Swarm - Past Present Future

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ESA

Swarm 10 Year Anniversary & Science Conference 2024
We have this morning heard how Swarm came to be – and if it should be summarized:
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“Never ever give up” if you have a good idea
Swarm – the past

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“It takes a village”
We have this morning heard how Swarm came to be – and if it should be summarized:

“Never ever give up” if you have a good idea

”It takes a village”

”Keep moving forward ”
How does this compare to the current situation for Swarm?
Swarm – current

How does this compare to the current situation for Swarm?

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”It takes a village”
How does this compare to the current situation for Swarm?

“Never ever give up” if you have a good idea

”It takes a village”

”Keep moving forward ”
What is the Swarm DISC?
The Swarm Data and Innovation Science Cluster (DISC) is an international consortium created to enhance the scientific return of the Swarm mission.

Main Tasks
Process & disseminate Swarm data, communication, identify, select and run New Swarm Products and Services.

Swarm DISC Consortium
The Swarm DISC Consortium currently consist of 35 partners from 19 countries in Europe and North America.
VirES for (not only) Swarm  
https://vires.services

- ecosystem of services:
  - highly interactive web for quick data exploration
  - Jupyter-based Virtual Research Environment
  - VirES Python client for API access to data
  - Heliophysics API

- offered data:
  - Swarm products (L1B MAG and EFI, L2)
  - rich collection geomagnetic models (L2 SHA, CHAOS, IGRF, ...)
  - calibrated measurements from CryoSat-2, GRACE-1,2 and GRACE-FO platform magnetometers.
  - INTERMAGNET ground observatory data

Virtual Research Environment

- ready-to-use cloud execution environment
  - access to VirES datasets
  - curated set of pre-installed libraries
  - collection of example recipes
- allows for custom data-processing and visualization

https://vre.vires.services  
https://notebooks.vires.services
Swarm observations together with a large number of other sources in the KNMI Space Weather Timeline Viewer
Swarm is a constellation of 3 identical satellites
- Lower pair (Alpha and Charlie) “side by side” nominally 150 km separation at the equator and 4-10 s along-track separation to avoid collision at the poles
- Upper satellite (Bravo) in nominally different local time orbit
The Swarm Satellite and Instrumentation

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"Even a (almost) perfect mission can get better"
Swarm 10 years in orbit!

- 56,204 orbits for Swarm Alpha
- 56,200 orbits for Swarm Charlie
- 55,508 orbits for Swarm Bravo
- 102 Level-2 data products

550 peer-reviewed articles

The Swarm spacecrafts, instruments and community are ready for the years to come.
The Swarm mission has been extended several times in the past through a scientific assessment performed by ACEO (ESAC) followed by PB-EO approval. A new procedure ESA/PB-EO(2020)40 is in place to align the mission extension with the 3 year cycle of the FutureEO program in time for the Ministerial Conferences.

Swarm is currently extended through 2025, and if onboard recourses and funding allows, the plan is to fly the mission through the current solar cycle and deorbit during next solar minimum (~2030) to allow lithospheric measurements close to Earth while the Sun is quiet.
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Swarm Mission Lifetime

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Swarm is currently extended through the current solar cycle with missions close to Earth while the next extension will be in 2026.

Swarm Mission Launch (Nov. 2013)

- Planned extension #1 (TBD)
- Planned extension #2 (TBD)

* The Advisory Committee for Earth Observation

**Shortly after this meeting we will start working on the mission extension report to be presents for ACEO* first week of November 2024**
The Swarm lower pair has been raised twice the past two years and will now slowly (!) decay until reentry ~2031-2032 timefram.

Swarm Bravo completed a delta orbit raise to maintain proper separation with the lower pair while staying away from dense Starlink orbits.

Lower pair separation at the equator stopped at 1.4 deg, same as before 2019.

* Subtract Earth Radius 6371 km
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With the current decay rate and reasonable predictions we might reach ~380 km end 2031.
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Not entirely successful at staying away from Starlink... But Bravo has good fuel resources left and can be maintained in orbit for a significant time still.
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Plans to reduce down to ~1.2 deg toward the end of the mission while closer to Earth.

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Swarm-E/CASSIOPE e-POP

Although the routine Swarm-E operation has come to an end, e-POP is still going strong. Phase F activities and new opportunities

CSES

Some CSES data made available in “Swarm-like” data format to encourage joint analysis of Swarm and CSES magnetic data

MSS-1: First Macau Science Satellite

Launched on 21 May 2023
Commissioned end of 2023
Swarm - MSS collaboration on CalVal activities
NanoMagsat Constellation - New ESA Scout

- 3 cubesats (16u) at 575 km initial altitude
- Two satellites at 60° inclination, one near-polar
- Vector and scalar magnetometers, star tracker
- plasma instrument (Langmuir probe)

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What is next?...
From all we have learned today, can we identify the one key factor to success for Swarm?
We are welcoming you all to Bucharest, Romania for the 14th Swarm Data Quality Workshop 7 – 11 October 2024