ALTIKA, A NEW CONCEPT OF ALTIMETER FOR THE SARAL MISSION : DESCRIPTION AND PRE-FLIGHT PERFORMANCES

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Abstract
In partnership with scientific laboratories and industry, and for several years, CNES has studied the feasibility of a high-resolution ocean topography mission based upon a new class of wide-band Ka-band altimeter. AltiKa payload will be embarked in the SARAL satellite at the same time as the Argos3 instrument, in the frame of a cooperation between CNES and ISRO (Indian Space Research Organization) with an expected launch in 2011.
The mission objectives, the instrument description status and pre-flight performances are given in this poster.

Mission

AltiKa payload

- **A Ka-band altimeter**
  - single frequency instrument : ionospheric effects are negligible
  - enhanced bandwidth : vertical resolution and thus error budget improvement
- **A dual-frequency radiometer (24/37 GHz)**
  - required for tropospheric correction
  - Embedded in the altimeter
- **A Laser Retro-reflector Array**
  - minimum for orbitography and system calibration
- **DORIS** (Doppler Orbitography and Radiopositioning Integrated by Satellite)
  - required for achieving very high accuracy orbitography in low earth orbit (orbitography need)
  - measurements link with past or simultaneous missions like T/P, ENVISAT, JASON 1/2 in a well monitored terrestrial reference frame

Mission objectives

Central objective :

- ocean mesoscale circulation
- data assimilation in a global ocean model

Contribution to :

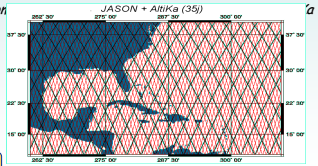
- Continental ice studies
- Sea-state analysis & forecast
- Low rain detection and characterization
- Coastal/inland water altimetry
- Mean sea level

Orbit : same as ERS and Envisat

- ✓ Polar (incl. = 98.55°) Sun-Synchronous orbit (6:00/18:00), 800 km altitude, low eccentricity
- ✓ ground track repetitivity period : 35 days

At least 2 satellites are needed to measure mesoscale variations of the ocean

Example of co… …a

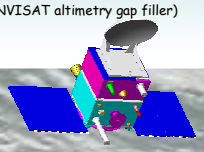


Mission status

AltiKa payload will fly in the frame of a cooperation with ISRO (Indian Space Research Organisation).

- AltiKa payload will be embarked on the SARAL satellite
- Demonstration of the Ka-band altimetry as a complement to Jason 2 (post-ENVISAT altimetry gap filler)
- Launch foreseen from mid 2011

View of the SARAL satellite



Rain and cloud effect in Ka-band

Effect of rain

- Rain has an effect on the Signal to Noise ratio
- CNES/CLS study on rain rates from TRMM/TMI data shows that :
  - Average for one year and all geographical areas show that around 3% of data will be unavailable
  - Unavailability can reach 10% locally depending on season (e.g. Bengal Golf)

Effect of clouds

- Clouds or rain cells smallest than AltiKa antenna footprint introduce distortions on the waveform and errors on parameters

Study using MODIS data : preliminary results show that this effect increases reasonably the noise on measurements and that for a certain amount of data (less than 10%), a dedicated processing will be necessary

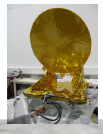
Instrument description and calibration results

Main characteristics

Parameter	Value
Altimeter band	35.75 GHz ± 250 MHz
Pulse bandwidth	500 MHz
Pulse duration	110 µs
Altimeter Pulse repetition frequency	~ 3.8 kHz (adjustable along the orbit)
Echo averaging (altimeter)	~ 25 ms
Altimeter Link budget	11 dB (sigma naught = 6.5 dB)
Antenna diameter	1000 mm
Radiometer band	23.8 GHz ± 200 MHz 37 GHz ± 500 MHz
Radiometric resolution	< 0.4 K
Radiometric accuracy	< 3 K
Radiometer averaging	200 ms
Data rate	38 kbits/s
Mass (altimeter+radiometer)	< 42 kg
Power consumption (altimeter+radiometer)	< 100 W

The antenna is common for altimeter and radiometer and is composed of

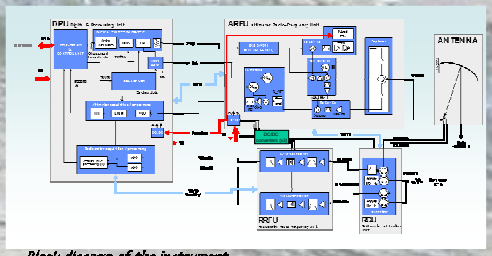
- o A fixed offset reflector
- o A three-band feed
- o A sky horn pointing to deep space



The AltiKa instrument consists of a Ka-band altimeter which functions are based on proven concepts and already developed sub-systems, as it inherits from Siral (CRYOSAT mission) and Poseidon3 (JASON2 mission), and an embedded dual frequency radiometer.

