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Copernicus Space Component Ground Segment and Operations Concept

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9–13 September 2013 | Edinburgh, UK

Outline

- Operations Phase Overview
- Operations Strategy
- Ground Segment Architecture
- Sentinels Collaborative Ground Segment
- **Sentinel-1, -2, -3 Data Access**

Copernicus Pre-Operations Status

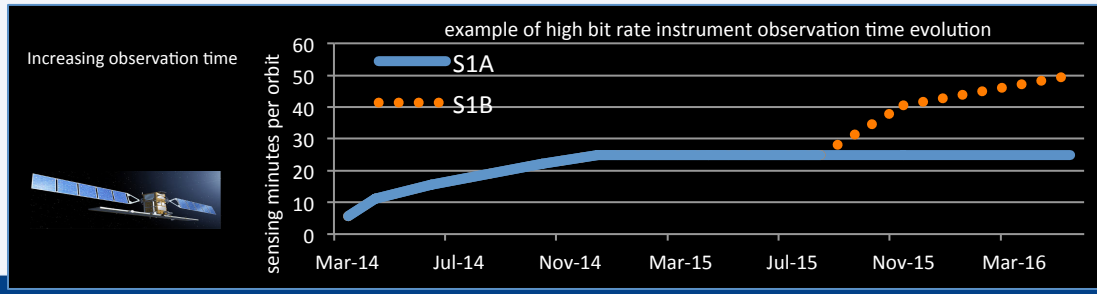
- Several Copernicus Core and Downstream services, and additional EU Agencies applications are **today** in 'Pre-Operations'

- The **GMES Space Component Data Access** (GSCDA) System provides since 2008 comprehensive and coordinated access to EO data products from multiple satellites to Copernicus space data users across Europe
  - The key component of the GSCDA is the Coordinated Data Access System (CDS), ensuring Data Set construction and dissemination by coordinating the Copernicus Contributing Missions (CCMs) production and dissemination flows

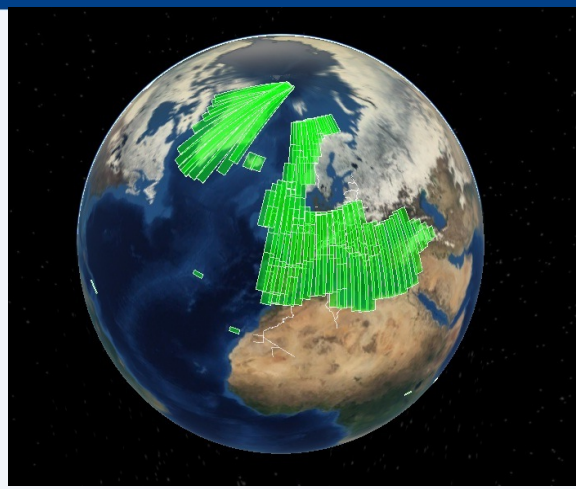
- Sentinel Space and Ground Segment development is on track for upcoming launch of the A units

Operations Phase Definition

- The ‘CSC Operations Concept’ refers to the period from mid 2014 onwards
- An initial **ramp-up phase** is envisaged marking the transition towards the Full Operational Capability
- This phase is characterised by a progressive integration of each Sentinel spacecraft in the overall system
- A gradual evolution is foreseen in the performance
  - ✓ of the availability of the overall system
  - ✓ of the data throughput and timeliness
  - ✓ of the services to users



Operations Strategy



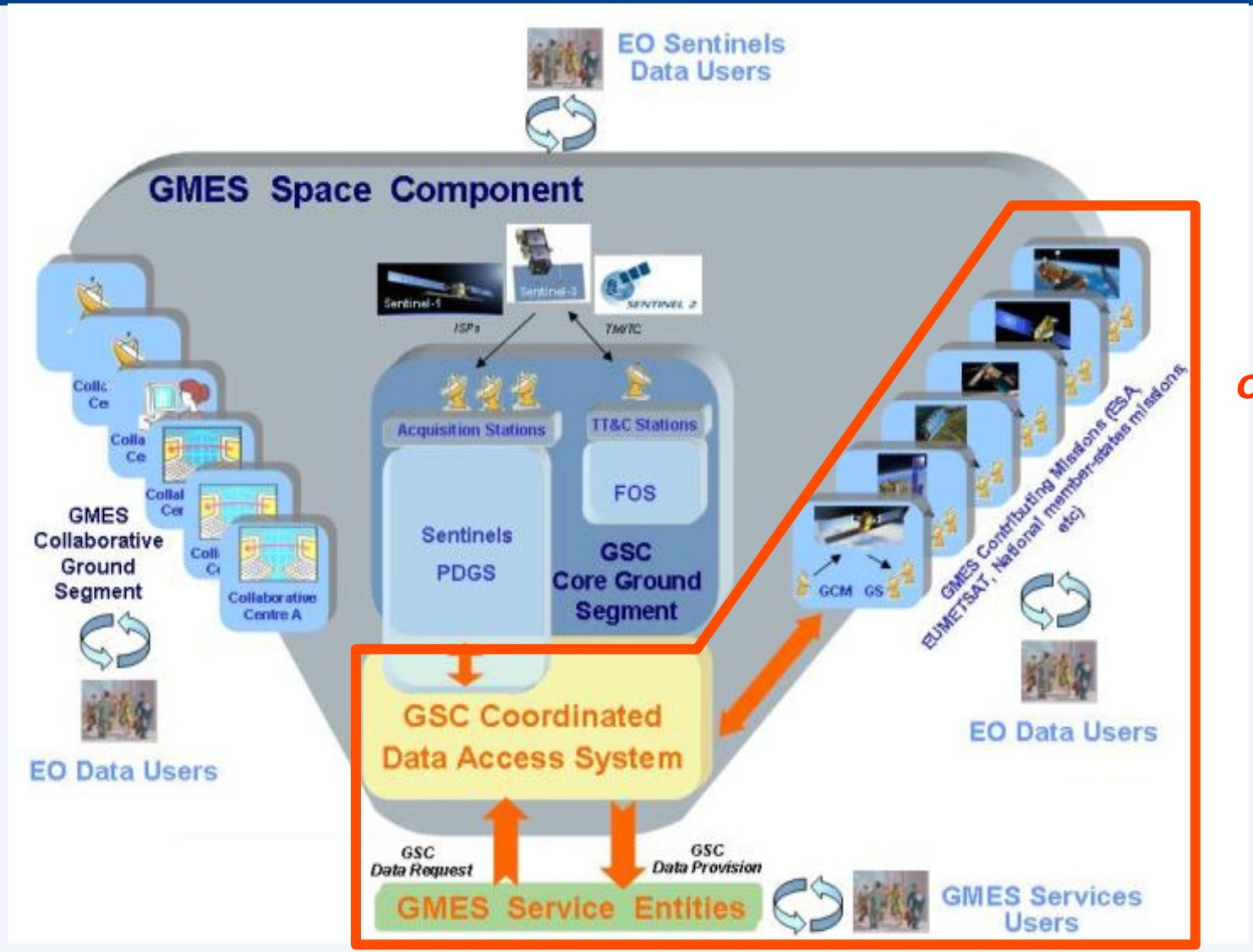
Main objectives of the Sentinels operations strategy:

