STATUS OF ERS-2 SAR & ENVISAT ASAR INSTRUMENTS AND PRODUCTS

*ESA, **BAE Systems, ***Aresys, ****Norut
• ERS SAR performance status

• ASAR performance status

• ASAR mission extension beyond 2010
ERS2 SAR instrument: Nominal operation after 14 years

ERS Platform:
- Piloted without gyroscopes since 2001: degraded attitude and Doppler performance:
  - IM mode: Doppler ambiguity resolver implemented in the processor
  - WV mode: no DAR implemented
- No tape recorders since June 2003 → loss of global coverage for Low Bit Rate Mode (Wave) but nominal mission for High Rate (Image mode)

ERS-1/2 SAR Wave Mode Mission Coverage:
- 2003 until today: Regional mission
  - Acquisition over ground stations visibility
  - Starting with some 8 % of global coverage now having some 40 % of global coverage with very good coverage over North Atlantic
ERS-2 Stations coverage

ERS-2 Stations coverage LBR

Recently added
Or
on-going

Station acquire nearly all passes within visibility
Harmonisation of ERS – Envisat products

Alignment of ERS Image mode to ASAR product since summer 2005:
- Replacement of the VMP → PGS-ERS (SGI) → PF-ERS (LINUX) in 2010

PF-ERS IM Processor →
- CEOS Raw
- CEOS SLC
- CEOS PRI
- CEOS GEC

ERS format (native)

<table>
<thead>
<tr>
<th>ENV RAW</th>
<th>ENV RMS</th>
<th>ENV IMP</th>
<th>ENV IMG</th>
<th>ENV I MM</th>
</tr>
</thead>
</table>

Envisat format (new)

Alignment of ERS Wave product into ASAR Wave products (2008/2009)

LRDPF →
- IWA
- UWA

PF-ERS WV Processor →
- WVI_1P
- WVS_1P
- WWW_2P
Harmonisation of ERS – Envisat products

- ERS Image alignment
- Porting to Linux
- Integration in MMFI
- ERS Wave alignment
- ERS WV mission reprocessing (off-line)
- ERS WV ZGM reprocessing (off-line)

Fully harmonised catalogue with ASAR WV mode data until 2001 (until ZGM operations)

Fully harmonised catalogue with ASAR WV
→ Gap filled between ERS and Envisat
→ 15 years of harmonised WV products
ERS Doppler performance

- ERS2 Pointing performance
  - Platform piloted without gyroscope (Zero Gyro Mode – ZGM-) since 2001
  - Yaw routinely derived from Scatt data & used at ESOC for attitude control monitoring (yaw values within $0.4 \pm 1.9$ deg.)

- Nominal data quality
  - still high Doppler Centroid Frequency [-5, +5] kHz
ERS-2 SAR transmitter pulse power now lower than prior to the gain change in February 2003:

- No more margin left to increase the gain level (but 40dB is still a lot of power)
- Noise floor shows a slow degradation
• Neustrelitz ground station.

### ERS External Calibration

<table>
<thead>
<tr>
<th>Name</th>
<th>Operation Dates</th>
<th>Mean RCS (dBm²)</th>
<th>Mean Stability (dB)</th>
<th>Peak-Peak RCS (dB)</th>
<th>No of Images</th>
</tr>
</thead>
<tbody>
<tr>
<td>GS1</td>
<td>13/04/96 – 08/09/09</td>
<td>58.93</td>
<td>0.54</td>
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<td>GS3</td>
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<td>63.59</td>
<td>0.32</td>
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</table>
ERS2 SAR (AMI) is performing well since the beginning of the mission
   – Slow degradation of the SNR due to the instrument aging

Degraded pointing impacting the interferometric capability of the ERS mission

Regional mission for IM and WV

Radiometric accuracy/stability is good and stable over time

Performance are routinely monitored and the results are available on a monthly basis
http://earth.esa.int/pcs/ers

Harmonisation process with Envisat almost completed
   – ERS WV reprocessing to start in early 2010
   – Reprocessing of WV ZGM data is planned for 2011
• ERS instrument performance status
• ASAR mission status
  – Instrument status
  – Calibration and performance
  – Algorithm, Processor and product status

