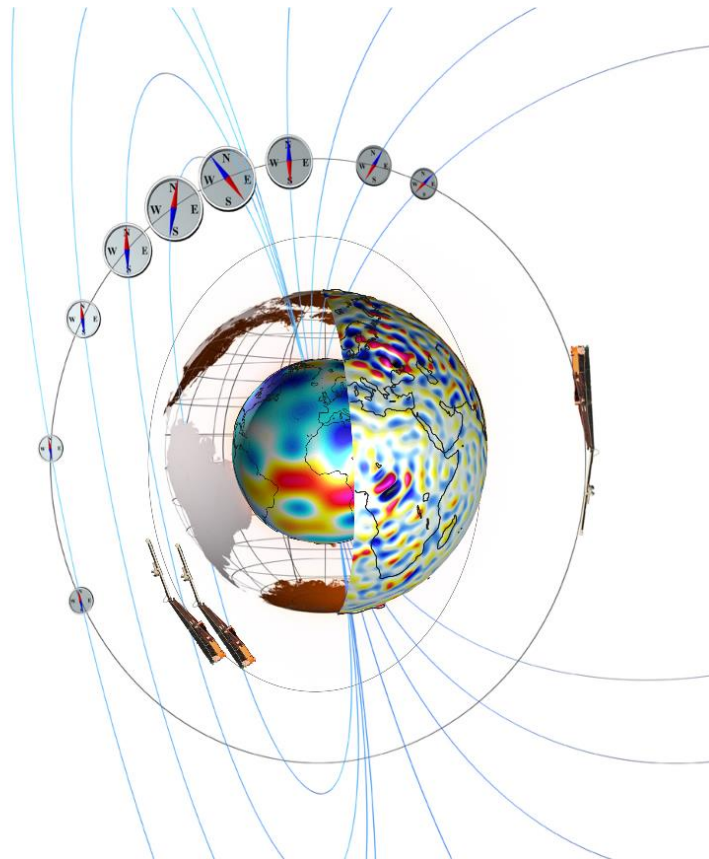

Statement of Work

Swarm DISC ITT 3.1

“New Swarm Products: Along-Track Ion Drift and Effective Ion Mass”



Doc. no: SW-SW-DTU-GS-124, Rev: 1

Record of Changes

| Reason | Description | Rev | Date |
|---------------|---------------------------------|-----|------------|
| Final version | Approved by the TEB | 1 | 2019-11-06 |
| Final version | Approved for publication by ESA | 1 | 2019-11-08 |

Table of Contents

| | | |
|----------|---|-----------|
| 1 | Introduction..... | 7 |
| 1.1 | Scope and Applicability | 7 |
| 2 | Applicable and Reference Documentation..... | 7 |
| 2.1 | Applicable Documents..... | 7 |
| 2.2 | Reference Documents | 7 |
| 2.3 | Terminology..... | 8 |
| 2.4 | Abbreviations | 8 |
| 3 | Background and Objectives | 9 |
| 3.1 | Background..... | 9 |
| 3.2 | Objectives of the Activity | 10 |
| 3.3 | Assumptions and Constraints..... | 11 |
| 4 | Work to be performed | 12 |
| 4.1 | Work Logic..... | 12 |
| 4.2 | Implementation..... | 12 |
| 4.2.1 | Task 1: Scientific justifications and product definition | 12 |
| 4.2.1.1 | Input | 12 |
| 4.2.1.2 | Task description..... | 12 |
| 4.2.1.3 | Deliverables | 13 |
| 4.2.2 | Task 2: Preparation and transfer of data sets | 13 |
| 4.2.2.1 | Input | 13 |
| 4.2.2.2 | Task description..... | 13 |
| 4.2.2.3 | Deliverables | 13 |
| 4.2.3 | Task 3: Product validation | 13 |
| 4.2.3.1 | Input | 13 |
| 4.2.3.2 | Task description..... | 13 |
| 4.2.3.3 | Deliverables | 13 |
| 4.2.4 | Task 4: Implementation (optional task pending positive review of phase 1) | 14 |
| 4.2.4.1 | Input | 14 |
| 4.2.4.2 | Task description..... | 14 |
| 4.2.4.3 | Deliverables | 14 |
| 4.2.5 | Task 5: Final presentation (independent of outcome of phase 1 review) | 14 |
| 4.2.5.1 | Input | 14 |

