How *swarm* became *Swarm*

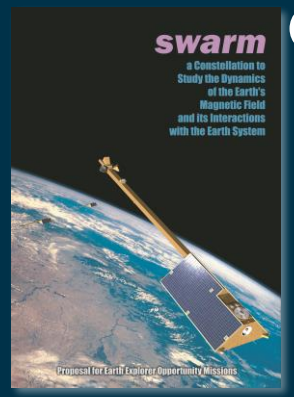
Roger Haagmans

Swarm 10 Year Anniversary &

Science Conference 2024

10-04-2024

2002

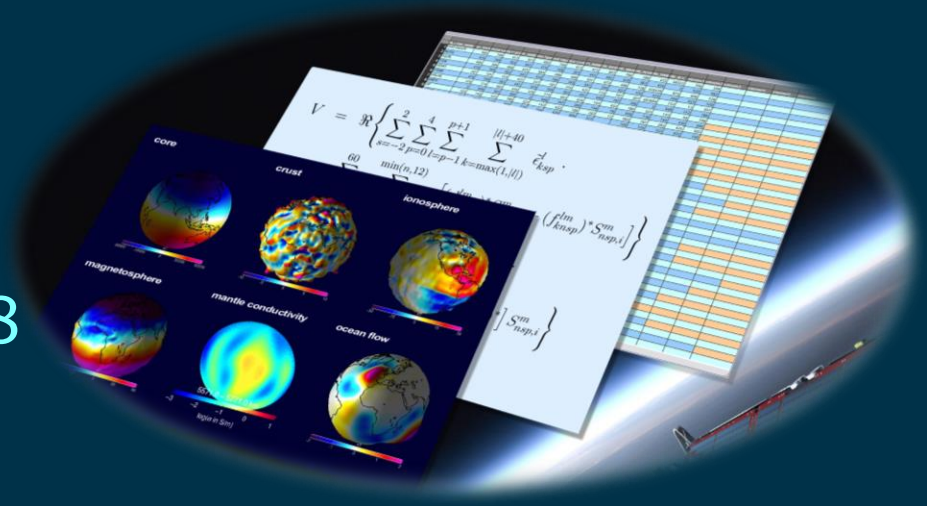


2004

2013

2018

2024



Feasibility → Implementation → Exploitation → Extension → Continuation

Celebrations with cake

2002

2004

2013

2018

2024

BGS

ESA

Feasibility

Implementation

Exploitation

Extension

Continuation

Airbus

DTU

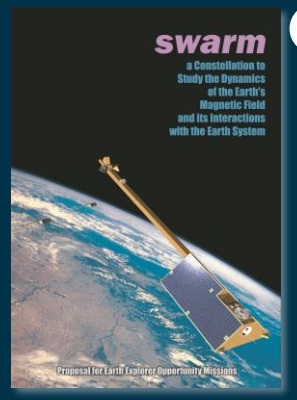
ESA competition

10 years in orbit

20 years since the "Frascati" selection

Swarm: the mission that was not supposed to fly

2002



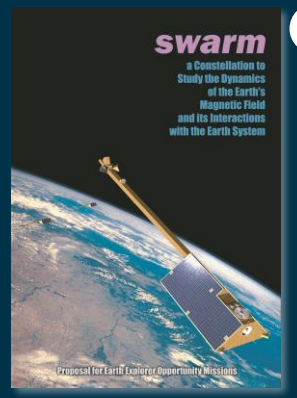
Feasibility

2004

- Proposal selected as spare mission together with ACE+ and EGPM
- How to optimize the constellation with respect to science return and in the meantime reduce costs?
- ~~Analyse merging with ACE+ because all have GNSS receivers~~