- Reliable provision of data to Copernicus users
- Ensure systematic and routine operational activities:
  - with a high level of automation
  - with pre-defined operations to the maximum extent possible

Sentinels operations approach:

- Sentinels are operated via a **pre-defined background** observation and downlink plan:
  - Scenario is updated on a regular basis (e.g. 6-months) taking into account user requirements evolution
  - Generally no on-demand planning is allowed
- All Sentinels acquired data is **systematically downlinked and processed** to generate a predefined list of **core products** within specific timeliness

Ground Segment Architecture



Operating today

Core and Collaborative Ground Segment

The Copernicus Space Component (CSC) Operations Concept relies on a Ground Segment consisting of:

- **A CSC (Core) Ground Segment**, with CSC-funded Functions and Elements, providing :
  - the primary access to **Sentinel** Missions data as well as
  - the coordinating access functions to **Contributing Missions** data
  - fulfilling the Sentinels Mission Requirement Documents

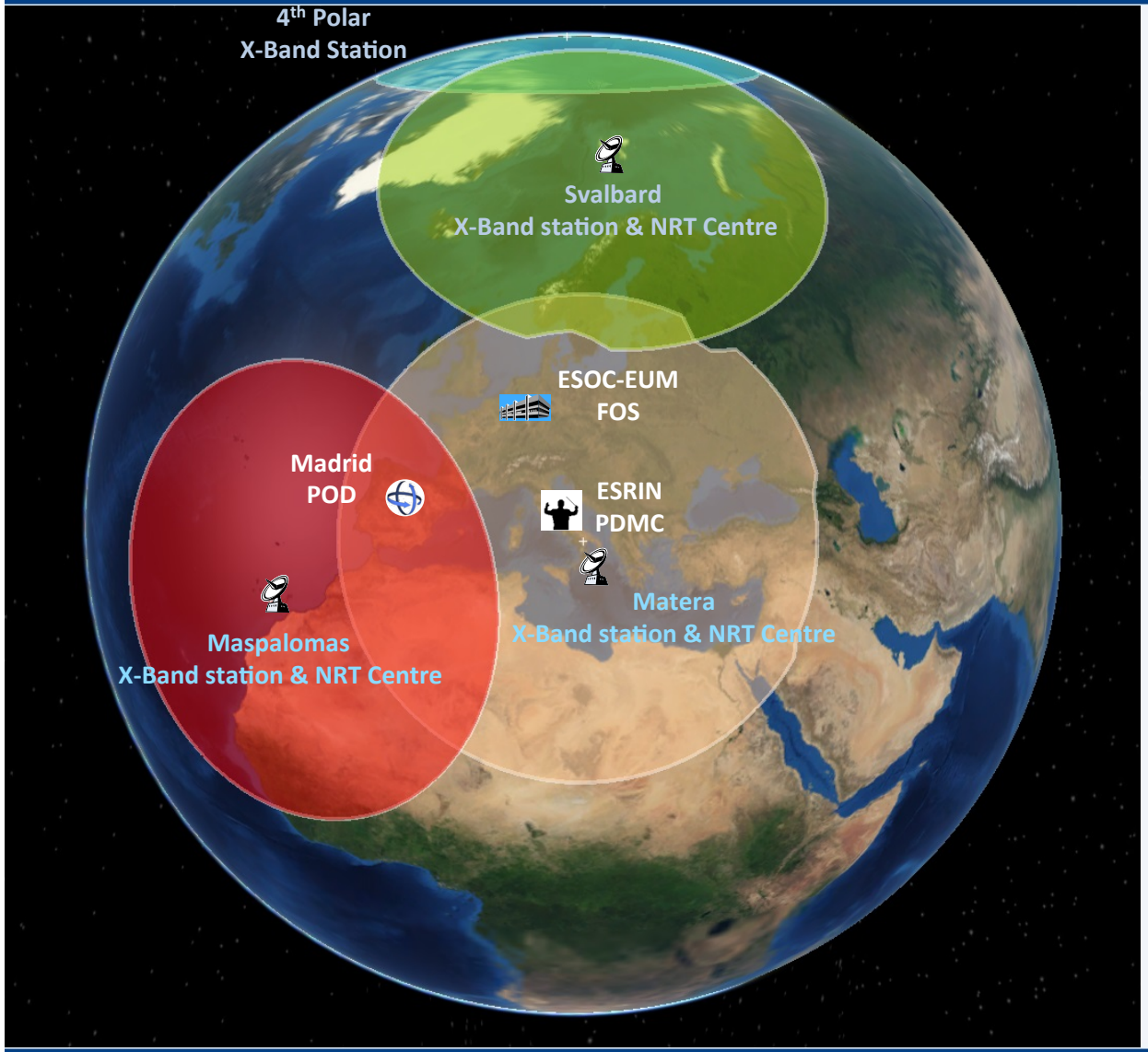
- **a Sentinel Collaborative Ground Segment**, with non CSC-funded Functions and Elements, providing:
  - a supplementary access to **Sentinel** Missions data, i.e. either through specific data acquisition services, or specific data products
  - the frame for cooperation

