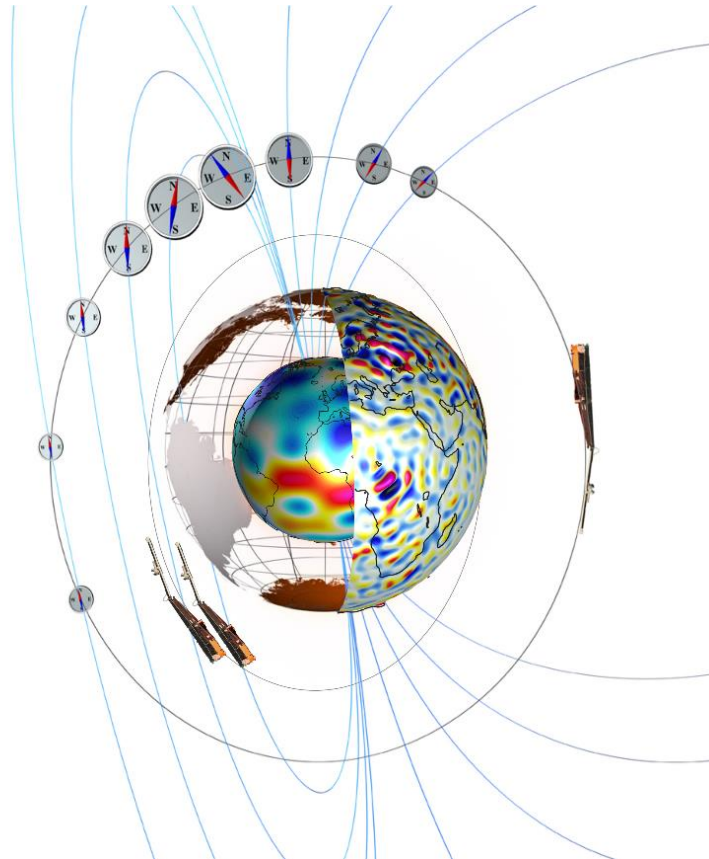# Statement of Work
Swarm DISC ITT 2.3
"Estimation of ion temperature at Swarm altitudes in support of studies of the thermal energy balance of the upper atmosphere"

Doc. no: SW-SW-DTU-GS-123, Rev: 1A

Record of Changes

Reason	Description	Rev	Date
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Table of Contents

1   Introduction

This Invitation to tender is issued by the Swarm DISC consortium on behalf of ESA within the reference frame of ESA contract 4000109587/13/I-NB, under the Swarm DISC Procurement Procedure described [RD-1].

1.1   Scope and applicability

This document describes the activity to be executed and the deliverables required under the Swarm DISC ITT 2.3 – "Estimation of ion temperature at Swarm altitudes in support of studies of the thermal energy balance of the upper atmosphere".

It will become part of the contract and shall serve as an applicable document throughout the execution of the work (with possible amendments recorded during the Negotiation meeting).

The document is structured as follows:

- Chapter 2 quotes applicable and reference documents (including applicable standards).

- Chapter 3 introduces the background and main objectives of the work, and presents the constraints on the system to be produced.

- Chapter 4 defines the work to be performed in the contract to produce the required output.

- Chapter 5 contains the requirements on deliverables and on general project management aspects.

- Chapter 6 contains schedule and milestones.

2   Applicable and Reference Documentation

2.1   Applicable Documents

The following documents are applicable to the definitions within this document.

[AD-1]   ESA-EOPG-MOM-IF-17 Swarm SPC to PDGS ICD v1.1

2.2   Reference Documents

The following documents contain supporting and background information to be taken into account during the activities specified within this document.

[RD-1]   SW-RS-DTU-GS-003 rev. 1B, Swarm DISC Procurement Procedure

2.3   Terminology

In this document the term '*shall*' indicates requirements which the products must meet, while '*should*' indicates a desirable product features and '*may*' is used to indicate a suggested feature.

