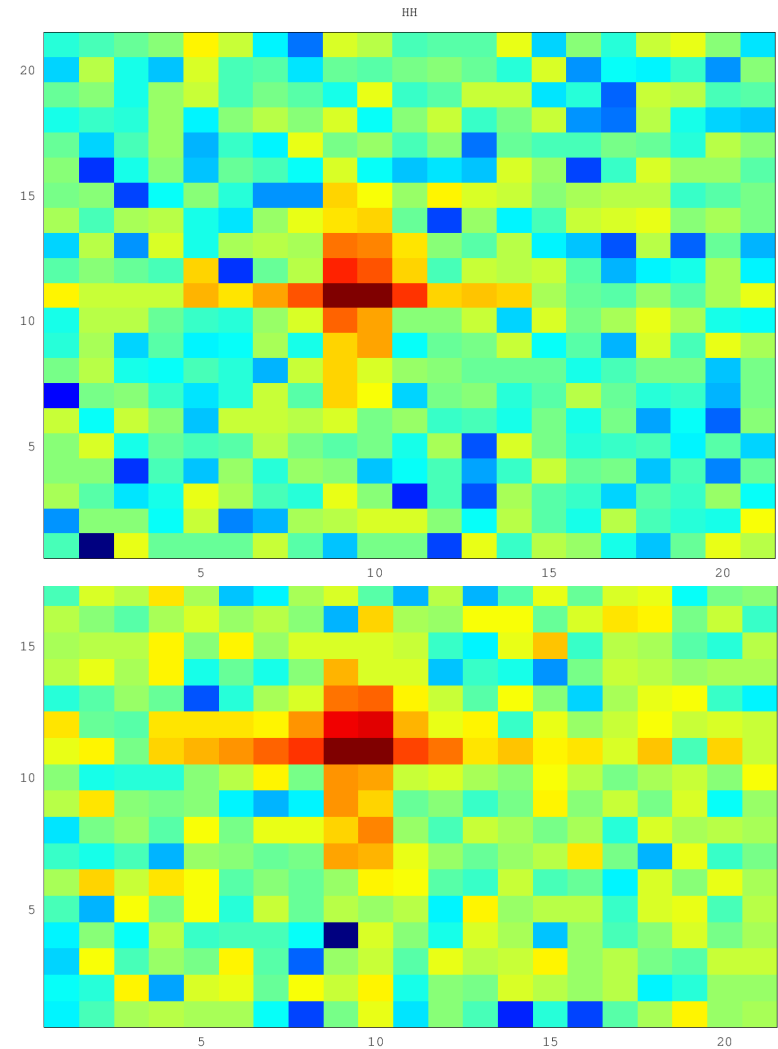
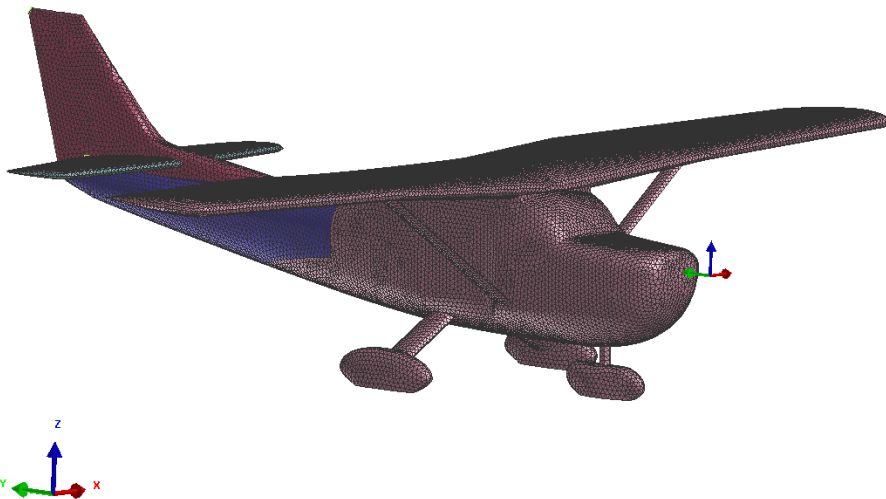
^{*} Norwegian Defence Research Establishment, P.O. Box 25, 2027 Kjeller, Norway

