European Space Agency

Directorate of Science

Cluster

ANNOUNCEMENT OF OPPORTUNITY

for

Guest Investigator
and
Early Career Scientist

February 2019

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Following the successful Cluster Guest Investigator (GI) announcements of opportunity in 2010 and 2014, and their implementation in 2011-2013 and 2015-2016 respectively, the European Space Agency (ESA) is issuing a 3rd Announcement of Opportunity (AO). This AO solicits special operation proposals for participation in the GI Programme of the ESA Cluster extended mission. The aim of the GI Programme is to open future spacecraft science operations to the community for the year 2020. Eligibility to propose for the GI Programme covered by this AO is open to all scientists of any nationality. Up to ten GIs will be selected through this call. Selected proposers will have to obtain funding for their research from their relevant Institution or Agency.

Proposals, which will detail future spacecraft and payload operations of the Cluster spacecraft and their scientific aims, will be assessed by members of the Cluster Science Working Team (SWT): Cluster Principal Investigators (PIs), Science Operations team members (Joint Science Operations Centre, JSOC), Mission Operations team members (European Science Operations Centre, ESOC) and ESA Cluster project science team. The evaluation will be submitted to a Peer Review Committee (PRC), appointed by ESA's Director of Science. Selection will be based on intrinsic scientific merit, potential to enhance the scientific achievement of the Cluster mission, and the feasibility with respect to spacecraft capabilities. The PRC will formulate a recommendation regarding which proposals should be awarded. The ESA Director of Science will receive the PRC recommendation and take the final decision about GIs to be appointed.

Additionally, this AO invites Early Career Scientists (ECSs) to submit proposals of a new science objective that can be met with a special data campaign based on a maximum of 10 orbits to be collected in 2020. The selected ECSs will be trained to carry out the observation campaign and will interact with the instrument and operation teams at ESTEC, ESOC, ESAC, and JSOC. They will participate in two Science Operations Working Group (SOWG) meetings, the first one to understand the work and the second one to do the operations planning. Up to ten ECSs will be selected and expected to work as a team on the data campaign linked to the selected science objectives, with the aim of publishing common papers based on the observations collected. This call offers the opportunity for selected ECSs to engage with an active science mission like Cluster. The review of the proposals will be performed at the same time and by the same committees as for the GI selection. The ESA Director of Science will receive the PRC recommendation and take the final decision about ECSs to be appointed.

1 Guest Investigator and Early Career Scientist Programme

1.1 Purpose

This AO solicits proposals for new payload/spacecraft operations utilising the Cluster mission through participation in the Cluster Guest Investigator (GI) and the Early Career Scientist (ECS) Programme.

1.2 Scope

Investigations are solicited which identify compelling future utilization of the Cluster spacecraft and payload for scientific study in 2020. All proposals to this AO must indicate the scientific goal along with a clear description of the science payload and spacecraft requirements of the study, based on information provided in Section 2, including instrument sampling rates and the required resolution for the science. Investigators are encouraged to propose the acquisition of data from more than one instrument. Inter-spacecraft separation can be changed but is limited to phasing manoeuvres due to the limited available fuel. Information regarding the orbit and the instruments coverage is given in Section 2. Proposers are strongly encouraged to examine the information available via the documentation section of the Cluster Science Archive (https://www.cosmos.esa.int/web/csa/documentation), which also accompanies this AO as part of the Proposal Information Package (PIP). In particular, proposers are directed towards the instrument user guides, to obtain information on spacecraft payload specifications. In addition, proposers may contact the Cluster Project Scientist and also instrument PIs directly for further information on instrument limitations and spacecraft limitations that may be pertinent to their proposal.

1.3 Proposal Information Package

The Proposal Information Package (PIP) contains the following documents:

- This Announcement of Opportunity document
- Letter of Invitation from the ESA Director of Science
- Latest Cluster instrument status
- Cluster ASPOC User Guide
- Cluster ASPOC Calibration Report
- Cluster CIS User Guide
- Cluster CIS Calibration Report
- Cluster DWP User Guide
- Cluster DWP Calibration Report
- Cluster EDI User Guide
- Cluster EDI Calibration Report
- Cluster EFW User Guide
- Cluster EFW Calibration Report
- Cluster FGM User Guide
- Cluster FGM Calibration Report
- Cluster PEACE User Guide
- Cluster PEACE Calibration Report
- Cluster RAPID User Guide
- Cluster RAPID Calibration Report

- Cluster STAFF User Guide
- Cluster STAFF Calibration Report
- Cluster WBD User Guide
- Cluster WBD Calibration Report
- Cluster WHISPER User Guide
- Cluster WHISPER Calibration Report
- Cluster JSOC System Specification DS-JSO-SS-0001

The above documents can be downloaded from https://cosmos.esa.int/cluster-ao3

1.4 Eligibility

For GIs, this call is open to the worldwide scientific community. Co-investigators of experiments on the Cluster mission are eligible to propose under this AO, while Principal Investigators are excluded.

