The ESA experience with the exploitation phase of Earth Explorer missions

Henri Laur, ESA Earth Observation Mission Management Division
ESA Earth Observation missions in exploitation

**Meteorological Missions**
- Driven mainly by weather forecasting and climate monitoring needs.
- These missions developed in partnership with EUMETSAT include the Meteosat Second Generation (MSG) family, forming the space segment of EUMETSAT’s Polar System (EPS), and the new generations of geostationary Meteosat satellites (MSG & METOP satellites).

**Sentinel Missions**
- Driven by user needs to contribute to the European Copernicus initiative.
- These satellite missions developed in partnership with the EU include:
  - 1-band imaging radar (Sentinel-1),
  - High-resolution optical (Sentinel-2),
  - Optical and infrared radiometer (Sentinel-3) and atmospheric composition monitoring (Copernicus Sentinel-4 & Sentinel-5 on board Metop missions MT16 and EPS-GO respectively).

**Earth Explorer Missions**
- Driven by scientific needs to enhance our understanding of how the oceans, atmosphere, hydrosphere, cryosphere and Earth’s interior operate and interact as part of an interconnected system.
- These missions, exploiting Europe’s excellence in technological innovation, pave the way towards new development of future EU applications.

**Data from non-ESA Missions**
- EOP Operated Missions
earth explorers

NEW VIEWS OF DYNAMIC EARTH

goce
smos
cryosat
swarm

European Space Agency
Carrying the first 3D gravity gradiometer in space and orbiting lower than any other Earth observation satellite, GOCE measured Earth’s gravity with **unprecedented accuracy**, resulting in the most accurate “geoid” ever produced.

The geoid is a virtual surface of a global ocean shaped only by gravity.

→ UNRIVALLED PRECISION

→ See ESA e-book: Earth’s gravity from space:
Some insight into the scientific achievements and legacy of the ESA’s gravity mission GOCE
NOVEL CONCEPT

SMOS – Soil Moisture and Ocean Salinity

SMOS uses an innovative technique of capturing images of “brightness temperature”. These images correspond to radiation emitted from Earth’s surface to produce global maps of soil moisture and ocean salinity for a clearer understanding of the water cycle.
CryoSat: The Ice mission

Reaching higher latitudes than earlier missions and carrying a sophisticated radar altimeter, CryoSat provides new evidence of Earth’s changing polar ice.

This information is allowing us to understand how this remote and fragile component of the Earth system is so intrinsically linked to the climate.
Harnessing European and Canadian *technological excellence*, the three identical Swarm satellites are measuring precisely the magnetic signals that stem from Earth’s core, mantle, crust and oceans, as well as from the ionosphere and magnetosphere.

Variation of Earth magnetic field
*between January and June 2014*
The Earth Explorers user communities → specialised communities

→ FOCUSED MISSIONS

Applications (CRYOSAT)

Applications (SMOS)
The Earth Explorers user communities ➔ specialised communities ➔ FOCUSED MISSIONS
The Earth Explorers user communities → specialised communities

**Application domain**

- Magnetic field and near-
- Topographic Mapping
- Sea-Ice
- Renewable Resources
- Methods
- Ice
- Other
- Calibration/Validation
- Coastal Zones
- Geodesy
- Geology
- Atmosphere
- Hydrology
- Oceanography
- Hazards
- Land Environment

**Requested mission data**

- ENVISAT
- ERS
- GOCE
- SMOS
- CRYOSAT
- SWARM
- PROBA-1
- PROBA-V
- TPM

**Statistics in September 2014**
The Earth Explorers user communities → small but growing communities

% of user projects with respect to total number of user projects

- Envisat: 54%
- ERS: 26%
- Third Party Missions: 23%
- Proba: 8%
- GOCE: 4%
- SMOS: 6%
- CRYOSAT: 6%
- SWARM: 2%

Total % is higher than 100 % because many projects use data from multiple missions

Statistics at end 2014
The Earth Explorers user communities → small but growing communities

 Nb of user projects

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The Earth Explorers user communities → growing number of publications

Source: Scopus
What are the Earth Explorers?

- New geoscience
- New technology in space
- Cool technology
- Unrivalled precision
- Novel concept
- Focused missions
- Revealing the Earth complexity
New technology and new geoscience

What are the consequences in the Exploitation Phase?

- Novel Concept
- Cool Technology
- Unrivalled Precision
- Focused Missions
- Revealing the Earth Complexity

Importance of flexibility
Importance of cal/val

New technology in space
New geoscience
New technology and new geoscience → what are the consequences in the Exploitation Phase?