| | | |
|----------|--|-----------|
| 4.2.5.2 | Task description | 14 |
| 4.2.5.3 | Deliverables | 14 |
| 5 | Requirements for Management, Reporting, Meetings, and Deliverables..... | 15 |
| 5.1 | Management | 15 |
| 5.2 | Reporting | 15 |
| 5.3 | Technical Documentation..... | 15 |
| 5.4 | Meetings | 16 |
| 5.5 | Other Deliverables..... | 16 |
| 6 | Schedule and Milestones | 17 |
| 6.1 | Schedule | 17 |
| 6.2 | Milestones | 17 |

List of Figures

| | |
|--|---|
| Figure 1 - Swarm data processing chain | 9 |
|--|---|

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 3.1 – “New Swarm Products: Along-Track Ion Drift and Effective Ion Mass”.

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 document is applicable to the definitions within this document.

[AD-1] [ESA-EOPG-MOM-IF-17 Swarm SPC to PDGS Interfacing Control Document](#)

2.2 Reference Documents

The following document contains 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](#)

[RD-2] [Burchill, J.K., and Förster, M., “Final report of the Langmuir Probe Pre Study on deriving along-track ion bulk drift and effective ion mass from LP and faceplate currents”, 2019-01-02.](#)

[RD-3] [Buchert, S. and T. Nilsson, “Langmuir Probe Level 1b Algorithm”, Swarm Document No. SW-TN-IRF-EF-003, Rev: 3C, 2018-05-14.](#)

[RD-4] [Burchill, J. K., and D. J Knudsen, “EFI TII Cross-Track Flow Data Release Notes”, Swarm Data, Innovation, and Science Cluster, SW-RN-UoC-GS-004, 2017.](#)

2.3 Terminology

In this document the term '*shall*' indicates requirements which the products must meet, while '*should*' indicates a desirable product feature.

2.4 Abbreviations

A frequently updated Acronyms and Abbreviations list for Swarm and related projects can be found [here](#) in the Swarm Data Handbook.

3 Background and Objectives

3.1 Background

The Swarm mission's objectives are described and existing Swarm products are disseminated through <https://earth.esa.int/swarm> and included links.

Swarm products available are described on the [Swarm Data Handbook](#) and visualizations of most Swarm products are available via the interactive 'VirES for Swarm' client. Tenderers are encouraged to visit VirES, to get an impression of the capabilities available.

The Electric Field Instrument (EFI) on the Swarm satellites includes a Thermal Ion Imager (TII) and spherical Langmuir Probes (LP), designed to provide in situ ionospheric ion drifts and temperatures (Burchill and Knudsen, 2017), as well as electron density and temperature (Buchert and Nilsson, 2018). Electron density and temperature are operational products, and a data set of cross-track plasma drift derived from Swarm EFI measurements is available to the public. Recently it has been suggested that Swarm EFI observations can be used to infer the effective ion mass and along-track ion drift, both important parameters for ionospheric research. Knowledge of the effective ion mass allows studying the composition of the ionosphere, which in turn is crucial for understanding and reproducing realistic ionization and transfer of energy scenarios between solar forcing and the thermosphere. The along-track ion drift is needed in order to fully cover the 3D ion drift distribution. Furthermore, the derivation of electron density and temperature from Swarm EFI measurements assumes a homogenous atmosphere of atomic oxygen and plasma stationary in the satellite frame, conditions that are not always satisfied. It is therefore of interest to investigate and develop new products for the effective ion mass and the along-track ion drift.