• ASAR mission extension beyond 2010
Summary of ASAR Status

• All modes operational with nominal performance since launch

• AP constraints removed thanks to the upload of the on-board s/w pacth#09 in may 2009

• Availability close to 100%

• Instrument status:
  • Redundant DSS (since 03)
  • Antenna TRM failures with no impact on performance

http://earth.esrin.esa.it/pcs/envisat/asar/public_reports/
ASAR: an alive antenna

TRM failures since launch:

- 1 partial PSU failure (4 TRMs) in Tx (HH & VV): May02
- 2 complete PSU failures (8 TRMs) in Tx & Rx, HH & VV: Feb03, Feb07
- Individual TRMs failures in Tx (9 in HH and 6 in VV): Apr04, May04, Nov04, Jan05, Nov05, Jan07, May07, Jul08, Oct08, Jan09, Jul09, Sep09, Oct09, Dec09

Total of: 21 TRMs failures in Tx-H and 18 in Tx-V
4 TRMs failures in Rx in each polarisation

→ No degradation on the performance and data quality
ASAR: an alive antenna

TRMs gain & phase drift in time

TRM drift is monitored on a daily basis for anomaly detection and characterisation

TRMs gain & phase drift can be corrected

- A first major correction performed on 14 & 16 September 2005
- A second one is currently on-going
  ➔ this will result in change in the antenna patterns and gain level which will require a small recalibration campaign
New AP swath parameters

Background:
- AP mode was causing since launch unplanned instrument unavailability leading to frequent power reset in order to recover
- Power cycle are undesirable due to their (potential) impact on the instrument hardware:
  - DSS-B is used since the DSS-A failure in 2003
- Restrictions were applied to AP IS5 data since 2006 and extended to all swaths in 2007

Patch#09 installed in May09:
- Patch#009 solves the problem by modifying the AP timing in order to avoid being in the conditions of the failure
- Significant impact on swath characteristics:
  - reduction of the coverage at near range for all swath except IS1
  - Loss of swath overlap for IS3 to IS7
- Only AP data is impacted not IM!!!!

<table>
<thead>
<tr>
<th>SWATH</th>
<th>Incidence Angles [deg]</th>
<th>Swath Width (ground-range) [km]</th>
<th>Overlap with previous swath (ground-range) [km]</th>
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<tr>
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<td>14.36 - 22.32</td>
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<td>20.30 - 26.22</td>
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<td>26.73 - 31.27</td>
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<td>IS5</td>
<td>35.68 - 39.35</td>
<td>36.81 - 39.35</td>
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<td>IS6</td>
<td>39.02 - 42.76</td>
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<td>IS7</td>
<td>42.48 - 45.27</td>
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New AP swath parameters

27th April 2009 at 21:10 UT (orbit 37429)

1st of June 2009 at 21:10 UT (orbit 37930)

AP swath IS2 (Ascending)
Presentation Summary

- ERS instrument performance status
- ASAR mission status
  - Instrument status
  - Calibration and performance
  - Algorithm, Processor and product status

- ASAR mission extension beyond 2010
• Instrument absolute radiometric calibration
  – Derivation of the absolute calibration factor
  – Determination of the radiometric accuracy and stability from transponders

<table>
<thead>
<tr>
<th>Tran. Site</th>
<th>Product Type</th>
<th>Operation Dates</th>
<th>Relative RCS (dB)</th>
<th>Num</th>
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<tr>
<td>NL</td>
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<td>0.06±0.33</td>
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<td>12/11/02 – 08/11/06</td>
<td>0.04±0.30</td>
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<td>KP</td>
<td>IMP</td>
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<td>APP</td>
<td>04/07/06 – 22/03/07</td>
<td>-0.75±0.38</td>
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<td>OT</td>
<td>IMP</td>
<td>04/12/06 – 08/10/08</td>
<td>-0.27±0.62</td>
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<tr>
<td></td>
<td>APP</td>
<td>30/10/06 – 05/11/06</td>
<td>-0.12±0.28</td>
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<tr>
<td>RE</td>
<td>IMP</td>
<td>22/08/06 – 01/10/07</td>
<td>-0.40±0.63</td>
<td>51</td>
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<tr>
<td></td>
<td>APP</td>
<td>24/08/06 – 23/11/06</td>
<td>-0.01±0.19</td>
<td>13</td>
</tr>
</tbody>
</table>