How to better address the consequences:

- To be ready for **surprises** both with sensor(s) and with data → *ESA exploitation teams readiness and imagination*

- To establish a **central role for the data quality activities** (cal/val, processing algorithms improvements), beyond the commissioning phase and for whole duration of the exploitation phase → *see next presentation*

- To explore **new products**, in particular those associated with secondary mission objectives

- To give **time for data to be used in operational environments** → *known data accuracy and easy data access are pre-requisites*
Central role for the data quality activities

→ a potential evolution

The **Expert Support Laboratories (ESLs)** were put in place in the **early 90’s** within the Envisat development phase. The initial contractual role of the ESLs was the definition and development of the **geophysical algorithms** for the Level 2 products.

The main evolutions of the ESL concept during the last 20 years are:

- within the Envisat exploitation phase, **industrial companies** (often SMEs) gradually joined the public research institutions within the ESL concept,
- the concept was **re-used for the Earth Explorers and for Sentinels** and in some cases expanded to the Level 1 algorithms,
- the ESLs have a **major influence** on the management and visibility of a mission Phase E, in particular for the **Earth Explorers**.

Need to **reinforce the role and responsibility** of the Expert Support Laboratories (ESLs) during the Earth Explorers exploitation phase.

Concept of (Mission) **Data Innovation and Science Cluster (DISC)**
Central role for the data quality activities

→ a potential evolution

From current Expert Support Laboratory (ESL) to Data Innovation and Science Cluster (DISC):

**Potential activities for a [Mission] DISC:**

- Develop & maintain data *processing algorithms*
- Leading role in sensor *Cal/Val activities*
- Monitoring sensor performances and impacts on *data quality* (or contribute to it)
- Contribute to *the animation of the mission user community*
- When appropriate, operate the *Exploitation (Community) Platform* (or contribute to animate it)
- When appropriate, coordinate mission data *reprocessing* (using ESA provided services or using other means)
- Contribute to the gradual uptake and visibility of *innovative products* (proposed inside or outside the DISC consortium)

DISCs could also have a role related to *national activities* and be co-funded by regional, national and/or European Union budgets.
Central role for the data quality activities

→ Gaining flexibility and involving the community

Traditional approach: “bring the data to users”

Mission operator → data request → data download → discussion/needs → results → User Communities

Data & processing requests → discussion/needs → results → User Communities

Future: “bring the users to the data”

User segment is within the Ground segment

Easier for user
More data
More results
Better service
More community spirit

Mission operator → data → Community Platform → data & processing requests → discussion/needs → results → User Communities

Easier for user
More data
More results
Better service
More community spirit
**Community Platform**

**Concept definition:**
Users access a collaborative platform *work environment* containing the required data and resources, as opposed to downloading and replicating the data ‘at home’.

**Community Platform (or Exploitation Platform)**

*Virtual Work Environment*

bringing together:

- Data Centre (EO and non-EO data)
- Computing Resources
- Integrated User Interface
- Workflows
- Documentation
- Collaborative Tools (toolboxes)
- Help desk & social network

**No plan yet for an ADM-Aeolus Community Platform**
To explore secondary mission objectives

**Sea ice thickness**

Arctic Sea Ice Thickness from ESA's SMOS satellite

**Strong winds**

Support to science element

European Space Agency
To explore secondary mission objectives

Best global bathymetry map
To explore secondary mission objectives

GOCE: un sismomètre dans l’espace

Air Density Perturbation Measured by GOCE

Minutes after earthquake

Wave propagation

Speed: 1100 m/s

Speed: 350 m/s

Tōhoku earthquake 2011

GOCE satellite (altitude 270 km)

Thermosphere

Mesosphere

Stratosphere

Troposphere

85 km

50 km

12 km
To ensure a long mission exploitation phase:

- Missions operations funded by ESA EOEP-3 (5 years)
- Missions operations funded by ESA EOEP-4 (4.2 years)

Mission extension reviews at regular intervals
Earth Explorer missions extension reviews: the criteria

The criteria against which mission extension proposals shall be evaluated are:

1. Technical feasibility of achieving the defined extended mission objectives
2. Need, usefulness and excellence of the mission in its extended phase
3. Uniqueness and complementary of the extended mission data sets
4. Degree of innovation and contribution to the advancement of EO capabilities worldwide
5. Affordability → Only for PB-EO
From R&D to operational use

- To ensure a long mission exploitation phase
- To prepare very early for a follow-on mission with potential partners

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- ERS-1/ERS-2
- Envisat
- GOCE
- SMOS
- CryoSat
- Swarm
- EarthCARE
- ADM-Aeolus
- Sentinels

Continuity
Main lessons learned so far with Earth Explorer missions exploitation:

- To be ready for **surprises** both with sensor(s) and with data
  → **flexibility, reactivity**

- To establish a **central role for the data quality activities**, beyond the commissioning phase and for whole duration of the exploitation phase
  → **collaborative, open, transparent**

- To explore **new products**, in particular those associated with secondary mission objectives
  → **opportunities, synergies**

- To give **time for data to be used in operational environments**
  → **prepare early for the future**