ESA Earth Observation Activities – interest/benefits for Poland

Warsaw, 29 May 2019

Gordon Campbell
Developments in ESA Earth Observation

- Space technology – instruments, systems, structures, mechanics, command and control, software, etc
- Ground segment technology – transmission, command and control, processing
- EO data exploitation (science, applications, services)
- Platform and processing capabilities
- AI/ML, BDA
ESA-DEVELOPED EARTH OBSERVATION MISSIONS

Satellites
28 under development
12 in operation

Science
Copernicus
Meteorology
Sentinel Launches

- **S-1**
  - Radar
  - **A** 3 Apr. 2014
  - **B** 25 Apr. 2016

- **S-2**
  - High Resolution Optical
  - **A** 23 Jun. 2015
  - **B** 6 Mar. 2017

- **S-3**
  - Medium Resolution Optical & Altimetry
  - **A** 16 Feb. 2016
  - **B** 25 Apr. 2018

- **S-4**
  - Atmospheric Chemistry (GEO)
  - **A** 2021

- **S-5P**
  - Atmospheric Chemistry (LEO)
  - **A** 13 Oct. 2017
  - **B** 2027

- **S-5**
  - Atmospheric Chemistry (LEO)
  - **A** 2021
  - **B** 2027

- **S-6**
  - Altimetry
  - **A** 2020
  - **B** 2025

**Sentinel Launches**
Sentinels – step change
Earth Explorer 9

Launch around 2025

FORUM
Greenhouse Effect / Climate Change

SKIM
Ocean Surface Currents
Meteorology

- Meteosat SG
- MetOp
- Meteosat TG
- MetOp SG

< Current Systems

< Post-2020 Systems
Earth Observation Science – applications for tomorrow
ESA provides EO mission data addressing almost all parameters retrievable by EO satellites. 

➔ Extreme user diversity
What are we trying to do?
GOCE: the utility of gravity measurements
CryoSat: Near Real Time Ice Thickness

Arctic Sea Ice Thickness

Ice Volume

30 thousand cubic km

Glacier Decline
Cryosat
SMOS: recent results

Ocean acidification

Fresh water inflows
Swarm: Key Discoveries

Liquid Iron Jet Stream
3000 km below surface
40 km/year and it is speeding up

GNSS Blackout Phenomenon due to ‘thunderstorms’ in the ionosphere
EO applications – benefits for the citizen
Water management
Urban Management

Proportion of impervious surfaces

Baku, 22 October 2003

Quickbird, 0.6 m

Barcelona: Corine Land Cover v Urban Atlas
Air quality

Sentinel-5P: NO\textsubscript{2} Concentrations in Europe

- 7 Nov. 2017
- 19 April 2018
Land subsidence and infrastructure stability
Natural hazards and risk management

Annual displacement -5 0                5 mm/year
EO for European Regions
Regional Initiatives so far

- **Stakeholder consultation**
  - Sept 2016/April 2018

- **Science Exploitation Projects**
  - Q3 2018

- **Application Development Projects**
  - Q4 2018

- **Stakeholder consultation**
  - March 2017
  - Q2 2018
  - Q4 2018

- **Science Exploitation Projects**
  - June 2018
  - Q2 2019
  - Q2 2019

- **Application Development Projects**
  - December 2018
  - Q3 2019
  - Q3 2019

- **Stakeholder consultation**
  - January 2019

- **Science Exploitation Projects**
  - Q2 2019

- **Application Development Projects**
  - Q2 2019
Regional Initiatives: overview

Objectives
Concrete embedding of EO capabilities within regional Earth science programmes, regional environmental protection agreements and regional sustainable development strategies
In each region:
- Connect innovative EO R&D, application and service developments with the required underlying customized platform and processing capabilities
- Augment connectivity between EO and conventional Earth science, environmental protection and natural resources management practices

Scope - separate but coordinated actions for each region:

- Project Office: stakeholder engagement, communication and planning
- Science projects connect with regional Science programmes
- Application projects Integrate EO in ecosystem assessment & sustainable growth