2.4   Abbreviations

Statement of Work

Acronym or abbreviation	Description
CDM	Configuration and Data Management
Cat-1 / -2	Category-1 products are data products generated at a Swarm DISC partner, outside the PDGS, but published via the PDGS. Category-2 products are generated at the PDGS.
DISC	(Swarm) *Data, Innovation and Science Cluster* – a consortium of scientific and technical partners supporting the data processing for the ESA Swarm mission
DPA	Description of Processing Algorithm
DTU	Technical University of Denmark, DK
DQW	Data Quality Workshop
EOX	EOX IT services Gmbh, Austria – Developer and operator of the VirEs visualization platform
ESA	European Space Agency
ITT	Invitation To Tender
KO	Kick Off
PDD	Product Definition Document
PDGS	Payload Ground Data Segment
SLA	Service Level Agreement
SVN	SVN Repository with server located at DTU. Presently, the following URLs apply: https://smart-svn.spacecenter.dk/svn/smart/SwarmESL-All https://smart-svn.spacecenter.dk/svn/smart/SwarmL2 (heritage from the L2PS Project)
TBC	To Be Confirmed
TBD	To Be Defined
TDS	Test Data Set
TTO	Transfer To Operation
VirES	Virtual research platform https://vires.services
WBS	Work Breakdown Structure
WPD	Work Package Descriptions

3 Background and Objective(s)

3.1 Background

Swarm is a constellation of satellites operated by ESA. The objective of the Swarm mission (https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/swarm) The objective of the Swarm mission is to provide the best ever survey of the Earth's geomagnetic field and the near Earth's space environment. For this aim, the mission provides observations of the magnetic field, electron density and temperature, ion drift, and neutral density. These observations have been applied in many scientific studies and greatly advanced our understanding of the geomagnetic field and space physics – read more at https://earth.esa.int/web/guest/missions/esa-eo-missions/swarm/activities/publications.

Data from the Swarm mission are described in the *Swarm Data Handbook*: https://earth.esa.int/web/guest/missions/esa-eo-missions/swarm/data-handbook

The Electric Field Instrument on the Swarm satellites includes a Thermal Ion Imager (TII), designed to provide in situ ionospheric ion drifts and temperatures. However, ion temperature are no longer provided due to technical issues of the TII instrumentations. Ion temperature is one of the key parameters into the thermal balance of the ionosphere-thermosphere coupling.

3.2 Objective(s) of the Activity

The objective of the activity is to make use of available Swarm observations aided by model predictions of parameters that are not available from Swarm to derive estimated time series of ion temperature that are thoroughly validated against independent data. The ion temperature is needed in support of studies of the energy balance of the upper atmosphere.

An additional objective is to achieve a better understanding of how the quality of the data and models used to derive the product affects its accuracy and validity.

The proposal shall properly describe the assumptions behind the proposed approach to derive ion temperatures. In particular heating and cooling processes, and the limitations of the applicability of the product due to the assumptions made should be considered.

Furthermore, the proposal shall discuss how ionospheric processes and variability at high latitudes affect the proposed approach.

The proposal should discuss how the satellite constellation could support the derivation, characterization, or quality flagging of the suggested products.

The expectation is the development of a data product describing the ion temperature along Swarm orbits (for all orbits and all three satellites), which can then be visualized in VirES in comparison to time series of other Swarm measurements. No special developments of advanced visualizations is expected within this project.

3.3 The Swarm data processing chain

All Swarm related data products are made available to users through the PDGS.