- Altimeter function is based on the full Deramp technique
- Radiometer function is based on the direct detection principle. The radiometer radiofrequency unit (RFU) consists of two RF receivers, which are developed by EADS ASTRIUM.

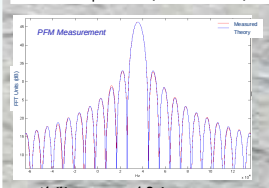
The radiometer must be switched-off during radar altimeter emission.



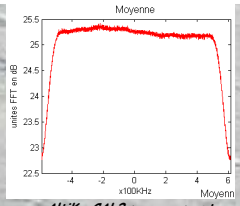
Block diagram of the instrument

Calibration modes

- ❑ Calibration-1 : provides with the altimeter point target response (complex spectrum).
- ❑ Calibration-2 : provides with the altimeter receiver transfer function after Deramp (in the frequency domain) by averaging the natural thermal noise in the reception channel over a long period.
- ❑ Radiometer calibration : RCU can commute every N seconds to a sky horn pointing to deep space (cold reference) or to a load at ambient temperature (hot reference)



AltiKa measured Point target response (CAL1 mode)



AltiKa CAL2 measurement

- o Cal1 and Cal2 are Compliant to requirement
- o Very good stability of the PTR
  - -Versus frequency
  - -Versus T°

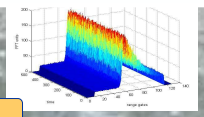
SARAL Payload Integration Module after thermal vacuum

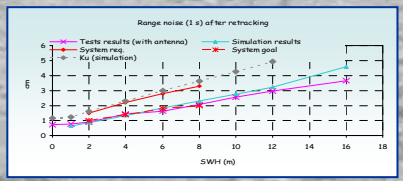
AltiKa pre-flight measured performances

Range and SWH performance

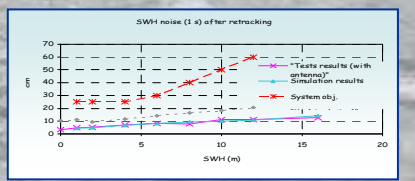
- Accuracy of the altimeter range measurement over sea surface : **about 1 cm for a SWH of 2 meters**
- Improvement of about 40% on the range noise versus Ku-band performances
  - Better estimate of the velocity fields (topography gradients) and better analysis of the eddies structure along-track

Test bench simulated waveforms



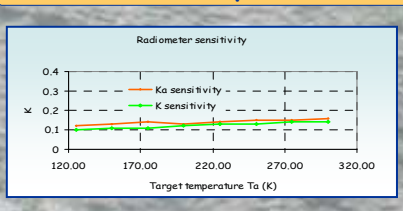


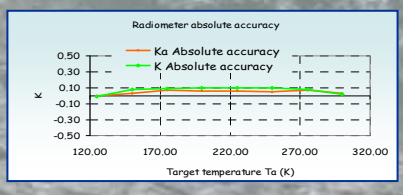
1 second range noise (cm) versus SWH : ground tests results



1 second SWH noise (cm) versus SWH : ground tests results

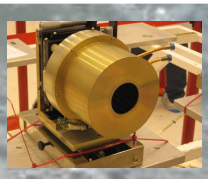
Radiometer performances





Radiometer performances during acceptance tests, for an ambient temperature of 20°C, without antenna
Worst case, in temperature and with antenna, absolute accuracy < 1.3 K
➔ Fully compliant to the specifications
Ka sensitivity req. < 0.4 K
K sensitivity req. < 0.3 K
Absolute accuracy req. < 3 K

-Acceptance tests in thermal vacuum using radiometric target in front of antenna horns.
-Dynamic of brightness temperature from 110 K to 310 K, for 3 ambient temperatures (0°C, 20°C and 40°C)
- Calibration of the radiometric model developed by TAS-F (implemented in ground segment)
⇒ Estimation of the radiometer performances (in terms of sensitivity and absolute accuracy), at 20°C



Black body (radiometric target)
Accuracy of 0.25 K

Tests in thermal vacuum involving cryogenic means