Customized platform and processing resources
Baltic Regional Initiative

- Support to National & Regional Monitoring/Reporting
- Data access, management & processing
- Routine Monitoring & Analysis/Reference Datasets
- Support to Baltic Management Actions/Plans
- Communication, Education and Citizen Engagement
- Support to Cooperative Baltic Research
- Support to Regional Baltic Initiatives/networks
- Development of Customized Baltic Applications & Services
- Support to National & Regional Monitoring/Reporting
EO for security and law enforcement
Security and Law enforcement

Use of civilian systems means:
- Information is open source
- Information is shareable
- Data are traceable
Security and Law Enforcement – operational capabilities
Security and law enforcement – environmental crime

- IUU fishing and trafficking
- Ivory poaching and trafficking
- Timber poaching and trafficking
- Wildlife trafficking
- Waste trafficking and dumping
- Illegal/illicit mining
Security and law enforcement – crimes against humanity

War crimes
Ethnic cleansing
State involvement in irregular conflict
Violence against minorities
Security and law enforcement – counter-proliferation

Unlicensed/irregular materials production
Unlicensed/irregular facility operations
Unlicensed/irregular trafficking of controlled materials
Facility safety against non-state actors
Use of WMD
Security and law enforcement – terrorism/organized crime

- Weapons trafficking
- Safety of critical facilities
- Irregular fighters training camps
- Returning FTFs
Security and law enforcement – fragility, conflict & violence

Natural resources management
Environmental Protection
Post conflict reconstruction support
Justice and rule of law
Onset of violence precursors
Epidemic prevention
Security and law enforcement – new EO data sources

HyperScout
BiomassSAR

Prisma
Security and law enforcement – new AI capabilities

Courtesy Starlab

Courtesy R Cresson, IRSTEA

Courtesy R Cresson, IRSTEA
EO services – Enabling industrial growth
Geomarketing and urban information
Extractives management

Courtesy EffeGIS

Courtesy Atlantis Scientific

Courtesy SatIm
Renewable resources management
Renewable energy
Insurance and risk management
Increasing business – waste management support
EO market development

European & Canadian EO Service Companies Revenue growth

(EARSC, 2017)

European & Canadian EO Service company employment growth

(EARSC, 2017)
EOEP Block 4 dashboard

**INNOVATION**

<table>
<thead>
<tr>
<th>Number of contracts with</th>
<th>science</th>
<th>applications</th>
<th>industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>new capability</td>
<td>87</td>
<td>19</td>
<td>36</td>
</tr>
<tr>
<td>expanded application</td>
<td>18</td>
<td>20</td>
<td>82</td>
</tr>
<tr>
<td>study/support development</td>
<td>48</td>
<td>2</td>
<td>18</td>
</tr>
</tbody>
</table>

43% of EOEP contract addresses innovative new developments

On average, 24 contracts per year are placed under the Permanently Open Call

**EMERGING MARKETS ENABLED BY EOEP**

<table>
<thead>
<tr>
<th>developing sector</th>
<th>estimated value (Bn €)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agro-Insurance</td>
<td>17</td>
</tr>
<tr>
<td>Agro-chemicals</td>
<td>239</td>
</tr>
<tr>
<td>payment for Ecosystem Services</td>
<td>35</td>
</tr>
<tr>
<td>Renewable Energy</td>
<td>280</td>
</tr>
</tbody>
</table>

**WHO WE WORK WITH**

- universities/academies
- public sector
- private sector

**WHERE WE WORK**

- World
- Asia Pacific
- South
  - South East Asia
  - South America
- Europe
- Africa

**ENHANCED PORTFOLIO**

Application performance improvement:

- Information content: 1.5 - 4
- Update times: 2 - 10
- Cost per hectare: 2 - 5
- Spatial resolution/scale: 10 - 30

**FOCUS ON SMEs**

40% of industrial contractors are SMEs

64% of all industrial spend with SMEs

<table>
<thead>
<tr>
<th>since 2013</th>
<th>science</th>
<th>applicant</th>
<th>industry growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of contracts involving SMEs</td>
<td>95</td>
<td>37</td>
<td>225</td>
</tr>
<tr>
<td>Contract spend with SMEs (M€)</td>
<td>7.7</td>
<td>5.1</td>
<td>23.5</td>
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<tr>
<td>Industrial spend with SMEs</td>
<td>67%</td>
<td>71%</td>
<td>75%</td>
</tr>
<tr>
<td>Industrial spend with SMEs</td>
<td>25%</td>
<td>27%</td>
<td>63%</td>
</tr>
</tbody>
</table>