[†] Fraunhofer FHR-PSR, Fraunhoferstraße 20, 53343 Wachtberg-Werthhoven, Germany

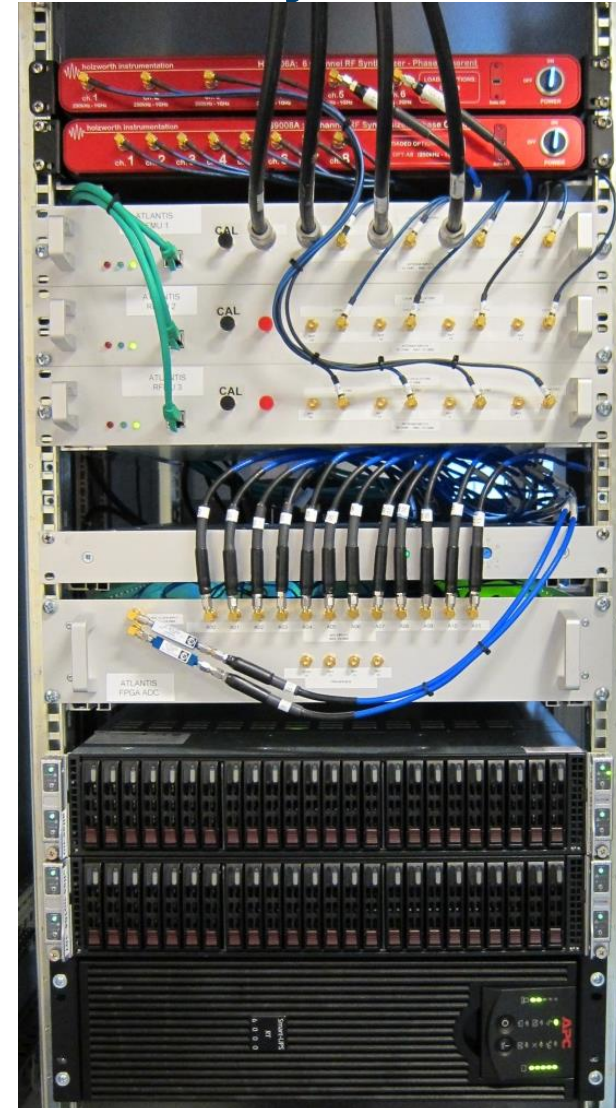
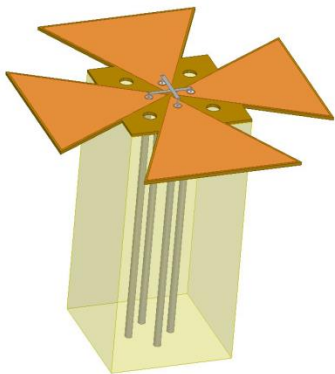
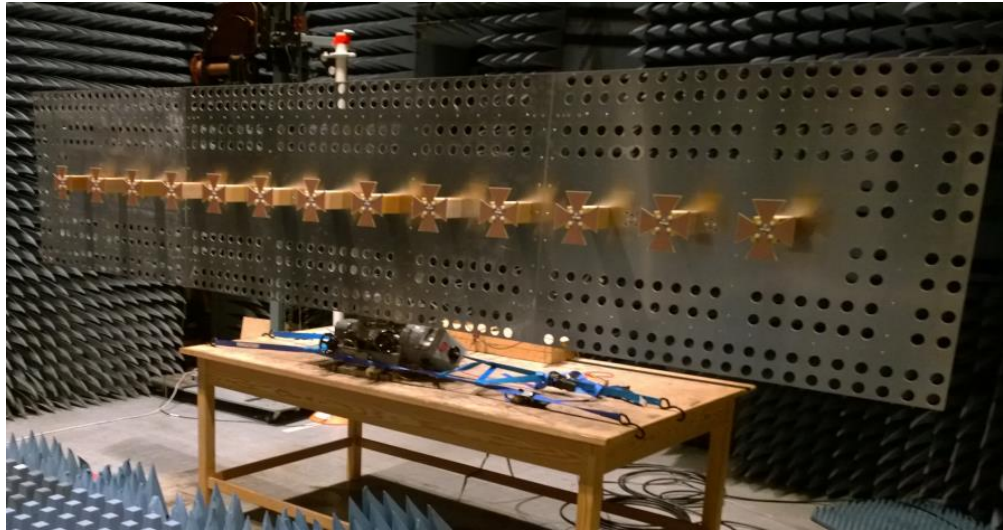
SET-231 Specialist's Meeting on Multi-Band Multi-Mode Radar in Lisbon, Portugal