An ECS is an undergraduate or postgraduate (Masters/PhD) student or a scientist who has received his or her highest degree (BSc, MSc, or PhD) within the past seven years. For ECSs, this call is open to the worldwide scientific community.

Proposals to exploit Cluster data along with other satellites data (e.g. MMS, THEMIS, Arase/ERG, Geotail, Swarm, Solar Orbiter, Parker Solar Probe), or proposals for theoretical and/or modelling studies focused on the goals and objectives of the mission, are encouraged.

1.5 Privileges and Responsibilities of the selected Guest Investigator

The selected GIs will be invited to present their proposal to the Cluster SWT and initiate their investigation. Following successful operation implementation, each GI will be expected to present a report of the outcome to the SWT in writing and, if possible, in person at the SWT meeting following the completion of the proposed observations. It is expected that each GI will publish at least one paper in the refereed literature.

1.6 Privileges and Responsibilities of the selected Early Career Scientist

The selected ECSs will be trained to carry on the observation programme and will interact with the instrument and operation teams at ESTEC, ESOC, ESAC and JSOC. They will participate in two Science Operations Working Group (SOWG) meetings, the first one to understand the work and the second one to do the operations planning. Up to ten ECSs will be selected and expected to work as a team on the best science objectives proposed, with the aim of publishing common papers based on the observations collected. Since only one science proposal will be selected, the selected ECSs are expected to work jointly on its execution. The goal is to keep the investigation manageable by the operation teams and at the same time involve a maximum number of ECSs. Following successful operation implementation, the ECS team is expected to present an informal report of the outcome to the SWT in writing and, if possible, in person at the SWT meeting following the completion of the proposed observations. It is expected that the Early Career Scientists will publish at least one common paper in the refereed literature.

1.7 Timetable

Activity	Date / Deadline
Announcement of Opportunity issued	25 February 2019
Deadline for Letter of Intent	28 March 2019, 12:00 CET (noon)
Deadline for Proposal submission	29 May 2019, 12:00 CEST (noon)
Evaluation phase	June-September 2019
Selection	October-November 2019
Execution of GI operations	2020

1.8 Letters of Intent

Prospective GI and ECS proposers must submit a mandatory Letter of Intent (LoI) by the deadline reported in Section 1.7. LoIs will be accepted exclusively in electronic PDF format, submitted via the interface available at https://cosmos.esa.int/cluster-ao3

ESA will confirm by e-mail the reception of the LoI.

The LoI should be concise (not more than 3 pages, size A4, font size 12) with a maximum file size of 50 Mbytes. The LoI should provide the following information:

1. A descriptive title for the proposal.
2. Name, affiliation, mailing address, telephone number and e-mail address of the proposer. If the proposal is from a team, the name, affiliation and email address of each member of the team should be included. A Guest Investigator or an Early Career Scientist should be identified from that team who will lead the investigations.
3. A brief abstract (1 page maximum) indicating: scientific rationale; data set(s) required; duration of operations (this should not be more than 10 orbits); region of space for observations; spacecraft distance separation and constellation configuration, relation to other missions/ground-based instruments where applicable.
4. Intended source for funding.

1.9 Proposals

The deadline for submission of proposals in response to the present Call for GIs and ECSs is reported in Section 1.7. Late submissions will not be considered. Proposals not preceded by a LoI will not be considered. Submission of proposals is accepted exclusively in electronic form, in PDF format, using the interface available at https://cosmos.esa.int/cluster-ao3

ESA will confirm by e-mail the reception of the proposal.

The page limit (page size A4, font size 12), including references and figures, is 6 pages and the maximum file size is 100 Mbytes. The proposal must contain: 1 cover page; scientific objectives (including the abstract and data requirements): 3 pages; management plan: 1 page; and funding statement: 1 page.

Details about the proposal's expected content are reported here below.

1.9.1 Cover page

The cover page of the GI or ECS proposal shall contain the following information:

- The header "Proposal for the Cluster Guest Investigator and Early Career Scientist Programme"
- The date of submission
- A descriptive title
- Name, affiliation, mailing address, telephone number and e-mail address of the prospective GI or ECS
- Names and affiliations of proposed team members
- Intended source of funding.

1.9.2 Scientific objectives of the proposed investigation

This section of the proposal should describe the scientific goal of the investigation. Points to be addressed must include, but are not limited to, the following:

- An abstract of 200-300 words

- The scientific background and context of the proposed research, including why the science objectives cannot be achieved from previous Cluster observations (see previous constellations at: http://sci.esa.int/cluster/23160-constellation-geometry-over-time/)

- A description of supporting observations (if any) required

- The expected results and their significance

- Data requirements
  A detailed description of the required operations, including instrument modes of operation, time resolution, normal telemetry mode or burst mode, spacecraft configuration (see limitations below), duration of operations (it should not exceed 10 orbits) and region of space that measurements will be taken, should be provided. Special campaigns with other missions and ground-based observations may also be included. The preferred dates to execute the operations can also be given, however their final execution will depend on the selected proposals and on possible conflicts between proposals.