**PARTNERSHIPS**

<table>
<thead>
<tr>
<th>since 2013</th>
<th>Contract Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;250 k€</td>
<td>&gt;400 k€</td>
</tr>
<tr>
<td>average number of countries involved per contract</td>
<td>3.4</td>
</tr>
<tr>
<td>average number of partners involved per contract</td>
<td>4.7</td>
</tr>
</tbody>
</table>
Outcomes – what happens after ESA EO projects?
Booming Statistics

Copernicus Data Statistics
4 Dec. 2017

Sentinel Registered Users

Volume of User Downloads
40.6 PB

Published Products
5,268,509

Registered Users
110,357

Sentinel missions operated by ESA
Earth Explorer missions
Heritage missions
Third Party & Contributing Missions
Can European Industry compete in the “hit-based” Digital Platform Ecosystem?

EO Browser platform: monthly hits 2018

>20,000 active users each month

187 countries

a global success

Can European Industry compete in the “hit-based” Digital Platform Ecosystem?
Embracing AI and Big Data and NewSpace
Some questions we are addressing

1. (science) How can AI and Big Data developments foster new/improved understanding of Earth system processes, their interaction, their responses to anthropogenic forcing (and the consequences for us)?

2. (applications) What are the new applications or the improved analyses made possible with AI and Big Data Developments?

3. (industry) how are the AI/Big data developments enabling enhanced fusion of spatial information with mainstream commercial information services, what opportunities does this create for Europe and what developments should ESA be supporting?

4. (industry) how does the increased use of mainstream AI/big data/ICT in EO result in EO being just another dataset and what industrial opportunities does this create?

5. How can AI and new ICT capabilities enhance data collection and data fusion to support the responses to the above?
Moving with the times – evolution in science

**Experimental**
Last Millennia
Observation and Description of Natural Phenomena

**Theoretical**
1600 - ...
Newton’s laws, Maxwell’s equations

**Computational**
Last Decades
Simulation of Complex Phenomena

**Data Intensive**
Now & Future
Unify theory, experiment & simulation with multidisciplinary data & distributed communities

**Big Data**
Volume
Velocity
Variety
Veracity
Value

$F = \frac{G M_1 M_2}{r^2}$
DIAS – Creating an EO Data Ecosystem

- Copernicus Data and Information Access Services
- Common DG-GROW-ESA approach to EO data exploitation with Copernicus at its core
- Create & enable European EO Data ecosystem for research & business
- Starts in June 2018
NewSpace industry that is:
- innovative
- World leading
- Sustainable
Opening up opportunity for European SMEs

Global Geospatial Analytics Market
US$ 72.21 Bn by 2020
→ 3x increase in 5 years
Research and Markets, 2016

Global revenue from direct & indirect application of AI
US$36.8Bn by 2025
CAGR of 56.8%.
(Tractica)

"Over 2000 EO smallsats expected by 2026"
No easy answers, no magic solutions
And even when it goes to plan there are difficulties...
Moving forward together: Future EO
FutureEO – Structured around 4 Blocks

1. Foundations, Concepts & Technology
2. Research Missions
   - FORUM or SKIM
3. Mission Management
4. Earth Science for Society
FutureEO – 21st Century Innovation

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

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

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

- **21st Century EO**

**Increased Data Diversity & Volumes**

**EO AFRICA**
Block 1 – Foundations, Concepts and Technology

End-to-end preparation of EO missions – incl. tech developments and science activities to raise TRL/SRL and mitigate risks

- Call for Innovative Early (Mission) Concepts
- Early phases of EE-11, Sentinel-1/2/3-topo/3-opt NG, future Meteo Missions, Mission of Opportunity, including related IPD and science/campaign activities
- Other Instrument Pre-developments
- Cross-cutting technology pre-developments, e.g. for small instrument concepts, platforms (equipment miniaturisation, standardisation, ...) and new enabling technologies
Block 2 – Research Missions

Completion of Earth Explorer-9

Earth Explorer-10 phase B1

Up to 2 Explorer ‘Scouts’ (‘smallsats’)
- Valuable science for ~30 M€
- Challenge issued in early 2019
- Mission(s) selected after Space19+, for development and launch within 3 years

Timely early development activities
- A future operational wind measurement mission
Block 3 – Mission Management

Mission Operations
- Phase E2 of Earth Explorer missions (Phase F if relevant)
- Extension before PBEO in 2022 and part of 2023

Payload Data Ground Segment
Generic elements and Services for data accessibility, archiving, network, etc.