2016-10-18

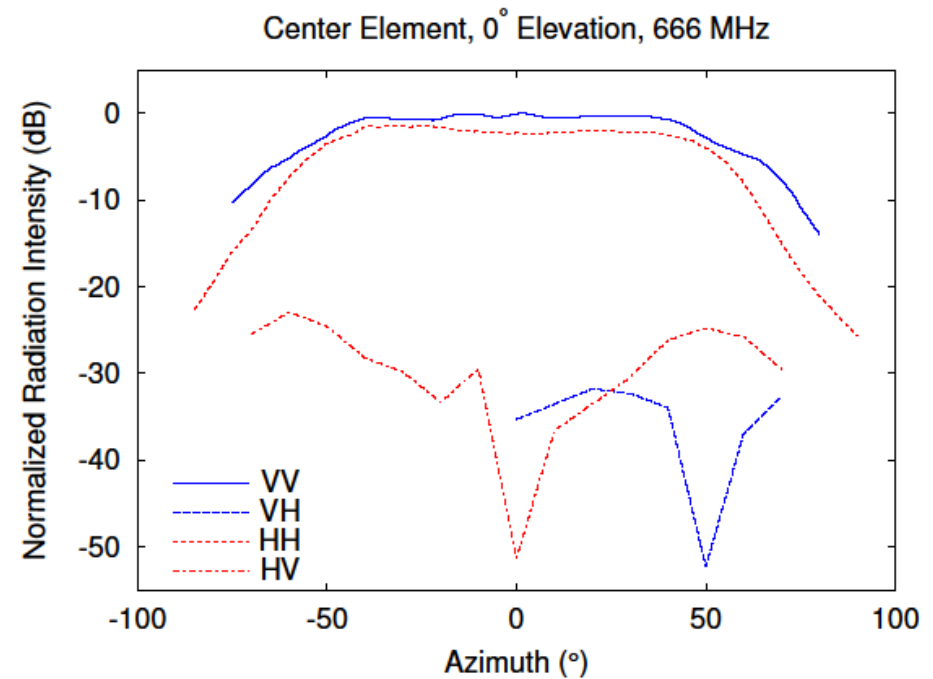
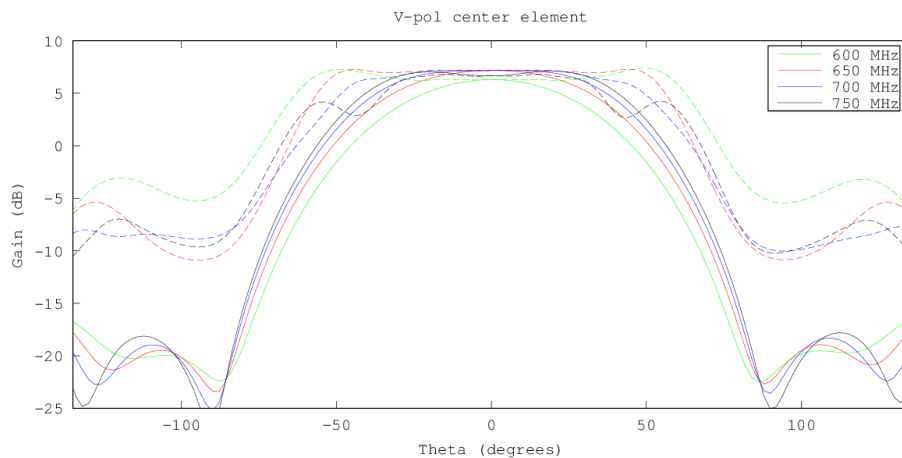
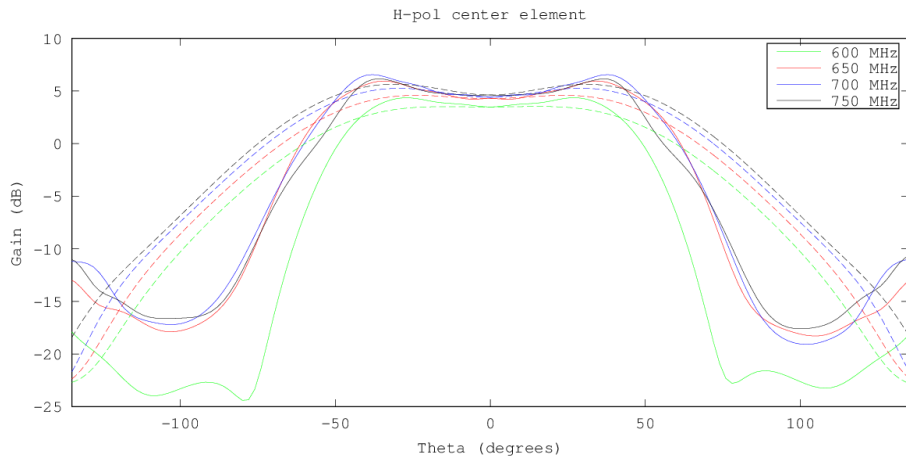
The objective was to compare the response in co- and cross-polarization of a Cessna 172 aircraft at DVB-T frequencies, and compare it to the simulated RCS



