The Jason-CS Ocean Surface Topography Mission Payload Design and Development

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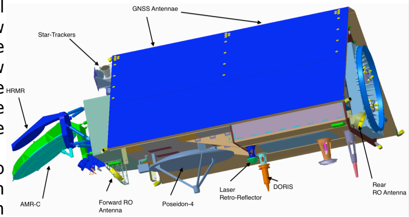
1. Jason-CS : Ocean Surface Topography Continuity of Services

Jason-CS will fulfil the objectives of continuing the long term retrieval of global sea level rise/ variability in addition to providing NRT geophysical parameter data, such as wind speed, to operational users. It will follow ocean surface topography reference missions since 1992 and provide improved geophysical parameter retrievals as a result of the use of new technology combined with experience of ESA/CryoSat data over ocean. The result benefit operational and science oceanographic communities with the state of the art in design and will secure optimal operational and science data return in the long term.

The development brings together several organisations that plan to procure 2 satellites, with the first of these, Jason-CS A, planned for launch readiness in 2019 and a planned to ensure continuity of the long-term ocean surface topography climate data record until the late 2020's.



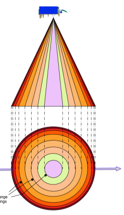
2. Poseidon-4 Radar Altimeter – Primary Payload

Designed to improve on the performances over heritage altimeters by incorporating State of the Art technology. (Right) overall mission requirements for the operation LR mode and the science SAR mode. Improved theoretical performances in red. The table is under review noting SSB requires further analysis.

	Jason-CS LRM (cm)	Jason-CS SAR (cm)
Instrument range noise (MLE-3)	1.5 (1.25)	0.8 (0.5)
Ionosphere	0.5	0.5
Sea State Bias	**1**	**1**
Dry Troposphere	0.7	0.7
Wet troposphere	1	1
Orbit error	1.5	1.5
Altimeter Range RSS	**2.7 (2.55)**	**2.4 (2.29)**

2.1 State of The Art:

Right: Pulse limited altimeters allow retrieval of geophysical parameters (elevation, wind speed and SWH) over single shot scales between about 1km to 5km.
Middle: Filtering the along track rates of change of phase allows improvement of along-track resolution (300m)
Left: Focusing the echoes improves the overall SNR and thus improves performances.



Fig, 2.1-a

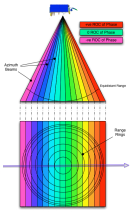


Fig. 2.1-b

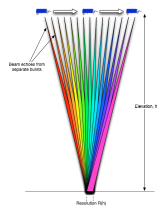


Fig. 2.1-c

2.2: Altimeter Performance

In-Orbit CS-2 data allows assessment for future missions: (Left) Range noise as a function of SWH between LR and SAR Processing. (Right) SWH noise.

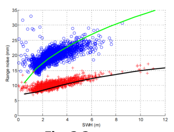


Fig. 2.2-a

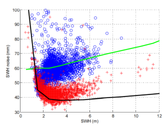


Fig. 2.2-a

2.3 Improvements with SAR

Breakthroughs have been made with SAR altimetry from CryoSat-2.

- Evidence (Fig. 2.3-a) that the SAR data does not show a mesoscale/ sub-mesoscale phenomena now associated with footprint size.
- Fig. 2.3-b shows the current theoretical performances in range noise for LRM compared with SAR based on 'State of the Art' technology and processing.

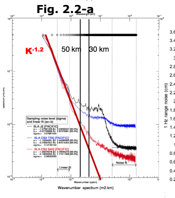


Fig. 2.3-a

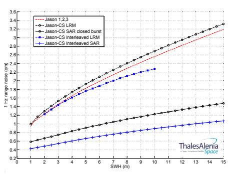


Fig. 2.3-b

3. AMR-C: Low Frequency Advanced Microwave Radiometer (Climate Quality)

The AMR-C (Fig. 3.1-a) is being developed by NASA-JPL and combines the existing design of the AMR (Jason-2 and Jason-3) with the potential addition of an on-board calibrator to improve retrievals of Brightness Temperature at 18.7, 23.8 and 34 GHz by means of a hot source. In addition, as is the baseline with Jason-3, a periodic 10-30 day cold sky calibration (Fig. 3.1-a) is being planned that involves a pitch manoeuvre of 80° that will be carried out over land in order to minimise loss of Poseidon-4 data over its primary target regions. This two point calibration system in addition to other potential sources of external calibration will improve overall accuracy.

