# DOCUMENT

# DRAGON 5 COOPERATION PROPOSAL INFORMATION NOTE FOR SCIENTISTS


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# 1 INTRODUCTION

## 1.1 Purpose and structure of the document

ESA, together with the National Remote Sensing Center of China (NRSCC), an entity under the Ministry of Science and Technology (MOST) of the P.R. China, have cooperated in the field of Earth observation application development for the last 24 years. This cooperation has been successively strengthened by the creation of dedicated joint Earth Observation cooperation called the Dragon Cooperation. There have been the following 4 years programmes to date:

- Dragon 1 (2004-2008);
- Dragon 2 (2008 – 2012);
- Dragon 3 (2012 – 2016);
- Dragon 4 (2016 – 2020).

A strong interest has been expressed by all parties to continue and further strengthen the successful cooperation between Europe and China under the framework of Dragon. Therefore, a call for follow-on cooperation between ESA and MOST called Dragon 5 is proposed in this document.

Chapter 1 outlines the purpose of this document and provides lists of relevant documents and abbreviations;
Chapter 2 provides background to the Dragon cooperation;
Chapter 3 illustrates the opportunity, including the conditions and the science objectives;
Chapter 4 provides the proposals' review and evaluation criteria;
Chapter 5 provides an overview of the call schedule.

## 1.2 Applicable documents

[A1] Terms and conditions for the use and distribution of Copernicus Sentinels data
https://scihub.copernicus.eu/twiki/pub/SciHubWebPortal/TermsConditions/TC_Sentinel_Data_31072014.pdf

[A2] Legal notice on the use of Copernicus Sentinel Data and Service Information
https://sentinels.copernicus.eu/documents/247904/690755/Sentinel_Data_Legal_Notice

[A3] ESA data policy for ERS, Envisat and Earth Explorer missions
https://earth.esa.int/web/guest/-/revised-esa-earth-observation-data-policy-7098

[A4] Terms and Conditions for the Utilisation of ESA's Earth Observation Data
https://earth.esa.int/files/terms

[A5] List of free ESA EO data sets
https://earth.esa.int/web/guest/data-access/browse-data-products

[A6] Terms and Conditions for the Utilisation of Data under ESA's Third Party Missions scheme
https://earth.esa.int/files/TPMterms

## 1.3 Reference documents & websites

[R1] The Dragon 4 Programme website (http://dragon4.esa.int )

[R2] 2017 Dragon 4 Programme e-brochure

[R3] Dragon 4 mid-term Symposium (http://dragon4.esa.int/2018-symp/page_programme.php )

[R4] Dragon 4 2019 Symposium (http://dragon4.esa.int/2019-symp/page_programme.php )

[R5] ESA Climate Change Initiative (CCI) (http://cci.esa.int/ )

## 1.4 List of Acronyms

| Acronym | Definition |
|---|---|
| AATSR | Advanced Along Track Scanning Radiometer |
| ATSR | Along Track Scanning Radiometer |
| ADEN | ALOS Data European Node |
| ADM Aeolus | ESA Earth Explorer Atmospheric Dynamics Mission (ADM-Aeolus) will provide global observations of wind profiles from space |
| ALOS | Advanced Land Observing Satellite operated by JAXA |
| AO | Announcement of Opportunity |
| AOI | Area(s) of Interest – a geographical region or area located by geo-coordinates |
| ASAR | Advanced Synthetic Aperture Radar on board Envisat |
| ASCAT | Advanced SCATterometer on the Metop-1 polar orbiting satellite |
| AVNIR-2 | ALOS Advanced Visible and Near Infrared Radiometer type 2 |
| Beijing-1 | Commercial micro-satellite with high resolution panchromatic (4m) and multi-spectral imaging sensors (32m), launched in October 2005 and stopped to provide data in 2012 |
| Beijing-2 | Commercial micro-satellite constellation consisting of three microsatellites with high resolution panchromatic (1m) and multi-spectral imaging sensors (4m), launched in 2015 with life expectancy of 7 years |
| BIOMASS | ESA Earth Explorer due for launch 2022, carrying P-band SAR for measuring global forest biomass |
| CBERS 4 | CBERS-4 is an Earth Resources Satellite jointly developed by China and Brazil. It was launched successfully on 7th Dec., 2014 |
| CFOSAT | CFOSAT is a Sino-French collaboration satellite ocean wave and wind measurement, the satellite was launched in October 2018 |
| CNES | Centre National d'études Spatiales or National Centre for Space Studies |
| Copernicus programme | Previously known as GMES (Global Monitoring for Environment and Security), is the European Programme for the establishment of a European capacity for Earth Observation employing Sentinels satellites |
| COSMO-SkyMed | **CO**nstellation of small **S**atellites for the **M**editerranean basin **O**bservation. Series of 4 X-band SAR satellites flying in constellation and operated by Agenzia Spaziale Italiana |
| CRYOSAT-2 | ESA Explorer satellite - CryoSat-2 carries a sophisticated radar altimeter to measure ice thickness and variations |
| Deimos | Satellite acquiring VHR (75cm pan-sharpened) multispectral optical imagery |
| DORIS | Doppler Orbitography and Radio-positioning Integrated by Satellite instrument is a microwave tracking system that can be utilized to determine the precise location of satellites |
| EarthCARE | ESA Explorer satellite EarthCARE is a joint European-Japanese mission addressing the need for a better understanding of the interactions between cloud, radiative transfer and aerosol processes |
| ENVISAT | ENVIronment SATellite |
| ELP | ESA's Living Planet Programme, which comprises a science and research element, which includes the Earth Explorer missions. The operational element is Earth Watch. |
| EO | Earth Observation |
| ERS | European Remote Sensing Satellite of which there were 2 |
| ESA | European Space Agency |
| FLEX | ESA FLuorescence EXplorer (FLEX) mission carrying a high-resolution imaging spectrometer FLORIS (FLuORescence Imaging Spectrometer) |
| FY | Polar orbiting and geo-stationary meteorological satellites of china |
| GeoEye | Satellites acquiring VHR (0.41m pan-sharpened) multispectral optical imagery |

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| GF- 1 to 7 | High-resolution earth observing system of China, their payloads include optical and SAR sensors for NRT applications |
| GMES | Global Monitoring for Environment and Security |
| GOCE | Gravity field and steady-state Ocean Circulation Explorer |
| GOME | Global Ozone Monitoring Experiment |
| GOMOS | Global Ozone Monitoring by Occultation of Stars |
| HJ | Chinese optical and SAR satellite constellation for environment and disaster monitoring. The two optical satellites HJ-1-A and HJ-1-B were launched in 2008. The HJ-1-C SAR was launched in 2012 and was only operational for a short period. |
| HY | Chinese Ocean Satellites, including HY-1A/B and HY-2 |
| ICEYE | X-band constellation of SAR satellites acquiring imagery in VV polarisation |
| JAXA | Japan Aerospace Exploration Agency |
| Jilin-1 | A china's self-developed remote sensing satellite for commercial use, it was launched in October 2015 |
| MERIS | MEdium Resolution Imaging Specrometer Instrument |
| MIPAS | Michelson Interferometer for Passive Atmospheric Sounding |
| MIRAS | Microwave Imaging Radiometer using Aperture Synthesis |
| MOST China | Ministry of Science and Technology, China |
| MSI | Multi Spectral Imager - optical instrument on board Sentinel 2 |
| MWR | MicroWave Radiometer |
| NRSCC | National Remote Sensing Center of China |
| NRT | Near Real Time |
| OceanSat-2 | Satellite with an Ocean Colour Monitor instrument operated by the Indian Space Research Organization |
| OLCI | Ocean Land Colour Instrument on board Sentinel 3 A & B |
| PI | Principal Investigator |
| PALSAR | ALOS Phased Array L-band SAR |
| PAZ SAR | X-band frequency SAR, the satellite is positioned in the same orbit as TerraSAR-X and TanDEM-X resulting in a three SAR satellite constellation |
| PLEIADES | Pleiades is a two-spacecraft constellation of CNES, providing VHR optical imagery |
| PlanetScope | Satellite constellation consisting of groups of VHR individual satellites (Doves) |
| PRISM | ALOS Panchromatic Remote sensing Instrument for Stereo Mapping |
| PROBA-V | Project for On-Board Autonomy – Vegetation (improved smaller version of the large VGT (Vegetation) optical instrument of SPOT-4 and SPOT-5 missions) |
| QuickBird | Archive mission, satellites acquiring VHR (<0.61m pan-sharpened) multispectral optical imagery |
| RA | Radar Altimeter |
| Radarsat-2 | C-band fully polarimetric SAR with several different imaging modes |
| RapidEye | A constellation of five mini satellites that can acquire and process up to 5 million km² of imagery daily to generate unique land information products |
| SAR | Synthetic Aperture Radar |
| S1-A/B | Sentinel 1 A & B satellites with a C-band SAR sensor |
| S2-A/B | Sentinel 2 A & B satellites with an optical imager |
| S3-A/B | Sentinel 3 A & B satellites with optical and thermal radiometers, a SAR altimeter and a MWR |
| SCIAMACHY | SCanning Imaging Absorption SpectroMeter for Atmospheric CHartographY |
| SKYSAT | Is the VHR constellation component of Planets satellite imaging portfolio |
| SLSTR | Sea Land Surface Temperature Radiometer on board Sentinel 3 A & B |
| SMOS | ESA Earth Explorer satellite – Soil Moisture Ocean Salinity |
| SPOT | Satellite Pour l'Observation de la Terre, commercial high resolution optical imaging satellite |
| SRAL | SAR Radar Altimeter on Sentinel 3 A & B |
| SSO | ESA Single Sign on Account to access the proposal submission template |