The Fraunhofer FHR developed ATLANTIS DVB-T passive bistatic radar was used together with an FFI-developed crossed-bowtie dual-pol linear array antenna



The new antenna has through simulations and anechoic chamber measurements shown to be suited for polarimetric measurements



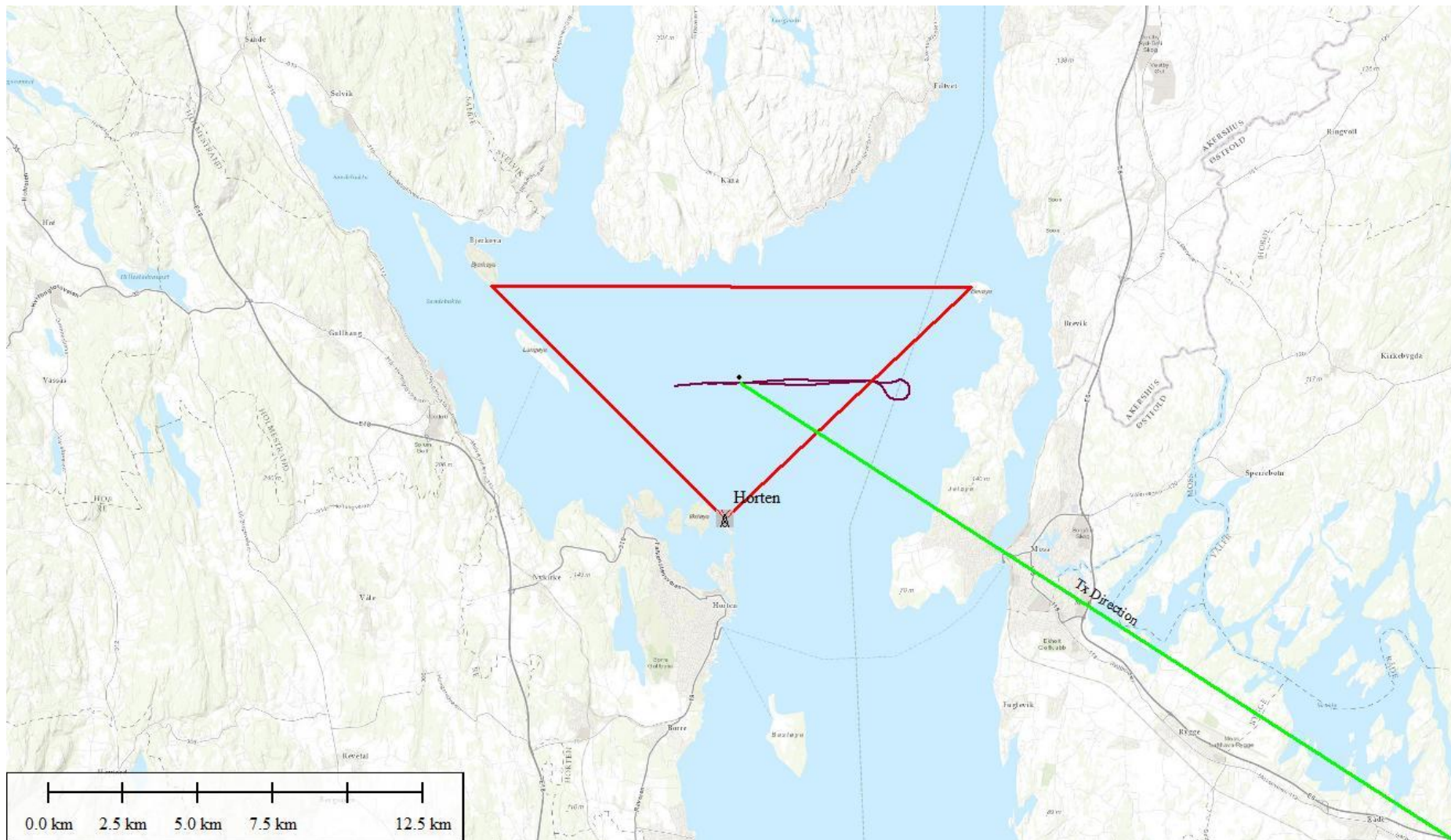
Targets



Trial site: Oslo fjord north of Horten

Antenna pointing north

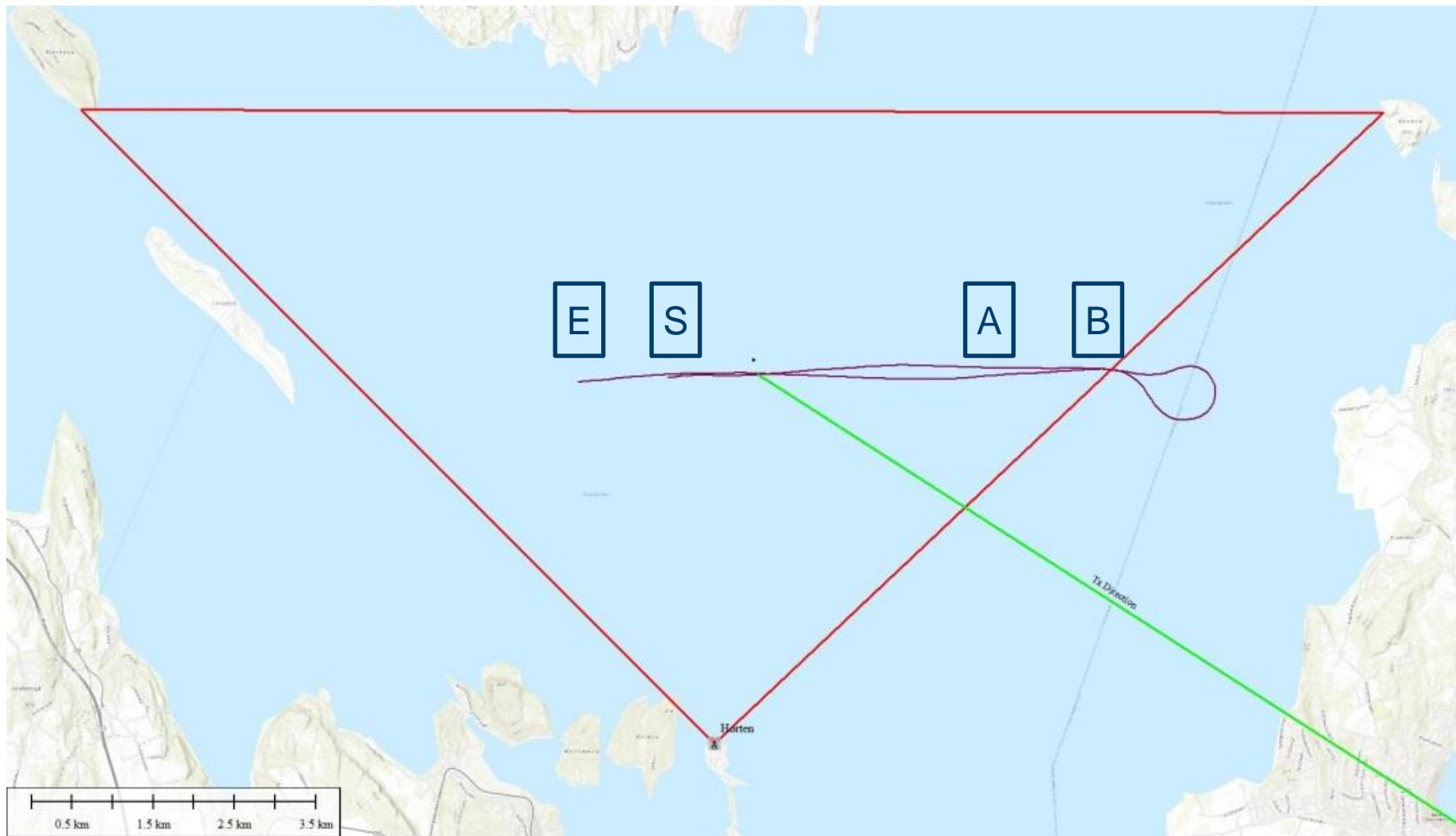
Transmitters at Halden (63 kW EIRP) & Hvingingen (1 kW EIRP)



Trial site: Oslo fjord north of Horten

Antenna pointing north

Transmitters at Halden (63 kW EIRP) & Hvingingen (1 kW EIRP)



Visible: Processing cabinet, surveillance antenna, calibration antenna, reference antenna Halden, reference antenna Hvingingen/Kongsberg