Swarm: the mission that was not supposed to fly

2002

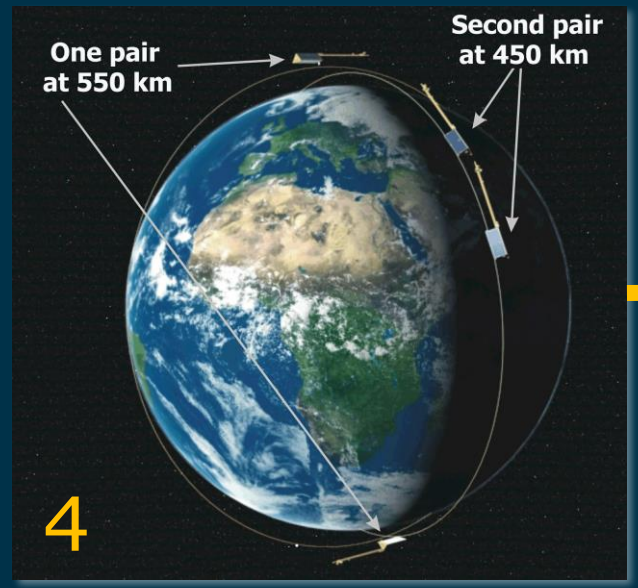


Feasibility

2004

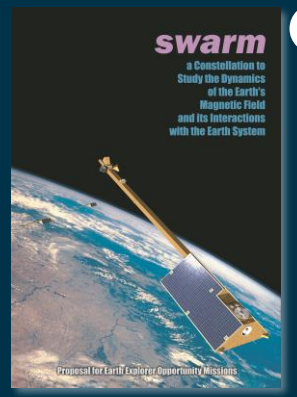
Mission was presented at the IUGG in 2003 in Sapporo.
Newspaper interview with Eigil Friis-Christensen:

Mission End-to-End simulator (including NASA)



Swarm: the mission that was not supposed to fly

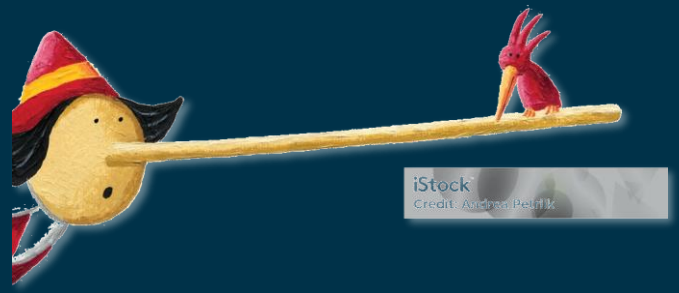
2002



Feasibility

2004

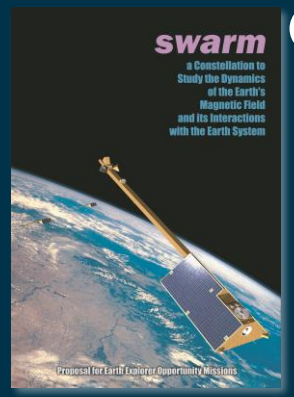
- Rules changed: selection of only 1 mission due to budget constraints, so open competition
- French contribution: absolute scalar magnetometer
- ESA Science Directorate: debt of Canada to space science programme becomes a contribution to the Swarm electric field instrument from Canada
- User Consultation Meeting at ESRIN, Frascati, 2004



- Swarm mission selected for implementation and is still flying

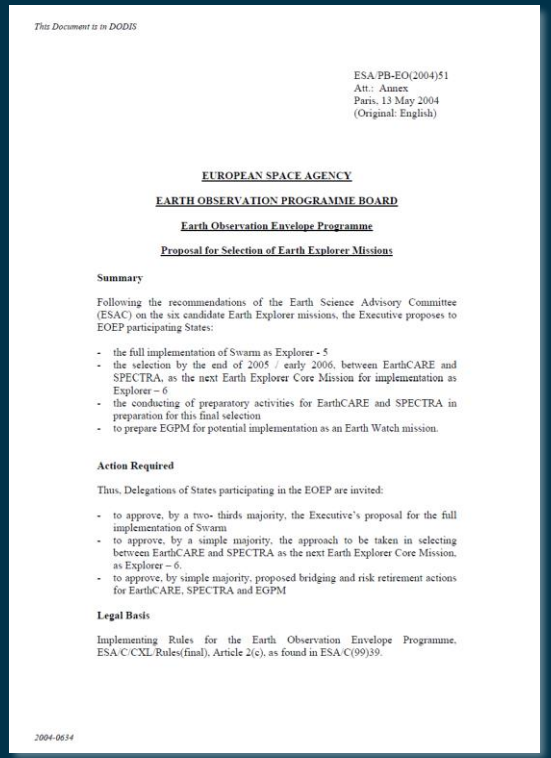
Swarm: the mission that was going to fly