CSC Core Ground Segment Functions

- **Main Facilities** include:
  - Sentinel Flight Operations Segment (FOS) for spacecraft monitoring/control
  - Sentinel Data Acquisition and Near Real Time Product Generation
  - Sentinel Processing and Archiving Centres (PACs)
  - Sentinel Mission Performance Centres (MPCs)
  - Sentinel Precise Orbit Determination Service (POD)
  - Sentinel Payload Data Management Centre (PDMC)

- **Coordinated Data Access Systems** for Sentinel and CCMs include:
  - CSC Gap and EO data requirements analysis tools and systems
  - CSC Multi-Mission Mission Planning and scheduling
  - CSC User Services, e.g. Registration, Helpdesk, Account Management
  - CSC End to End Monitoring and Control including Reporting

Core Ground Segment Layout



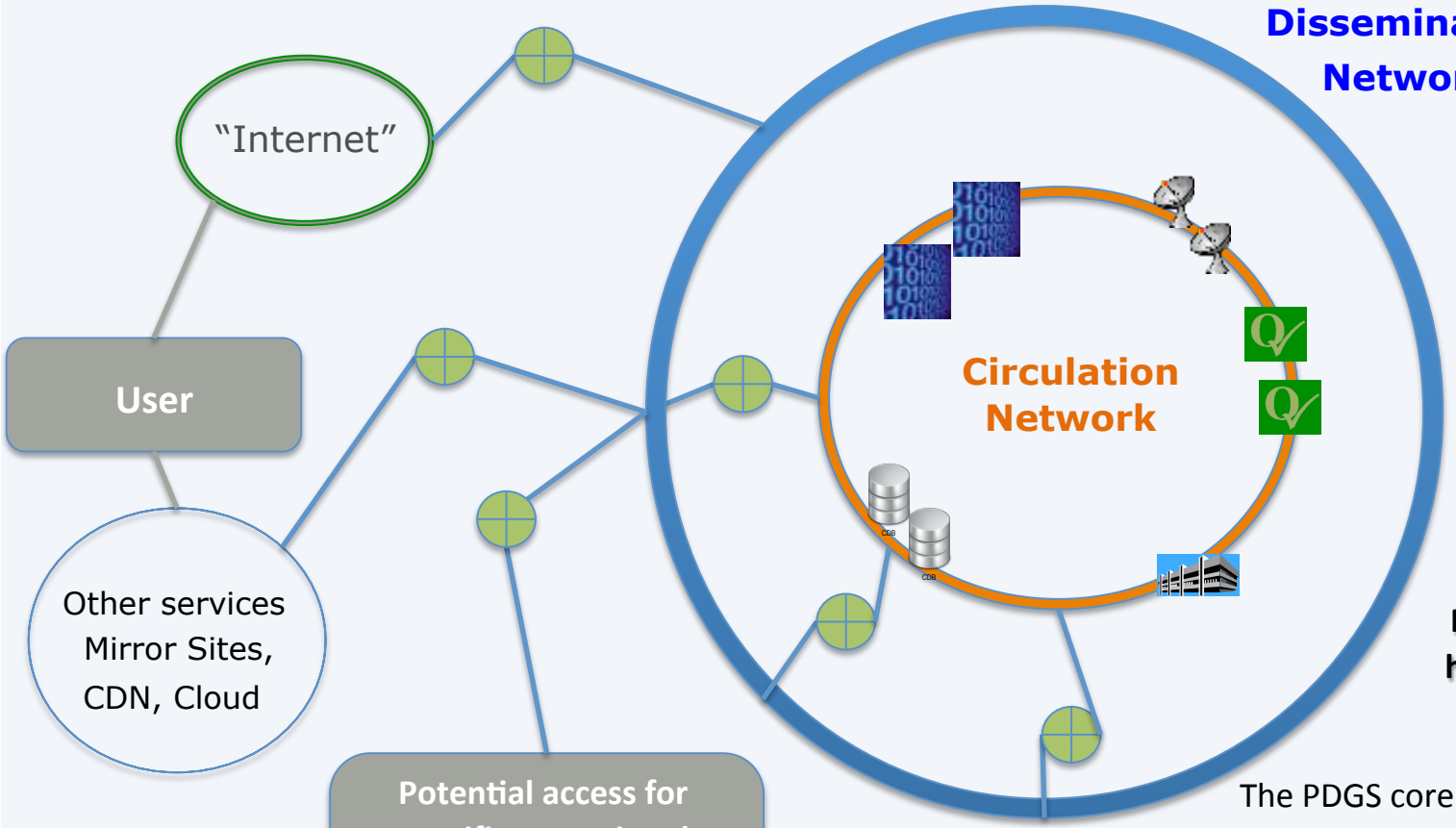
- Fight Operations Segment (FOS)
- X-Band Stations & Near Real Time Processing Centre (CGS)
- Payload Data Management Centre (PDMC)
- Precise Orbit Determination Service (POD)

Core Ground Segment Layout

Archive and Offline Processing Centre

Mission Performance Centre (MC)

Ground Circulation and Dissemination Network



Network Infrastructure highly scalable: 10 Gbps

The PDGS core functions acquisition, production, preservation do not impact the user access

Complete dissemination includes the EUMETCAST broadcast services for S3 Marine products

Sentinels Collaborative Ground Segment

- Dissemination of data through **collaborative agreements** allows further valorising the development of operational ground segment function complementing the CSC Core Ground Segment

- The collaboration provides a frame for **specialised solutions** to further enhance the Sentinels missions exploitation in the area of:

    1. Sentinels data acquisition and Quasi/Near Real Time production (Local stations)
    2. Complementary collaborative data products and algorithms definition
    3. CSC data product dissemination and access (e.g. mirror sites)
    4. Development of innovative tools and applications
    5. Complementary support to Calibration/Validation activities

- The collaboration will rely on the definition of formal agreements as well as the implementation of dedicated operational interfaces