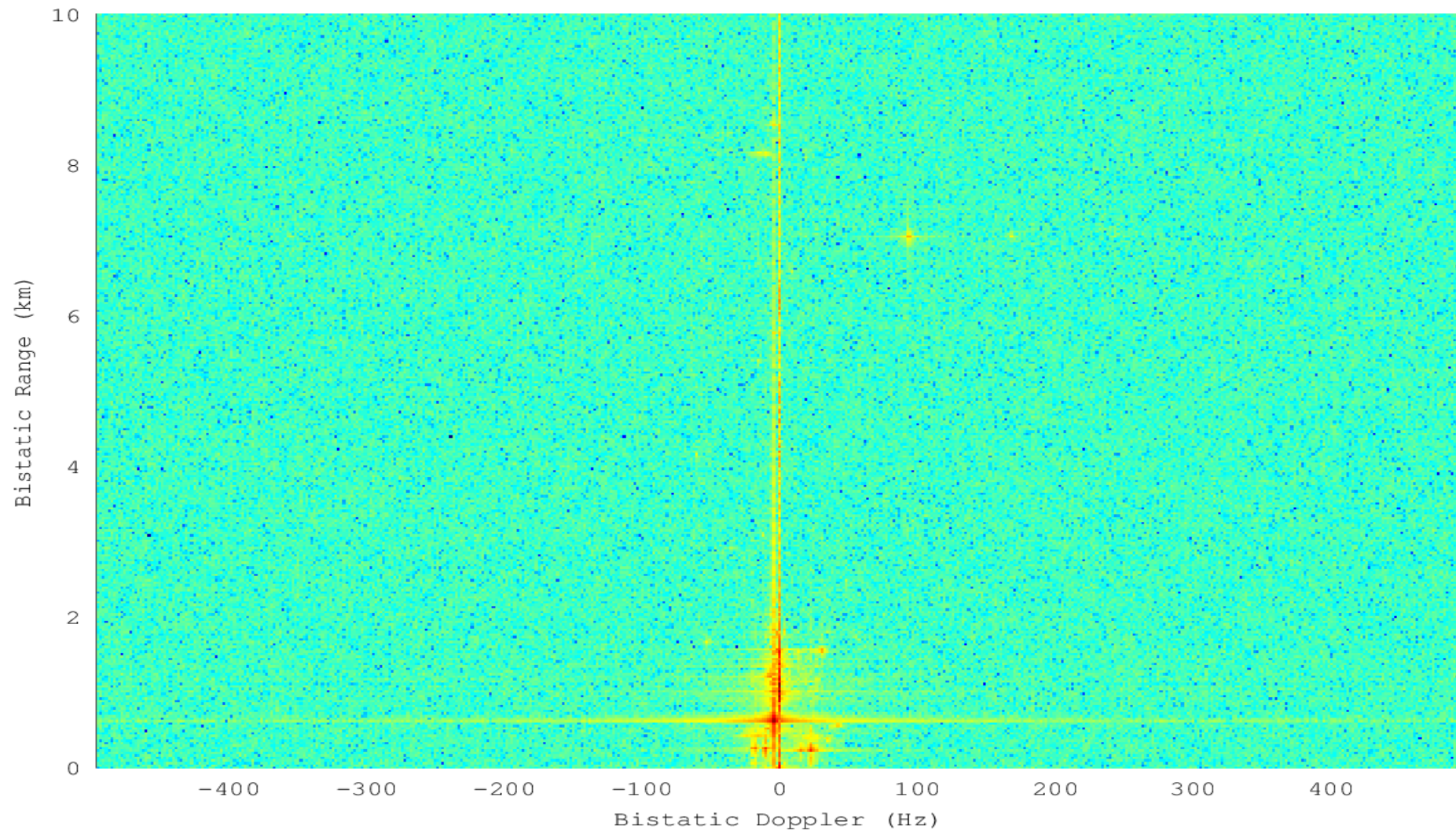


Signal Processing

- 0.5 s integration time is used
- The noise was taken as an average of range-Doppler cells at long range and high Doppler frequency.
- The H- and V-pol array are calibrated separately and continuously.
- The SNR- and RCS-ratios for these two polarisations will diverge to some extent using this type of calibration.
- Digital beamforming with uniform weights were applied to 5 of the H- and 5 of the V-polarised elements.
- We look for detections in a square of the range-Doppler map centered at the GPS-position of the target (20 range cells and 7 Doppler cells).

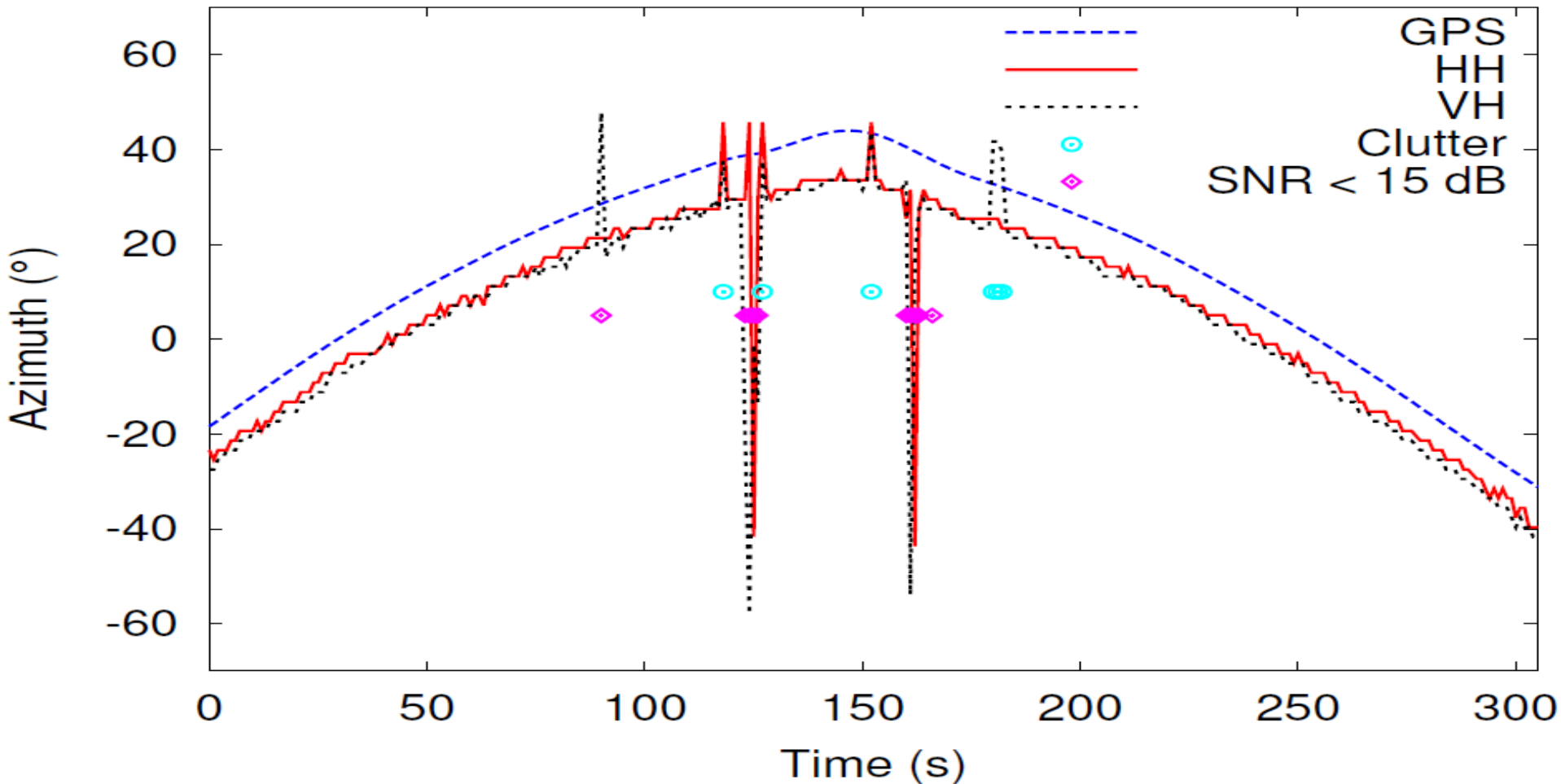
Detections are done in the bistatic domain