Table 2(c). ASAR Transponder Relative Radar Cross-Sections
ASAR radiometric accuracy and stability:

- NL transponders and all swaths (previous slide):
  - IMP: relative RCS = 0.06 ± 0.33dB
  - APP: relative RCS = 0.04 ± 0.30dB

- All transponders and all swaths:
  - IMP: relative RCS = -0.23 ± 0.60dB
  - APP: relative RCS = -0.09 ± 0.41dB

http://earth.esa.int/pcs/envisat/asar/public_reports/

<table>
<thead>
<tr>
<th>Product</th>
<th>All Swaths</th>
<th>IS1</th>
<th>IS2</th>
<th>IS3</th>
<th>IS4</th>
<th>IS5</th>
<th>IS6</th>
<th>IS7</th>
<th>Num</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMP</td>
<td>-0.23±0.60</td>
<td>-0.16</td>
<td>-0.19</td>
<td>-0.57</td>
<td>-0.40</td>
<td>-0.06</td>
<td>-0.05</td>
<td>-0.28</td>
<td>459</td>
</tr>
<tr>
<td>IMG</td>
<td>-0.18±0.63</td>
<td>-0.32</td>
<td>-0.21</td>
<td>-0.47</td>
<td>-0.40</td>
<td>0.17</td>
<td>0.08</td>
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<tr>
<td>IMS</td>
<td>-0.18±0.60</td>
<td>-0.30</td>
<td>-0.06</td>
<td>-0.58</td>
<td>-0.36</td>
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<tr>
<td>APP</td>
<td>-0.09±0.41</td>
<td>-0.37</td>
<td>-0.22</td>
<td>-0.07</td>
<td>-0.02</td>
<td>-0.03</td>
<td>0.07</td>
<td>-0.07</td>
<td>133</td>
</tr>
<tr>
<td>APG</td>
<td>-0.08±0.50</td>
<td>-0.33</td>
<td>-0.21</td>
<td>0.00</td>
<td>-0.12</td>
<td>-0.14</td>
<td>0.20</td>
<td>-0.09</td>
<td>132</td>
</tr>
<tr>
<td>APS</td>
<td>-0.10±0.52</td>
<td>-0.21</td>
<td>-0.26</td>
<td>0.02</td>
<td>-0.31</td>
<td>-0.15</td>
<td>0.10</td>
<td>0.06</td>
<td>131</td>
</tr>
</tbody>
</table>
ASAR instrument performance (1/2)

- IRF parameters measured using the transponders:
  - IRF Quality parameters

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Azimuth Res (m)</th>
<th>Range Res (m)</th>
<th>ISLR (dB)</th>
<th>PSLR (dB)</th>
<th>SSLR (dB)</th>
<th>No of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMP</td>
<td>22.14±0.49</td>
<td></td>
<td>-13.48±0.55</td>
<td>-16.72±0.99</td>
<td>-22.76±1.76</td>
<td>459</td>
</tr>
<tr>
<td>IMG</td>
<td>22.39±0.47</td>
<td>21.6 – 35.8</td>
<td>-13.54±0.53</td>
<td>-16.90±1.01</td>
<td>-23.51±1.68</td>
<td>458</td>
</tr>
<tr>
<td>IMS</td>
<td>4.77±0.04</td>
<td>9.43±0.05</td>
<td>-14.45±0.29</td>
<td>-19.07±0.46</td>
<td>-28.38±0.63</td>
<td>450</td>
</tr>
<tr>
<td></td>
<td>5.56±0.07</td>
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<td></td>
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<tr>
<td>APP</td>
<td>27.61±0.79</td>
<td></td>
<td>-12.87±0.47</td>
<td>-19.13±0.99</td>
<td>-27.04±1.61</td>
<td>133</td>
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<tr>
<td>APG</td>
<td>27.70±0.76</td>
<td>22.6 – 36.4</td>
<td>-12.94±0.49</td>
<td>-19.23±0.97</td>
<td>-27.70±1.30</td>
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<tr>
<td>APS</td>
<td>4.42±1.83</td>
<td>8.40±0.07</td>
<td>3.95±2.49</td>
<td>-1.98±1.38</td>
<td>-16.90±4.33</td>
<td>131</td>
</tr>
</tbody>
</table>