Swarm data products available are described on the Swarm Data Handbook and visualizations of most Swarm data products are available via the interactive 'VirES for Swarm' client (https://vires.services).
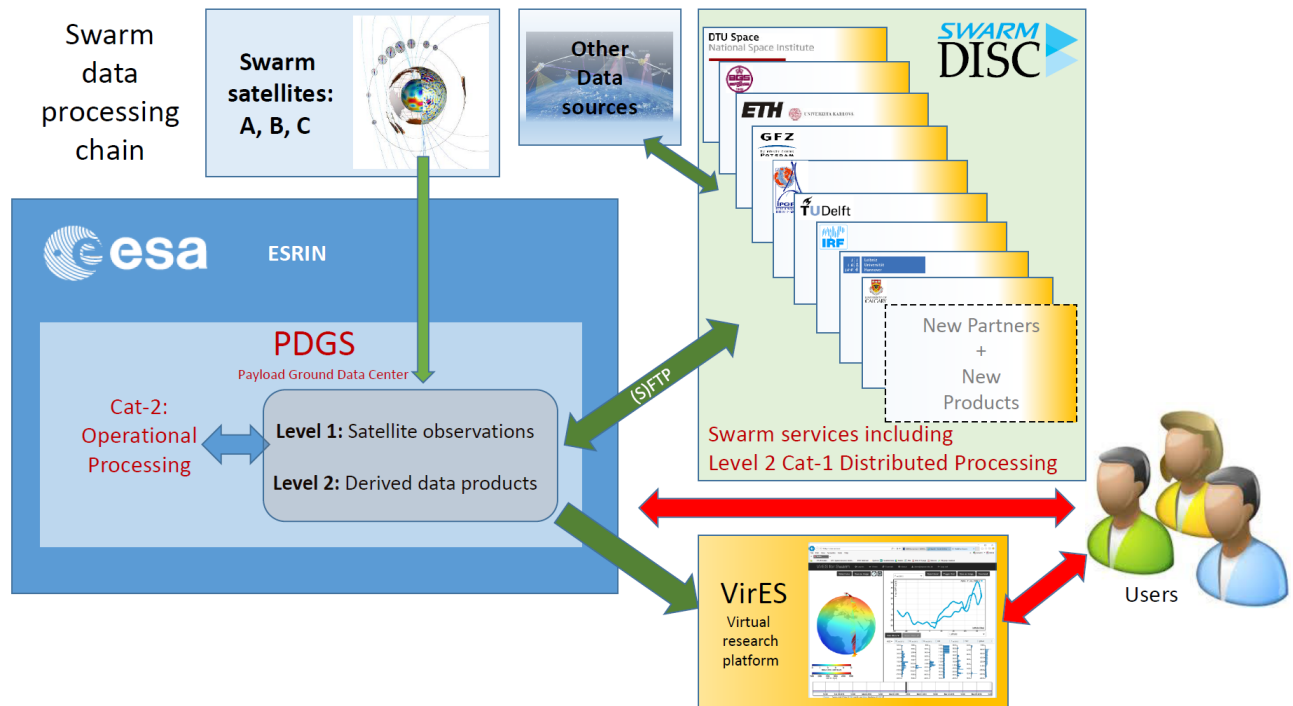
Figure 1 - Swarm data processing chain

This project shall deliver it's data products as part of the Level 2 distributed processing network, as a new product in the Swarm data processing chain (see Figure 1). The data products shall be suitable for generation on a regular basis pending availability of the required input data products and upload via SFTP to the Payload Data Ground Segment (PDGS) at ESA for publication.

During Swarm operations, the Level1b processors may be enhanced and improved, triggering the reprocessing of the full mission data and the subsequent release of such new product baseline. Furthermore, data quality assessment processes may reveal anomalies that could lead to the regeneration and replacement of a specific group of already existing data products with an updated file counter. The proposal shall support versioning of the output data products and describe which steps will be taken in order to ensure the data quality of the output products, should new releases of the input data become available in both the re-processing or re-generation scenarios.

3.4 Assumptions and Constraints

Official Swarm products made available by the Swarm PDGS shall be used by the project. In case data from other sources are needed for processing purposes these products need to be defined and described in detail.

Approval of deliverables will normally require 14 days for review by Swarm DISC Project Office. Approval of payment milestones is subject to approval of the related deliverables.

4   Work to be performed

All deliverables in the form of Technical Notes described here will require an informal review – reviewer to be appointed by the Swarm DISC technical representative – and subsequent written approval.

The following sections describe the tasks anticipated to complete this project. Required output deliverables are listed in chapter 5.

4.1   Work Logic

The work to be performed should as a guideline cover the following tasks: Definition and development of the product including a validation of input data and study of limitations to model assumptions, a scientific validation of the developed product, the implementation of the product toward the ESA PDGS and verification and validation of the product performance, plus preparation of the product for provision in an operational setting. The presentation of the results on international conferences and the compilation into a scientific publication is also expected.

Immediately after Kick-off, the proposer is expected to provide a brief summary (about 200 words) to be published on the Swarm mission website https://earth.esa.int/web/guest/missions/esa-eo-missions/swarm/activities/scientific-projects/disc.

4.1.1   Task 1: Product definition

4.1.1.1   *Input*

- Statement of Work (this document)
- Scientific literature
- Swarm data products and product documentation
- Supporting data and models
- Proposal (should include a first iteration of the product definition and work plan)

4.1.1.2   *Task Description*

Based on a review of the existing scientific literature and documentation of existing Swarm data products (https://earth.esa.int/swarm/), the Contractor shall define a new high-level data product of estimated ion temperatures along the Swarm orbits. The definition of the new product shall be based on a good understanding of the assumptions made and the limitations that results from the assumptions, especially their applicability at low, mid, and high latitudes, and/or geomagnetic activity.

The task includes a thorough validation of the input Swarm data against independent means and investigation of the validity of the models used in the derivation of the product. An investigation into the effect of the input quality on the resulting product is also required.

Furthermore, the product definition shall consider how the multi-satellite constellation will support the derivation, characterisation, or quality flagging of the developed product.