H-pol Angle -12 degrees 160614₁13533.207 UTC

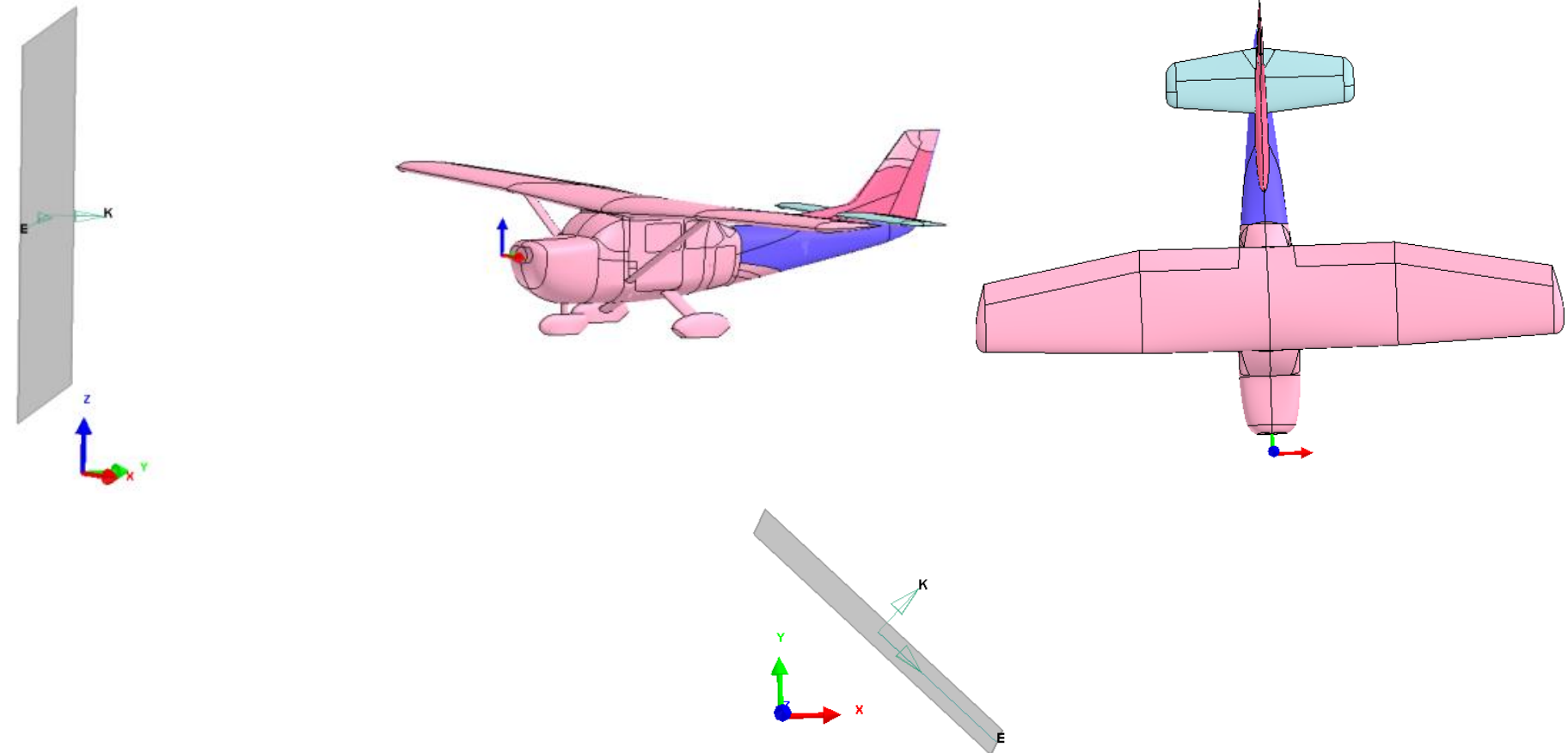


The beamforming was tested for HH and VH, and compared to the GPS track.

