PAU: A HYBRID MICROWAVE RADIOMETER/GPS REFLECTOMETER TO IMPROVE SEA SURFACE SALINITY ESTIMATES FROM SPACE

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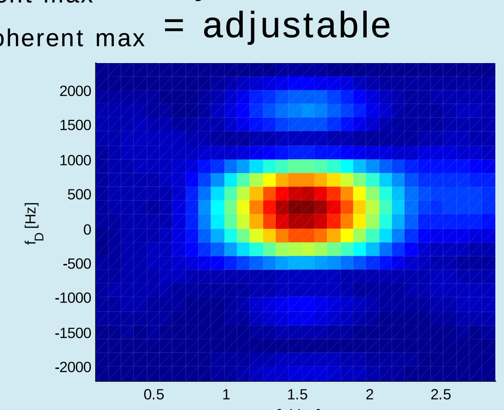
INTRODUCTION

- Global Navigation Satellite Signals Reflectometry (GNSS-R) techniques are being used in a number of remote sensing applications: altimetry and sea state over the ocean , soil moisture over land, ice age or altimetry over ice
- Most studies focused on the analysis of waveforms (time-domain correlations) for Doppler frequency shift that maximizes the received peak amplitude, but full Delay-Doppler Map (DDM) provides more information
- PAU in INTA mSat-1 is simplified PAU instrument that will compute complete DDMs on-board or store raw data on-board
- Evolution of previous proposal for SeoSat/INGENIO [1] to test the feasibility of correcting sea state in L-band radiometry using GNSS-R with applicability, for example, in future ESA SMOS follow-on missions

HERITAGE

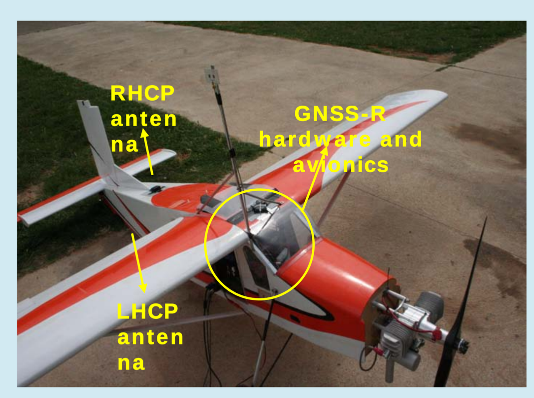
1. griPAU ground-based instrument [2]
⇒ sea state determination and impact on T_B
- 24x32 DDM points (min $\Delta\tau$=0.09 chips, Δf_d=200 Hz)
- $T_{coherent\ min}$ = 1 ms/$T_{coherent\ max}$ = adjustable
- $T_{incoherent\ min}$ = 1 ms/$T_{incoherent\ max}$ = adjustable

griPAU instrument: down-looking antennas for GNSS-R and L-band radiometer, up-looking antenna for GPS-receiver

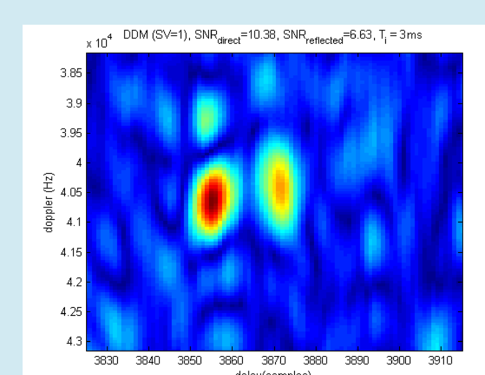


Sample DDM over ocean (Tcoherent = 1 ms) measured with gri-PAU (ALBATROSS 2009 field experiment, h = 382 m heigth)

2. UPC airborne GNSS-R altimeter [3]
- On-board data recording
- On-ground data processing

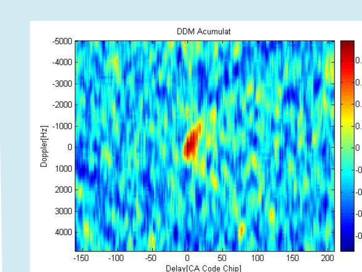


Remote Control Aircraft carrying a GNSS-R altimeter: direct and reflected signals combined before data recording