1.9.3 Management plan

A brief Management Plan, describing, if applicable, the division of work among the investigation team members must be part of the proposal. Of primary importance is the proposed timetable for the analysis of the data.

1.9.4 Funding statement

The proposer must include a budget summary identifying the intended source of funding for the proposal. This does not refer to the costs incurred by ESA in operating the spacecraft. The budget summary should indicate how the costs of the proposer(s) themselves and their science activities related to the proposal activities will be covered e.g. by national agency or existing grants.

1.10 Evaluation and further steps

1.10.1 Evaluation Criteria

Proposals will be evaluated according to the following criteria:

- Scientific merit of the proposal
- Usage of multi-spacecraft capability of the Cluster mission
- Combined usage of Cluster data with observations collected by other heliophysics missions (e.g. MMS, THEMIS, Arase/ERG, Geotail, Swarm, Solar Orbiter, Parker Solar Probe) and/or related ground-based measurements
- Feasibility with respect to spacecraft capabilities, the demands placed upon the mission and science operations teams in addition to the PI team(s) supplying the validated data, if applicable.

1.10.2 Selection

ESA's Director of Science will appoint a Peer Review Committee (PRC) to scientifically evaluate all proposals.

The Cluster SWT will assess the GI and ECS proposals against scientific and operational criteria defined in the previous sections and provide the PRC with a summary review. The PRC will then formulate a recommendation regarding which proposals should be awarded. The ESA Director of Science will receive the PRC recommendation and make the final decision about GIs and ECSs to be appointed.

1.10.3 Implementation

1.10.3.1 Initiation of appointed Guest Investigators and Early Career Scientists' activities

The appointed GIs and ECSs will be invited to participate in the Cluster SWT meeting or to present their results to the next Cluster workshop. Additionally, ECSs will participate in two Cluster SOWGs, the first one through videoconference facilities and the second one in person. Where appropriate, the GIs will be assigned a point of contact within the relevant Cluster PI team(s), who will be the primary interface(s) for the duration of the investigation. GI and ECS appointments will normally have a duration until December 2020.

1.10.3.2 Data delivery

The data from the selected instruments will be delivered to the GIs and ECSs directly from the instruments team PI (on request). The expected time from data acquisition by the instruments to provision of data to the GIs and ECSs is 3 months, which will allow

for adequate preliminary data processing and calibration by the PI teams. This level of calibration is sufficient for at least qualitative analysis; the highest level of calibration is not possible in such a short timescale, as calibration is inter-instrument dependent. GIs and ECSs are advised to communicate directly with the PI teams regarding appropriate data use and interpretation. The data format will be based on the formats delivered by the Cluster Science Archive (CSA; https://cosmos.esa.int/web/csa), i.e. Cluster Exchange Format (CEF) or Common Data Format (CDF). Alternatively, PIs can give data access to the GIs and ECSs through dedicated web-based tools (e.g. clweb, http://clweb.irap.omp.eu/). The proprietary data period for the GIs and ECSs will be 6 months after data delivery to them. During this period, data access is limited to the selected proposers and the PI teams. After at most 9 months, the PI teams will deliver the data to the CSA where it will be publicly accessible. This will enable the PI teams to keep to their agreed CSA delivery schedule and will also provide the selected proposers time to carry out their analysis.

Schedule:
T0: acquisition of data
T0+3 months: PI data delivery to GIs and ECSs
T0+9 months: PI data delivery to CSA

1.10.3.3 Conclusion of appointed Guest Investigators and Early Career Scientists' activities

Twelve months after the acquisition of their data, the GIs and ECSs will supply the ESA Project Scientist, representing the SWT, with a final report. This report should summarise the main results and list all publications resulting, or partially resulting, from the investigation. In addition, the GIs and ECSs will provide the Project Scientist with any subsequent publications resulting from the proposed investigation. ECSs will be invited to report on the lessons learned from this experience and what, if anything, they and the project could have done to make it even more successful.

1.11 Contact with ESA

Requests for further information and clarification should be addressed to:

C.P. Escoubet
ESA/ESTEC (SCI-S)
Postbus 299
2200 AG Noordwijk
The Netherlands
Phone: (31) 71 5653454
Email: Philippe.Escoubet@esa.int

A. Masson
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Camino bajo del Castillo, s/n
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E-28692 Madrid
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2 Overview of the Cluster mission

2.1 Scientific Objectives

The Cluster mission consists of four spin-stabilised satellites which were launched in pairs on 16 July and 9 August 2000 into an elliptical polar orbit of period ~ 57 hours, with an initial perigee altitude of 19,000 km and apogee altitude of 119,000 km. Following several months of commissioning, the spacecraft started scientific operations in February 2001.

The Cluster mission is an in-situ investigation of the Earth's magnetosphere using four identical spacecraft simultaneously. It permits the accurate determination of three-dimensional and time-varying phenomena and makes it possible to distinguish between spatial and temporal variations.