This project shall deliver its products as a new product in the Swarm data processing chain (see Figure 1, and the applicable document AD-1).

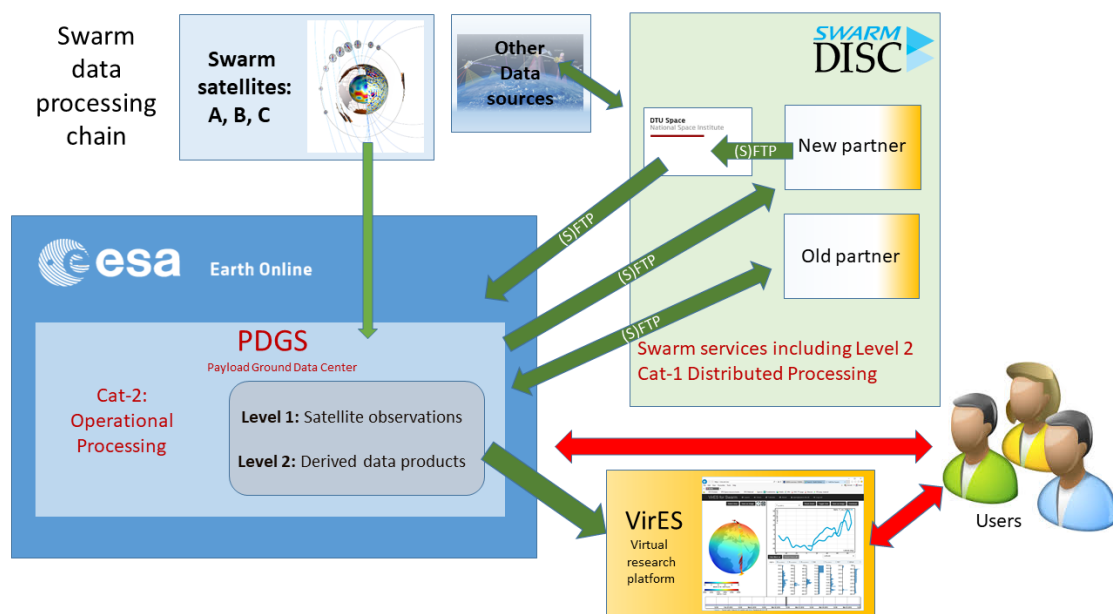


Figure 1 - Swarm data processing chain

(Category-2 products are generated at PDGS. Category-1 products are generated by Swarm DISC partners, and published via the PDGS.)

3.2 Objectives of the Activity

It is necessary to investigate how effective ion mass and along-track plasma drift can reliably be derived from observables of the EFI with improved knowledge of the assumptions regarding homogeneity and stationarity. The ultimate goal of the ITT is to design, validate, and implement new products for the along-track ion drift and effective ion mass. Currently, no well-established methods of deriving these products from Swarm measurements exist. Therefore, a two phased approach will be adopted with a technical review after the first phase. The first phase will consist of the derivation and validation of methodologies including the publication of the historical data set. The second phase will focus on operational implementation.

In phase 1 this activity *shall*:

- Elaborate and propose an algorithm that allows the estimation of the along-track ion drift from Swarm EFI observations.
- Elaborate and propose an algorithm that allows the estimation of the effective ion mass from Swarm EFI observations.
- Validate the derived data sets against independent data. These data can be observations from other satellite missions or from ground-based instrumentation.
- Validate the derived data sets against empirical models on a statistical basis.
- Do an inter-comparison between data sets derived from the three different Swarm satellites and assess the validity of assumptions.
- Clearly state any assumptions that have to be made in order to derive the products; clearly explain the involved limitations to the application of the product.
- Provide a thorough analysis on the validity of the derived products in terms of regions of proposed applications.
- Indicate the validity of the data set, for example with data quality flags.
- During the project, deliver at least one publication submitted for peer review and one presentation to a Swarm Data Quality Workshop or similar event.
- Provide post processed data sets from the start of the mission to PDGS.