ESA Member States Collaborative Ground Segment process

Implementation of the Sentinels collaborative GS within ESA member States is based on 3 main steps:

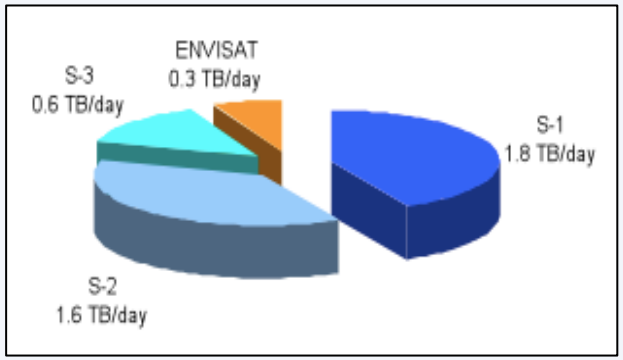
1. **Definition of process and collection of collaboration proposals**
   - Requirements collection: questionnaire for ESA Member States released in 2011
   - Enables ESA to make a preliminary assessment of the planned initiatives
2. **Proposal technical feasibility analysis**
   - Execution of simulation scenarios. Identification of potential conflicts
   - Proposal refinement with collaborative partner
3. **Formalisation of collaboration**
   - Document the technical operational interfaces
   - Integrate, verify and validate the derived implementation

Implementation of the collaborative GS with **international partners** will follow a similar process, lead by the European Commission supported technically by ESA

Sentinels Core Products

Sentinel-1	Sentinel-2	Sentinel-3
PDGS Core production for users dissemination & retrieval		
SAR L0	-	-
SAR L1 SLC	MSI L1B	OLCI L1
SAR L1 GRD	MSI L1C	SLSTR L1
SAR L2 OCN (waves, wind, radial velocity)	(*)	OLCI Water Color L2
		OLCI Land L2
		SLSTR Water L2
		SLSTR Land L2
		SRAL L2
		Synergy/Vegetation L2

(*) Toolbox for atmospheric corrections provided to support users in L2 production



	Corresponding average production rate (24h/24h)	Corresponding User products
Sentinel 1A *	150 Mb/s	L0 & all L1
Sentinel 2A *	200 Mb/s	All the different L1
Sentinel 3A	200 Mb/s	L1 & L2

(*) based on average 15min downlink/Orbit

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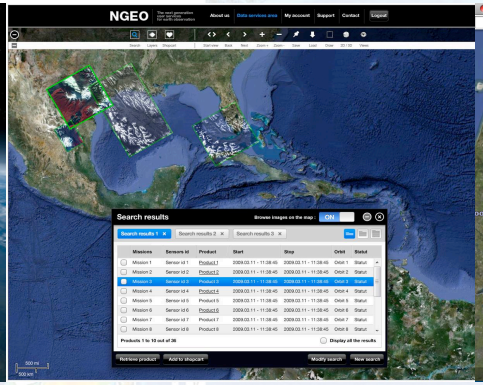
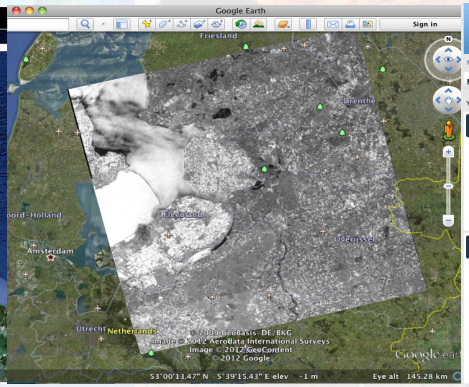
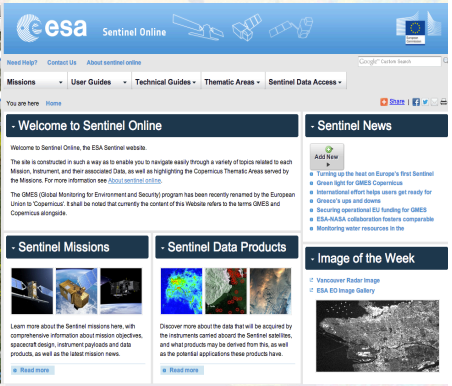
Sentinels-1, -2, -3

Data Access Overview







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Sentinel Data Access – A Collective Vision

September 2009: ESA Member States approve the Joint Principles for a Sentinel Data Policy based on a **free, full and open access to Sentinel data**

July 2013: this data policy approach is **confirmed by the European Commission through the issue of a draft Delegated Regulation** establishing registration and licensing conditions for Copernicus users and defining criteria for restricting access to Copernicus dedicated data and Copernicus Service information

Summer 2013: the European Commission agrees to elaborate and implement together with ESA **a plan for serving not only the Copernicus Services but a wider user base**, taking into account the diversity of the Sentinel data user community and the objectives set in the EU Copernicus Regulation

A collective Vision takes shape within and beyond Europe

Maximise access and exploitation of the Copernicus Space Component (CSC) data by the broad Regional, National, European and International user community

Data Access – Assembling the Puzzle

The Copernicus Space Component (CSC) Data Access determines and is determined by:

- Programmatic and financial framework
  - ➔ including co/mixed-funding, industrial policy, international agreements
- Sentinels and Copernicus Contributing Missions Data Policies definition
  - ➔ Including ownership of data and derived knowledge, licencing conditions
- User typologies
  - ➔ Including specific data needs, support requirements, priorities
- Space and Ground Segment architecture and technical constraints
  - ➔ Including design, implementation, interfaces, technology
- Operational Concept
  - ➔ Including observation scenario, data acquisition and processing approach, archiving and preservation, data quality and delivery timeliness

Pieces of a jigsaw puzzle that are being assembled to ensure seamless access to CSC data by an heterogeneous user community

Programmatic Framework

CSC data access funding

- Development of the CSC data dissemination platforms is co-funded by the European Union and the European Space Agency
- Operations of the CSC overall and its data dissemination platforms are funded by the European Union (EU-ESA Agreement to be finalised in 2014)
- Operations of the CSC data access points in support of ESA's Member States Sentinels Collaborative Ground Segment are funded by ESA MS