2002



Feasibility

2004



This Document is in DODIS

ESA/PB-EO(2004)51
Att.: Annex
Paris, 13 May 2004
(Original: English)

EUROPEAN SPACE AGENCY

EARTH OBSERVATION PROGRAMME BOARD

Earth Observation Envelope Programme

Proposal for Selection of Earth Explorer Missions

Summary

Following the recommendations of the Earth Science Advisory Committee (ESAC) on the six candidate Earth Explorer missions, the Executive proposes to EOEP participating States:

- the full implementation of Swarm as Explorer - 5
- the selection by the end of 2005 / early 2006, between EarthCARE and SPECTRA, as the next Earth Explorer Core Mission for implementation as Explorer – 6
- the conducting of preparatory activities for EarthCARE and SPECTRA in preparation for this final selection
- to prepare EGPM for potential implementation as an Earth Watch mission.

Action Required

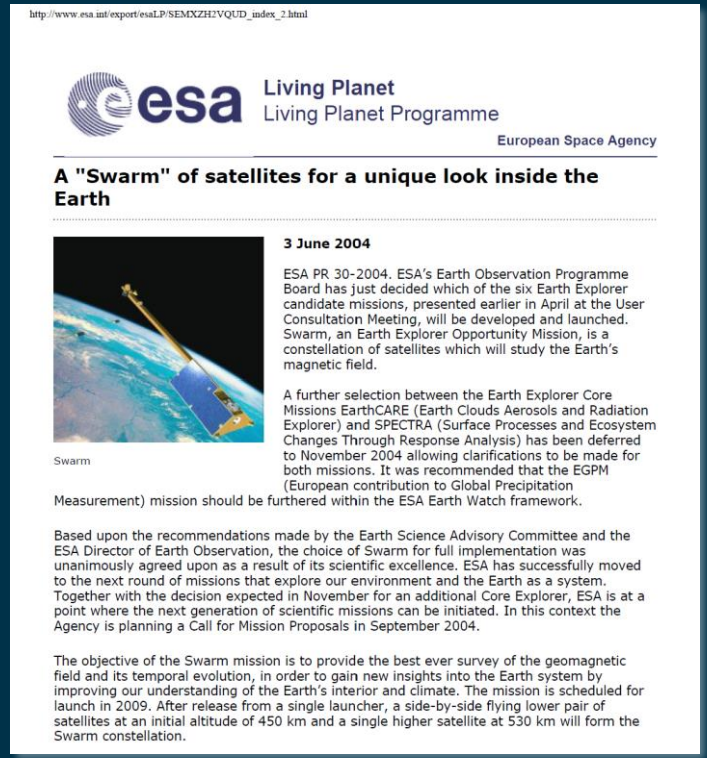
Thus, Delegations of States participating in the EOEP are invited:

- to approve, by a two- thirds majority, the Executive's proposal for the full implementation of Swarm
- to approve, by a simple majority, the approach to be taken in selecting between EarthCARE and SPECTRA as the next Earth Explorer Core Mission, as Explorer – 6.
- to approve, by simple majority, proposed bridging and risk retirement actions for EarthCARE, SPECTRA and EGPM

Legal Basis

Implementing Rules for the Earth Observation Envelope Programme, ESA/C/CXL/Rules(final), Article 2(c), as found in ESA/C(99)39.

2004-0634



http://www.esa.int/export/esaLP/SEMXZH2VQUD_index_2.html

esa Living Planet
Living Planet Programme
European Space Agency

A "Swarm" of satellites for a unique look inside the Earth

Swarm

3 June 2004

ESA PR 30-2004. ESA's Earth Observation Programme Board has just decided which of the six Earth Explorer candidate missions, presented earlier in April at the User Consultation Meeting, will be developed and launched. Swarm, an Earth Explorer Opportunity Mission, is a constellation of satellites which will study the Earth's magnetic field.