In phase 1 this activity *should*:

- Harness public outreach opportunities that may arise from this new product.

In phase 2 this activity *shall*:

- Implement operational processing software that produces time series of along-track ion drift and effective ion mass.
- Document the processing algorithm and the final products.

- Provide visualization use cases, sample data sets, and assist the operator of VirES in specifying and testing relevant web visualization(s).
- Take into account that during Swarm operations, the Level1b processors may be enhanced and improved, triggering the reprocessing of the full mission data and the subsequent release of new product baseline. Furthermore, data quality assessment processes may reveal anomalies that could lead to the re-generation and replacement of a specific group of already existing data products with an updated file counter. Therefore, the Contractor shall support versioning of the output data products and describe which steps they will take in both the reprocessing or re-generation scenarios in order to ensure the data quality of their output products.

3.3 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 in the proposal. Swarm Level0 data will be provided by Swarm DISC if needed.

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.

The activation of the phase 2 option will be decided based upon an independent review of the scientific value of the products developed in phase 1 and the formal approval of ESA. The review process will take place between milestones 1.03 and 1.04, see section [6.2](#).

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 justification of input data and study of limitations to product derivation, 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.

The Contractor is expected to provide a brief summary of the project (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> preferably prior to Kick Off and no later than a week hereafter.

4.2 Implementation

4.2.1 Task 1: Scientific justifications and product definition

4.2.1.1 Input

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

4.2.1.2 Task description

Based on a review of the existing scientific literature and documentation of existing or recent Swarm products (see <https://earth.esa.int/web/guest/missions/esa-eo-missions/swarm/data-handbook>), the Contractor shall define and justify the following new products: along-track ion drift and effective ion mass.

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 update the work plan submitted in the proposal for the validation of the products, and the implementation, verification, and operation of the processor that is to be developed for producing the new products.

4.2.1.3 Deliverables

- TN-01: Updated work plan
- TN-02: Product Definition Document (including scientific justification)

4.2.2 Task 2: Preparation and transfer of data sets

4.2.2.1 Input

- TN-01: Work plan
- TN-02: Product Definition Document
- AD-1: Interfacing Control Document

4.2.2.2 Task description

Prepare the data set of along-track drift and effective ion mass including quality flags for all three Swarm satellites from the start of the mission. The format of the data set shall comply with AD-1. The historical data sets shall be delivered to PDGS.

4.2.2.3 Deliverables

- DL-01: Historical data sets delivered to PDGS
- DL-02: Product Definition Document (TN-02) published on the Swarm Data Handbook.

4.2.3 Task 3: Product validation

4.2.3.1 Input

- TN-01: Work plan
- TN-02: Product Definition Document
- DL-01: Historical data sets
- Supporting data and models

4.2.3.2 Task description

The Contractor shall compare the new products with space based and ground based observations as well as conduct statistical comparisons against ionospheric models, to demonstrate the validity of the data set, and to the extent possible assess the accuracy of the data. The validation analysis shall include assessment of limitations and applicability of assumptions. The output of the activity shall be documented in a validation report. The product definition document shall be updated to include information about how quality flags are defined and applied to the product.

4.2.3.3 Deliverables

- TN-03: Validation report
- TN-02: Updated Product Definition Document (including quality flags)

4.2.4 Task 4: Implementation (optional task pending positive review of phase 1)

4.2.4.1 Input

- TN-01: Work plan
- TN-02: Product Definition Document
- Swarm products and documentation

4.2.4.2 Task description

The Contractor shall implement the processor at its premises. 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 Contractor shall collect all necessary input data to run the processor for a test period, and generate and deliver a first operational data set.

The Contractor shall prepare a plan for how continued operational provision of the product could be supported beyond the end of the contract. This plan shall describe the support needed for maintaining operational production including answering user questions received by ESA EO helpdesk in the event that a future operational phase is to be negotiated.