Collaborative Agreements

- ESA is establishing collaborative agreements with its MS as concerns Sentinel data access
- Similarly EU will lead the establishment of international collaborative agreements. ESA will provide technical support

Sentinel data ownership

- Sentinels ownership, including data, is currently with ESA
- Transfer of ownership to the EU is envisaged during the initial operations phase

Copernicus Data Policy Regulation

Copernicus Data Policy is legally established in the related European Commission draft Delegated Regulation which defines:

- Conditions for **full and open access to information** produced by the Copernicus services and of data collected through the Copernicus dedicated infrastructure (e.g. Sentinels spacecraft)
- **Criteria for restricting access** to that information and data
- Conditions for **user registration**

Users shall have **free, full and open** access to Copernicus dedicated Sentinel data and Copernicus service information

Copernicus Data Policy Regulation

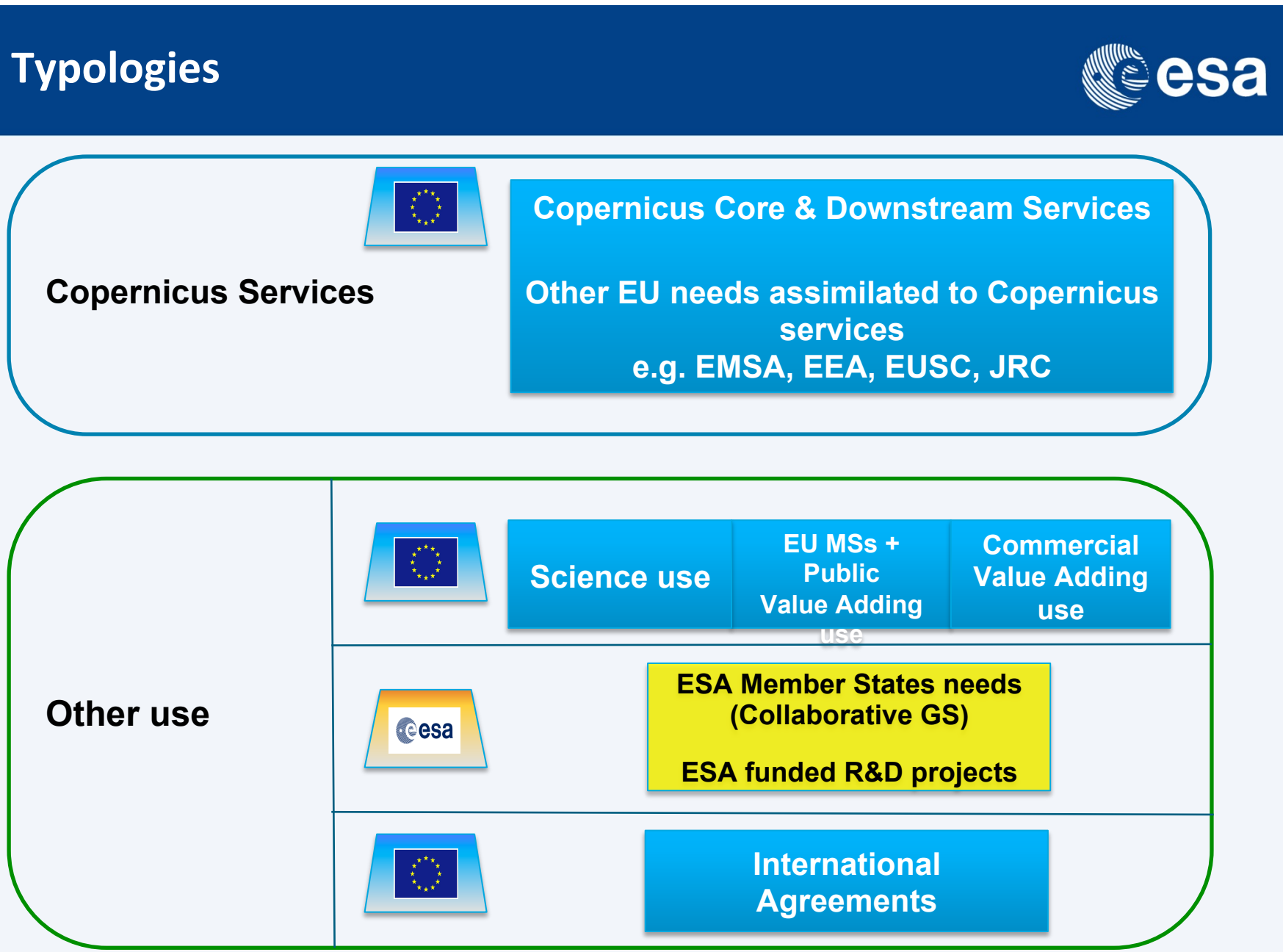
- To access download services, users shall register online on the Copernicus dissemination platforms. Registration shall be free of charge. Registration is not required for discovery services and view services

- Access to Copernicus dedicated data and Copernicus service information shall be given for the purpose of the following use in so far as it is lawful: reproduction, distribution, communication to the public, adaptation, modification and combination with other data and information

- Specific restrictions may be applied mainly where the open dissemination of Copernicus dedicated data and Copernicus service information presents an unacceptable degree of risk to the security interests of the EU or its Member States

- Where the requests for access exceed the capacity of the Copernicus dissemination platforms, access to Copernicus resources may be reserved to specific user typologies (e.g. public services, industry, research organisations,…)