Improved Performance: The expected improvement of the AMR-C with its predecessors in terms or reducing the path delay (PD) drift is provided in Fig. 3.1-c.

Heritage: The design and inversion algorithms that convert tri-channel brightness temperature to obtain total column water vapour correction for the radar altimeter are well understood at the lower frequencies. The AMR-C will provide basis for correcting the altimeter for the Wet Tropospheric delay

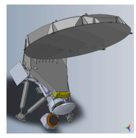


Fig. 3.1-a

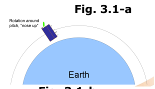


Fig. 3.1-b

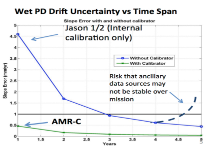


Fig. 3.1-c

5. Precise Orbit Determination and Attitude: DORIS/ GNSS/LRA + Star Trackers

The Precise Orbit Determination (POD) package consists of three elements of heritage.

DORIS: will be embarked to provide the main component of data for on-board navigation, also used in the NRT processing. It also supplies the ultra stable oscillator that drives the Poseidon-4 precise retrievals and positional information allowing improved altimeter surface tracking improving coastal and inland water retrievals. The DORIS is procured with significant support from CNES.

GNSS: The heritage Sentinel-3b instrument enhanced to 12 channels is being embarked for use with GPS constellations

LRA: The Laser Retro-reflector Array is planned to be procured by NASA-JPL and is used with global laser stations as an independent measure of delay used in the POD processing.

Star Trackers: Used within the on-board Attitude and Orbit Control System (AOCS) the 3 instruments attitude information (quarternions) key to the Poseidon-4 SAR retrievals that are sensitive to platform 'mis-pointing'.

4. HRMR : High Resolution Microwave Radiometer

An ESA study has recently commenced following recommendation of the OSTST in 2012 that a higher frequency radiometer will complement a lower frequency retrieval of Total Water Vapour Content for the correction of the wet tropospheric path delay experience by the Ku/C Band Altimeter over all surfaces and supporting sub-mesoscale retrievals from the altimeter .

The benefits are an improvement of resolution (~10km) in addition to more accurate retrievals in coastal regions. Fig. 4.1-A, shows (top) land cannot be seen in higher frequency retrievals compared with (bottom) those from lower frequencies. The HRMR also offers an on-board cross-calibration system with the AMR-C and may thus help reduce the effects of drift in the wet tropospheric correction (the main error in long term retrievals of sea level elevation change).

The current competitive Phase 'A' study draws on extensive heritage from instruments such as AMSU-B (NOAA KLM), HSB (Aqua), MHS (Metop) and MWS Metop Second Generation).

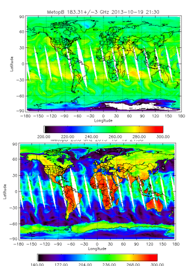


Fig. 4.1-A Courtesy, NOAA.

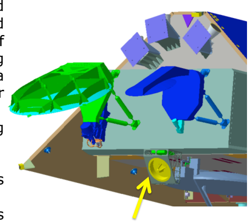
6. Radio Occultation with TriG

Recognising the interest in retrieving, from the occultation of GNSS satellites, temperature and pressure profiles the partner Agencies have conducted an initial assessment to determine if number of retrievals from a high elevation satellite in a drifting non sun-synchronous orbit are of use. The profile data as used for assimilation into Numerical Weather Prediction models.

The RO The Radio Occultation package is being developed by NASA-JPL based on TriG.

The main requirements are:

- to achieve the retrieval of about 1000 occultation's per day.
- Provide NRT L1b and L2 products within 3 hours (90%)
- Measurement for ray path tangents up to 80km
- Measurement with ray path tangents extending to 500km altitude.



(Fig. 4.1-a)Forward looking RO antenna. A rear antenna is also planned

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