An evolution of the Ground Segment targeting increased collaboration with scientific users

→ the case of BIOMASS mission

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Why?
New sensor technology, new geoscience \(\rightarrow\) consequences in the Exploitation Phase:

- To be ready for **unexpected aspects** both with sensor(s) and data
  \(\rightarrow\) **Exploitation teams readiness and imagination** \(\rightarrow\) **flexibility, reactivity**

- 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
  \(\rightarrow\) **collaborative, open, transparent, traceable**

- To explore **new products**, in particular those associated with secondary mission objectives
  \(\rightarrow\) **opportunities, synergies**

- To give **time for data to be used by operational agencies/services**
  \(\rightarrow\) **Pre-requisites for operational users are known data accuracy and easy data access**

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**Agency point of view**

- Lessons learned with Earth Explorers operations!

**Earth Explorer**

- **Importance of flexibility**
- **Importance of cal/val**

**new sensor technology**
**new geoscience**
“Am I using the latest version of the dataset?”

“I don’t like the official dataset but I have a good idea for improving it.”

“I cannot do all what I want with the tool box.”

“My computation takes too much time!”

“I don’t have enough space to store all my TB data.”

“How to share my results (few GB of data) with my peers?”

“Where do I find in-situ data to validate my results?”
People are changing

Information technology changes (quickly) the behaviour of people.

Recent examples:

- **Streaming services** for music/video data (instead of downloading data),
- **Active collaboration** for a common goal (e.g. wikipedia, tripadvisor, … ),
- **Passive collaboration** through crowdsourcing (e.g. road traffic information).

The benefits for people is generally to get more information, or faster information, or cheaper information.
Today, services to Earth Explorers mission users are Scattered

- Data Access (e.g. Data Hub)
- Webpage & Wiki
- Tools (e.g. Toolbox)
- Processing (e.g. Cloud Toolbox)
- Re-processing (e.g. GPOD)
- Training (e.g. MOOCs)
- Forum
Need of new services for mission users

*Shall not be only download data or documentation.*

New flexible services needed:
- Possibility for specialized users to access the processing algorithms source code of the mission products and to edit/modify it
- Possibility for triggering/executing large scope reprocessing
- Possibility for self-validating the results of a processing algorithm modification
- Possibility for users to propose new mission processing algorithms

How to provide the above new services to users, and to regroup existing services?

⇒ Use of virtual research environment

⇒ a “Mission Analysis Platform”
“Analysis Platform”

What is an Analysis Platform

Virtual open and collaborative environment

bringing together:

- data centre (EO and non-EO data)
- computing resources and hosted processing
- collaborative tools (processing tools, data mining tools, user tools, …)
- concurrent design and test bench functions
- communication tools (social network) and documentation
- accounting tools to manage resource utilisation

The concept of Mission Analysis Platform is central in ESA Ground Segment evolution strategy
Ground segment, data management and data exploitation “infrastructure” → for an Earth Explorer mission

→ in virtual environments (“e.g. Cloud”)
→ seamless data chain through layers from data acquisition to exploitation also with non-EO data
→ ensuring interaction with users in all steps of this data chain.
Better addressing scientific community needs

- **Ease of data access**
  - Remote sensing data from ESA science missions (and complementary/similar missions)
  - Ground data from ESA campaigns (field data and cal/val)

- **Ease of data sharing**
  - For both ESA and from communities/projects that may have complementary data

- **Ease of data transport**

- **Joint code/algorithm development** *(Product Algorithm Laboratory – PAL)*, addressing intellectual property rights issues

- **Enable interoperability of data/code/algorithms**

- **Supported transparency in research, development and validation**
With which mission to begin?
• ESA’s 7th Earth Explorer mission selected in May 2013
• Implemented as full polarimetric P-band SAR mission
• To be deployed in space in 2022
Innovative instrument

- First P-band (435 MHz) SAR in space
- Full polarimetric (HH, HV, VV)
- 6 MHz bandwidth
- Level 1: 50 x 50 m² resolution
- Multi-pass interferometry with a 3 days repeat cycle
- Two mission phases: Tomography (year 1), Interferometry (year 2-5)
**New products**

**Level 2/3 products to be delivered**

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**Forest biomass**
- Above-ground biomass (tons/hectare)
  - 200 m resolution
  - 1 map every 7 months
  - Global coverage of forested areas
  - Accuracy of 20%, or 10 t ha$^{-1}$ for biomass < 50 t ha$^{-1}$

**Forest height**
- Upper canopy height (meter)
  - 200 m resolution
  - 1 map every 7 months
  - Global coverage of forested areas
  - Accuracy of 20-30%

**Disturbances**
- Areas of forest clearing (hectare)
  - 50 m resolution
  - 1 map every 7 months
  - Global coverage of forested areas
  - 90% classification accuracy

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*First P-band SAR in space*
Variety of Retrieval Methods

Same sensor to deliver 3 pieces of independent information

- PolSAR (SAR Polarimetry)
- PollInSAR (Polarimetric SAR Interferometry)
- TomoSAR (SAR Tomography)

*First 14th months only*
Variety of forest types

- Tropical and subtropical wet deciduous forests
- Tropical and subtropical dry deciduous forests
- Tropical and subtropical coniferous forests
- Temperate deciduous and mixed forests
- Temperate coniferous forests
- Boreal Forests and taiga
- Grassland, tropical and subtropical savannas and shrublands

