Ka-band radar studies
CNES pre-phase A work

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Inputs from: J. Lambin, Th. Amiot, JC. Souyris, B. Lazard,
Past programmatic context

- WSOA on-board Jason-2/OSTM (PhD Vivien Enjolras)
- WatER proposal
- Several R&D studies initiated; some still in progress

Current context: renewed perspectives for Wide-Swath altimetry

- CNES-NASA plans for cooperations: on-going at agencies level

- Study Re-activation (R&D, research groups, engineering studies)
- New PASO study (*Plateau d’Architecture des Systèmes Orbitaux*)
  - Dedicated study/funding (phase 0) 2007-2008
  - Specific actions + synthesis of other activities

- Next stage would be a phase A study (2nd half 2008, TBC?)
■ **CNES-LEGOS science team**: Nelly Mognard, Anny Cazenave, Yves Ménard

■ **Programmatics**: Eric Thouvenot (Ocean), Hervé Jeanjean (Land surfaces)

■ **Coordinator of PASO study**: Bruno Lazard

■ **Mission engineering studies**: Juliette Lambin

■ **Payload technical team**: Bruno Cugny, Jean-Claude Souyris, Alain Mallet (payload study)
CNES Payload studies

**NADIR ALTIMETER**:  
Trade-off for Nadir altimeter (opened questions)

- Ku/C vs Ka band
- SAR mode to improve resolution along track,
- Radiometer definition (2/3 or more channels including swath measurements, see Estelle Obligis presentation)
- Based on AltiKa (WatER proposal) or Poséidon and SIRAL/SRAL heritage
- POD receiver: DORIS/GNSS used for OLTC (Open loop tracking Command) + LRA

See next slides example of SRAL design (bi-frequency, LRM+SAR mode)  
Compared to AltiKa
SRAL (Ku/C) radar altimeter main figures

DPU figure (AltiKa design)
M=10 kg
V=255x300x249 mm
C=36W

RFU figure:
M=14.3 kg
V=270x470x373 mm
C₁=51 W (LRM)
C₂=63 W (SAR)

Antenna figure (Pos3 design)
M=7 kg
Diameter=1.2 m
Focal length=430 mm
3.2.4.2.3 AltiKa Payload budgets

Present AltiKa payload budgets in terms of mass, volume, power consumption and telemetry data rate are given in Table 3.

<table>
<thead>
<tr>
<th>Equipment or Unit</th>
<th>Mass (kg) Nominal/Max(1)</th>
<th>Volume (mm³) L x W x h</th>
<th>Power consumption (W) Nominal/Max(1)</th>
<th>TM data rate (kbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AltiKa Instrument</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Altimeter &amp; radiometer)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DPU</td>
<td>10.5 / 11</td>
<td>230 x 298 x 249</td>
<td>26.5 / 33</td>
<td>65.5</td>
</tr>
<tr>
<td>ARFU</td>
<td>12 / 12.5</td>
<td>325 x 305 x 250</td>
<td>41 / 47</td>
<td>-</td>
</tr>
<tr>
<td>Antenna assembly</td>
<td>11 / 11.5</td>
<td>Reflector : 1000</td>
<td>NA</td>
<td>-</td>
</tr>
<tr>
<td>RCU</td>
<td>1.5 / 1.7</td>
<td>300 x 180 x 50</td>
<td>1.5 / 1.7</td>
<td>-</td>
</tr>
<tr>
<td>K-band RRFU</td>
<td>1 / 1.1</td>
<td>92 x 179 x 48.5</td>
<td>3.8 / 4.1</td>
<td>-</td>
</tr>
<tr>
<td>Ka-band RRFU</td>
<td>1 / 1.1</td>
<td>92 x 170 x 48.5</td>
<td>3.2 / 3.5</td>
<td>-</td>
</tr>
<tr>
<td>RRFU converters (x3)</td>
<td>0.5 / 0.6</td>
<td>3x(25 x 100 x60)</td>
<td>2 / 2.2</td>
<td>-</td>
</tr>
<tr>
<td>Harness</td>
<td>3 / 3.5</td>
<td>-</td>
<td>NA</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total for AltiKa instrument</strong></td>
<td>40.5 / 43</td>
<td>-</td>
<td>80 / 91.5</td>
<td>65.5</td>
</tr>
<tr>
<td><strong>DORIS instrument</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BDR</td>
<td>16.5 / 16</td>
<td>388 x 366 x 165</td>
<td>23 / 28 (2)</td>
<td>1.5</td>
</tr>
<tr>
<td>Antenna</td>
<td>2 / 2</td>
<td>Diam: 160; h:428</td>
<td>NA</td>
<td>-</td>
</tr>
<tr>
<td>LRA</td>
<td>1 / 1.5</td>
<td>Diam:190; h:90</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Total for AltiKa payload without ICU</strong></td>
<td>60 / 64.5</td>
<td>-</td>
<td>103 / 119.5</td>
<td>67</td>
</tr>
<tr>
<td><strong>ICU (raw estimate)</strong></td>
<td>4 / 5</td>
<td>TBD</td>
<td>&lt; 10 (TBC)</td>
<td>&lt; 3 (TBC)</td>
</tr>
</tbody>
</table>

Table 3: AltiKa payload budgets
CNES Payload studies (cntd)