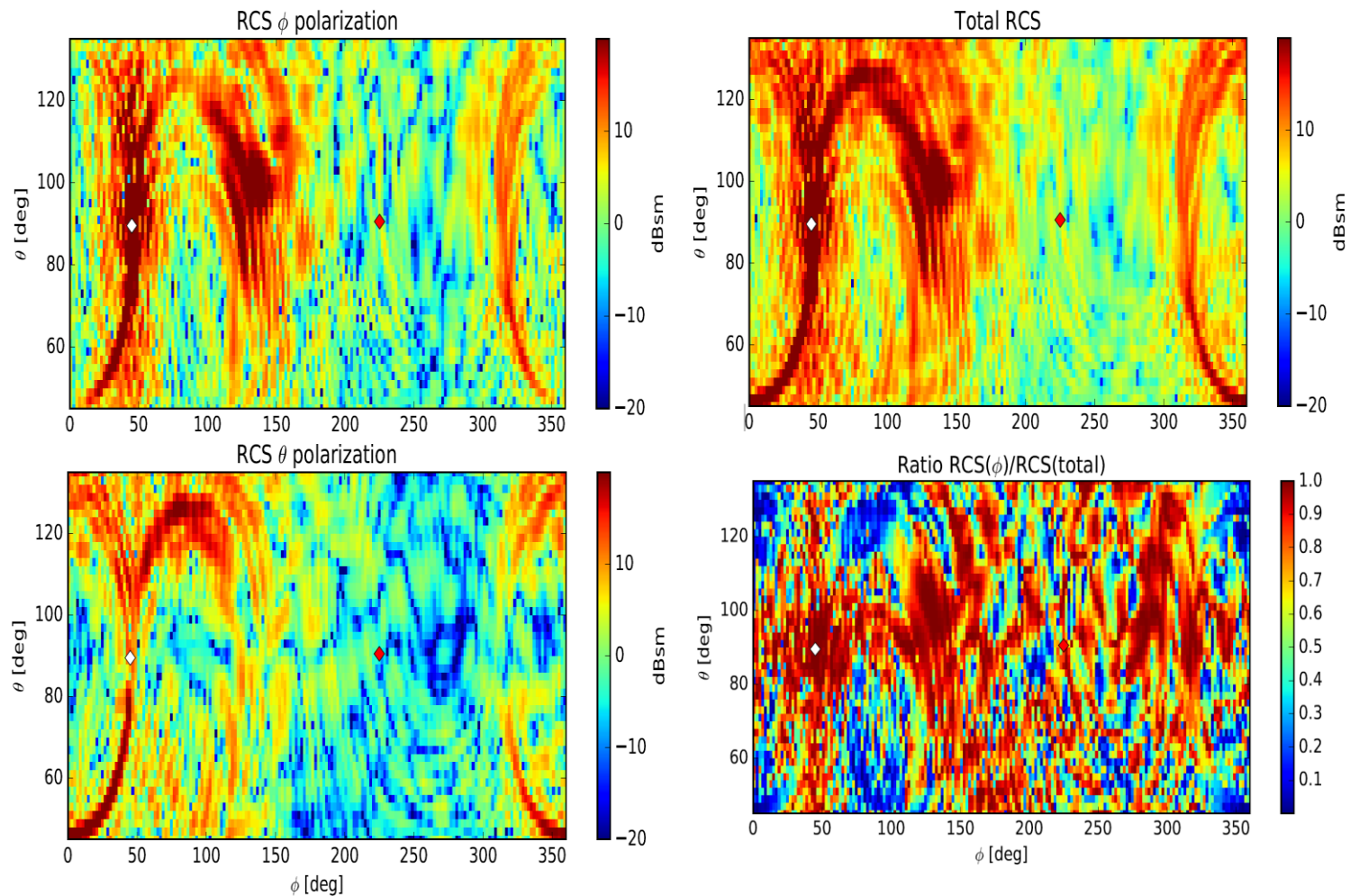
Cessna 172, 666 MHz



Electromagnetic model of the Cessna aircraft is a modified commercial CAD-model (grabcad.com)



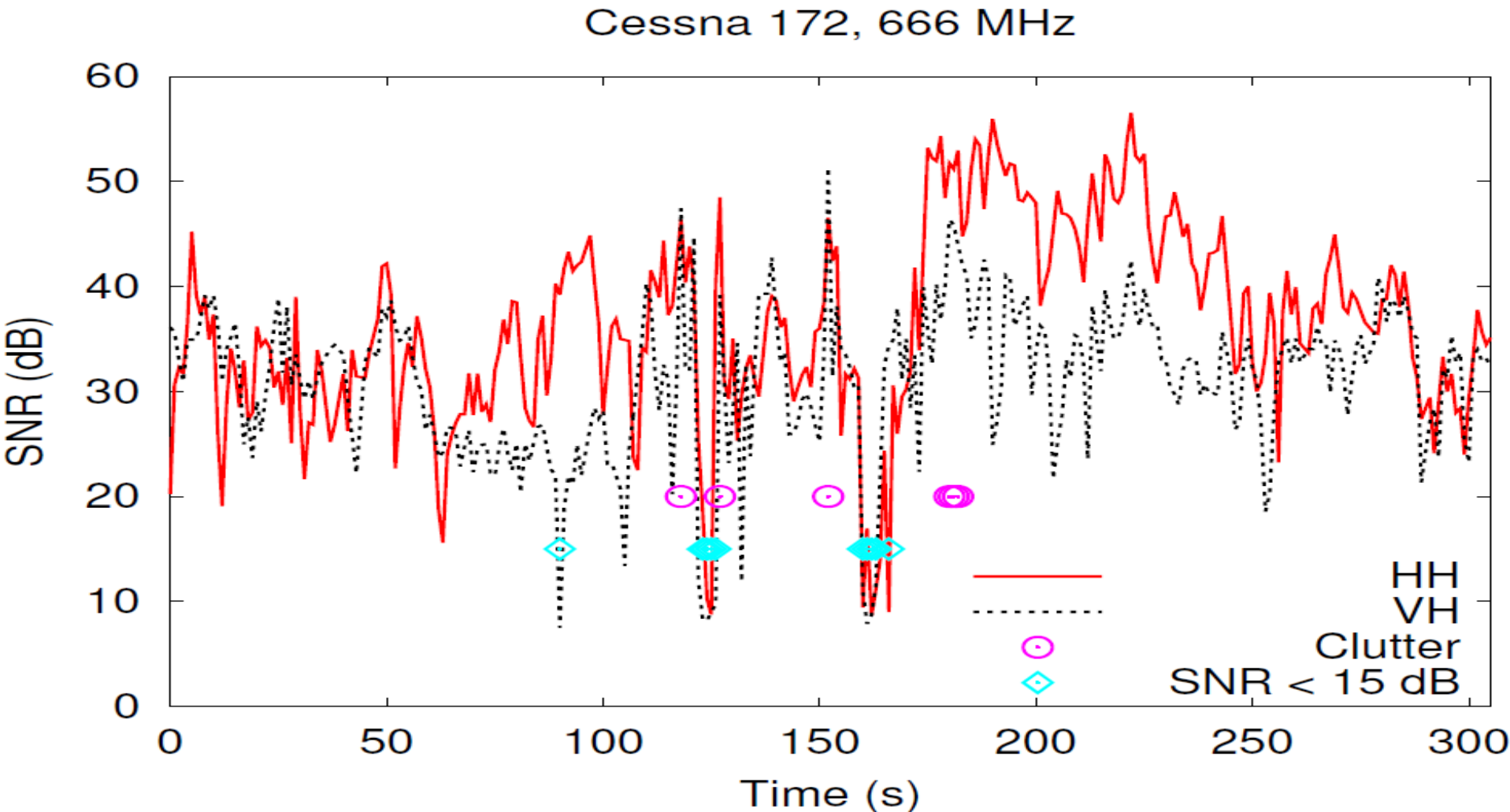
RCS simulations of the Cessna showed an advantage of Co-Polarized signals, especially in areas where specular reflections on the airframe happens.



