ESA Earth Observation
Recent Achievements & Space19+

57th European Space Sciences Committee Plenary Meeting
Amsterdam, 9 May 2019

Maurice Borgeaud, ESA
Head of the ESA Earth Observation Department "Science, Applications and Climate"
ESA Vision for EO

“Taking the Pulse of our Planet”
A successful Track-Record
ESA-Developed Earth Observation Missions

ESA Satellites
15 in operation
25 under development
12 in preparation

Science

Copernicus

Meteorology

European Space Agency
Recent ESA EO Results
Future EO – Continue Successful R&D and Science

**Flying Missions**
- GOCE (2009-2013)
- SMOS (2009)
- Cryosat (2010)
- Swarm (2013)
- Aeolus (2018)

**Future Missions**
- EarthCare (2022)
- Biomass (2022)
- FLEX (2023)
- EE-9 (2025)
- EE-10 (2027)

**Science & Innovation**
- 4,700+ Reg. Users
- 300+ Publ. per Year

**High Risks for Great Rewards**
- 2 Cand.
- 3 Cand.
Aeolus

L2B Rayleigh-clear and Mie-cloudy HLOS winds

15 Sept. 2018
Aeolus

ECMWF model
HLOS winds

15 Sept. 2018
Copernicus – global European leadership in EO

> 225,000 registered users
= tip of the iceberg

6 operational services
- Land
- Atmosphere
- Ocean
- Climate
- Disaster
- Security

250 TB satellite data distributed per day

full, free & open data policy

7 satellites flying
- S1
- S2
- S3
- S4
- S5P
- S5
- S6

preparing Copernicus 4.0
Pine Island Glacier
Antarctica

18 months of ice flow & calving

Sentinel-1
June 2017 – January 2019

Contains modified Copernicus Sentinel-1 data
Copernicus: Air Pollution around the World

Sentinel-5P
NO₂ Tropospheric Column

2018 February

SSP NO₂ tropospheric column (10^{15} molec./cm²)
Air Pollution Monitoring

NO\textsubscript{2} average April - September 2018

Sentinel-5P data

© Contains modified Copernicus data (2018), processed by KNMI
Climate Change: Glacial Ice Loss

Global total -9625 Gt

ACN -1069
ALR -10237
ASL -416
ASC -1237
CEU -687
CAU -428
GRL
ISL
RUA -1044
ASN
ASW
ASE
SAN -1208
TRP
ANT
NWL

Change in glacial ice mass (cumulative) 1961 - 2016 in Gigatonnes (Gt)

360 Gt = 1 mm sea level rise (sum for the regions has been rounded)

ALR: Alaska -3019
WNA: Western Canada & USA -428
ASC: Arctic Canada North -1069
ALS: Arctic Canada South -1237
GRL: Greenland -687
ISL: Iceland -1227
SM: Svalbard and Jan Mayen -687
SCA: Scandinavia -38
RUA: Russian Arctic -1044
ASN: North Asia -26
CAU: Canada -38
ASC: Central Asia -43
ASW: South Asia West -25
ASC: South Asia East -112
TRP: Low Latitudes -46
SAS: Southern Andes -3208
NZL: New Zealand -26
ANT: Antarctic and Subantarctic -96

All values in Gt
EO at Space19+
Six Mega Trends in Earth Observation

Earth as the ‘Human Planet’

Climate Change

Shifting Citizen Values

Tech Revolution, vast EO Potential

New Players & Partners

Data-Driven Economy
EO is the European Citizens’ Priority in Space

Q: In the future, do you believe that priority should be given or not to space activities that allow us to ... ?