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| ScanSAR | The antenna is scanned in range several times during the synthetic aperture |
| SpotLight | Mechanical antenna steering in the azimuth direction is used to increase the illumination time, resulting in an increased synthetic aperture |
| StripMap | The antenna beam has a fixed pointing direction with respect to the platform |
| SWARM | ESA Earth Explorer Satellites - The Swarm mission will provide measurements of the Earth's geomagnetic field simultaneously over different regions of the globe |
| TanSat | A China's satellite to measure methane and carbon dioxide levels in the atmosphere |
| TerraSAR-X | TerraSAR-X1 (also referred to as TSX or TSX-1) is a German SAR satellite mission for scientific and commercial applications |
| TPM | Third Party Mission |
| VHR | Very High Resolution |
| WorldView | Satellites acquiring VHR (<0.5m pan-sharpened) multispectral optical imagery |
| WS | Wind Scatterometer |
| WFV | Wide Field of View |

# 2 BACKGROUND TO THE DRAGON COOPERATION

The Dragon Programme – a joint undertaking between ESA, the Ministry of Science and Technology (MOST) and the National Remote Sensing Centre of China (NRSCC) – is a wide-ranging research initiative designed to encourage increased exploitation of ESA Earth observation (EO) satellite data within China. After 16 years of cooperation, this pioneering programme has become a model for scientific and technological cooperation between China and Europe, raising the research level in Earth observation to help meet new global challenges. In the new phase – Dragon 4 – some 637 scientists from 234 European and Chinese research institutes have been working together for four years to produce new science and results. The use of data from several new missions such as the Chinese FY, GF and TanSAT missions, the European Copernicus Sentinel missions and Earth Explorer satellites as well as Third Party Missions such as COSMO SkyMed and Proba V have provided improved temporal, spatial and spectral coverage over the selected Dragon 4 test sites. By stimulating and supporting novel research, collaborative projects and training, Dragon 4 promises to yield a wealth of scientific output, thus ensuring that this unique initiative continues to deliver outstanding results.

Since 2004, this dedicated science and exploitation programme has brought together the European and Chinese EO scientific community, representing more than 230 institutes to work on a broad range of projects designed to encourage increased exploitation of ESA and Chinese Earth observation satellite data. Dragon has also promoted collaborative research at ESA, through participation of young Chinese scientists as international research fellows. Building on the success of the past years, Dragon 4 teams up scientists to work on 28 projects and 77 sub-projects across a wide range of thematic areas.

Dragon provides a unique platform for the joint exploitation of EO data from optical, infrared, thermal and microwave sensors for science and application development.

- The Dragon 1 programme (2004 to 2008) focused on the exploitation of ESA ERS and Envisat data for science and application development in China.
- Dragon 2 and 3 presented new opportunities for the exploitation of satellite data for scientific research with the launch of new satellite missions including the ESA Explorer missions and the Chinese Huanjing constellation. In addition, the provision of archive data allowed for change detection and time series analysis
- Dragon 4 exploits data from several new missions such as the Chinese FY, GF and TanSat missions, as well as European Sentinel and Earth Explorer satellites to address the following priority themes: Atmosphere, Climate & Carbon Cycle, Oceans and Coastal Zones, Ecosystems including Forest and Grasslands, Urbanization & Smart Cities, Hydrology & Cryosphere, Solid Earth & Associated Disaster Risk Reduction, Agriculture Food & Water, Calibration/Validation.

As well as EO exploitation for science and applications, the Dragon cooperation from the start has fostered the training of Chinese and European young scientists who are engaged on the projects to undertake research. The young scientists report their findings at annual symposia in the poster sessions and have published papers in the dragon Symposium proceedings at the mid stages and in the final results for each programme. Under this mechanism and since 2004, a total of 764 post graduate young scientists have been awarded higher degrees by research M.Sc. and Ph.D. level or have done post doctorate research. ESA and NRSCC organise with host institutions in China annual advanced training courses in ocean and coastal zones, land, atmosphere and hydrology applications. To date 1181 Chinese young scientists have received training in EO data exploitation by attending these courses. These courses are taught by the Dragon senior scientists. ESA and MOST-China have also promoted an exchange of visiting fellows hosted by institutes both in China and Europe, with Chinese fellows visiting institutes in Europe from 3 to 12 months and European fellows visiting institutes in China from 3 to 6 months.

# 3 DESCRIPTION OF THE CALL

## 3.1 Objectives of the call

The main objectives of this announcement of opportunity are:

- **Promote the exploitation of Copernicus Sentinels, ESA, ESA TPM and Chinese EO data**
  - *for science and application development*
- **Stimulate scientific exchange**
  - *by the formation of joint Sino-European teams*
  - *academic exchanges particularly Young Scientists*
- **Publish co-authored results**
  - *in ESA and NRSCC joint results publication (2022) & (2024)*
  - *in leading scientific journals*
- **Provide training to young European and Chinese scientists.**

## 3.2 General conditions of the call

The European Space Agency (ESA) jointly with The National Remote Sensing Center of China (NRSCC) under the Ministry of Science and Technology (MOST), announce the opportunity to conduct research and application development projects using ESA, Copernicus Sentinels, ESA Third Party Missions and Chinese EO data.

Proposals shall be submitted via the dedicated web site at https://earth.esa.int/aos/dragon5

ESA/NRSCC may decide to select only a portion of the proposer's investigation, in which case the investigator will be given the opportunity to accept or decline such partial acceptance.

Access to the ESA and Copernicus Sentinels EO data sets necessary to execute the projects will then be provided to the selected Principal Investigators free of charge. For the requested ESA Third Party Missions and Chinese Missions data, access to EO datasets will be granted subject to data access agreements and data availability.

The progress and accomplishments of the selected projects will be monitored by ESA/NRSCC. All selected Principal Investigators will be required to submit periodic progress reports or publications in the Dragon 5 annual Symposia describing the status of their projects results and to prepare papers for publication in English at the mid-term stage (June 2022) and at the end of the Dragon 5 applicable period (June 2024). PIs shall also present their results at a limited number of specialised workshops or symposia organised by ESA and NRSCC or at invited special sessions organised at other international conferences or Symposia.

The kick off for the Dragon 5 cooperation will take place in Hohhot, Inner Mongolia P.R. China, from 15 to 17 July 2020 with high level representatives from Europe and China.

The call will provide opportunities for scientists from Europe and China to cooperate for the exploitation of Copernicus Sentinels. Chinese, ESA and ESA TPM EO data in P.R. China, and at other regional and global scales. It is expected that the projects will be managed through bilateral cooperation agreements between the Chinese and the European Partners. Proposals are invited which cover the exploitation of products for research and development of applications for EO data analysis, EO data shall include some or all of the following sources:

- ESA EO missions' data both archive and operational (i.e. ERS, Envisat, Earth Explorers, Earthwatch-ProbaV, see annexes 1, 2, and 3);
- Copernicus Sentinels missions' data via the Sentinels Scientific/Open access Data Hub (see annex 4)
- Third Party Missions' data, provided by ESA (see annex 5);

- Chinese EO missions' data (see annex 6).

The Principal Investigators (PIs) are expected to evaluate their data requirements thoroughly, in terms of both quantities and types. Apart from the Sentinels' missions with no quota restriction, the provision of other EO data could be subject to priorities for scheduling and operating the sensors and to the capacities and constraints of the ground segment.

Proposals should carefully consider the formation of joint Sino-European teams and it would be expected that institutions in both Europe and China would be engaged. The project should seek to train young post graduate scientists and it is expected that the co-investigators' list should indicate the inclusion of young scientists and to indicate the level of post graduate training that will be provided (i.e. Masters, doctorate degrees or post doctorate research).

