Mission and System Characteristics of the European Radar Observatory (Sentinel-1)

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Outline

• Mission Objectives & Requirements
• System Requirements & Technical Concept
• Conclusions
Mission Objectives

Should aim at customer satisfaction taking into account funding sources and the interest of the different customer categories including:

• Sponsors: Technology Research & Development Agencies, Departments of Industry
• Earth Observation Investigators: Studying Methods and Developing Applications
• ‘End Users’: Earth Scientists, Institutional Users, Service Providers, (other) Companies, (other) Professional & Private Users, etc.
Technology Research & Development

- Innovation
- Spin-Off
- Economic Development
- Employment
- (Geographical) Return
- ....and other Benefits to Mankind
Earth Observation Research

- Study radar signature of the Earth
- Establish application potential for
  - Earth sciences
  - Operational services
- Need best possible sensitivity, temporal & spatial resolution, image quality
- Request multi-parameter space: different wavelengths, (full) polarimetry, interferometry
‘End’ Users

• Immense but dispersed community
• Have sometimes not (yet) identified themselves as SAR users
• Do not always understand SAR-speak: wavelength, dB, speckle, signal-to-noise ratio
• May need geo-referenced information (images) here and now
• Want information at minimum cost
• Priorities not always compatible with SAR potential
End User Requirements

- **Access to Information**
  - Coverage
  - Revisit Rate
  - Timeliness
  - Continuity

- **Information Content and Quality**
  - Choice of Wavelength
    (P, L, S, C, X, other, multi-band?)
  - Sensitivity & Accuracy
  - Spatial & Radiometric Resolution
  - Repeat Observation
  - Polarimetry
  - Interferometry
Programme Context

• Component of GMES EU & ESA’s Global Monitoring for Environment and Security Programme

• European Radar Observatory (Sentinel-1) a Polar Orbiting Satellite System

• Continuation of Operational Applications of SAR

• Currently in its Requirement Definition Phase
Origin of Mission Requirements

Following Programmatic Priorities and GMES Pilot Services Aiming at

- Monitoring the European Marine Environment
- Monitoring the Arctic Environment and Sea-Ice Zones
- Monitoring and Assessing Land Surface-Motion Risks
- Open Ocean Surveillance
- Forest Monitoring
- Water Management and Soil Protection
- Forest Fire and Flood Management
- Food Security & Crop Monitoring
- Global Mapping for the Humanitarian Community
Monitoring the European Marine Environment

Daily surveillance of marine transport corridors with information delivery within one hour of observation

ASAR Wide Swath
22 November 2003

Dover
Ostende
Calais

© ESA 2003
Arctic Environment and Sea-Ice

Daily Monitoring of Ice-infested Areas Along the Major Transport Routes
Land Surface-Motion Risks

2-Weekly measurements of subsidence over all major urban areas and surveillance of transport infrastructure (e.g. gas pipelines).

Bay of Naples, Italy
Open Ocean Surveillance
Wind & Wave Product (ASAR)
Forest Monitoring

Annual Global Map for Climatic Change Detection
Sustainable Management
Nature Protection
Water Management and Soil Protection

Monthly Global Mapping of Environmental State to Support inter alia the European Union’s Thematic Strategy on Soil Protection

Surface Soil Moisture derived from Envisat ASAR (Southern Germany)
Forest Fire and Flood Management

Food Security & Crop Monitoring

Rice Mapping in China, Hongze Area using single date HH/VV Envisat ASAR Data

From: Thuy Le Toan & Tan Bingxiang, DRAGON Project
Global Mapping for the Humanitarian Community Needs Fast Global On-demand Access
Mission Requirements

- **Continuity**: At least 10 years of service
- **Performance and Data Quality**: ERS/Envisat
- **Operations**: Systematic with On Demand Option
- **Processing and Archiving**: All products to level-1
- **Distribution**: from Archive/Near Real Time
- **Coverage & Revisit**: Global Monthly, Fast Global Access on Demand, Regional bi-weekly, Regional Daily (12 hourly desirable)
- **Timeliness**: 3 hours (1 hour desirable for special cases)
Mission Requirements, cont.

• Centre Frequency: C-Band 5405 MHz
• Interferometry: yes, service dependent
• Spatial and Radiometrical Resolution: ERS/Envisat baseline
• Swath Width: Minimum 200-300 km, larger desirable, 20 x 20 km for Wave Mode
• Polarisation: VV (Wind, Waves and Oil Spills), HV or VH (ship detection), VV or HH, VV and HH (desirable), VV and VH or HH and HV, Full Polarimetry (best for classification)
Technical Concept

A Two-Satellite Constellation with Four Nominal Operational Modes Designed for Inter-Operability with other Systems for Full Compliance with User Requirements.

1. **Stripmap Mode (SM)**
   Stripmap mode, dual polarisation, medium size swath, high radiometric performance, very high spatial resolution

2. **Interferometric Wideswath Mode (IW)**
   ScanSAR mode, dual polarisation, large size swath, high spatial resolution, burst synchronisation for ScanSAR interferometry

3. **Extra-wide Swath Mode (EW)**
   ScanSAR mode, dual polarisation, very large size swath, low spatial resolution

4. **Wave (WV)**
   Sampled stripmap mode, single polarisation, low data rate
System Requirements

- **Orbit** Near-Polar Sun-Synchronous
- **Mean Local Solar Time at Ascending Node** 18:00 hours
- **Repeat Cycle** 12 days
- **Cycle Length** 175 orbits
- **Swath Width**
  - 80 km (SM), 240 km (IW), 400 km (EW),
  - 20 km x 20 km (WV).
System Requirements, cont.

- **Polarisation**
  VV+VH or HH+HV (all modes)

- **Spatial Resolution (Ground Range x Azimuth)**
  4 x 5 m, single look (SM), 5 x 20 m single look (IW), 25 x 80 m 3-looks (EW), 20 x 5 single look (WV).

- **Noise Equivalent σ°** -25 dB

- **Radiometric Stability** 0.5 dB

- **Radiometric Accuracy** 1.0 dB
Conclusion

The Sentinel-1 mission is being designed to satisfy its user requirements in terms of data availability, coverage & revisit, timeliness and the quality of its data products.

While its technical requirements are subject of a running consolidation study it appears difficult fully satisfying coverage and revisit requirements even with a two satellite constellation. Therefore (further) international collaboration will be required.