TOP 5 Priorities:

<table>
<thead>
<tr>
<th>Priority</th>
<th>Green</th>
<th>Yellow</th>
<th>Red</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify the effects of climate change</td>
<td>53</td>
<td>38</td>
<td>7</td>
<td>98</td>
</tr>
<tr>
<td>Better understand what is happening on Earth</td>
<td>45</td>
<td>45</td>
<td>8</td>
<td>98</td>
</tr>
<tr>
<td>Further our knowledge of the universe</td>
<td>44</td>
<td>43</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Protect mankind against threats from outer space (asteroids, etc.)</td>
<td>39</td>
<td>43</td>
<td>14</td>
<td>96</td>
</tr>
<tr>
<td>Explore the solar system</td>
<td>38</td>
<td>46</td>
<td>13</td>
<td>97</td>
</tr>
</tbody>
</table>

“In the eyes of Europeans, the primary area of progression for space activities would be to foster a better understanding of what is happening on Earth, particularly regarding the climate”
Starting Point: EO Europe 2040 Strategy

Four Objectives by 2040

1. Address key societal challenges & deliver excellent science for Europe through novel observations from space

2. Expand the use of space products and services into non-space sectors, both institutional and commercial

3. Foster synergies between national, commercial and European programmes through a system-of-systems perspective

4. Make the European EO sector the strongest and most competitive in the world

End-to-end Approach for World-class Earth Science and Operational Earth Observation
EO Space19+ blocks for EO Europe 2040

Future EO
New name EOEP, envelope structure & legal basis remain
Bring 21st century innovation to EO

Operational EO
Copernicus & Meteorology
In partnership with European Commission and EUMETSAT

Customised EO
• InCubed+
• Global Development Assistance
• Altius Phase E
• TRUTHS

Basic Activities
• Earthnet
• Heritage Data Programme
• Discovery, Preparation & Technology Development
Stable Member State Funding

EOP Current and Future Programmes (M€) - Member States Funding Only

- COPERNICUS
- METEO
- COPERNICUS 2.0
- Future EO-1
- EOEP-1…5
- FUTURE METEO
- FUTURE EO-2..3
- EOP Corridor 900MC
- TRUTHS
- Add. Act
- Safety+Sec. EO
Future EO – Structured around 4 Blocks

1. **Foundations, Concepts & Technology**

2. **Research Missions**

   FORUM or SKIM

3. **Mission Management**

4. **Earth Science for Society**
Future EO – New Approach

Building on Success

• Improving the well-established EOEP Programme
• Continuity of limited adaptation of Declaration, IR, …

Elements of Change

• 3-year segments linked to the “CM cycle”
• Each segment covers in priority the entire development of a new Explorer mission – this offers a long-term vision for the coming suite of Explorers
• The schedule for new Calls must be synchronised (in order to start phB2 after the coming CMs)
• New Future-EO-1 period would cover 3 segments (with segment-1 being tabled for subscription at Space19+)
• Limited overlap with EOEP-5 in order to initiate “New Space” approaches without delay
Future EO – driving 21st Century Innovation

**Hardware & Technology**
- Big Data
- Small & Big
- HAPS

**Operations**
- Increased Data Diversity & Volumes
- EO AFRICA

**Software & Applications**
- Machine Learning
- Artificial Intelligence
- Data Analytics
- Internet of Things
- Cloud Computing

**Safety & Security**
- EO contribution to ESA-wide pillar

**21st Century EO**
- Operations
- Software & Applications
- Safety & Security
- Hardware & Technology
Future EO – Earth Explorer 9
Two Candidates – Launch around 2025

**FORUM**
Far-infrared Outgoing Radiation Understanding and Monitoring
Benchmark measurements will improve our understanding of the greenhouse effect and contribute to climate change assessments accuracy

**SKIM**
Sea-surface Kinematics monitoring
Will carry novel wide-swath scanning multibeam radar altimeter to measure ocean-surface currents with Doppler technique

EE9 Users Consultation Meeting
Cambridge, 16-17 July 2019
Future EO – Earth Explorer 10
Three Candidates – Launch around 2027