Continuity proposals on the thematic areas of Dragon 4 projects are welcome, inviting research continuity and exploitation of new ESA, Copernicus Sentinels, ESA Third Party Mission and Chinese EO missions' data. For an overview of Dragon 4 projects and achievements, please refer to [R1].

## 3.3 Organisation of a project's proposal

For a specific topic in table 1, each proposal shall be led 2 Principal Investigators (PIs), one from Europe and one from China.

### *3.3.1 Principal Investigator(s) tasks for proposal submission*

The proposal shall be completed by either the Principal Investigators (PI) from European or China. All information pertinent to a proposal shall be included by submitting the proposal. Nb. The PI shall create or have created an ESA Single Sign On account to be able to access the on-line submission forms.
https://earth.esa.int/web/guest/general-registration (Register to create a new EO SSO account)
https://earth.esa.int/aos/dragon5 (with an EO SSO account) click on **Submit a project proposal for Dragon 5**

The following information shall be provided:

1. Completion of the Project information
   - Title (insert the project's title);
   - Dragon topic and sub-topic (select from pull down list, from table 1 in the information from scientists);
   - Identify the study area (select from pull down list);
   - Provide the Executive summary (insert the summary).

2. Insert the 2 PIs contact and affiliation details.

3. Provide the list of co-investigators (down load, complete and up-load the pdf of the list of co-investigators).

4. Team Composition, Experience, Innovation and Contribution Dragon 5
   - complete the text boxes informing on team composition and experience.

5. Detailed Description and Schedule Dragon 5
Complete the text boxes taking note of the information to be inserted;
   - Detailed description;
   - Schedule (providing and overall plan, detailing the schedule of the research, the deliverables at each stage and reporting at annual Dragon Symposia in 2021, 2022, 2023 and 2024);
   - Expected results (inform on the expected outputs of the research and if they are products and descriptions, algorithms, model runs etc.);
   - Young scientists' contribution (outline the contribution to the projects objectives and results reporting at annual Symposia, either as poster presentations and papers submitted to Symposia proceedings. On the European side,

each project may expect to receive an ESA award for Young Scientists support subject to ESA standard contract conditions).

6. Inform on EO data to be utilised
   - ESA products (select your EO data requirements from the pull down list);
   - ESA TPM products (select your EO data requirements from pull down list);;
   - Sentinels data (down load, complete and up-load .pdf with your Sentinels EO data requirements)
   - Chinese EO data (down load, complete and up-load .pdf with your Chinese EO data requirements).

7. Up-load vector descriptor files for your Areas of Interest (.kmz or .shp)

8. Acceptance of the Dragon Call conditions.

## 3.4 Research and development on Dragon 5 topics

Proposals from Sino-European teams will be invited that will address the following Dragon 5 themes identified by MOST China and ESA as shown in table 2. As for the Dragon 4 cooperation programme, the proposed themes have been aligned in order to reflect key societal issues and their relation of the science component to other initiatives, e.g. UN sustainable development goals, GEO societal benefit areas and the ESA EO science for society strategy. Continuity of Dragon 4 projects will be considered.

| **Topic** | **Sub-topic** |
|---|---|
| 1. Solid Earth | *1.1 Seismic deformation monitoring*<br>*1.2 Monitoring of surface deformation of large landslides*<br>*1.3 Infrastructure health diagnosis and safety monitoring*<br>*1.4 Subsurface target detection* |
| 2. Oceans & Coastal zones | *2.1 Algae and phytoplankton blooms*<br>*2.2 Marine dynamic environment*<br>*2.3 Sea surface characteristics*<br>*2.4 Marine disasters*<br>***2.5 Sea level rise and coastal zones management*** |
| 3. Atmosphere | *3.1 Greenhouse gases and carbon emissions*<br>*3.2 Air quality*<br>*3.3 Atmospheric-terrestrial-marine carbon cycle* |
| 4. Climate Change | ***4.1 Climate change modeling***<br>***4.2 Climate change adaptation and mitigation***<br>***4.3 Climate change resilience***<br>***4.4 Disaster prevention and monitoring*** |
| 5. Sustainable Agriculture and Water Resources | *5.1 Food security*<br>*5.2 Crop growth and yield monitoring*<br>*5.3 Water resources and its utilization*<br>*5.4 Drought and flood disaster* |
| 6. Ecosystems | *6.1 Detection of forest cover change*<br>*6.2 Collaborative estimation of forest quality parameters*<br>*6.3 Grassland and its degradation monitoring*<br>*6.4 Forest and grassland disaster monitoring* |
| 7. Urbanization and Environment | *7.1 Urban expansion*<br>*7.2 Urban land use structure and its change*<br>*7. 3 Urban environment*<br>*7.4 Smart cities* |

| Topic | Sub-topic |
|---|---|
| 8. Cryosphere and Hydrology | ***8.1 Inversion of key elements of the cryosphere in Pan Third Pole Region***<br>***8.2 Validation of key elements of cryosphere in Pan Third Pole Region***<br>*8.3 Integration of eco-hydro models and multi-source data simulation*<br>*8.4 Wetlands and ecology* |
| 9. Calibration and Validation | *9.1 Satellite calibration field network and cross calibration*<br>*9.2 Cross radiation calibration and normalization processing*<br>*9.3 Validation network and technology*<br>*9.4 Common product production and verification services* |
| **10. Data Analysis** | ***10.1 Big Data Analytics***<br>***10.2 Artificial Intelligence and Machine Learning***<br>***10.3 Cloud Platforms*** |

Table 1. Dragon 5 ESA-MOST Joint Proposal Topics [new Dragon 5 items in bold]

## 3.5 Requests for information concerning the call

Further information regarding this call may be found on the dedicated website (https://earth.esa.int/aos/dragon5) and also by contacting the ESA Dragon team at the following email address: dragon@esa.int .

In P.R. China email and telephone assistance will be available for the call duration from Prof. Gao Zhihai (email: dragon@ifrit.ac.cn; zhgao@ifrit.ac.cn.)

# 4 SUBMISSION & EVALUATION OF PROPOSALS

## 4.1 Proposal submission

**[IMPORTANT]** Please follow the guidelines for submission available at: https://earth.esa.int/aos/dragon5 .
Each proposal shall be led by a European and a Chinese Principal Investigator.

All investigators shall have read and accepted the Terms and Conditions for the utilisation of ESA Earth Observation data, ESA Third Party Missions data and Copernicus Sentinels data, as applicable. Please refer to section 1.2 of this document for the terms and conditions.

The Principal Investigators shall have read and accepted the Terms and Conditions for the utilisation of each Chinese EO data, and access to some Chinese EO data are need to submitting data request to dragon office in Chinese side.

## 4.2 Review Panel and procedures

Proposals that are submitted in the framework of the Dragon 5 cooperation will be reviewed by a scientific committee with representatives appointed by ESA and MOST/NRSCC:

- With expertise that encompass scientific research, technology, applications development, national and international research programmes and EO satellite missions;
- With a broad understanding of the uses of Earth observation data, including uses in operational systems.

The purpose of the review is:

- To assess whether the specific projects are in accordance with ESA, ESA TPM, Copernicus Sentinels & Chinese EO data policy and with the specific objectives of the Dragon 5 cooperation;
- To evaluate the scientific, application and technical merits of the proposed projects in relation to their technical feasibility.

The final decisions concerning the acceptance of proposals for projects will be made upon recommendation of the scientific review committee. Final approval will be granted according to the ESA and MOST-NRSCC acceptance procedures.

## 4.3 Evaluation criteria

Within the overall context of the ESA Earth Observation mission objectives, the evaluation process is expected to identify opportunities to exploit the potential of the ESA Earth Observation mission. The following criteria will be used in the evaluation process:

- Suitability of the proposal to the conditions for scientific use of EO and other data;
- Continuity of the ESA-MOST Dragon 4 projects and themes and / or new scientific exploitation of EO and other data;
- Relevance of the proposed project to the objectives of the ESA Earth Observation and Chinese EO missions and the specific call objectives;
- The merit of the project from a scientific, technological, economic and operational viewpoint and the degree of innovation of the proposal;
- The technical feasibility of completing the project and achieving positive results within a period of typically four years, with special emphasis on the adequacy and practicability of the schedule presented in the proposal;
- The competence and relevant experience of the Principal Investigators as an indication of their ability to complete the project successfully;
- Involvement of young scientists and in particular assignment of research packages lasting 1 to 4 years and reporting;
- Proposed teaming on both European and Chinese side, including the identification of Principal Investigators and joint teams to undertake research packages within each project;

- The Principal Investigators shall in particular be responsible for the management and coordination of the research project and coordination of results reporting at annual Symposia including publication of papers in Symposia proceedings and journal publications.