Use Typologies



Data Access – A major undertaking

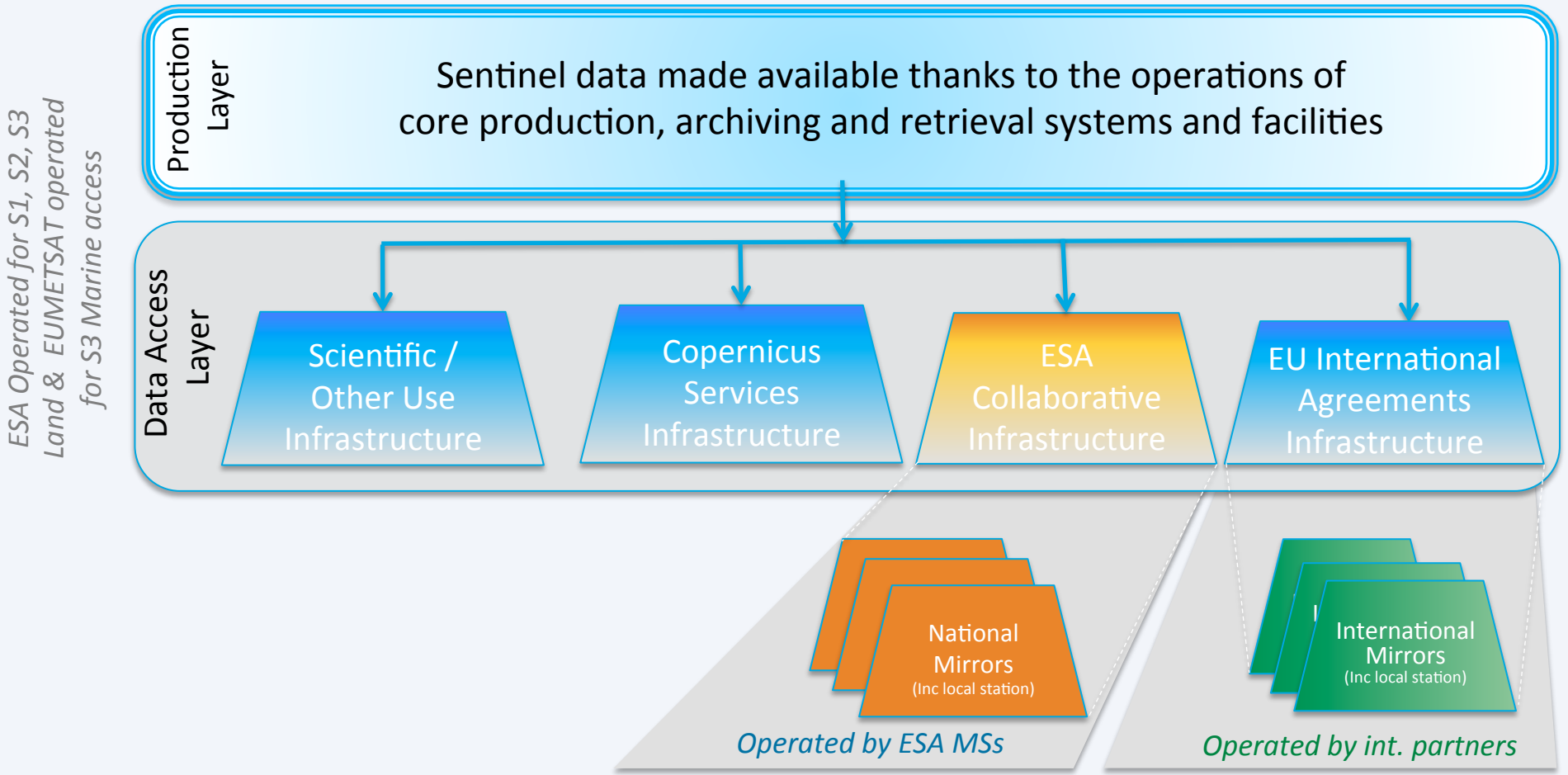
A major European Earth Observation Ground Segment design challenge

- **Systematic processing and availability** of the complete mission within the day
  - ➔ corresponding to a sustained generation rate (24h/7d) of a continuous stream of **500Mb/s of user products** (Sentinel-1,-2,-3 A series)
- Distributed interconnected network of centres
  - ➔ ensuring a global redundant and balanced production and archival approach
- Local centre access capacity built on top of a **powerful network backbone**
  - ➔ **10Gb/s bandwidth** with several Gb/s network access at single centres

Successful thanks to efforts of European Industry

- Sentinel-1 Centres and production capacity successfully deployed and tested to support the launch and commissioning campaign
- Sentinel-2 and Sentinel-3 ground segments under nominal development life-cycle