A further selection between the Earth Explorer Core Missions EarthCARE (Earth Clouds Aerosols and Radiation Explorer) and SPECTRA (Surface Processes and Ecosystem Changes Through Response Analysis) has been deferred to November 2004 allowing clarifications to be made for both missions. It was recommended that the EGPM (European contribution to Global Precipitation Measurement) mission should be furthered within the ESA Earth Watch framework.

Based upon the recommendations made by the Earth Science Advisory Committee and the ESA Director of Earth Observation, the choice of Swarm for full implementation was unanimously agreed upon as a result of its scientific excellence. ESA has successfully moved to the next round of missions that explore our environment and the Earth as a system. Together with the decision expected in November for an additional Core Explorer, ESA is at a point where the next generation of scientific missions can be initiated. In this context the Agency is planning a Call for Mission Proposals in September 2004.

The objective of the Swarm mission is to provide the best ever survey of the geomagnetic field and its temporal evolution, in order to gain new insights into the Earth system by improving our understanding of the Earth's interior and climate. The mission is scheduled for launch in 2009. After release from a single launcher, a side-by-side flying lower pair of satellites at an initial altitude of 450 km and a single higher satellite at 530 km will form the Swarm constellation.

SWARM - THREE EXPLORERS OF THE EARTH MAGNETIC FIELD AND ITS ENVIRONMENT

A. Schönenberg, R. Haagmans, A. Regan, A. Ginati, Y. Menard
ESA – ESTEC, Noordwijk – The Netherlands

ABSTRACT

ESA`s Living Planet Programme [1], [2] includes two types of complementary user driven missions: the research oriented Earth Explorer missions and the operational service oriented Earth Watch missions. There are two classes of Earth Explorer missions, Core and Opportunity. In response to a call for Opportunity mission proposals in 2001, which resulted in 25 proposals being submitted by early 2002, three mission candidates, ACE+, EGPM and Swarm, were chosen for feasibility study. At the end of the feasibility study Swarm was approved for implementation as the fifth Earth Explorer mission to be launched in 2009.