## 4.4 Follow-on actions and activities

An analysis of data requirements will be done by ESA and NRSCC to define a product/programming quota of the restrained dataset based on the amount of data requested in the proposal. The results of the evaluation (acceptance/rejection or request for modifications) will be transmitted to the Principal Investigators (PIs) who shall inform their teams accordingly.

At the start-up of an accepted project the PIs will be granted:

- Access to all ESA EO data systematically available online requested in the frame of the proposal, a detailed list of systematically available on-line products is available at the address: https://earth.esa.int/web/guest/data-access/browse-data-products
- A product/programming quota of the restrained ESA and ESA TPM EO dataset for the project.
- A product/programming quota for some restrained Chinese EO data for the project.

Following notification, the selected Principal Investigators will have to:

- Confirm their intention to proceed with the project;
- Confirm the funding of the project (including a written confirmation from the funding entity)[Note 1];
- Agree to the allocated data quantities and the delivery conditions;

In some cases, the principal investigators will be required to amend their proposal in order to meet the acceptance criteria and in accordance with the remarks expressed by the evaluators.

# 5 SCHEDULE

| | |
|---|---|
| Opening of the call | 16 December 2019 |
| Deadline for submission of proposals | 12:00 (CET) 28th February 2020 |
| ESA/MOST-NRSCC review meeting | Early to mid-April 2020 |
| Notification of evaluation to proposers | Following both ESA and MOST China approval end April / May 2020 |
| Symposium for Kick Off Dragon 5 cooperation projects | 16 to 17 July 2020, China |
| Start of ESA and Chinese EO data order/delivery | 17 July 2020 |
| Projects completion, final results publication and reporting | June 2024 (4 years) |

Table 2 The schedule of the Dragon 5 AO and Cooperation Duration

Note 1 ESA will fund mission support for European Dragon PI participation to the Annual Symposia and / or Dragon 5 Training Courses. Subject to selection via the ESA Open Call for Dragon Young Scientists ESA will also fund young European scientists engaged in the selected Dragon 5 projects, covering 4 years periods of the Dragon 5 co-operation. Similar to the Dragon 4 programme it is assumed that for the selected European part of the projects the remainder of the costs will be funded by sources outside of ESA.

# 1 ANNEX - ARCHIVE ESA EO MISSIONS

## 1.1 ERS

Archive products derived from the following instruments on-board the ERS-1 (launched in 1991 and ended on 10 March 2000) and ERS-2 (launched in 1995 and retired on 5 September 2011) satellites can be made available to this opportunity:

- **Active Microwave Instrument (AMI).** It operates in C-band (5.3 GHz) and combines the functions of a *Synthetic Aperture Radar (SAR)* and a *Wind Scatterometer (WS)*. Through its set of four antennae (three for the Scatterometer and one for the SAR), the Earth's surface is illuminated and the backscattered energy is received to produce data on wind fields and wave spectra, and to prepare high resolution images. Three modes of operation are possible: the image mode (SAR), the wave mode (SAR) and the wind mode (WS).
- **Along Track Scanning Radiometer (ATSR)**. It consists of two instruments, an Infra-Red Radiometer (IRR) and a Microwave Sounder (MWS). On board ERS-1 the IRR is a four-channel infra-red radiometer used for measuring sea-surface temperatures (SST) and cloud-top temperatures, whereas on board ERS-2 the IRR is equipped with additional visible channels for vegetation monitoring. The MWS is a two channel passive radiometer.
- **Radar Altimeter (RA).** It is a Ku-band (13.8 GHz) nadir-pointing active microwave sensor designed to measure the time return echoes from ocean and ice surfaces. Functioning in one of two operational modes (ocean or ice) the Radar Altimeter provides information on significant wave height; surface wind speed; sea surface elevation, which relates to ocean currents, the surface geoid and tides; and various parameters over sea ice and ice sheets.
- **Global Ozone Monitoring Experiment (GOME).** It is a nadir-scanning ultraviolet and visible spectrometer for global monitoring of atmospheric Ozone on-board ERS-2. A key feature of GOME is its ability to detect other chemically active atmospheric trace-gases as well as aerosol distribution.

A detailed description of available ERS data products is provided at:
https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/ers
https://earth.esa.int/web/guest/data-access/browse-data-products?selectedTags=ers

## 1.2 ENVISAT

Archive products derived from the following instruments onboard the ENVISAT satellite mission (launched in 2002 and ended in 2012) can be made available under this call:

- **MEdium Resolution Imaging Specrometer Instrument (MERIS).** It measures the solar radiation reflected by the Earth, at a ground spatial resolution of 300m and 1200m, in 15 spectral bands, programmable in width and position, in the visible and near infra-red. It allows global coverage of the Earth in 3 days.
- **Advanced Synthetic Aperture Radar (ASAR)** It operates at C-band and ensures continuity with the image mode (SAR) and the wave mode of the ERS-1/2 AMI. It features enhanced capability in terms of coverage, range of incidence angles, polarisation, and modes of operation. This enhanced capability is provided by significant differences in the instrument design: a full active array antenna equipped with distributed transmit/receive modules which provides distinct transmit and receive beams, a digital waveform generation for pulse "chirp" generation, a block adaptive quantisation scheme, and a ScanSAR mode of operation by beam scanning in elevation.
- **Advanced Along Track Scanning Radiometer (AATSR)**. Its main goal is to establish continuity of the ATSR-1 and ATSR-2 data sets of precise sea surface temperature (SST), thereby ensuring the production of a unique 10 year near-continuous data set at the levels of accuracy required (0.3 K or better) for climate research and for the community of operational as well as scientific users who will have been developed through the ERS-1 and ERS-2 missions.
- **Radar Altimeter 2 (RA-2).** It is an instrument for determining the two-way delay of the radar echo from the Earth's surface to a very high precision: less than a nanosecond. It also measures the power and the shape of the reflected radar pulses. Its measurements are used to determine the ocean topography, to map and monitor sea ice, polar ice sheets, and most land surfaces. Measurement of the radar echo power and shape enables the determination of wind speed and significant wave height at sea, thus supporting weather and sea state forecasting

- **Michelson Interferometer for Passive Atmospheric Sounding (MIPAS).** It is a Fourier transform spectrometer for the measurement of high-resolution gaseous emission spectra at the Earth's limb. It operates in the near to mid infrared where many of the atmospheric trace-gases playing a major role in atmospheric chemistry have important emission features
- **Global Ozone Monitoring by Occultation of Stars (GOMOS).** It is the newest ESA instrument aiming at ozone monitoring. It is a tool to provide altitude-resolved global ozone mapping and trend monitoring with very high accuracy, as needed for the understanding of ozone chemistry and for model validation.
- **SCanning Imaging Absorption SpectroMeter for Atmospheric CHartographY (SCIAMACHY)**. Its primary mission objective is to perform global measurements of trace gases in the troposphere and in the stratosphere

No restrictions are envisaged for those instruments providing a **systematic flow of data and available on-line** (e.g. MERIS, AATSR, Altimeter). See the following link for the full list of these products and fast registration procedure to access them:
https://earth.esa.int/aos/registration
https://earth.esa.int/files/regproducts

**For restrained instrument data** (e.g. ASAR and SAR HR mode), PIs will be given a ceiling quota compatible with the project needs and ESA's acquisition/production capacity. Products will then be ordered through the ESA on-line catalogue EOLI-SA. https://earth.esa.int/web/guest/eoli . Dragon PIs will be provided with their own user accounts to order restrained ESA products through EOLI-SA.

A detailed description of available ENVISAT data products is provided at the address: https://earth.esa.int/web/guest/data-access/browse-data-products?selectedTags=envisat .

## 1.3 GOCE

The Gravity Field and Steady-State Ocean Circulation Explorer (GOCE) was launched on 17 March 2009 and ceased operation on 11 November 2014. GOCE was dedicated to measuring the Earth's gravity field and modelling the Earth's geoid with extremely high accuracy and spatial resolution.

- The GOCE **Gradiometer** measured gravity gradients in all spatial directions. The measured signal is the difference in gravitational acceleration at the test-mass location inside the spacecraft caused by gravity anomalies from attracting masses of the Earth.

Access to GOCE data is on-line at:
http://eo-virtual-archive1.esa.int/Index.html

More information about the GOCE mission and available resources is available at:
http://www.esa.int/Our_Activities/Observing_the_Earth/The_Living_Planet_Programme/Earth_Explorers/GOCE
https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/goce

# 2 ANNEX OPERATIONAL EARTH EXPLORERS MISSIONS

## 2.1 SMOS

The Soil Moisture and Ocean Salinity (SMOS) mission has been designed to observe soil moisture over the Earth's landmasses and sea surface salinity over the oceans. The satellite was launched on 2 November 2009.