KaRIN main figures:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>36.5 GHz</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>200 MHz</td>
</tr>
<tr>
<td>Pulse duration</td>
<td>6.1 µs</td>
</tr>
<tr>
<td>Pulse repetition frequency</td>
<td>8800 Hz</td>
</tr>
<tr>
<td>Peak RF power</td>
<td>1500 W</td>
</tr>
<tr>
<td>Duty cycle</td>
<td>5.3%</td>
</tr>
<tr>
<td>Mean instrument power</td>
<td>First est. 800 W</td>
</tr>
<tr>
<td>Antenna length</td>
<td>4 m</td>
</tr>
<tr>
<td>Antenna height</td>
<td>0.2 m</td>
</tr>
<tr>
<td>Mast length</td>
<td>10 m</td>
</tr>
<tr>
<td>Near range view angle</td>
<td>0.7°</td>
</tr>
<tr>
<td>Far range view angle</td>
<td>4.3°</td>
</tr>
<tr>
<td>Azimuth resolution</td>
<td>5 m</td>
</tr>
<tr>
<td>Range resolution (NR)</td>
<td>70 m</td>
</tr>
<tr>
<td>Range resolution (FR)</td>
<td>10 m</td>
</tr>
<tr>
<td>TM rate</td>
<td>First est. 500 Mb/s</td>
</tr>
</tbody>
</table>

NB : $\sigma_h$ close to 50 cm for NR pixels
Heigh error budget for different surface roughness

- 1 deg
- 4 deg
- 8 deg
- 16 deg

Look angle (degree)

Height error (m)
CNES Payload studies (cntd)

- **KaRIN**: Need to understand and decline high level performance @ Sub-System level
  - Preliminary requirements for: antenna, interferometric arm, RF unit, calibration sub-system, on-board processing taking into account the present KaRIN definition.
  - Identify main constraints for platform accommodation: field of view, pointing accuracy, volume, mass, Electrical interface, telemetry rate ...

- Preliminary definition of some of these equipments taking into account CNES/TAS (Thalès Alenia Space) heritage with Poseidon, AltiKa, SIRAL/Cryosat and SRAL/Sentinelle3 as well as the ongoing phase A studies concerning SWIM (low incidence High resolution scatterometer)
  - Critical analysis of sub-system RFU (Radio-Frequency Unit) + DPU (Digital Processing Unit): feasibility, phase stability performances, calibration schemes, optimization of power consumption for the different modes (First target 600 W for all payload including TMCU).
  - A priori exclusion of antennas, IF arm and Ka band EIK for detailed studies except if we have smart solutions to propose ...
Digital Processing unit

- High signal bandwidth (200 MHz) => trade-off between full-deramp technic and full band acquisition followed by digital pulse compression …
- Chronogram management taking into account altitude variations along the orbit: Tracking loop as for SRAL or digital detection of swath begin after pulse compression
- Echo digitization and processing (BAQ compression?) for the various modes (spatial resolution): ocean, coastal, hydro mode, calibration …

- Trade-off between on-board processing and data rate taking into account state of the art TMCU (Pléiades = 3x150Mb/s): first target fixed to an averaged 30 Mb/s rate with 256 Mb/s peak acceptable

- Assessment of a SAR mode to improve along-track resolution taking into account correlation time over ocean and over rivers

- Simulation of the impact of digital payload preliminary definition on interferometric phase level 0/1 products (Phase A) ?
CNES Payload studies (cntd)

- **2008 perspectives:**
  - End of PASO phase 0 satellite (end of March) followed by preliminary detailed payload studies to be continued until end of June 2008
  - R&D concerning RFU and Digital processing (to be decided end of this year)
  - Phase A start 2nd semester 2008
  - New Thesis?
Platform attitude (roll) corrections

R&D study with CLS:

- **2005-2006**: context of oceanography
  - Corrections of WSOA roll errors using ocean ascending/descending crossing points from an accurate description of roll signal error covariance
  - Possible improvement using the synergy with standard altimetry nadir missions and pre-correction of interferometric signals from oceanic variability

- **2007 (starting soon)**: roll corrections in the context of coastal / hydrology – two techniques will be assessed
  - Use of control points from geo-referenced DEM (SRTM type)
  - Propagation of errors estimated from ocean crossing points
End-to-end simulator: principle

- Tool developed using CNES R&D funding. Objective is to compare different multi-mission configurations of altimetry satellites (e.g., Jason-ENVISAT, WaterHM – Jason, Jason-TOPEX, Jason-TP-ENVISAT-GFO,...)

- Inputs:
  - Mission characteristics (orbit, nadir/swath, resolution, measurement errors...)

- Core:
  - Ocean model (MOG2D, tides)
  - Generation of synthetic observations
  - Assimilation code

- Output:
  - Performances assessment (assimilation output versus initial « truth »)
  - Several diagnostic levels
Plan to extend this simulator to **tidal analysis**

- Impact of Water-HM in SSO associated with non-SSO nadir mission
- Impact on mission if a non-SSO is selected (at the cost of instrument performance?)

**Work plan (2007-2008)**

- Several adaptations needed (tides modeling, diagnostic) ➔ in progress
- Study zone : North Atlantic European coast
- Case studies (inferred from PASO instrument study)
Ka band propagation studies

- R&D study initially scheduled Sept. 2007 (ONERA) delayed to November 2007 due to landing incident with the glider

  - Bibliography on Ka band backscattering of water and continental surfaces
  - Set-up of a probative measurement campaign including a calibration step.
  - Experimental data take @ polarizations VV and VH
  - Extension of an existing propagation model @ Ka band under low precipitation conditions (0.1 mm/h)
  - 2008: Data take representative of Alti-Ka mission
Ka band studies

ONERA-BUSARD (moto-glider)
Ka band studies (cntd)

Current configuration: vertical vision @ Ka band

Future configuration: phased Array antenna: assessment of WATERHM-like measurements?