4.2.4.3 Deliverables

- TN-04: Description of the processing algorithms and preferably submission of code to open source repository
- DL-03: First operational data set

4.2.5 Task 5: Final presentation (independent of outcome of phase 1 review)

4.2.5.1 Input

- All outcomes from the project

4.2.5.2 Task description

- Preparation and submission of at least one publication on the outcome of this project to a journal with peer review
- 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.
- Delivery of all documentation to Swarm DISC

4.2.5.3 Deliverables

- DL-04: One publication submitted to, or accepted, or published in a peer reviewing journal
- DL-05: A presentation of project achievements made during a Swarm DQW.
- DL-06: 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 / ESA. |
| 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 ESA must be via – or if agreed by DTU in copy to – the Swarm DISC Project Office, with attention to the DISC project manager: Swarm DISC Project Office DTU Space Centrifugevej, Building 356 DK-2800 Kgs. Lyngby Denmark Fax: +45 4525 9701 |

5.2 Reporting

| | |
|-------|---|
| GR-01 | The Contractor shall submit all documents to the DISC Project Office in searchable, non-protected PDF format, as well as their native format. |
| GR-02 | The Contractor shall ensure that electronic documents do not contain any harmful code (e.g. virus) |
| GR-03 | 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 | Work plan |
| TN-02 | Product Definition Document |
| TN-03 | Validation report |
| TN-04 | Description of the processing algorithms and preferably submission of codes to open source repository |

5.4 Meetings

| | |
|-------|--|
| ME-01 | The Contractor shall organize a Kick Off meeting via telecon where key persons are introduced and the project schedule is presented. |
| ME-02 | The Contractor shall at the Mid Term Review present highlights of recent achievements, status on work progress, and plan for the remaining part of the project to the Swarm DISC Project Office via telecon. The report should preferably be comprised of a limited number of slides provided to DTU one week before the telecon. ESA reserves the right to participate. |
| ME-03 | The Contractor shall prepare a presentation of the final result (DL-05) 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. |
| ME-04 | The Swarm DISC Project Office and ESA reserve the right to call up ad hoc meetings at any time for justified reasons. |

5.5 Other Deliverables

| | |
|-------|--|
| DL-01 | Historical data sets delivered to PDGS |
| DL-02 | Product Definition Document (TN-02) delivered for publication in the Swarm Data Handbook |
| DL-03 | First operational data set |
| DL-04 | One publication submitted for peer review |
| DL-05 | Presentation of project achievements to Swarm DQW |
| DL-06 | All Technical Notes, Presentations, Publications and other relevant project documentation delivered electronically to the Swarm DISC Project Office in searchable PDF format |

6 Schedule and Milestones

6.1 Schedule

| | |
|-------|--|
| SC-01 | The Contractor shall establish a schedule that is consistent with the planned start of work and the 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 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

Phase 1

| Milestone | Description | Suggested timeline |
|-----------|---|--------------------|
| MIL-1.01 | Project Kick Off (KO); TN-01 | KO |
| MIL-1.02 | Delivery 1: Mid Term Review; TN-02 | KO + 6 |
| MIL-1.03 | Delivery 2: TN-01 & TN-02 (updated), TN-03; DL-01, DL-02 | KO + 11 |
| MIL-1.04 | Final Delivery phase 1: DL-04, DL-05, DL-06; DL-01 (updated; if appropriate) | KO + 12 |

Phase 2 (if option activated)

| Milestone | Description | Suggested timeline |
|-----------|--|--------------------|
| MIL-2.01 | Start of phase 2 | KO + 13 |
| MIL-2.02 | Delivery 3: Mid Term Review; TN-02 (updated) | KO + 18 |
| MIL-2.03 | Delivery 4: TN-04; DL-03 | KO + 23 |
| MIL-2.04 | Final Delivery phase 2: DL-04 (if appropriate), DL-05, DL-06; DL-01 (updated; if appropriate) | KO + 24 |