- The main instrument is the **Microwave Imaging Radiometer using Aperture Synthesis (MIRAS)** which is an interferometric radiometer, operating between 1400-1427 MHz (L-band).

Access to SMOS data can be made following ESA SSO user registration on-line at:
https://smos-ds-02.eo.esa.int/oads/access/

More information about the SMOS mission is available at:
https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/smos
http://www.esa.int/Applications/Observing_the_Earth/SMOS

## 2.2 CRYOSAT-2

ESA's Earth Explorer CryoSat-2 mission, launched on 8 April 2010, is dedicated to precise monitoring of the changes in the thickness of marine ice floating in the polar oceans and variations in the thickness of the vast ice sheets that overlie Greenland and Antarctica.

- CryoSat-2's primary payload is the **SAR/Interferometric Radar Altimeter (SIRAL)**, which has extended capabilities to meet the measurement requirements for ice-sheet elevation and sea-ice freeboard.

Access to Cryosat-2 data is on-line at:
http://science-pds.cryosat.esa.int/

More information about the CRYOSAT-2 mission is available at:
https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/cryosat ,
http://www.esa.int/Our_Activities/Observing_the_Earth/The_Living_Planet_Programme/Earth_Explorers/CryoSat-2

## 2.3 SWARM

The Swarm mission is a constellation of three satellites carrying a new generation of magnetometers enabling measurements to be taken over different regions of the Earth simultaneously. Swarm also provides monitoring of the time-variability aspects of the geomagnetic field, this is a great improvement on the current method of extrapolation based on statistics and ground observations. The geomagnetic field models resulting from the Swarm mission will further our understanding of atmospheric processes related to climate and weather and will also have practical applications in many different areas, such as space weather and radiation hazards. The satellites were launched on 22 November 2013.

- Each satellite is carrying a science payload consisting of the following instruments: **Absolute Scalar Magnetometer (ASM); Vector Field Magnetometer (VFM); Electrical Field Instrument (EFI); Accelerometer (ACC); Laser Retro Reflector (LRR)**

Access to SWARM data is on-line at:
https://swarm-diss.eo.esa.int/

More information about the SWARM mission is available at:
https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/swarm

http://www.esa.int/Our_Activities/Observing_the_Earth/The_Living_Planet_Programme/Earth_Explorers/Swarm

## 2.4 ADM-Aeolus

ESA's Explorer Atmospheric Dynamics Mission-Aeolus satellite, creates a series of consistent global wind profiles for the first time (about 100 per hour), giving meteorologists better information with which to predict the weather. The unique location of the satellite, in orbit around the Earth, means that ADM-Aeolus will be able to provide wind profiles for the entire planet, including remote areas lacking any ground-based weather station.

- The core space element of ADM-Aeolus is **ALADIN (Atmospheric Laser Doppler Instrument)**, a direct detection LIDAR incorporating a fringe-imaging receiver (analysing aerosol and cloud backscatter) and a double-edge receiver (analysing molecular backscatter).

For access to data please see the following website.
https://aeolus-ds.eo.esa.int/oads/access/

More information about ADM-Aeolus mission and products are available at:
https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/aeolus
http://www.esa.int/Our_Activities/Observing_the_Earth/The_Living_Planet_Programme/Earth_Explorers/ADM-Aeolus
http://earth.esa.int/aos/AeolusCalVal

# 3 ANNEX - FUTURE EARTH EXPLORERS MISSIONS

## 3.1 EarthCARE

The EarthCARE mission aims to improve the representation and understanding of the Earth's radiative balance in climate and numerical weather forecast models by acquiring vertical profiles of clouds and aerosols, as well as the radiances at the top of the atmosphere. The satellite will be launched in 2021.

- The satellite will carry the following instruments: **Backscatter Lidar (ATLID) - ESA High-spectral resolution and depolarisation; Cloud Profiling Radar (CPR) - JAXA/NICT -36 dBZ sensitivity, 500 m vertical range, Doppler; Multi-Spectral Imager (MSI) - ESA 7 channels, 150 km swath, 500 m pixel; Broadband Radiometer (BBR) - ESA 2 channels, 3 views (nadir, fore and aft)**

Access to data will be confirmed following successful launch and operation of the satellite.

More information about the EarthCARE mission is available at:
https://earth.esa.int/web/guest/missions/esa-future-missions/earthcare
http://www.esa.int/Our_Activities/Observing_the_Earth/The_Living_Planet_Programme/Earth_Explorers/EarthCARE

## 3.2 BIOMASS

Forest type and forest cover worldwide are two characteristics that can be detected by today's satellites, but Biomass will take the information to the next level. Due for launch in 2022, the satellite will carry the first P-band synthetic aperture radar, able to deliver accurate maps of tropical, temperate and boreal forest biomass. The global mass of trees is not obtainable by ground measurement techniques. The five-year mission will witness at least eight growth cycles in the world's forests. Observations from this new mission will also lead to better insight into rates of habitat loss and, therefore, the effect this may have on biodiversity in the forest environment.

- The instrument will be **P-band Synthetic Aperture Radar (SAR)**

Access to data will be confirmed following successful launch and operation of the satellite.

More information about the BIOMASS mission is available at:
https://earth.esa.int/web/guest/missions/esa-future-missions/biomass
http://www.esa.int/Applications/Observing_the_Earth/The_Living_Planet_Programme/Earth_Explorers/Biomass

## 3.3 FLEX

The FLuorescence EXplorer (FLEX) mission will yield information about the health of the world's plants by measuring a faint florescence glow they give off as they photosynthesise. Importantly, the signal, which is invisible to the naked eye, varies according to environmental conditions and the health of the plant – and, therefore, if measured, it can be used to assess plant health and stress.

- The main instrument is FLORIS (FLuORescence Imaging Spectrometer) which is a high-resolution imaging spectrometer acquiring data in the 500–780 nm spectral range, with a sampling of 0.1 nm in the oxygen bands (759–769 nm and 686–697 nm) and 0.5–2.0 nm in the red edge, chlorophyll absorption and PRI (Photochemical Reflectance Index) bands.

Access to data will be confirmed following successful launch and operation of the satellite.
More information about the FLEX mission is available at:
http://www.esa.int/Applications/Observing_the_Earth/FLEX

# 4 ANNEX - COPERNICUS SENTINELS MISSIONS

ESA is developing a suite of new mission families called Sentinels, which aim to serve both the observational needs of the European Copernicus programme, as well as broader requirements for climate monitoring and prediction. Sentinels products will be made available to the Dragon 5 teams in agreement with the Legal notice on the use of Copernicus Sentinel Data and Service Information. **Data dissemination will be provided online via the standard scientific/open access data hub mechanism, via user self-registration.**

Further information about Sentinel missions, products and on-line access to data can be found at:
https://sentinel.esa.int/web/sentinel/home

The Sentinels missions include the following.

## 4.1 Sentinel 1 A/B

The Sentinel-1 mission comprises a constellation of two polar-orbiting satellites, operating day and night performing C-band synthetic aperture radar imaging, enabling them to acquire imagery regardless of the weather and sunlight conditions. Sentinel-1 will work in a pre-programmed operation mode to avoid conflicts and to produce a consistent long-term data archive built for applications based on long time series. The Sentinel-1 observation scenario available at: https://sentinel.esa.int/web/sentinel/missions/sentinel-1/observation-scenario .

Access to data is via the Sentinel Science hub by user registration.
https://scihub.copernicus.eu/

More information about Sentinel-1 data and products available at:
https://sentinel.esa.int/web/sentinel/user-guides/sentinel-1-sar

## 4.2 Sentinel 2 A/B

The Copernicus Sentinel-2 mission comprises a constellation of two polar-orbiting satellites placed in the same sun-synchronous orbit, phased at 180° to each other. It aims at monitoring variability in land surface conditions, and its wide swath width (290 km) and high revisit time (10 days at the equator with one satellite, and 5 days with 2 satellites under cloud-free conditions which results in 2-3 days at mid-latitudes) will support monitoring of Earth's surface changes. The coverage limits are from between latitudes 56° south and 84° north

- The high-resolution optical imaging Sentinel-2 mission carries a **Multi-spectral Imager (MSI)** for land and coastal monitoring.

Access to data is via the Sentinel Science hub by user registration.
https://scihub.copernicus.eu/

More information about Sentinel-2 data and products available at :
https://sentinel.esa.int/web/sentinel/user-guides/sentinel-2-msi

## 4.3 Sentinel 3 A/B

The Sentinel-3 satellites carry Envisat continuity instruments that provide medium resolution optical and thermal infrared data for land and ocean monitoring.