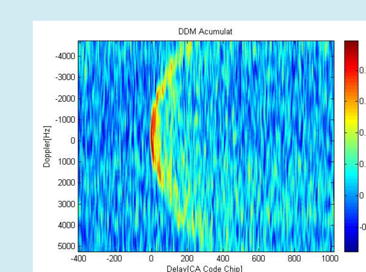


Sample result: left (direct signal DDM) and right (reflected signal DDM) ⇒ $\Delta\tau_{peaks}$ = 2·h·sin(elev)/c

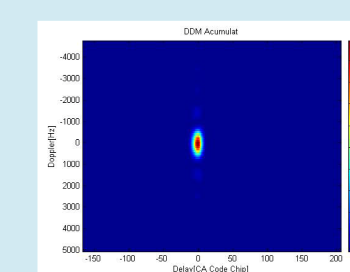
3. UK-DMC data processing [4]
- Open data set over land, sea and ice
- Using revised/updated version of DAAXA



DDM over land
$T_{coherent}$ = 1 ms
$T_{incoherent}$ = 200 ms

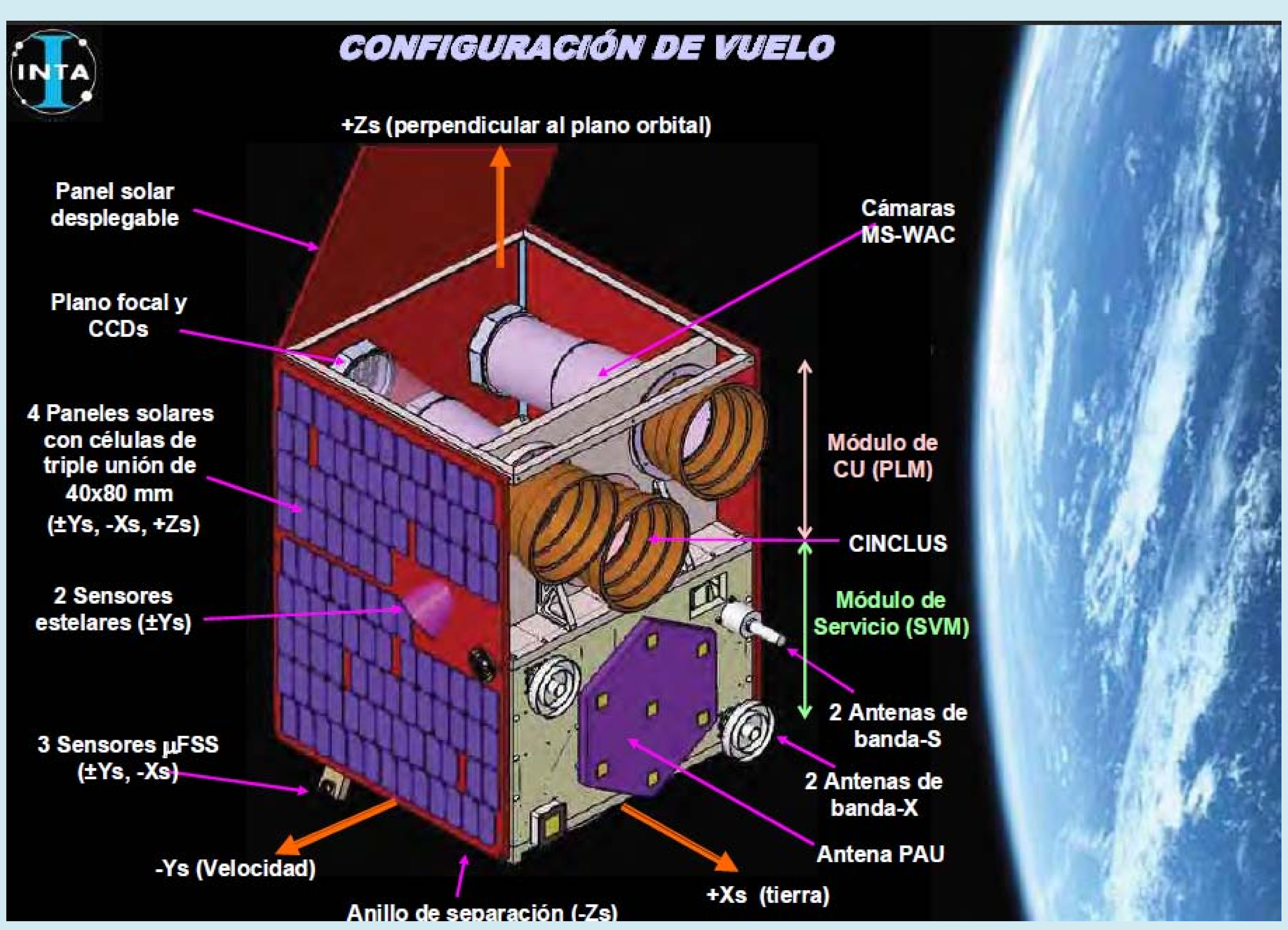


DDM over the ocean