The Contractor shall document the definition of the product. The product definition shall include information on the required input products, a definition of the data fields and metadata to be contained in the output product, information on the expected accuracy, time representation, temporal sampling and data volume of the product, as well as latency for availability of the product.

The Contractor shall propose a work plan for the implementation, validation and operation of the processor that is to be developed for producing the new product. The proposed work plan shall be supported by preliminary analysis results and should specifically address the anticipated coverage in terms of space and time for a valid product. It is expected that highly doubtful results for ion temperature are excluded from the product file. The product definition shall include a description of the strategy applied for distinguishing between valid and invalid data.

The work plan shall include the identification of the Swarm data, meta-data, and models required for the analysis, as well as independent data or models to be used for validation. One or more representative periods for initial testing and validation of the processor and resulting product shall be defined in the work plan.

4.1.1.3   *Deliverables*

- TN-01: Product definition document
- TN-02: Input data and model validation document
- TN-03: Work plan

4.1.2   Task 2: Processor implementation

4.1.2.1   *Input*

- TN-01: Product definition document
- TN-02: Input data and model validation document
- TN-03: Work plan
- Swarm data products and documentation
- Supporting data and models

4.1.2.2   *Task description*

The Contractor shall implement the processor at its premises, according to the work plan. The processor shall be implemented to produce the data set, in accordance with the product definition document. The Contractor shall document the algorithms that are applied in the processor in a technical note. The Contractor is strongly encouraged to adopt an open source approach for the code development. The output files must contain all necessary information on model data, if used, and assumptions, enabling the reproducibility of the results. The Contractor shall collect all necessary input data to run the processor for a test period, and generate and deliver a first test data set.

4.1.2.3   *Deliverables*

- TN-04: Description of the processing algorithms and preferably submission of code to open source repository
- DL-01: First test data set

4.1.3   Task 3: Product validation

4.1.3.1   *Input*

- TN-01: Product definition document
- TN-02: Input data and model validation document

- TN-03: Work plan
- Supporting data and models

4.1.3.2   *Task description*

The Contractor shall compare the new data product of ion temperature with independent data or models, to investigate the validity of the data set and the accuracy of the data. The proposal shall present a detailed validation plan including the description of the independent data and models to be used for comparison. The product validation shall also verify the strategy used for excluding invalid results for ion temperature derivations.

The output of the activity shall be documented in a validation report, which shall be delivered along with the preliminary dataset used in the validation.

4.1.3.3   *Deliverables*

- TN-05: Validation report
- DL-02: Preliminary dataset used for validation

4.1.4   **Task 4: Preparation and transfer of data to PDGS**

4.1.4.1   *Input*

- TN-01: Product definition document
- **Error! Reference source not found.**: Interface Control Document

4.1.4.2   *Task description*

In order to assist the visualisation of the new data set in VirES, the Contractor shall develop visualization use cases and test data sets. The Contractor is encouraged to interact as early as possible with EOX in support of their implementation of the product visualization.

The Contractor shall implement functions for operational transfer of data to PDGS – i.e. data products uploaded to ESA FTP server in correct file format, etc., see **Error! Reference source not found.**. The Swarm DISC System Manager will offer Unix scripts that exemplifies generation of header and dissemination files.

The Contractor shall produce the output data in the final product format and upload it to PDGS. First data should be delivered at least 2 month prior to project finalization. Full mission data from the beginning of the Swarm mission shall be delivered by the Final Presentation. The Contractor shall verify the successful upload of the product files in collaboration with the DISC project officer.

The Contractor shall prepare a plan for continued operational provision of the product beyond the end of the contract. The plan shall describe the support needed for maintaining operational production including answering user questions received by ESA EO helpdesk during an ongoing future operational phase.

4.1.4.3   *Deliverables*

- TN-06: Technical note describing use cases for visualisation of the product
- TN-07: Technical note documenting implementation of data transfer functionality
- DL-03: PDD published on the Swarm Data Handbook
- DL-04: First data delivered to PDGS
- DL-05: Plan for continued operation
- DL-06: Full mission data delivered to PDGS

4.1.5   Task 5: Final presentation

4.1.5.1   *Input*

- All outcomes from the project

4.1.5.2   *Task description*

- Preparation and submission of peer reviewed publication about the outcome of this project
- Presentation of project achievements at a Swarm Data Quality Workshop (or similar event to be agreed with the Swarm DISC Project Office) towards the end of the project.
- Conclude delivery of final project deliverable documentation to Swarm DISC

4.1.5.3   *Deliverables*

- DL-07: One Peer reviewed publication submitted
- DL-08: A presentation of project achievements made during a Swarm DQW
- DL-09: Final project documentation delivered electronically to the Swarm DISC Project Office in searchable PDF format

5   Requirements for Management, Reporting, Meetings and Deliverables

The following are the requirements for Management, Reporting, Meetings and Deliverables applicable to the present activity.