Celebration: Swarm selected in 2004

Gauthier Hulot

2013

2024

Mission Advisory Group including the 3 lead proposers

Implementation

Exploitation

Extension

Continuation

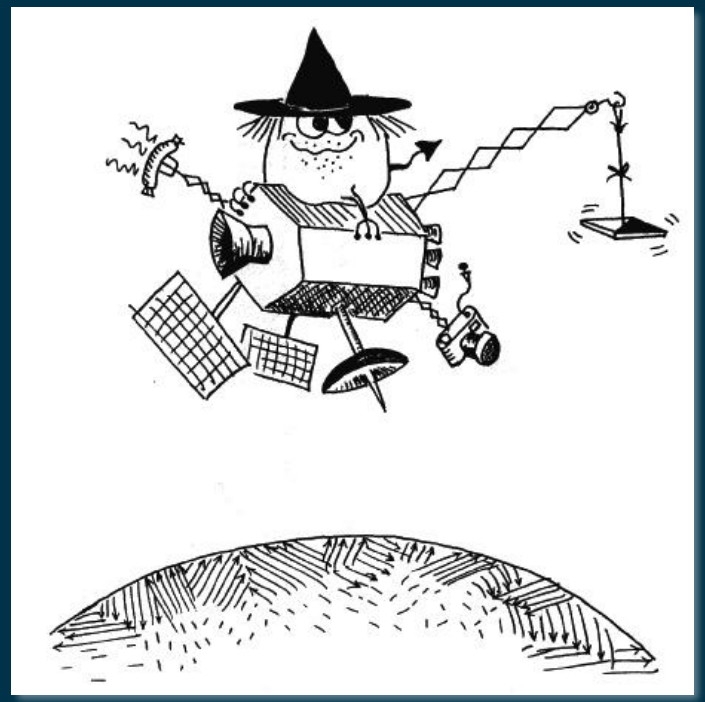
2004

Eigil Friis-Christensen

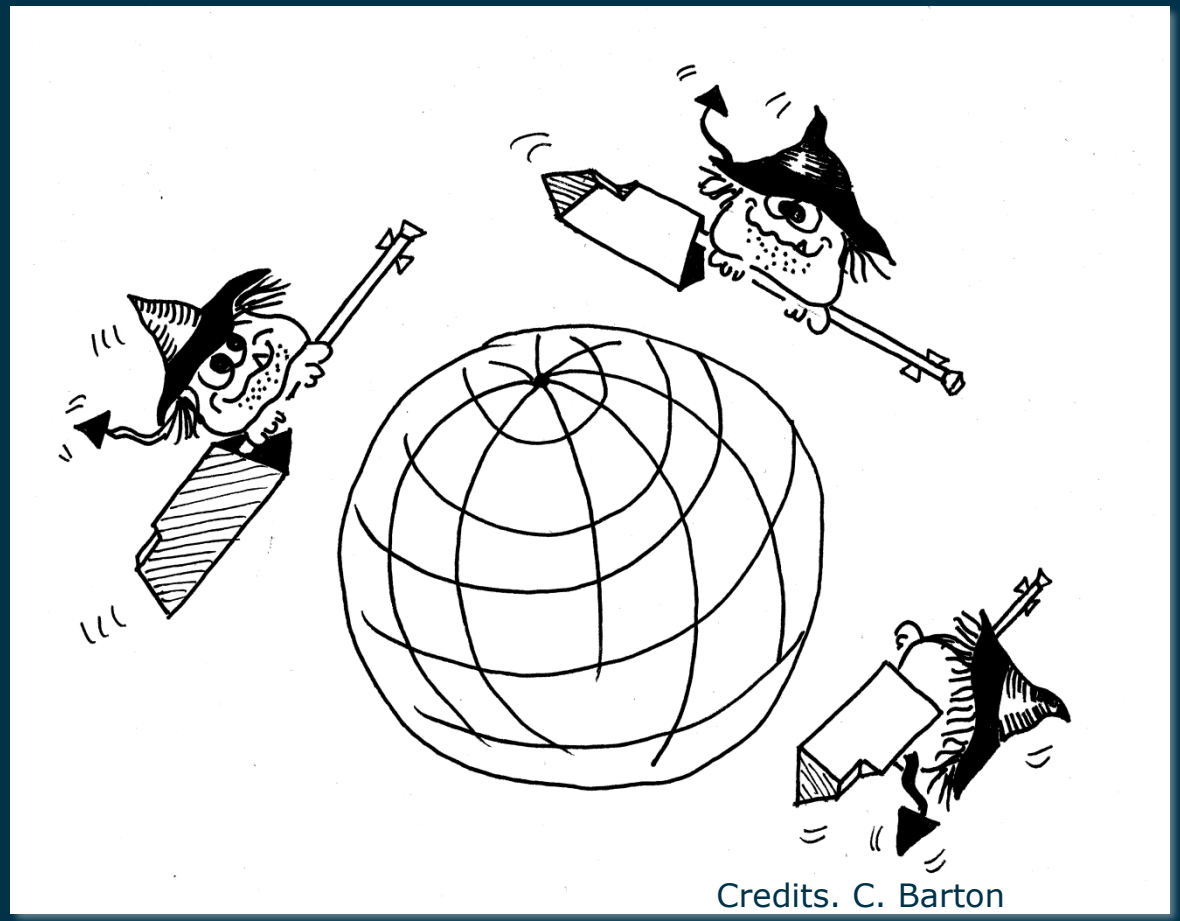
Hermann Lühr

Early Design Phase of the Swarm Project

First Satellite Design



First Constellation Design



Credits. C. Barton

Implementation Phase: change in design - less CHAMP

2002

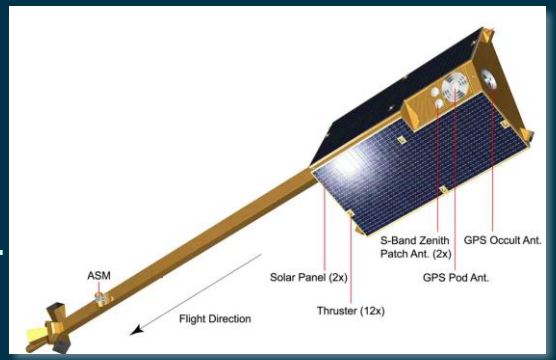
Credits: Airbus

2013

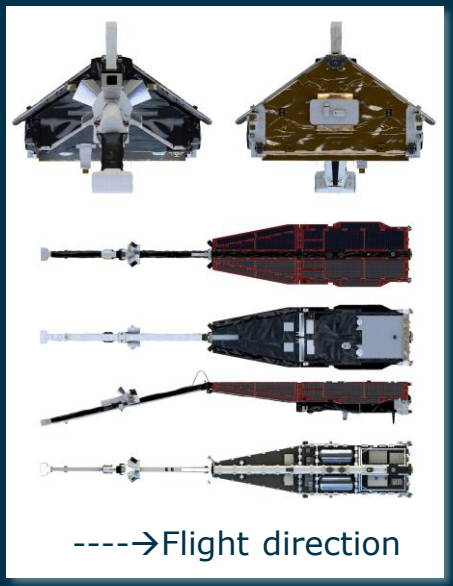
Feasibility

Implementation