$T_{coherent}$ = 1 ms
$T_{incoherent}$ = 200 ms

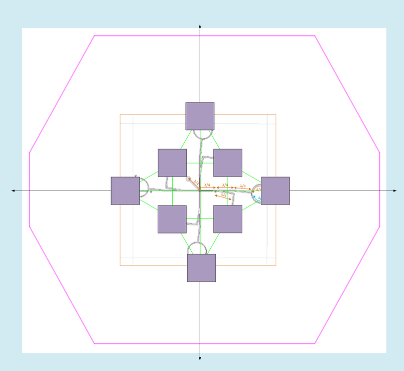


DDM over the ice
$T_{coherent}$ = 1 ms
$T_{incoherent}$ = 200 ms

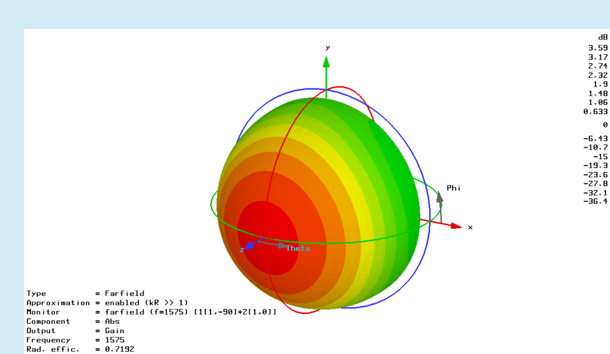
PAU in INTA mSat-1 instrument



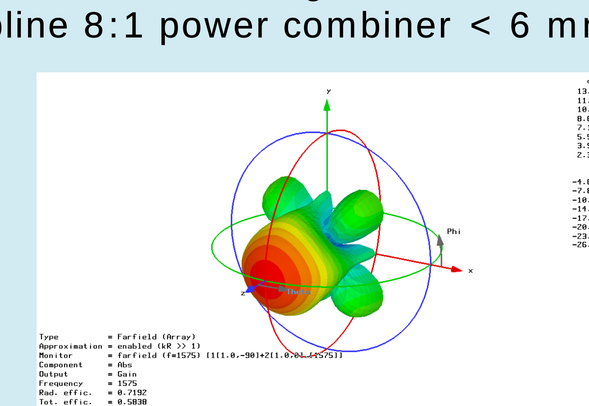
1. Antenna array [5] optimized for lowest possible ohmic losses and maximum gain implemented on a planar structure (microstrip patches + stripline 8:1 power combiner < 6 mm thick)