5.1   Management

MG-01.   The Contractor shall assign a responsible project manager as point of contact with the DISC project office / the Agency.

MG-02.   A point of contact shall be assigned for subContractors, if any, but generally any correspondence with the project will be via the project manager assigned in MG-01

MG-03.   All correspondence between the project and the Agency must be via – or if agreed by DTU in copy to – the Swarm DISC project office:

> Swarm DISC Project office
> DTU Space
> Centrifugevej, Building 356
> 2800 Kgs. Lyngby
> Denmark
> Fax: +45 4525 9701

5.2   Reporting

RP-01.   The Contractor shall submit all documents to the DISC Project Office in searchable, non-protected PDF format, as well as their native format.

RP-02.   The Contractor shall ensure that electronic documents do not contain any harmful code (e.g. virus)

RP-03.   The Contractor shall ensure that short minutes of meeting are produced, recording participants and any decisions made during the Kick Off meeting as well as status report meetings, and send a copy of these to the Swarm DISC project office, not later than three days after these meetings.

RP-04.   The Contractor shall produce a short quarterly (or other interval as agreed) progress report, which is sent via e-mail to the Swarm DISC project office. This report shall contain highlights of recent achievements, status on work progress, references to publications or presentations, new challenges, etc. Swarm DISC will provide a Progress Reporting template.

5.3   Technical Documentation

TN-01.   Product definition document

TN-02.   Input data and model validation document

TN-03.   Work plan

TN-04.   Description of the processing algorithms and preferably submission of code to open source repository

TN-05.   Validation report

TN-06.   Technical note describing use cases for visualisation of the product

TN-07.   Technical note documenting implementation of data transfer functionality

5.4   Meetings

ME-01.   The Contractor shall organize a kick off meeting via Teleconference where key persons are introduced and the project schedule is presented.

ME-02.   The Contractor shall upon request - and at least at the Mid Term Review - present the project status to the Swarm DISC project office via Teleconference. The status report shall be provided to DTU one week before the teleconference. The Agency reserves the right to participate.

ME-03.   The Contractor shall prepare a presentation of the final result and present it to the Swarm DISC community at a suitable event (Data Quality Workshop or conference) in Europe to be agreed with the Swarm DISC Project Office. Presentation draft to be provided to Swarm DISC Project Office and ESA 5 working days before the event.

ME-04.   The Swarm DISC project office and the Agency reserves the right to call up ad hoc meetings at any time for justified reasons.

5.5   Other Deliverables

DL-01.   First test data set

DL-02.   Preliminary dataset used for validation

DL-03.   PDD published on the Swarm Data Handbook

DL-04.   First data delivered to PDGS

DL-05.   Plan for continued operation

DL-06.   Full mission data delivered to PDGS

DL-07.   One Peer reviewed publication submitted

DL-08.   A presentation of project achievements made during a Swarm DQW

DL-09.   Final project documentation delivered electronically to the Swarm DISC Project Office in searchable PDF format

6   Schedule and Milestones

This activity is expected to start as soon as possible in 2019, with a planned duration of 12 - 15 months.

6.1   Schedule

SC-01. The Contractor shall establish a schedule that is consistent with the planned start of work and the drafted milestones in section 6.2. Any deviation shall be identified and duly justified.

SC-02. The Contractor shall during execution monitor the major milestone schedule. Deviations shall be and reported to the DISC project office with justification.

SC-03. In the event that delays to milestone deliveries are anticipated, this shall be reported to the Swarm DISC project office As Soon As Possible.

6.2   Milestones

Milestone	Description	Event timeline (months)
MIL-01	Project Kick Off	KO
MIL-02	Progress teleconference	KO+3
MIL-03	Delivery of TN-01, TN-02, TN-03	KO+6
MIL-04	Mid Term Review: TN-04, DL-01	KO+8
MIL-05	Delivery of TN-07	KO+10
MIL-06	Delivery of TN-05, TN-06, DL-02, DL-04	KO+13
MIL-07	Final Presentation: DL-03, DL-05, DL-06, DL-07, DL-08, DL-09	KO+15