The interaction between the solar wind and the magnetosphere is a key element in the Solar Terrestrial Science Programme (STSP). Cluster has made great advances in determining the physical processes involved in the interaction between the solar wind and the magnetosphere by visiting key regions like the polar cusps and the magnetotail. The four Cluster spacecraft map in three dimensions the plasma structures contained in these regions. The simultaneous four-point measurements also allow differential plasma quantities to be derived for the first time. For example, the density of current flowing around the spacecraft is derived from the magnetic field measurements using Ampere's law.

Cluster's main goal is to study the small-scale plasma structures in space and time in the following key plasma regions:

- solar wind and bow shock
- magnetosheath
- magnetopause
- polar cusp
- magnetotail
- inner magnetosphere
- auroral zone (including the auroral acceleration region).

2.2 Payload Operations

The Cluster payload is operated based on Principal Investigator observational requests via the Joint Spacecraft Operations Centre (JSOC). JSOC is responsible for coordinating the science operations for the Cluster mission and works closely with the European Space Operations Centre (ESOC), which is responsible for the day-to-day operation of the four spacecraft.

Brief descriptions of the instruments and other information about the Cluster mission can be found on the ESA Cluster website: http://sci.esa.int/cluster

The Cluster science operation strategy is based on the Master Science Plan (MSP), which schedules the acquisition of science data by the four Cluster spacecraft. The MSP balances both the scientific objectives of the mission and the resources available for

that data collection. Those resources (on-board data storage, telemetry bandwidth, spacecraft visibility of the ground stations and the capacity of the ground segment to collect and process Cluster data) are an important constraint on Cluster science operations, together with constraints imposed by eclipses and manoeuvres. The Master Science Plan specifies targeting of regions in terms of data acquisition rates, normal mode, and burst mode. The latter yields much higher resolution data (factor of 6 in data volume) but at the cost of reducing the period over which data can be collected. In general, around 2 hours per orbit can be dedicated to burst mode or up to 4 hours in one orbit every 3-4 orbits. The most up-to-date information of the MSP can be found at the JSOC wiki web page http://jsocwiki.rl.ac.uk. For a general and historical background on MSP, please consult the JSOC MSP web page http://www.jsoc.rl.ac.uk/msp/. The Master Science Plan is produced in segments, each of one to two months duration and made available on the website above.

The detailed payload operations are coordinated via JSOC and are divided into planning periods, each of which typically covers three orbits of the spacecraft (sometimes extended to four orbits to maintain a weekly cycle of activities for each planning period). During this phase, JSOC will generate a draft command schedule for each instrument – based on the instrument modes derived from rules specified by each PI team, together with the knowledge of the Master Science Plan and the location of the spacecraft with respect to magnetospheric regions. JSOC will then iterate these draft schedules with the responsible PIs. When all instrument schedules are complete and approved by PIs, JSOC will merge the instrument command schedules to produce the payload command schedule and deliver this to ESOC. ESOC will process the payload command schedule and report the results to JSOC. JSOC will assess these results and, if necessary, make any required changes to the command schedule.

The first draft of the instrument command schedules will be released to the PIs about three weeks before the start of execution on the spacecraft. A week is then allowed for iteration between JSOC and the PIs, so that JSOC can deliver the final version of the payload command schedule to ESOC approximately two weeks before the start of execution on the spacecraft.

2.3 Telemetry rates

The spacecraft can send or record data at different telemetry rates. The normal mode (NM) is the most often used at 20 kbit/s.

NM1 is the default mode with CIS telemetry given to PEACE on SC2 and SC3, and EDI telemetry to PEACE on SC4. NM2 has the CIS telemetry restored on SC2, SC3 (even though CIS is off on both of these spacecraft).

NM3 gives the CIS telemetry mainly to RAPID and the rest to PEACE on SC2, SC3, allowing Burst Mode (see below) on RAPID. PEACE 3D distribution functions are now obtained every spin on SC2, SC3 and SC4 in normal mode.

Burst mode (BM) increases the telemetry rate by a factor 6 at 123 kbit/s and can be used on average 2 h per orbit or up to 4 h in one orbit every 3-4 orbits.

Wide Band Data (WBD) mode using Panská Ves station can download data from the WBD wave instrument at 220 kbit/s for a few hours per orbit. The location of WBD modes along the orbit depends on the spacecraft visibility and the availability of the ground stations. WBD data can also be obtained sparingly in BM2, but at the expense of losing most of the WHISPER wave data.

2.4 Orbit

The Cluster spacecraft were initially launched into an elliptical polar orbit, 19,000 x 119,000 km with a 57 hour orbit. During the course of the mission, the relative distance between the four spacecraft is being varied to form a nearly perfect tetrahedral configuration at 100, 250, 600, 2,000, 5,000 and 10,000 km inter-spacecraft distances targeted to study scientifically relevant regions at different scales. In the last few years, the constellation strategy has moved towards a multi-scale concept, enabling two scale sizes to be investigated at the same time. In these cases, three spacecraft are separated by 10,000 km with the last spacecraft separated from this plane by varying distances from 3 km up to several thousand kilometers. This configuration is targeted at boundaries, with the plane of the large-scale triangle parallel to the plane of the boundary and the final spacecraft separated a small distance from the main triangle in the normal direction.