- The instrument payload includes: **SAR Radar Altimeter (SRAL)**; **Ocean and Land Colour Instrument (OLCI)** -continuity from Envisat MERIS; **Sea Land Surface Thermal infrared radiometer (SLSTR)** – continuity from AATSR.

The latest products include vegetation synergy products by combining OLCI and SLSTR data. Next generation vegetation products will combine FLEX, OLCI and SLSTR data for vegetation condition assessment.

Access to data is via the Sentinel Science hub by user registration
https://scihub.copernicus.eu/
For SRAL and OLCI over water
https://coda.eumetsat.int/#/home

More information about Sentinel-3 data and products is available at :
https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-olci
https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-slstr
https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-altimetry
https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-synergy

## 4.4 Sentinel 4

Sentinel-4 will be a geostationary satellite for atmospheric composition monitoring. The main objective of the Sentinel-4 mission is to monitor key air quality trace gases and aerosols over Europe in support of the Copernicus Atmosphere Monitoring Service (CAMS) at high spatial resolution and with a fast revisit time. The target species of the Sentinel-4 mission include the key air quality parameters NO2 (nitrogen dioxide), O3 (ozon), SO2 (sulfur dioxide), HCHO (formaldehyde), CHOCHO (glyoxal), and aerosols. Complementarily, the Low Earth Orbiting (LEO) missions S5 and S5p will deliver the S4 target species and additionally CO (carbon monoxide), CH4 (methane), and stratospheric O3 (ozone)with global daily coverage for climate, air quality, and ozone/surface UV applications.

- The satellite will carry an **Ultraviolet-Visible-Near-Infrared (UVN)** light imaging spectrometer instrument embarked on the Meteosat Third Generation Sounder (MTG-S) satellite

Access to data will be confirmed following successful launch and operation of the satellite.

More information about Sentinel-4 mission and products are available at:
https://sentinel.esa.int/web/sentinel/missions/sentinel-4

## 4.5 Sentinel 5

Sentinal-5 is focused on air quality and composition-climate interaction with the main data products being O3, NO2, SO2, HCHO, CHOCHO and aerosols. Additionally SENTINEL-5 will also deliver quality parameters for CO, CH4, and stratospheric O3 with daily global coverage for climate, air quality, and ozone/surface UV applications.

- The Sentinel-5 mission consists of high resolution spectrometer system operating in the ultraviolet to shortwave infrared range with 7 different spectral bands: UV-1 (270-300nm), UV-2 (300-370nm), VIS (370-500nm), NIR-1 (685-710nm), NIR-2 (745-773nm), SWIR-1 (1590-1675nm) and SWIR-3 (2305-2385nm). The instrument will be carried on the MetOp-SG A satellite.

Access to data will be confirmed following successful launch and operation of the satellite.

More information about Sentinel 5 missions and products are available at:
https://sentinel.esa.int/web/sentinel/missions/sentinel-5

## 4.6 Sentinel 5-P

The main objective of the Copernicus Sentinel-5P mission is to perform atmospheric measurements with high spatio-temporal resolution, to be used for air quality, ozone & UV radiation, and climate monitoring & forecasting. The satellite's local time of ascending node crossing of 13.30 h has been chosen to facilitate the so-called loose formation operation with NASA's Suomi-NPP spacecraft. This concept will allow the utilization of co-located, high resolution cloud mask data provided by the VIIRS (Visible Infrared Imaging Radiometer Suite) instrument on-board Suomi-NPP during routine processing of the TROPOMI methane product.

- The mission consists of one satellite carrying the TROPOspheric Monitoring Instrument (TROPOMI) instrument. The TROPOMI instrument combines the strengths of SCIAMACHY, OMI and state-of-the-art technology to provide observations.

Access to Sentinel 5-P data is via Sentinel Science hub by user registration
https://scihub.copernicus.eu/

More information about Sentinel 5-P missions and products are available at:
https://sentinel.esa.int/web/sentinel/user-guides/sentinel-5p-tropomi/introduction

## 4.7 Sentinel 6

Sentinel-6 carries a radar altimeter to provide high-precision and timely observations of the topography of the global ocean. This information is essential for the continued monitoring of changes in sea level, a key indicator of climate change. It is also essential for operational oceanography. Mapping up to 95% of Earth's ice-free ocean every 10 days, it offers vital information on ocean currents, wind speed and wave height for maritime safety. The data are also important for protecting and managing the increasingly busy coastal zones. Sentinel-6 builds on heritage from the Jason series of ocean topography satellites and from ESA's CryoSat mission. Importantly, this new mission is designed to complement ocean information from Sentinel-3. More information about the Sentinel-6 mission is available at http://esamultimedia.esa.int/docs/EarthObservation/Sentinel6_facts_2015.pdf

# 5 ANNEX - ESA TPM MISSIONS

ESA Third Party Mission (TPM) data, either archived or newly available at the time, will contribute to Dragon 5. Those contributions will respect related Data Access Agreements and associated partial limitations (e.g. geographical, user nationality or other) as given by the data policy of the respective mission. The following TPM products will be available to the selected Dragon 5 teams with an associated quota of products. Investigators are requested to take note of these quotas when preparing their proposals and inform on their TPM data requirements. For all TPM missions, Dragon 5 project leaders will be requested to accept on-line the ESA Terms and Conditions for data use prior to data delivery. The satellite data available is divided into optical and SAR missions' sensors.

## 5.1 Optical ESA TPM sensors

### *5.1.1 PROBA-V*

All 1Km, 333m and 100m products are available to project investigators. Access to PROBA-V 1km data can be made following user registration on-line at:
https://earth.esa.int/web/guest/pi-community/apply-for-data/fast-registration

Access to PROBA-V 333m and 100m data will be made available after full proposal acceptance. Data will have to be retrieved from the Proba-V product Dissemination facility by PIs, free of charge. More information about PROBA-V Mission, products and data access is available at:
https://www.vito-eodata.be/PDF/portal/Application.html#Home

### *5.1.2 Planet*

For the Planet products, there is a limited quota on the number of products per year that can be requested. Satellite data available includes the following:

- RAPIDEYE archive;
- PLANETSCOPE archive and new;
- SKYSAT archive and new.

The RapidEye constellation of five Earth Observation satellites has been in operation since February of 2009. The system images a 77 kilometre wide swath. RapidEye's sensors produce imagery in five spectral bands (Red, Green, Blue, Red Edge and Near Infrared). Over 70% of RapidEye's imagery has a view angle of less than 10°, as the view angle of RapidEye imagery is always less than 20°. The constellation also has the capability for daily revisit to any point on earth. Each of the five satellites are identically calibrated so that images between satellites are indistinguishable from each other.

PlanetScope satellite constellation consists of multiple launches of groups of individual satellites (Doves). Therefore, on-orbit capacity is constantly improving in capability or quantity, with technology improvements deployed at a rapid pace. Each Dove satellite is a CubeSat 3U form factor (10 cm by 10 cm by 30 cm). The complete PlanetScope constellation of more than 120 active satellites in orbit is able to image the entire land surface of the Earth every day (equating to a daily collection capacity of 265 million km²/day). The constellation is constantly "on" and does not require ordering or acquisition planning.

The SkySat constellation is the VHR component of Planets satellite image portfolio. Skysat-A and B generation satellites were launched in 2013/14. The SkySat-C generation satellite (60 x 60 x 95 cm) is a high-resolution Earth imaging satellite, first launched in 2016, all collecting thousands of square kilometres of imagery. Each satellite is 3-axis stabilized and agile

enough to slew between different targets of interest. Each satellite has four thrusters for orbital control, along with four reaction wheels and three magnetic torquers for attitude control. All SkySats contain Cassegrain telescopes with a focal length of 3.6m, with three 5.5 megapixel CMOS imaging detectors making up the focal plane. Imagery are captured in a continuous strip of single frame images known as "scenes", which are all acquired in the blue, green, red, NIR-infrared, and panchromatic bands.

### 5.1.3 Pleiades/SPOT

There is a limited quota for archive and new acquisitions as follows:

- SPOT 6m Color or 1.5m Black&White MONO archive and new;
- SPOT 1.5m Color or bundle MONO archive and new;
- PLEIADES 2m Color or 0.5m Black&White MONO archive and new;
- PLEIADES 0.5m Color or bundle MONO archive and new;
- For STEREO products, the sqkm consumption is double;
- For TRISTEREO products, the sqkm consumption is three times.

Pleiades is a two-spacecraft constellation of CNES, introducing advanced technologies in Earth observation. Starting with the first launch in 2011, the Pleiades programme follows the SPOT programme satellite series services. The identical twin satellites deliver very-high optical resolution (0.5m resolution) and offer a daily revisit capability to any point on the globe.