- Grassland, temperate savannas and shrublands
- Grassland and floodable savannas
- Altitude grasslands and shrublands
- Tundra
- Mediterranean forests, woods and bushes
- Deserts and xeric shrublands
- Mangroves
- Rock and ice
Which user’s functionalities?
BIOMASS MAP functionalities

➡️ Data visualisation

- **2D Data visualisation**
  - Search, discovery, overlay
  - L1, L2/3

- **3D Data visualisation**
  - PolInSAR, TomoSAR

- **Time series visualisation**
- **In-situ measurement**
  (e.g. Forest Observation System)

- **Meteorological data**
Product processing (product generation)

- Select existing algorithms
  - Official ESA L2/3 algorithm
  - Research L2/3 algorithm

- Generate products
  - Systematic generation (every 6 months)
  - On demand

- Download data
  - Research L2/3 algorithm

- Share computed data
  - Share link to give access to the data
  - Export figure
  - Embedded content in webpages, pdf...

- Upload data
  - raster, vector, table

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Product Algorithm Laboratory

- **Modify/write processing algorithms**
  - Modify official L2/3
  - Compute own L2/3
  - Generate new products

- **Tools for self validation**

- **Create figures**

- **“Free access to all the functionalities”**
  - With a limit of processing time and data storage.
  - Additional resources can be ordered or allowed for specific users.

- **Share algorithms**
  - Share link to give access to the algorithm and/or environment

New concept at ESA!
Algorithm improvement by MAP users:
1. modify processing algorithm/code
2. generate the corresponding new dataset

3. Self Validation by MAP users using validation data available in MAP
4. ESA verification and approval of new official dataset

Mission Analysis Platform (MAP)
- **Processing algorithms evolution is easier as the development and implementation are made within the same environment**
- **Allow to arrive faster to stable algorithms for R&D missions on a user cooperative approach**
- **People outside the core science team can contribute to the product improvement cycle**
- **Approach breaks the wall between science and operations**

**Concepts of “Open Science”**

→ **Well adapted to R&D EO missions**
Information sharing

- **Forum**
  - FAQ
  - Conversations between users, with the agency...

- **Wiki**
  - All the information related to the mission, instrument, data acquisition...

- **Link to social networks**
  - Blogs
  - Facebook, Twitter, Research gate...

- **Link to online notebooks**
  - Write and execute live code (e.g. Jupyter)

- **Online courses**
  - Online tutorials
  - MOOCs (diploma)
  - Online workshops

To beConfirmed!
A MAP dedicated to an Earth Explorer mission shall:

- Be *attractive* for its users (*easy to use*),
- Stimulate the *collaboration* approach, yet recognising the individual contributions,
- Allow *faster* evolution and maturity of processing algorithms,
- Be compatible with the "*open science*" approach.
One more thing...
Joint BIOMASS-NISAR-GEDI Platform

→ Towards an ESA/NASA common project
Why should the same MAP deals with BIOMASS, NISAR and GEDI together?

- The three missions have **similar scientific objectives** (biosphere study, in particular forests);
- The three missions target the **same (science) communities**;
- Both BIOMASS and NISAR missions are **polarimetric SAR at low frequencies** (P-band for BIOMASS and L-band for NISAR), with **similar launch dates**;
- Both BIOMASS and NISAR missions are **complementary**: P-band data (BIOMASS) is better adapted to monitor high biomasses while L-band data (NISAR) is going to be the only data available over Europe and the USA;
- The three missions will use the **same type of in-situ measurements** for algorithm training and Cal/Val.

- The joint MAP activity will allow ESA and NASA to **test together** the proposed collaborative approach both on technical aspects (e.g. multi-cloud) and on user behaviour aspects, with low risk.
Joint Mission Analysis Platform model

*Unified user access to the functions of joint MAP*

- Up to date data and algorithms
- Cohesive community

Approved during last bilateral ESA-NASA JPPG (Joint Program Planning Group) meeting!
How to implement it?
Approach to build the BIOMASS MAP

Timeline and phasing approach in synergy with L2/3 activities

L2/3 algorithm roadmap

2016
L2/3 Requirements

Phase B/C
L2/3 algorithm definition & prototyping

Pilot MAP
Support the L2/3 algorithm definition & prototyping
Open to MAG members

Campaign data

2019
Phase C/D
L2/3 algorithm implementation & testing

Full MAP
Absorb the L2/3 algorithm implementation, testing, then product generation
Expanding gradually outside the science team

+ Third party mission
+ Mission data

2021
Phase E
L2/3 algorithm evolution

L2/3 algorithm roadmap

European Space Agency

Slide 30
Mission Analysis Platforms today at ESA

- View PROBA-V data in full resolution
- Develop and run your applications with direct access to PROBA-V archive
- Explore PROBA-V Time Series
- Produce N-daily PROBA-V synthesis
Mission Analysis Platforms today at ESA

VirES is an interactive data manipulation and retrieval interface.

Pilot Mission Exploitation Platform for Salinity:

SMOS Pi-MEP

Serve as enhanced validation platform (matchup in-situ, filtering, spatial/temporal scales, validation testbed and “plug-in”)

(not open to users yet)
“Your task is not to foresee the future, but to enable it.”
Antoine de Saint-Exupéry

Any questions?