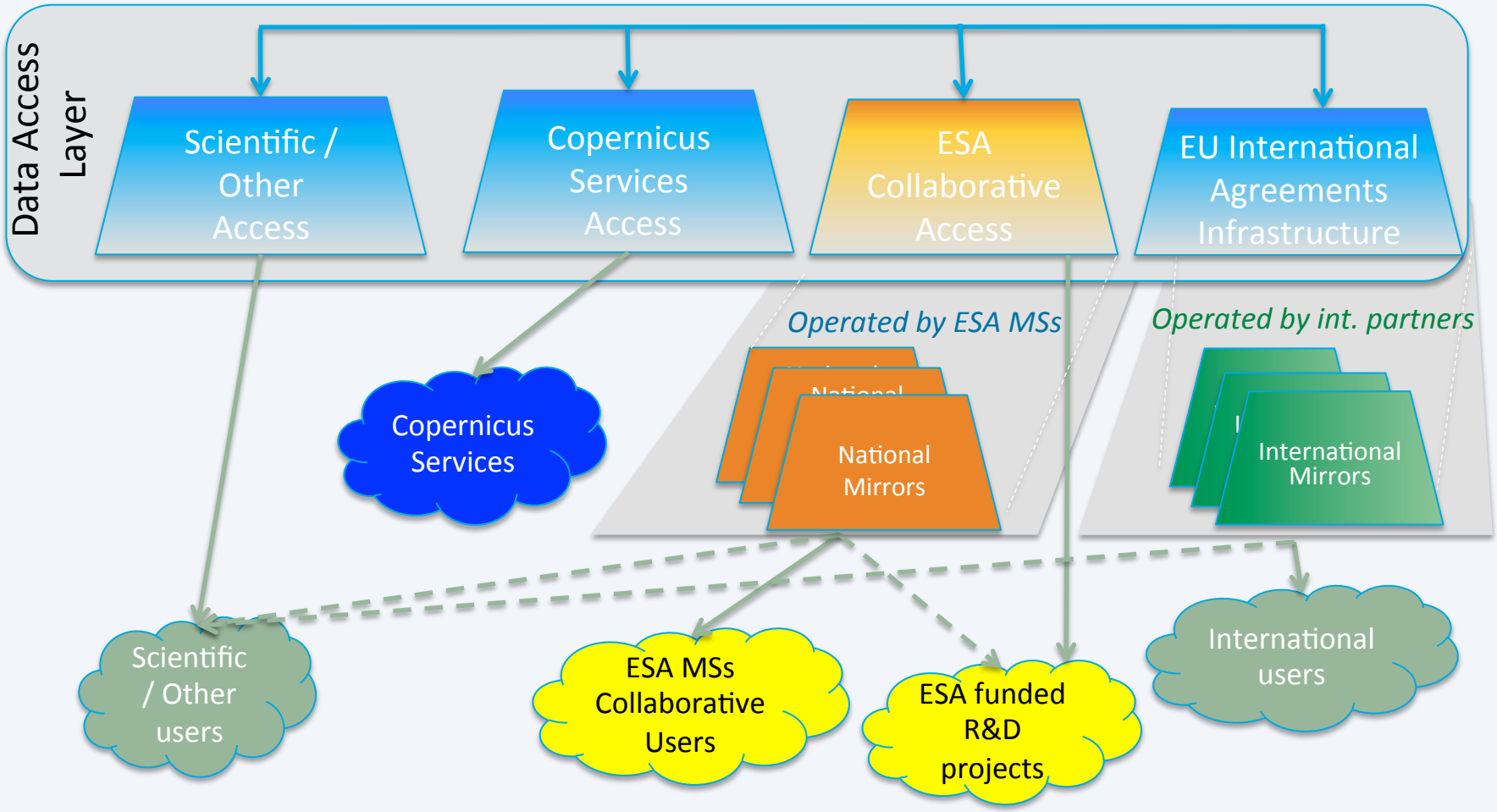
Sentinel Data Access
Different infrastructures adapted to different needs



Tailored data access infrastructures…

…serving different user needs

Sentinel Data Access
Different infrastructures adapted to different user typologies



The Sentinel Data Policy and the funded operational accesses offer a dedicated access per user type potentially complemented by additional data retrieval points

Data Access Service Infrastructure
Copernicus Services

Copernicus Services Access

Committed performances for Copernicus services operations

(Operations based on service level agreements funded by EU Copernicus operations MFF budget)

Registration based on a user request verified according to EU eligibility rules

The free data access include:

- Access to NRT/24h and consolidated Sentinels products
- Access to the different Copernicus Contributing Missions data
- On-demand production
- Access via user available bandwidth to the Copernicus backbone with committed reliability performances
- EUMETCAST access for Sentinel-3 marine products
- Dedicated data sets generation (CORE DATASETS e.g. land coverage)
- Possibility of requesting ADDITIONAL DATASETS
- Full time access to emergency services (24h/7/365, incl. rush mode) (for authorized users)
- Service Desk support through dedicated user account management
- Access to GCMs data, according to GSCDA Terms and Conditions

Access Points

ESA & EUMETSAT catalogues & dedicated servers, EUMETCAST services for Sentinel-3 Marine

Data Access Service Infrastructure
ESA Collaborative Access

ESA Collaborative Access

Targeted performances to support ESA Member States

(Operations defined through dedicated agreements
for a limited number of interfaces funded by ESA GMES Segment-3 budget)

User account pre-registration based on the terms of agreement

The free data access include:

- Access to a dedicated rolling archive of the Sentinel NRT/24h and consolidated Sentinels products
- Access via user available bandwidth to a dedicated dissemination bandwidth with committed reliability and performances
- Dedicated support for limited on-request data set generation or on-demand processing

Access Points

Rolling archive Data Hub server supporting dedicated product discovery and ftp & http downloads

Data Access Service Infrastructure
EU International Agreement

EU International Agreement

Targeted performances to support EU International Agreements

(Operations defined through dedicated agreements for a limited number of interfaces funded by EU Copernicus MFF budget)

User account pre-registration based on the terms of agreement

The free data access include:

- Access to a dedicated rolling archive of the Sentinel NRT/24h and consolidated Sentinels products
- Access via user available bandwidth to a dedicated dissemination bandwidth with committed reliability and performances
- Dedicated support for limited on-request data set generation or on-demand processing

Access Points

Rolling archive server supporting dedicated product discovery and ftp & http downloads, EUMETCAST services for Sentinel-3 Marine

Data Access Service Infrastructure
Scientific and other use

Scientific / Other Use of Sentinel data

Shared and open resources for scientific and other use accesses

(Access funded by EU Copernicus budget and granted to all potential users to be confirmed)

User self-registration

The free data access includes:

- Access to a dedicated **Rolling Archive** of a consolidated production baseline (products availability may be deferred)
- Access **via user available bandwidth** to a dedicated dissemination bandwidth ensuring gateway to the scientific GEANT backbone
- **Access configured to avoid resources saturation** resulting from massive downloads by a limited user community (e.g. maximum number of parallel downloads, maximum volume per retrieval,…)

Access Points

Rolling archive server supporting dedicated product discovery and http downloads, EUMETCAST services for Sentinel-3 Marine

Sentinel-1 Users Operations preparation

Sentinel-1 Test & Reference data *(Access granted to all potential users)*

- **Test data sets** to support launch preparation provided through the respective accesses
  - ➔ V1 is available (format description and representative products): https://scihub.esa.int/
  - ➔ V2 available this Autumn (launch format version and representative products)
- **Instrument reference data sets** will be available all along the mission lifetime starting from the commissioning operations
  - ➔ Data sets over selected areas will be collected (e.g. super sites) as soon as the instrument and the data will be considered sufficient for exploitation preparation
- Detailed timeline for provisions of data to users during commissioning and ramp-up will be made published prior to launch