The SPOT (from French "Satellite pour l'Observation de la Terre") constellation has been supplying high-resolution, wide-area optical imagery since 1986. The last satellites, SPOT 6 and SPOT 7, will assure data continuity through to 2024. All of the SPOT satellites provide imagery in Panchromatic and Multispectral bands with a swath of 60km. The HRV (IR) sensor on board SPOT 1-4 provides data at 10 m spatial resolution Panchromatic mode and 20 m (Multispectral mode). The HRG sensor on board SPOT-5 provides spatial resolution from 2.5 m in the panchromatic band to 10 m in the multispectral mode. The SWIR band imagery remains at 20 m. The NAOMI sensor on board of SPOT 6 & 7 provides data up to 1.5 m spatial resolution Panchromatic and Multispectral.

### 5.1.4 Deimos-2

There is a limited quota for archive and new acquisitions as follows:

- L1 pan sharpened or bundle: archive or new'
- L1 stereo pair: archive or new.

Deimos-2 is a very-high resolution (75cm pan-sharpened) multispectral optical satellite and is the second satellite of the Deimos Earth Observation system, following Deimos-1, which was launched in 2009. The satellite provides mid-resolution, very-wide-swath imagery. Deimos-2 was launched on 19 June 2014, with a mission lifetime of at least seven years. It operates from a Sun-synchronous orbit at a mean altitude of 620 km, with a local time of ascending node (LTAN) of 10h30, which allows an average revisit time of two days worldwide (one day at mid-latitudes). The spacecraft design is based on an agile platform for fast and precise off-nadir imaging (up to 30° over nominal scenarios and up to 45° in emergency cases), and it carries a push-broom very-high resolution camera with 5 spectral channels (1 panchromatic with 1m resolution, 4 multispectral bands with 4m resolution).

### 5.1.5 WorldView 2&3/GeoEye-1/QuickBird

There is a limited quota for archive and new acquisitions from DigitalGlobe Inc. satellites as follows:

- Panchromatic (30, 40, 50/60, 60cm) or 4-band (30, 40, 50/60, 60cm) or 8-Bands (30, 40, 50/60cm) or SWIR (7,5cm): STANDARD / ORTHO READY STANDARD

- For ORTHO READY STEREO and MAP SCALE ORTHO1:12000 products, the sqkm consumption is double.

WorldView-2, launched in October 2009, is an imaging satellite of DigitalGlobe Inc. of Longmont, CO, USA (follow-on spacecraft to WorldView-1). WorldView-2 collects images at 0.41m panchromatic and 1.64m 8-bands multi-spectral data. Along with the Pan (450-800 nm) and the four typical multispectral bands (blue, green, red, NIR), WorldView-2 has four

additional bands for enhanced multispectral analysis (coastal blue, yellow, red edge, NIR2). Together they are designed to improve segmentation and classification of land and aquatic features beyond any other space-based remote sensing platform. The additional spectral bands also enable WorldView-2 to more accurately present the world as the human eye can perceive it, creating a more realistic "true colour" view of the world.

With the launch of WorldView-3 on 13 August 2014, the DigitalGlobe constellation was able to set a new technological bar for commercial satellite imagery, offering customers the highest available resolution, revisit rate, capacity and spectral diversity. WorldView-3 is operating in a sun-synchronous orbit at an altitude of 617 km, which results in an average revisit time of < 1 day. WorldView-3 collects images at 0.31m panchromatic, 1.24m 8 VNIR bands, 3.7m in the 8 SWIR bands and a 30m resolution in the CAVIS (Clouds, Aerosols, Vapors, Ice and Snow).

GeoEye-1, launched in September 2008, is an imaging satellite of DigitalGlobe Inc. of Longmont, Colorado, United States. The spacecraft is in a sun-synchronous orbit with an operating altitude of 681km. GeoEye-1 collects images at 0.41m panchromatic and 1.65m 4-bands multi-spectral data. The sensor is optimised for large projects, as it can collect over 350,000 square kilometres of VHR satellite imagery every day. GeoEye-1 can revisit any point on Earth once every three days, or even sooner depending on latitude and elevation angle.

QuickBird was a satellite in a sun-synchronous orbit with an operating altitude of 450 km. It completed one revolution every 93.4 minutes and absolved more than 15 revolutions per day. QuickBird simultaneously collected up to 0.61m panchromatic and 2.88 m 4 band multi-spectral data. The large swath width of 16.5 km combined with 128 Gigabit on-board storage enabled QuickBird to collect with high geolocational accuracy 210,000 km2 of high-resolution imagery per day, or more than 75 million km2 of imagery data annually (over three times the size of North America). Along with the Pan (450-900 nm, stretching from the Blue to the Near Infrared) QuickBird provided four typical multispectral bands in the visible to near-infrared range: Blue (450-520 nm), Green (520-600 nm), Red (630-690 nm) and Near Infrared (760-900 nm).

## 5.2 SAR ESA TPM sensors

### *5.2.1 ALOS-1 PALSAR & optical sensors*

ALOS-1 was a satellite carrying an optical and L-band SAR payload. All products are archive since the satellite is no longer operational. Products that can be requested include:

- PRISM;
- AVNIR-2;
- PALSAR.

For the PRISM products, there is a limited quota on the number of products per year that can be requested. For AVNIR-2 and PALSAR products, an unlimited number of products per project per year per product type can be requested. Available products are the ones available in the ESA archive which mostly covers the ADEN zone, and some OOZ data. The PI of the project requesting the ALOS-1 data has to be European. The co-PI can be Chinese.

More information about ALOS Mission and products distributed by ESA under this ESA TPM agreement available at : https://earth.esa.int/aos/alos

### *5.2.2 COSMO-SkyMed*

A limited quota of archive products and new acquisitions can be requested for each project. The following modes can be requested: ScanSAR (Wide and Huge) and StripMap (PingPong and Himage).

More information about the COSMO-SkyMed Mission and products distributed by ESA under this ESA TPM agreement are available at : https://earth.esa.int/aos/cosmoskymed

### 5.2.3 RadarSat-2

Radarsat-2 is a fully polarimetric imaging SAR operating at C-band (5.405 GHz). A limited quota of archive products or new acquisitions can be requested for each project. The following modes can be requested:

- ScanSAR Wide;
- ScanSAR Narrow;
- Wide, Standard, Extended Low;
- Extended High, Fine;
- Standard, Fine.

For more information on these modes, swath width, resolution and polarisations available refer to:
https://directory.eoportal.org/web/eoportal/satellite-missions/r/radarsat-2

### 5.2.4 Iceye (collection will be opened early next year)

A limited quota of archive products or new acquisitions can be requested for each project. The following modes can be requested:

- Stripmap;
- StripMap high;
- SpotLight;
- ScanSAR.

ICEYE's is an X-band constellation of SAR satellites acquiring imagery in VV polarisation. The overall mission is to enable better decision making for everyone by providing timely and reliable Earth observation data. To achieve that goal, the company is developing its own synthetic-aperture radar (SAR) sensor technologies suitable for satellites under 100kg in weight. ICEYE is building a constellation of 18 SAR satellites by the end of 2020, which will enable a 3 hour on average revisit rate around the globe.

For more information on the products available refer to:
https://www.iceye.com/hubfs/Downloadables/ICEYE-SAR-Product-Guide-2019.pdf

For SLC and GRD demonstration products see:
https://www.iceye.com/

### 5.2.5 Paz (collection will be opened early next year)

A limited quota of archive products or new acquisitions can be requested for each project. The following modes can be requested:

- High Resolution SpotLight (HS);
- SpotLight (SL);
- StripMap (SM);
- ScanSAR (SC).

PAZ SAR is operating at X-band frequency and the satellite is positioned in the same orbit as TerraSAR-X and TanDEM-X and features exactly identical ground swaths and acquisition modes, the three form a high-resolution SAR satellite constellation.

For more information about mission status, these modes and spatial resolution see:
https://directory.eoportal.org/web/eoportal/satellite-missions/p/paz

# 6 ANNEX - CHINESE EO DATA

## 6.1 Archived data

A series of archived Chinese EO data and products are available for Dragon 5 use, including FY-3, CBERS, HJ -1A/B, GF -1, TanSat and global covered GLASS-ABB/BBD/FAPAR/GPP/LAI/LST data and more different thematic data.

Access to archived Chinese EO data can be made following user registration on-line at:
http://www.chinageoss.org/en/index.html
The data can be downloaded after approval to data request on line.

## 6.2 HY-1 & 2

There are three satellites in the HY-1 Series, 1A, 1B and 1C. HY-1A was launched in 2002, HY-1B in 2007 and HY-1C in 2018. They carry sensors designed to monitor and measure Ocean Colour and SST. The two main sensors are: COCTS - Chinese Ocean Colour and Temperature Scanner (developed by SITP) & CZI - Coastal Zone Imager (CCD Camera) (developed by CAST).