Due to Sun-Moon orbit perturbations, the apogee of the Cluster spacecraft has been slowly drifting away from Earth to reach an altitude above 130,000 km at apogee. To keep a good communication link with the ground stations, the apogee of the four Cluster spacecraft was lowered in November 2009 by about 5,000 km resulting in a reduced orbit period of around 54 hours. In addition, the orbit inclination has drastically changed from its original polar orbit and reached a minimum inclination and perigee altitude in 2011 (Figure 1). Since 2011, inclination and perigee altitude are increasing again. In summer 2018, the perigee of the Cluster satellites was between around 30,000 km (SC2) and 36,000 km (SC4). It will progressively decrease to reach around 10,000 km (SC2) up to 25,000 km (SC4) by the end of 2022. The inclination is around 130 degrees since 2015.

Proposers are invited to examine the JSOC catalogues, which contain the most up-to-date orbit information. These catalogues can be accessed through this link http://cdhf5.bnsc.rl.ac.uk/pub-query/output_form?JSOC=1 (background information on JSOC catalogues: http://www.jsoc.rl.ac.uk/pub/jsoc_cats/index.php). In addition, the orbit visualisation tool (OVT) can be used to examine Cluster orbits in 3 dimensions. OVT is a public software available at http://ovt.irfu.se/. The required input files for OVT are available from the JSOC web page (http://www.jsoc.rl.ac.uk/pub/ovt/). Cluster orbit, as well as other spacecraft, can also be obtained and plotted from the satellite situation centre at: https://sscweb.gsfc.nasa.gov/

Preliminary Swarm orbit files can be found at:
http://www.jsoc.rl.ac.uk/pub/ovt/swarm.php

Along-track separation grows to a few minutes. During operations this separation will be maintained at less than 10s. As the Swarm orbit decays due to the drag, it is not very predictable and the in-orbit phase can be significantly different after some months. So the only thing reliable is the orientation and evolution of the Swarm orbital planes.