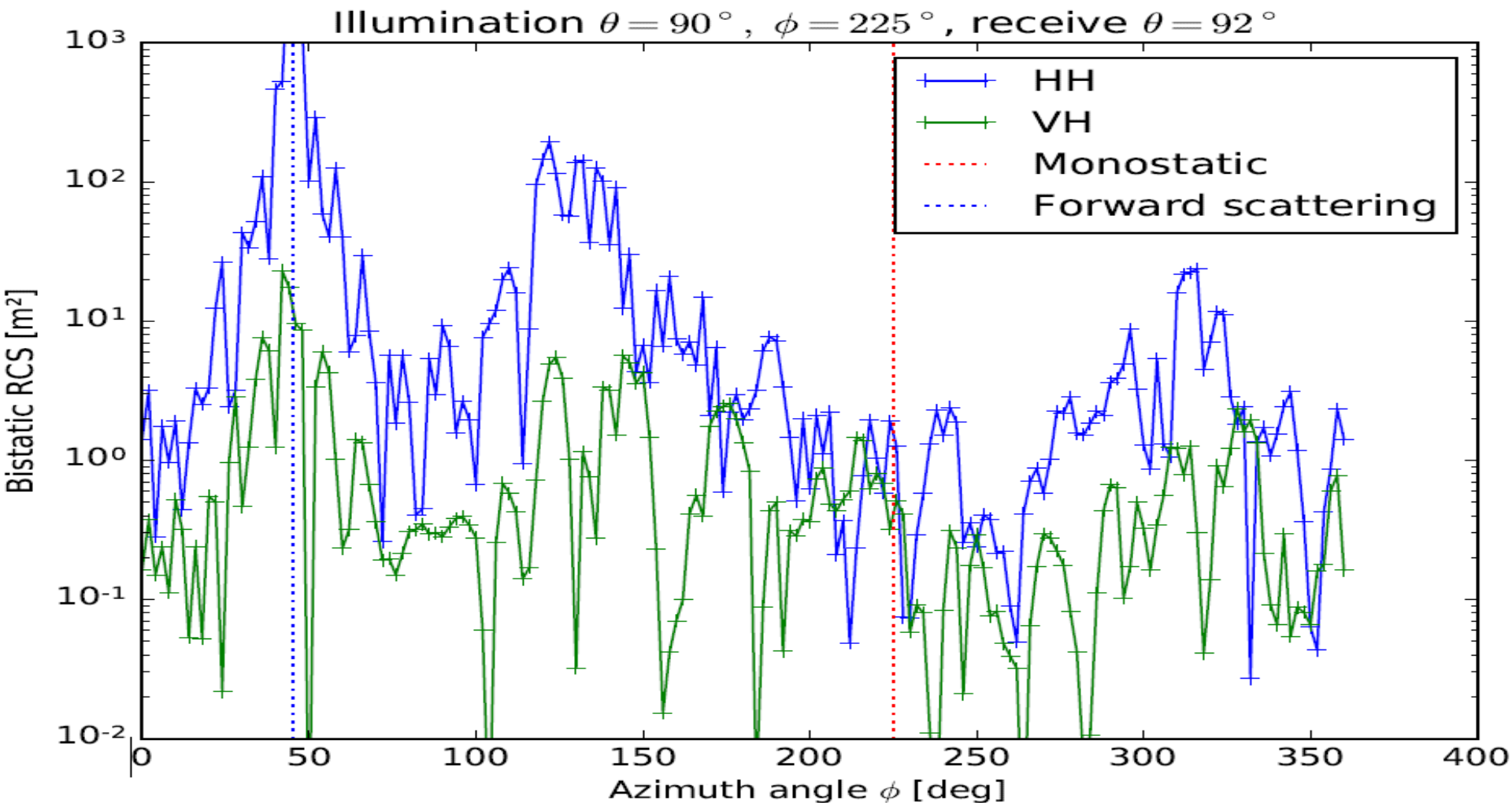
Processing influence on DS suppression

- In general, strong DS sidelobes/clutter floor mask the weak target echo.
- Known **analog methods** for suppressing DS are terrain shielding, antenna nulling, and applying a cross-polarized surveillance antenna wrt the transmitted DS.
- Sufficient dynamical range may allow **digital handling** of the problem: Direct signal cancellation, array antenna digital nulling, signal reconstruction.
- **Here FHR-method is used:** Reference signal **reconstructed** to perfect copy of transmitted signal. Perfect signal modified by «Reciprocal filtering» and cross-correlated within a DVB-T symbol, resulting in zero sidelobes due to orthogonality.
- If successful reconstruction and calibration, only the RCS affects the SNR for a given bistatic range.

In clear weather and low altitude (150 mASL) an advantage was seen with Co-polarized signal reception.



For the recorded interval, an extracted portion of the simulation is shown.



Summary

- Dual bowtie array elements show a good wideband response, good polarization isolation, and are well suited for an array antenna.
- The dual-polarized array show good performance in digital beamforming.
- Measurements and simulation of a Cessna 172 RCS response indicate that for DVB-T frequencies, co-polarized measurements in a H-transmit scenario will yield better detection performance.
- (An underlying premise is a proper digital suppression of the DS such that there is little advantage of applying a cross-polarised receiver surveillance antenna for DS suppression.)
- But more experiments should be made before concluding in general.

Questions ?