Generic Fiducial Reference Measurements

Geophysical Products
- Development & maintainance of ‘Level 2’ products
- For missions in Phases B/C/D/E (9), including cal/val campaigns
Block 4 – Earth Science for Society

- Address Grand Science Challenges (incl. ESA-EC/RTD Initiative)
- Bring EO Solutions for:
  - Environmental Threats (adaptation, mitigation, resilient society)
  - Sustainable Development (targets & indicators)
- Pioneer AI for EO (Big Data)
- Consolidating the Regional Initiatives (focus on user needs)
- EO for Security Actors
- EO Africa (users engagement & uptake of EO solutions)
Implemented through dedicated **Joint Flagship Activities**: Set of coordinated calls and ITTs by ESA and EC focused on key science challenges where the unprecedented European EO capabilities (e.g., EEs, Sentinels, national missions,…) may contribute;

Flagship joint actions will be supported by:

- **Science Clusters** of ESA and EC projects promoting coordination, knowledge/data sharing collaboration and cross-fertilization among projects;
- **Joint workshops**, reviewing progress and defining science roadmaps;
- **Joint communication and training**;
- **Open Science Tools** (e.g., Virtual Labs) maximizing the impact of new IT capabilities for open science;
- Coordinated **contribution to major international science endeavors**
- **Fostering transfer of science results** into new solutions for society
EO Solutions for a Resilient Society: Environmental Threats - Context


It will support the definition and implementation of actions to address diverse threats such as climate change natural disasters, management of scarce natural resources and economic disruption.

It will address
• environmental resilience (e.g. mitigation of geophysical risk),
• social and economic resilience (e.g. protection of critical infrastructure operations),
• natural resource (e.g. ensuring equitable access to water/energy/materials)
• regional stability (e.g. monitoring compliance with regional stability agreements)
Regional Initiatives 2021 onwards – Future EO1

DG RTD Horizon Europe Regional Actions

Science exploitation
- Integrate new techniques and data
- Develop and validate new data products and integrate into large scale Earth science programmes
- Develop new tools and methodologies
- Set up and execute regional capacity building activities and events

Applications & services development
- Embed EO in regional innovation clusters
- Expand integration of EO in updated Regional Strategies
- Address evolving requirements in Regional Environmental agreements
- Integrate new algorithms and datasets

Customized Regional Platform and Processing Capabilities
EO4 Security Exploitation

Verification of new EO datasets
- Feature/process detection capability (Earth Explorers, national missions, small satellites)
- Data collection reliability
- Information delivery reliability
- Augmented system effectiveness

Scaling up support to Law Enforcement and FCV
- Environmental crimes
- Crimes against humanity
- Counter-proliferation
- Terrorism/Organized Crime
- SDG16

Stakeholder engagement
- Awareness and acceptance
- Working practices
- Legal and regulatory constraints
- Fitness for purpose

Infrastructure requirements consolidation
- Data collection and processing
- Data fusion and combination
- Data storage
- Data analytics
- Visualization

European Space Agency
Overall coherence

Grand Science Challenges

Regional Initiatives  EO for Resilient Society  EO for Security  EO for SDGs
Take home messages

• Europe is a world leading EO player – continue being part of the growth
• ESA EO activities support full development cycle:
  • New instruments, systems etc, ground segment and exploitation
  • science to operational and commercial applications
• Evolution in ICT etc creates new opportunities – important to ensure agility:
  • Rapid support, facilitation and enabling for short term opportunities
  • Staying power to support longer term developments
• Evolution in EO and ICT is accelerating potential for wider operational EO uptake
  • EU legislation etc (CAP, environment directives)
  • SDGs
  • Industrial and commercial services
  • Citizen engagement
• ESA is at the service of Member States:
  • Ensuring relevant customized support to strategic priorities
  • Leverage complementary national/regional investments
• Hello opportunity!
Thanks!

www.esa.int