The HY-2 satellite is a marine remote sensing satellite developed by China and launched in 2011. Two HY-2 satellites, HY-2A and Hy-2B, have been successfully launched in 2011 and 2018. The objective of HY-2 is monitoring the dynamic ocean environment and includes following payloads:

- The radar altimeter is used to detect the height of the sea surface, significant wave heights, the wind speed and marine basic parameters;
- The microwave scatterometer is used to global sea surface wind field monitoring;
- The scanning microwave radiometer is used to obtain the global sea surface temperature, sea surface wind field, the water vapour content, cloud water content, sea ice, rainfall etc.;
- The calibration microwave radiometer is used to provide water vapour content calibration service to the altimeter.

More information about the HY missions is available at: www1.nsoas.org.cn/NSOAS_En/Satellites/index.html .
The HY-1 & HY-2 data can be acquired by user registration at: https://osdds.nsoas.org.cn/#/ .

## 6.3 FY Series

There are two types of Chinese Meteorological Satellites (FY Series): Polar System (FY 1,FY-3) and Geostationary System (FY-2,FY-4). Polar-orbit satellites operational system can provide both local and global environment data; geostationary satellites system can provide observation of East-Asia hemisphere hourly. Products derived from FY-1D, FY-2E/F/G/H, FY-3A/B/C/D and FY-4A can be made available to this opportunity.

FY-1 series are China's first generation sun-synchronous orbiting meteorological satellites. Observing instruments aboard FY-1D are as follows:

- Multi-channel Visible and Infrared Scan Radiometer (MVISR);
- Space Environment Monitor (SEM) for observing energetic particles in solar winds.

China's first geostationary meteorological satellites were named FY-2 satellites. Observing instruments aboard FY-2 includes following:

- Stretched Visible and Infrared Spin Scan Radiometer (S-VISSR);
- Space Environment Monitor (SEM).

FY-3 satellites are China's second generation polar-orbiting meteorological satellites, with substantively enhanced functionalities and technical capabilities. FY-3 Products derived from the following instruments can be made available under this call:

- Visible and Infrared Radiometer (VIRR);
- Medium Resolution Spectral Imager(MERSI);
- Infrared Atmospheric Sounder (IRAS);
- Micro-Wave Temperature Sounder (MWTS);
- Micro-Wave Humidity Sounder (MWHS);
- Micro-Wave Radiation Imager (MWRI);
- Backscatter Ultraviolet Sounder (SBUS);
- Total Ozone Unit (TOU);
- Earth Radiation Measurement (ERM);
- Solar Irradiance Monitor (SIM);
- Space Environment Monitoring (SEM);
- Space Environment Suite (SES).

FY-4 is China's second generation geostationary meteorological satellite. FY-4 Products derived from the following instruments can be made available under this call:

- Advanced Geostationary Radiation Imager (AGRI);
- Geostationary Interferometric Infrared Sounder (GIIRS);
- Lightning Mapping Imager (LMI);
- Space Environment Package (SEP).

More information and access to FY data can be made by user registration at following website: http://www.nsmc.org.cn/en/NSMC/Channels/outline.html (Chinese and English versions)
Data will be delivered free of charge by http://satellite.nsmc.org.cn/portalsite/default.aspx?currentculture=en-US .

## 6.4 CBERS-04

The China-Brazil Earth Resources Satellite (CBERS) was jointly developed by China and Brazil since 1988. CBERS-04 was launched successfully on 7 December 2014. The payloads of CBERS-04 are as follows:

- Panchromatic & CCD Camera (PAN). The PAN Camera has three spectral bands in the visible and near infrared range and one panchromatic band. It has a nadir spatial resolution of 5 meters for panchromatic bands and spatial resolution of 10 meters for multispectral bands;
- Multispectral Camera (MUX). The MUX Camera has a nadir spatial resolution of 20 meters and a swath width of 120 km. It has four spectral bands in the visible and near infrared range;
- Infrared Multispectral Scanner (IRS). The IRS instrument has a spatial resolution of 40 meters (for three visible to short-wave infrared spectral bands) and 80 meters (for one thermal infrared band). Its swath width is 120 km;
- Wide Field Imager (WFI). The WFI camera has a nadir spatial resolution of 73 meters in four visible to near-infrared spectral bands. It has a swath width of 866 km.

Access to CBERS-04 data can be made following user registration by Chinese PI on-line at:
http://218.247.138.119:7777/DSSPlatform/index.html (only Chinese version).

## 6.5 Jilin-1

The Jilin-1 satellite, the China's self-developed remote sensing satellite for commercial use, was launched in October 2015. Jilin-1 consists of four satellites, one for high-resolution images (<1 m), one for testing new space technology and another two for video. It is operated by Chang Guang Satellite Technology Co., Ltd under the Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences. The satellites will focus on providing photographs to commercial clients, while helping with harvest assessment, geological disaster prevention and resource surveys.

Jilin-1 data will be available for use of Dragon 5 projects. The Jilin-1 data can be acquired by user registration at: http://www.chinageoss.org/en/index.html

## 6.6 CFOSAT

A Sino-French collaboration mission CFOSAT was launched in 2018, the satellite has two wave and wind measuring instruments, surface wave investigation and monitoring (SWIM) and wind scatterometer (SCAT). CFOSAT is designed to study ocean surface wind and wave conditions to improve forecasts for marine meteorology and knowledge of climate variations.

CFOSAT data will be available for use of Dragon 5 projects. Access to data can be made by user registration online at: https://osdds.nsoas.org.cn/#/ .

## 6.7 TanSat

The TanSat is a satellite to measure methane and carbon dioxide levels in the atmosphere, and was launched in 2016. It is sponsored by MOST China.

Access to TanSat data can be made following user registration on-line at:
http://satellite.nsmc.org.cn/portalsite/default.aspx?currentculture=en-US .

## 6.8 GF-1

The GF-1 satellite was launched on 26 April 2013, as part of High-resolution Earth observing system of China. It has three payloads including a high-resolution pan sensor, a high-resolution multispectral CCD camera (PMS) and a mid-resolution multispectral camera with 800 km swath (WFV). The GF-1 WFV data (16 m resolution) will be available for Dragon 5 use.

More information about the GF-1 missions is available at:
http://www.cnsageo.com/#/detailIndex?secondIndex=0&id=2&code=5 .
Access to GF-1 WFV data can be made by user registration online at: http://www.cnsageo.com

## 6.9 GF-6

The GF-6 satellite was launched on 2 June 2018, is an optical remote sensing satellite with red-edge band. It is on 645 km sun synchronous orbit, and its local time of descending is 10:30 a.m. GF-6 is configured with one 2/8m Panchromatic & Multispectral Scanners (PMS) and one 16m WFV Multispectral Cameras, which have the ability of high resolution and wide swath imaging on the same satellite. The GF-6 WFV data (16 m resolution) will be available for Dragon 5 use.

More information about the GF-6 missions is available at:
http://www.cnsageo.com/#/detailIndex?secondIndex=1&id=7&code=5

Access to GF-6 WFV data can be made by user registration online at: http://www.cnsageo.com

## 6.10 Zhangheng-1

The Zhangheng-1 (Seismo-Electromagnetic Satellite, CSES) is the first platform of China's earthquake observation system in space and was launched successfully in 2018. The Zhangheng-1 satellite carries 8 instruments, including search-coil magnetometer (SCM), electric field detector (EFD), high precision magnetometer (HPM), GNSS occultation receiver (GOR), plasma analyzer package (PAP), langmuir probe (LAP), high energetic particle package (HEPP) and detector (HEPD), and tri-band beacon (TBB). It is flying in a sun synchronous orbit with an altitude of 507 km and descending node time of 14:00 LT., which will have a lot of application prospects in the study of seismology, geophysics, space sciences, and so on. Zhangheng-1 data will be available for use of Dragon 5 projects. The Zhangheng -1 data can be acquired by user registration at: http://www.chinageoss.org/en/index.html .

## 6.11 Luojia-1

Luojia-1 satellite is the first dedicated night-time light remote sensing satellite in the world and was successfully launched in 2018. Its spatial resolution is 130 m. As its range spans 250 × 250 km, global night-time light image acquisition can be completed within 15 days under ideal conditions, representing a significant technological advance in Chinese remote sensing capabilities from surface monitoring to social and economic development monitoring. The Lujia-01 satellite provides thematic products, such as the GDP index, carbon emission index, urban housing vacancy rate index, and so on. It dynamically monitors macroeconomic operation in the world and provides an objective basis for government decision-making.

Access to Luojia-1 data can be made by user registration online at: http://59.175.109.173:8888/app/login_en.html .