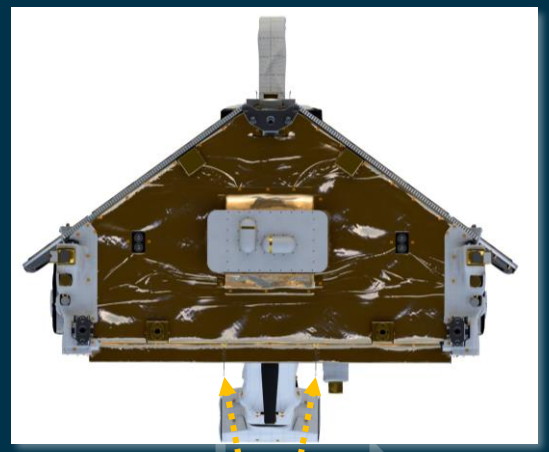
2004

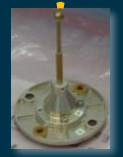


No GNSS occultation -> boom to the back



Implementation Phase: too much mass to launch?





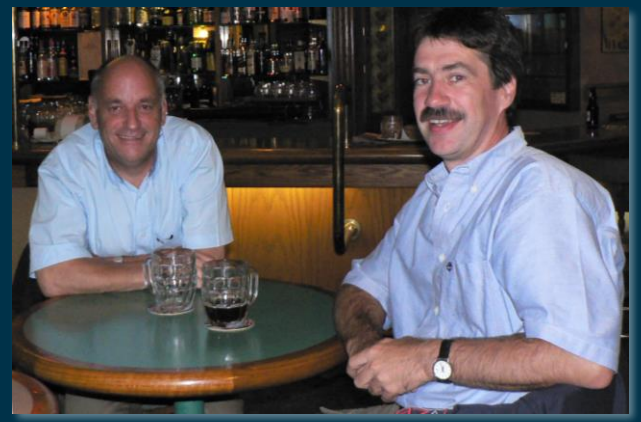
Feasibility

2013

Implementation

2004

Langmuir probes from IRF, Uppsala, Sweden



Visit at IRF with Nico Stricker: a huge "probe" was situated in the entrance hall
–> picture taken with Nico next to this "prototype" Langmuir probe
-> advice to Yvon Menard our project manager: need for a bigger launcher!

Implementation Phase: too much mass to launch?

2002

ESA review meeting: during Phase B

Too much launch mass!