Support Tools *(Access granted to all potential users)*

- **User tools** will be available to support product exploitation (e.g. ENVISAT user toolboxes evolution)
  - ➔ Consolidated version planned for the end of the instrument commissioning phase
  - ➔ Product Readers available before S1-A launch
- Local rolling archive management environment
- **Prototype services for hosted processing** are under consolidation (target: Launch +1 year on reference data sets)
- **Sentinel Online** technical Web portal: https://sentinel.esa.int

Similar approach planned for Sentinel-2, -3 and -5 Precursor to support user readiness

Data Access – Future Evolution

A **progressive evolution** of the Data Access infrastructure is already foreseen for deployment **in the timeframe 2014-2016**

Adapting the data access to the user demand

- Based on the EU decision to enlarge the user basis, enhancements are prepared along the following lines:
  - **Adapt the access capacity to the measured user scenario**
  - Reduce the need of products download
  - Increase reprocessing flexibility
  - Enlarge access to the archived data

Data Access Infrastructure Scalability

- Built-in system scalability will be used to adapt the different data access infrastructures
  - Network centre configuration scalable within the 10Gb/s range
- Large & distributed complementary pick-up points will be prototyped to reach a new range of potential scalability

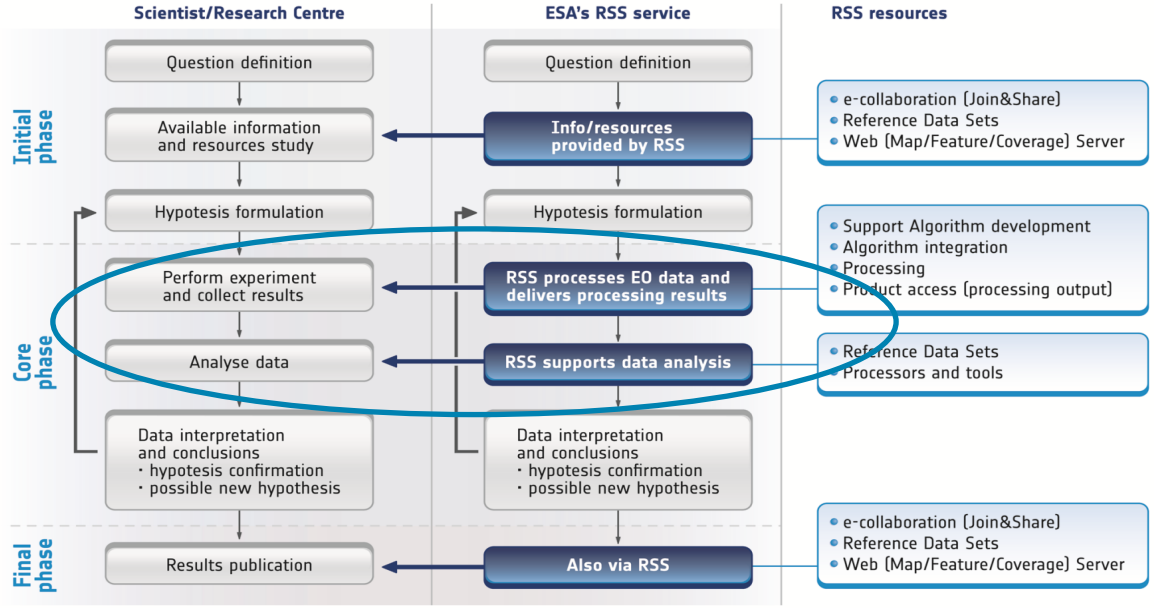
Hosting access

- New operational paradigm will be prototyped to reduce the need to transfer the products
  - Demonstration capacity for user processing hosting capability will be setup on S-1 reference data sets, (e.g. reusing existing ESA projects)
- Research support service will be introduced to support (big) data access

Data Access – Future Evolution
Research Support Service

Lessons learned from ENVISAT and the Earth Explorer Missions (*)

- When large amounts of data are at stake, **scientific data exploitation and research activities require a research support service** that provides the scientist with algorithm integration and data processing competences and resources;
- The user can concentrate on the algorithm development and evolution whilst the data is temporary available for his/her processing needs



(*) A MODEL FOR THE SCIENTIFIC EXPLOITATION OF EARTH OBSERVATION MISSIONS: THE ESA RESEARCH AND SERVICE SUPPORT, IEEE Geoscience and Remote Sensing Newsletter, March 2012 pp.10-18

Data Access – Future Evolution
Research Support Service

- The service responsibility would in:
  - Interaction with Principal Investigators
  - Algorithm understanding and support to computational optimization
  - Resources planning (data, storage, integration, capacity, etc)
  - Algorithm integration (porting, design, implementation, test)
  - Management of data provision (access, replica, caching, coverages)
  - Processing environment set-up
  - User support (for on-demand processing)
  - Bulk Processing management

- The required infrastructure comprises:
  - Computing and cloud based resources
  - Network and security needs within the already planned capacity

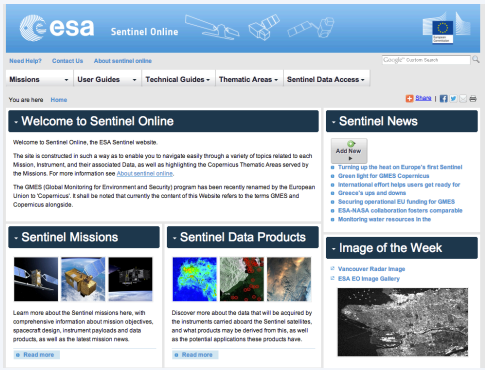
- The main benefits introduced by the support services are:
  - No cost to move and process same data
  - Algorithms runs on large data amounts
  - Access to cloud resources for flexible capacity(e.g. to meet demanding deadlines)

Further Information

- During Living Planet Symposium: ESA staff will be available at the GMES/ Copernicus stand to answer questions and provide further information

- Sentinel-1, -2, -3 Data Access unveiled: **full presentation** will be made available in GSCDA and Sentinel Online websites

- Copernicus Space Component Data Access Operations Website
http://gmesdata.esa.int/web/gsc/home



- **Sentinels Online Webportal**
https://sentinel.esa.int

- Copernicus Space Component Website
http://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus

- Copernicus Programme Website
http://copernicus.eu