**STEREOID**

Bistatic SAR as passive followers of Sentinel-1
Two <500kg spacecraft

**Applications**
- Cryosphere
- Oceanography
- Geosphere

**Daedalus**

Explore mesosphere, lower thermosphere & Ionosphere
Focus on temperature, heating processes & composition structure
Includes four Cubesats at 120 km altitude

**G-CLASS**

Science on daily water cycle
Geostationary C-band SAR
Benefits for weather forecasting, hydrology, mountain cryosphere
Block 4 – Earth Science for Society

- Address Grand Science Challenges (incl. ESA-EC/RTD Initiative)
- Bring EO Solutions for environmental threats (adaptation, mitigation)
- Pioneer Artificial Intelligence for EO (Big Data)
- Consolidating the Regional Initiatives (focus on user needs)
- EO Africa (users engagement & uptake of EO solutions)
- Permanent Open Call to investigate latest innovative ideas
Scouts – SmallSat Challenge

- Respond to the dynamism of a quickly evolving scientific & technological EO environment
- Through new development methodologies, high-risk approaches (e.g. use COTS) and existing assets
- Reduce time & cost to deliver demonstrations of novel EO techniques, results in Earth sciences and non-commercial applications
  - CaC 30 M€ at 2019 e.c.
  - Short schedule of max. 3 years
- Complementary to the EE
- Free-and-open data policy
- ITTs currently under preparation
Operational EO – Copernicus 4.0

Anthropogenic CO₂ Mon. Mission
- Causes of Climate Change

CRISTAL – Polar Ice & Snow Topography
- Effects of Climate Change

CIMR – Passive Microwave Radiometer
- Sea: Surface Temp. & Ice Concentration

Land Surface Temperature Mission
- Agriculture & Water Productivity

CHIME – Hyperspectral Imaging Mission
- Food Security, Soil, Minerals, Biodiversity

L-band SAR Mission
- Vegetation & Ground Motion & Moisture
Customised EO – 4 Programme Elements

**InCubed+**
Continuation of InCubed 2020-2024 
InCubed format

**Global Development Assistance**
Bring operational EO solutions in ODA 
New element up to 2024

**Altius (PhE)**
Operational O\(_3\) Monitoring 2020-2024 
Extend existing element

**TRUTHS (PhA)**
Calibration to support Climate Forecasting 
New element
### Basic Activities

<table>
<thead>
<tr>
<th>Earthnet</th>
<th>Heritage Space</th>
<th>Other Basic Activities</th>
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</table>
| • Coordinated access to > 35 non-ESA EO missions  
• Dialogue & support of NewSpace in EO  
• International EO cooperation (CEOS, USA, China, Africa, International Charter)  
| • Ensuring all ESA heritage data & information preservation, access & stewardship  
• Cross-Directorate  
• Covering over 60 ESA space missions  
| • Innovation (Discovery, Preparation & Technology Development)  
• Common infrastructure (ESOC, ICT, test centres, …)  
• Networks & Knowledge (Education, ESA_lab@, Communication, …)  

EO Calibration and Validation

- Discussed at the recent ESSC plenary meetings
- ESSC Executive Summary sent to EOP Director on 3 Jan. 2019
- Applies more to Copernicus missions than Earth Explorers and MET missions
- In discussion with EUMETSAT to agree on a common approach captured in a Validation and Fiducial Reference Measurements (FRM) "strategy"
- Essential Cal/Val needs defined at the beginning of a Project/Programme based on UR’s and Mission/System Requirements => independent EU funded Cal/Val service might therefore be difficult to implement
- Work under progress at ESA and EUM. Preliminary joint presentation made to EC
• Starts next Monday….  
• Largest Earth observation event worldwide  
• 4200 registered participants  
• 1000 oral scientific presentations distributed over 180 sessions  
• 50 Agora sessions (round table) distributed over 3 Agoras  
• 50 exhibitors and 60 sponsors  
• 2100 participating kids to the LPS Educational programme
Thank you for your attention!

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