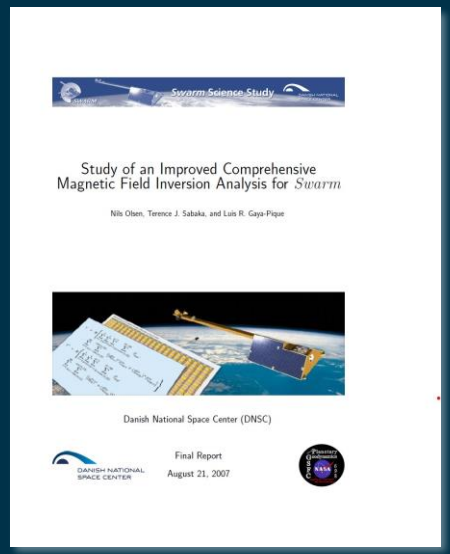
Question: Which instrument to remove, the accelerometer?

2013

Feasibility

Implementation

2004



Answer: End-to-end+ study: change of initial constellation saves fuel without impacting the science

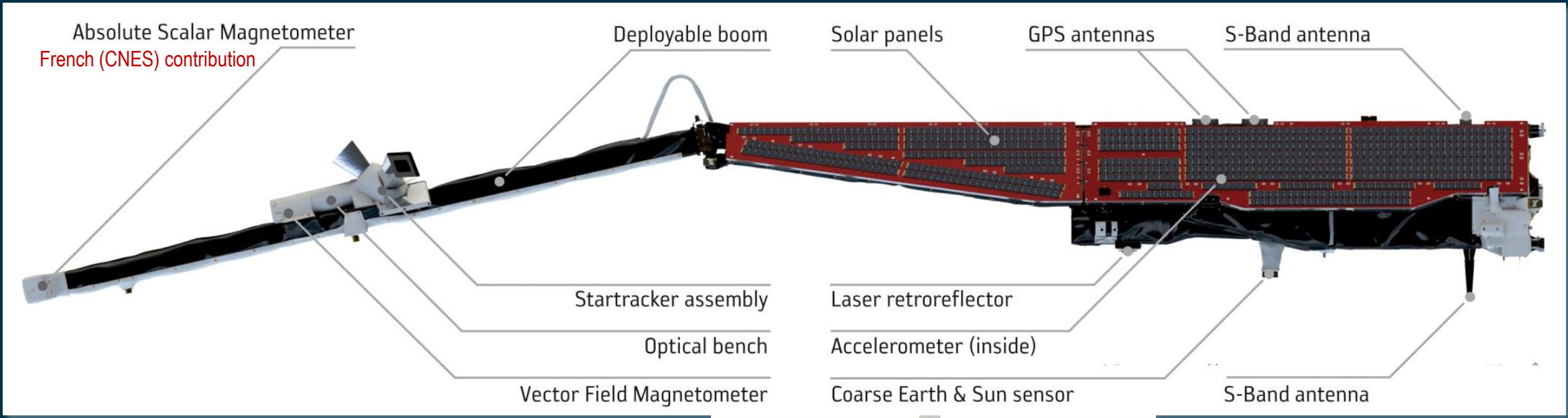
Realism before launch: plenty of mass left, so tanks are filled up with fuel

Situation after in orbit commissioning: approximately 60kg of fuel left in each satellite!

Accelerometer kept (unfortunately as "experiment") but in the meantime with good products for science analysis