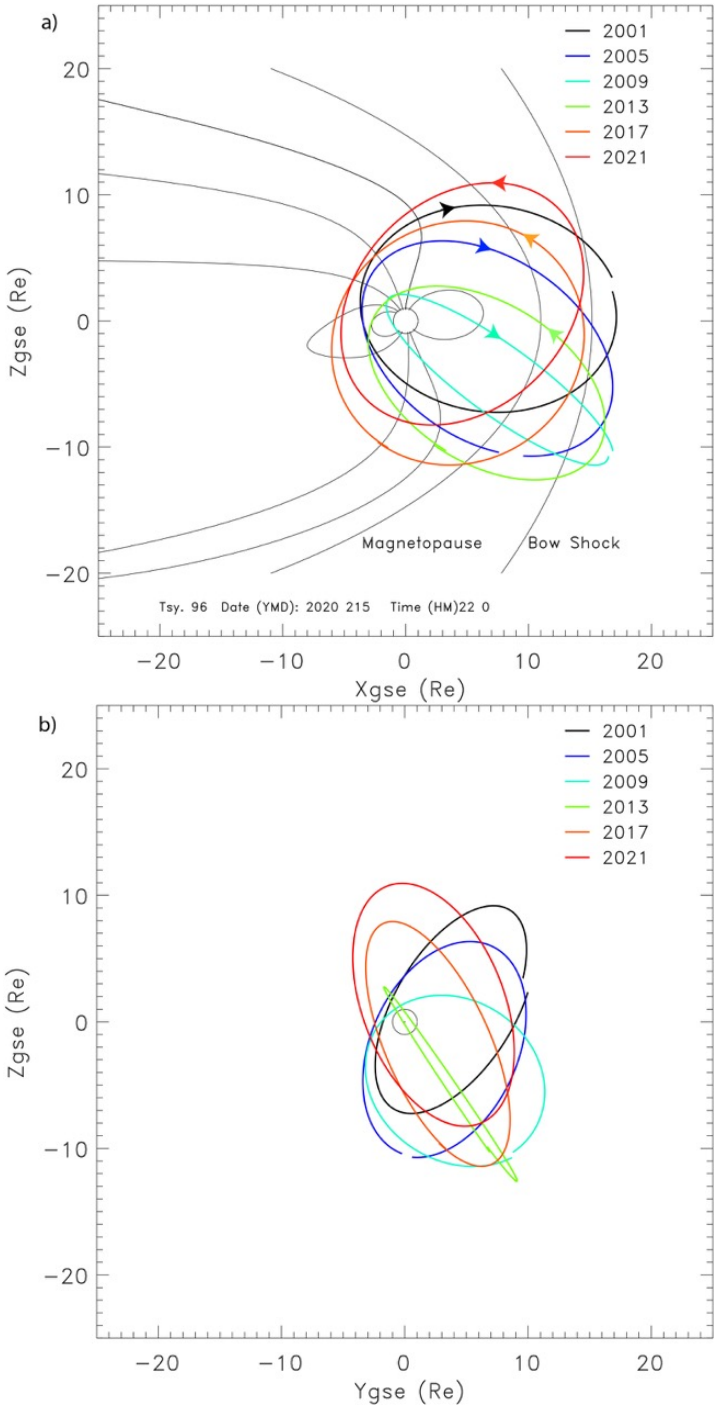

Figure 1. Sketch of the Cluster orbit evolution from 2001-2021, in (a) the X-Y GSE plane and (b) the Y-Z GSE plane

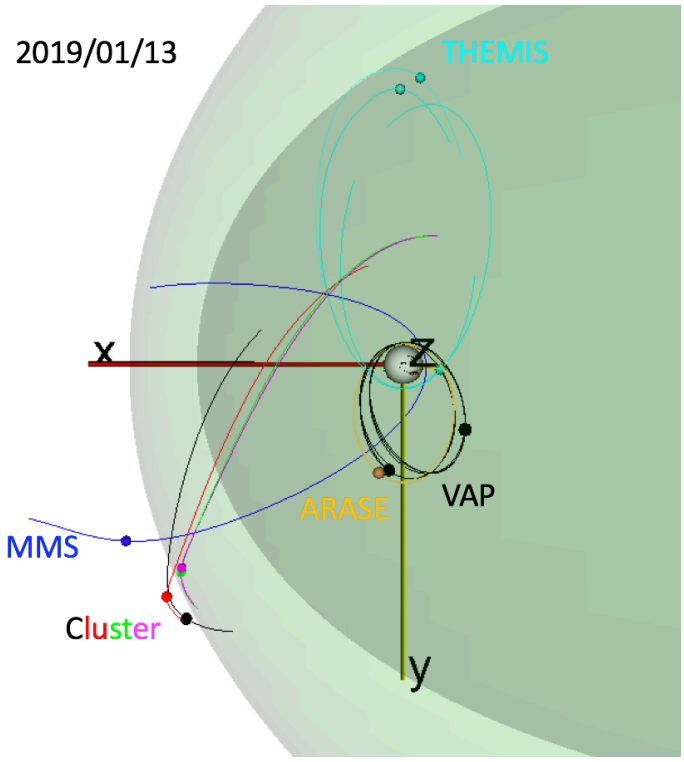

Figure 2. OVT orbit plot in X-Y GSM plane on 2019/01/13.

The OVT tool also allows importing of NASA's Satellite Situation Center (SSC) satellite orbit. The Cluster orbit can then be displayed together with other magnetospheric spacecraft orbits with respect to the main boundaries of the magnetosphere. Figure 2 shows an example, on 13 January 2019, with Arase (ERG), Cluster, MMS, THEMIS and Van Allen probes (VAP).

2.5 Eclipses

For part of the year, the Cluster spacecraft encounter one eclipse every orbit. The short eclipses (less than 1 h) last from late February to mid-March and the long eclipse in the first half of September (see Table 2). The Cluster spacecraft have been operating very successfully for a number of years. They are well beyond their projected operational lifetime and, as a result, the batteries cannot be used anymore. Thus, around short eclipses, most of the payload is not operated except FGM and EFW in reduced time resolution mode. The eclipse periods are therefore excluded from this AO. Outside of the eclipse season, the spacecraft are able to collect data all along the orbit.

Spacecraft	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Eclipse Start-Stop	2020/02/25-2020/03/16	2020/02/25-2020/03/16	2020/02/25-2020/03/14	2020/02/25-2020/03/14
	2020/09/07-2020/09/12	2020/09/07-2020/09/11	2020/09/05-2020/09/12	2020/09/05-2020/09/12

Table 2. Eclipse periods for 2020. The first row shows the spring eclipse season and second row the autumn eclipse season.

2.6 Power sharing

The spacecraft solar arrays are degrading with time, mainly due to radiation from energetic protons that darken the solar cells. On some spacecraft, we have to share transmitter operations with some instruments. Typically, during two to three intervals of a few hours per orbit, the Electron Drift Instrument (EDI) and the Wave Experiment Consortium (WEC) instruments are switched off (WEC is composed of the EFW, DWP, STAFF, WBD and WHISPER instruments). These intervals will be selected to minimise science loss and should, in principle, be transparent for a GI or Early Career Scientist proposing a specific region of the magnetosphere as the target for their investigation.