Array topology

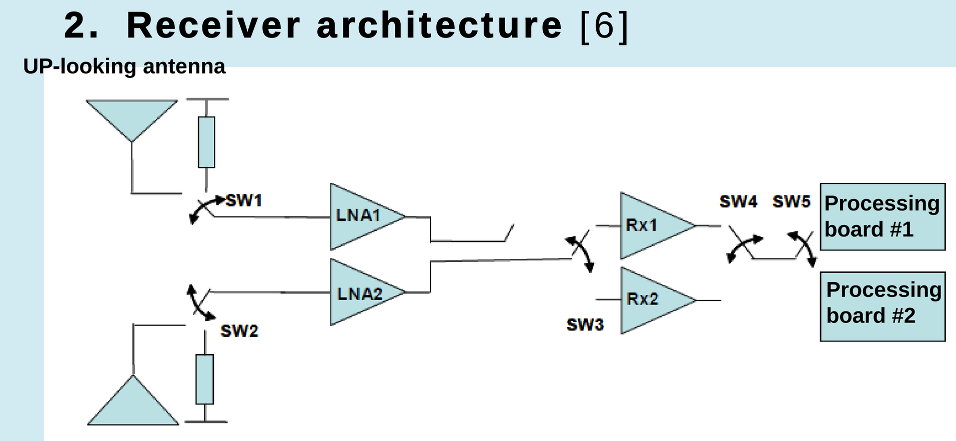


LHCP-polarization elementary pattern

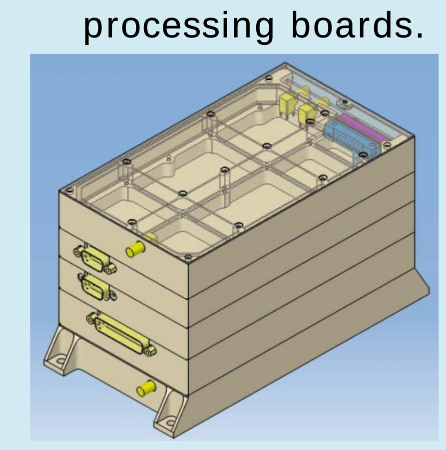


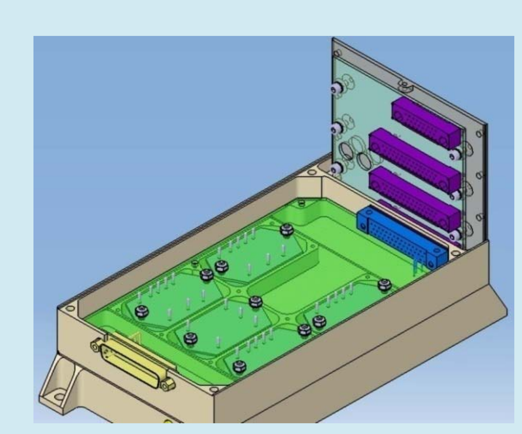
Array radiation pattern

2. Receiver architecture [6]



- Simplified design:
  - Radiometer operated as a TPR with frequent calibration,
  - GNSS-Reflectometer operated while the receiver is connected to the antenna, and
  - Combination of up-looking and down-looking channels through a coupler to save one receiving chain
- Frequencies: RF = 1575.42 MHz, IF = 70 MHz, Fs = 16.384 MHz
- Architecture: Two cold redundant receivers and processing boards.





3. Signal Processor
- Processing boards: Virtex-4 FPGAs, with in-orbit reconfiguration capability
- Interfaces: CAN (commands & reconfiguration), Space-Wire (data)
- Dummy processing: Sequential search of all GPS satellites using 1 ms incoherent integration time + 1000 incoherent averaging
- On-board real-time processing (DDM size: 4096 samples in delay x 16 samples in Doppler) or raw data acquisition

CONCLUSIONS

- PAU in INTA mSat-1 is a small secondary payload to test sea state correction in L-band radiometric observations (ΔTB vs Δ Volume under normalized DDM)
- Direct and reflected signals combined will allow also to make scatterometric and altimetric measurements
- Planar antenna trade-off between relatively low ohmic losses (~60%), high gain (~13.4 dB), side lobes (-11 dB at 90º), mass and thickness (< 6 mm).
- Computes real-time DDMs or stores raw data for ground processing
- Basic processing scheme: Tcoherent = 1 ms, T incoherent = 1 s + blind sequential search of GPS satellites in view.

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