![Graph for IMP](image1)

![Graph for APP](image2)
• NES0 monitoring:
  – Based on data measurement over areas of very low backscatter (ocean, lakes)
Instrument calibration & performance

- ASAR is performing well since the beginning of the mission

- Performance are routinely monitored and the results are available on a cyclic basis
  http://earth.esa.int/pcs/envisat/asar/public_reports

- Quality parameters are well within the requirement

- Radiometric accuracy/stability is good and stable over time

- Geometric calibration is good

- Pointing performance is good
Presentation Summary

• ERS instrument performance status
• ASAR mission status
  – Instrument status
  – Calibration and performance
  – Algorithm, Processor and product status
• ASAR mission extension beyond 2010
Noise removal (WS/ AP)

• Thermal noise visible on areas with very low signal level

• Noise range variation created by the SAR focussing (Tx energy normalisation, antenna pattern compensation, rg. Spreading loss correction, processing gain)

• Noise profile can be accurately estimated and removed from the original product.

• Prototype running for WSM and AP products.
  ➔ Integration in the operational ASAR processor is on going (mid-2010)
Extended validation was accomplished comparing:
  • L2-WVW vs Buoy, L2-WVW vs WAM, WAM vs Buoys

→ The RAR modulation transfer function (MTF) used in current ESA SAR L2 wave retrieval algorithms:
  • overestimates the SAR SWH at low wind speeds (low sea states)
  • underestimates the SAR SWH at high winds (high sea states)

→ Upgraded MTF improving significantly the SAR SWH and slightly the swell direction

→ Update of the processor will be made as soon as possible
• ERS instrument performance status
• ASAR mission status
  – Instrument status
  – Calibration and performance
  – Algorithm, Processor and product status

• ASAR mission extension beyond 2010
Mission Extension Scenario

Inclination

MLST 22:00

22:10

98.5°

New sun sync. inclination

Milestones

Altitude

799.8 Km

-17.4 Km

782.4 Km

10/2010

5/2012

01/2014

Phase E2

35/501, nominal control

Phase E3

30/431, inclination drift
ASAR Mission extension

• **ASAR configuration for the mission extension:**
  – Keeping the beam radiating patterns as today
  – Adjusting the instrument timing around the existing beam to maintain the performances:
    • New set of PRF, SWST, SWL, pulse length... have been defined
    • No degradation on instrument performance after instrument reconfiguration

• **Impact assessment on ASAR mission**
  – No change necessary in the current L1 and L2 algorithms
  – **Minor impact on swath characteristics:**
    • Overall coverage reduced by ~11-12km on ground.
    • Swaths closer to nadir and shifted from 4.1km (at near swath) to 15.7km (at far swath).
    • Swath extent lowered by 1.6-5.3 km for all the swaths
    • Swath overlap roughly of same order (decreases at far range)
  – **No impact on most of the SAR applications based on radiometry**
    • Interferometry mission severely impacted

• **Verification phase of ~1 month after the orbit change**
  • Verification of Instrument configuration, Internal calibration, processor, calibration,…
  → Data might be of slightly degraded quality
### New swath parameters

<table>
<thead>
<tr>
<th></th>
<th>IS1</th>
<th>IS2</th>
<th>IS3</th>
<th>IS4</th>
<th>IS5</th>
<th>IS6</th>
<th>IS7</th>
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<tbody>
<tr>
<td><strong>Incidence angles</strong></td>
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<td>now</td>
<td>15.0</td>
<td>19.14</td>
<td>26.0</td>
<td>31.0</td>
<td>35.8</td>
<td>39.2</td>
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Thank you