2.7 Manoeuvres limitations

Fuel constraints mean that manoeuvres or reconfigurations of the four Cluster spacecraft are limited to "along the orbit-track" manoeuvres. Proposers could, for example, consider changing the distance between Cluster 3 and Cluster 4 between 5 km and 10,000 km and also the orientation of the triangle formed by spacecraft 1, 2, and 3. The simplest way to investigate these formation possibilities is to take the orbit information for the four spacecraft and impose 'along track shifts' of the orbit. So by taking orbit information of SC1, SC2, SC3 and SC4 at an epoch t, adding dt1, dt2, dt3 and dt4, and examining the resulting shift in orbit. The time shifts dt1, dt2, dt3, dt4 must be kept constant while assessing a specific formation but can be changed to assess another formation. Proposers can examine such 'dt' shifts up to about ± 5 hours.

It is suggested that if the proposer is considering such activities then they should contact the Project Scientist before submitting the proposal to ascertain the extent of possibilities with the orbit.

Figure 3 shows the separation distances achieved so far in the various scientific regions. More details on the exact distance can be found at http://sci.esa.int/cluster/23160-constellation-geometry-over-time/

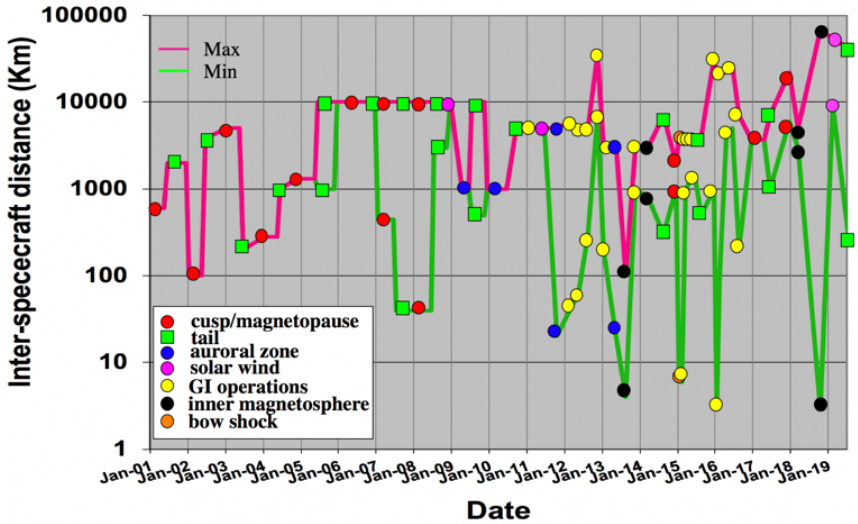

Figure 3. Cluster spacecraft separation since the beginning of the mission. Yellow marks show previous GI investigations (more details at http://sci.esa.int/cluster/23160-constellation-geometry-over-time/)

Proposers are encouraged to check that their required Cluster constellation or data for their investigation have not been collected previously.

2.8 Data access

The nominal data route on Cluster is as follows: data from the Cluster spacecraft are acquired by ground stations, routinely Villafranca (near Madrid, Spain) and Maspalomas (Canary Islands, Spain), with Panská Ves (Czech Republic) used to obtain high-resolution wave data from the WBD instrument. Passes on other stations are used for manoeuvre or eclipse operations and extra data dumps. The raw data are then de-commutated and sent to the Cluster Active Archive (CAA) at ESAC where the PI teams can access them online. After arrival at the PI institute, the data are processed and the summary (SP) and prime parameters (PP) are produced and sent to the Cluster Science Data System (CSDS). The CSDS is open access to the scientific community.

The summary parameters data consist of physical parameters at 1-minute resolution and the prime parameters are spin-averaged (4s). Both are available to the public. In addition, quicklook summary plots (CSDSweb) are produced after data have been downloaded on the ground, typically after a few hours to a few days. These products are also public.

Spacecraft: Instrument (below)		Cluster 1	Cluster 2	Cluster 3	Cluster 4
ASPOC		Failed at launch	End Operations	End Operations	End Operations
CIS		HIA 2x 40mn/day	Failed at launch	Failed (Dec. 2009)	CODIF only
EDI		Re-activated Electric Field	Ok (EEPROM failed)	Re-activated Electric Field	Failed at launch
FGM		Ok	Ok	Ok	Ok
PEACE		Ok	Ok*	Ok*	Ok
RAPID		Only Electrons	Electrons and ions, only head 3 for both	Only Electrons	Electrons and heads 1 & 3 for ions
WEC	DWP	Ok	Ok	Ok	Ok
	EFW	Probes 2 & 3	Probes 3 & 4	Probe 4	Probes 1 & 2
	STAFF	Ok	Ok	Ok	Ok
	WBD	Ok	Ok	Max. 15 min/hr	Ok
	WHISPER	Ok	Ok	Ok	Ok

*one anode (of 12 anodes) is broken in one sensor (either HEEA or LEEA)

Table 1: Cluster payload status in December 2018

High-resolution data are produced at the PI institute and are delivered 6-9 months after acquisition to the Cluster Science Archive (CSA). High-resolution data since the beginning of the mission are available at the CSA: https://csa.esac.esa.int and proposers can browse the information therein. As mentioned previously, of particular relevance

to new proposals is the section on documentation, some of which is included as part of this PIP (see Section 1.3). The user guides describe the products available to users of the CSA and these contain a description of how the instruments operate. Table 1 gives an overview of payload configuration and operational capability across the four spacecraft. The latest status (November 2018) of the instruments is provided in the PIP.

For successful proposers the data will be sent by the PIs to the GIs and Early Career Scientists in CEF or CDF format. It is envisaged that the timeframe for this would be around 3 months. Proposers should note that instrument calibrations will be preliminary.

2.9 Operational Constraint Summary for Proposers

- The expectation is that proposed operations will be integrated into the Master Science Plan and implemented within the normal operations cycle. Typically, constellation manoeuvres are executed every 3-6 months. This will constrain the number of GI proposals that can be executed during 2020.
- There is limited flexibility for re-configuration but phasing manoeuvres (slow drift of a spacecraft along its orbit) are possible. Enquiries regarding phasing of the spacecraft may be made prior to proposal submission to the Project Scientist to ensure feasibility.
- Eclipse periods (February/March and beginning of September) are excluded from this AO.
- Some of the payload is not operational (see Table 1).
- Data-taking will be interrupted during manoeuvres when (a) manoeuvres are needed to maintain spacecraft orbit separation (every 3 months), and (b) when ESOC need to carry out special operations to maintain and protect the spacecraft and their systems. The former will be planned and reported one or two months in advance via the JSOC website, but the latter may be required at very short notice. It should be noted that the instruments with high-voltage component will be re-started 2 hours after the end of the manoeuvres.
- Proposers need to be aware that the WBD data are obtained almost exclusively through real time telemetry directly to ground stations operated at Panská Ves in the Czech Republic. There, the largest antennas available are 10m diameter, which means that the greatest distance from Earth that WBD tracks can be scheduled is approximately 10-12 R_E. For larger distances, BM2 could be used on the four spacecraft to collect WBD data.

3 Further information

Proposers are encouraged to contact the Project Scientist and/or appropriate Cluster Principal Investigator(s) at an early stage of their proposal.

General information about the Cluster mission can be obtained from the Cluster Project Scientist.

3.1 Contacting the ESA Project Scientist

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Email: Philippe.Escoubet@esa.int

or his Deputy:

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ESA/ESAC (SCI-O)
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Phone: (34) 918 131 837
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3.2 Instrument PI Address Information

ASPOC (Active Spacecraft Potential Control experiment)
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CIS (Cluster Ion Spectroscopy experiment)
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DWP (Digital Wave Processing instrument)
Misha Balikhin
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EDI (Electron Drift Instrument)
Roy Torbert
Space Science Center, Institute for the study of Earth, Oceans and Space, Morse Hall, University of New Hampshire, 8 College Road, Durham, NH 03824-3525, USA.
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EFW (Electric Field and Wave experiment)
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FGM (Fluxgate Magnetometer)
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PEACE (Plasma Electron and Current Experiment)
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RAPID (Research with Adaptive Particle Imaging Detectors)
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STAFF (Spatio-Temporal Analysis of Field Fluctuation experiment)
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WBD (Wide Band Data receiver)
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WHISPER (Waves of High Frequency and Sounder for Probing of Density by Relaxation)
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4 List of Acronyms

AO	Announcement of Opportunity
ASPOC	Active Spacecraft Potential Control experiment
BM	Burst Mode
CDF	Common Data Format
CEF	Cluster Exchange Format
CIS	Cluster Ion Spectroscopy experiment
CAA	Cluster Active Archive
CSA	Cluster Science Archive
CSDS	Cluster Science Data System
DWP	Digital Wave Processing instrument
ECS	Early Career Scientist
EDI	Electron Drift Instrument
EFW	Electric Field and Wave experiment
ESA	European Space Agency
ESAC	European Space Astronomy Centre
ESOC	European Space Operations Centre
ESTEC	European Space Research and Technology Centre
FGM	Fluxgate Magnetometer
HEEA	High Energy Electron Analyser
JSOC	Joint Science Operations Centre
GI	Guest Investigator
GSE	Geocentric Solar Ecliptic (reference frame)
GSM	Geocentric Solar Magnetospheric (reference frame)
LEEA	Low Energy Electron Analyser
LoI	Letter of Intent
MMS	Magnetospheric MultiScale
MSP	Master Science Plan
NM	Normal Mode
OVT	Orbit Visualisation Tool
PEACE	Plasma Electron and Current Experiment
PI	Principal Investigator
PIP	Proposal Information Package
PP	Prime Parameters
PRC	Peer Review Committee
RAPID	Research with Adaptive Particle Imaging Detectors
STAFF	Spatio-Temporal Analysis of Field Fluctuation experiment
THEMIS	Time History of Events and Macroscale Interactions during Substorms
SC	Spacecraft
SOWG	Science Operations Working Group
SP	Summary Parameters
SWT	Science Working Team
WBD	Wide Band Data receiver
WEC	Wave Experiment Consortium
WHISPER	Waves of High Frequency and Sounder for Probing of Density by Relaxation