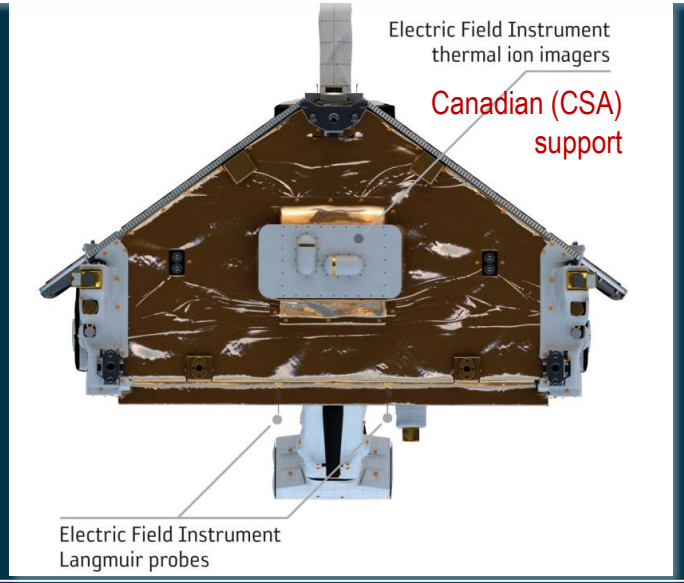

Credits: Airbus

From a magnetic satellite to a magnetic field satellite



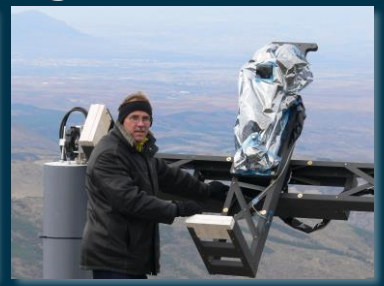
Flight direction →

- Total length of ~9m
- 468kg incl. 106kg of fuel;
- ~1.0 m² cross section
- 4 years lifetime

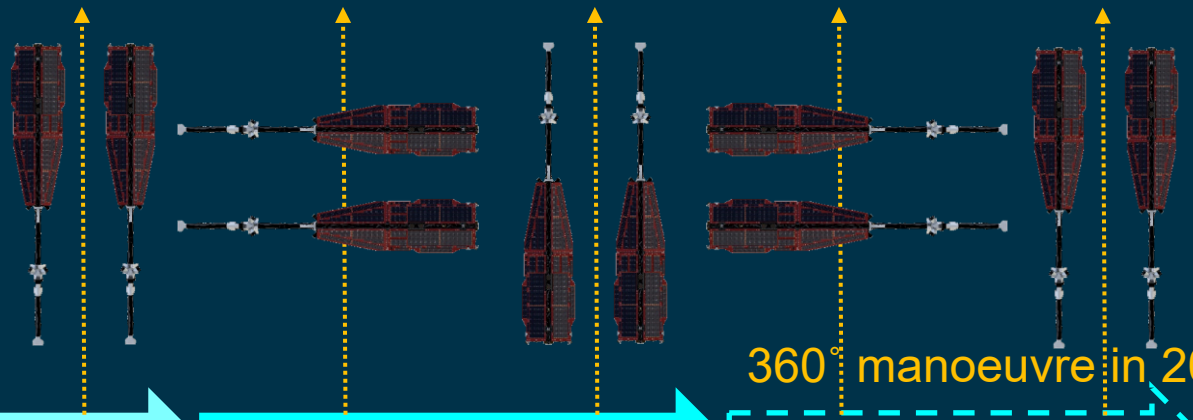


Magnetic properties and effects: tackled by design, pre- and inflight characterisation

Optical bench alignment, DTU



2013

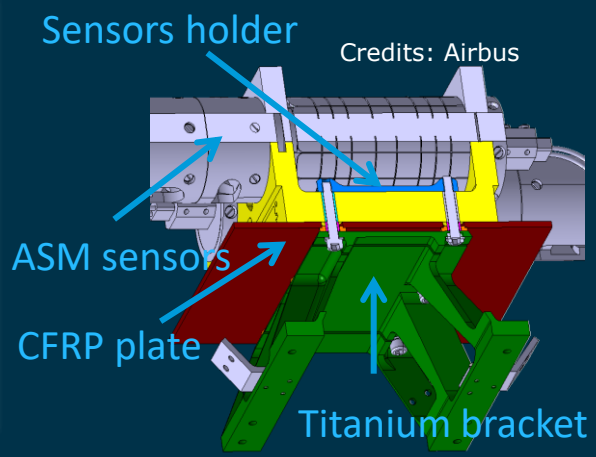


360° manoeuvre in 2014

Feasibility → Implementation → Exploitation → Extension → Continuation

Sun angle related effect, tackled by scientist, industry and ESA

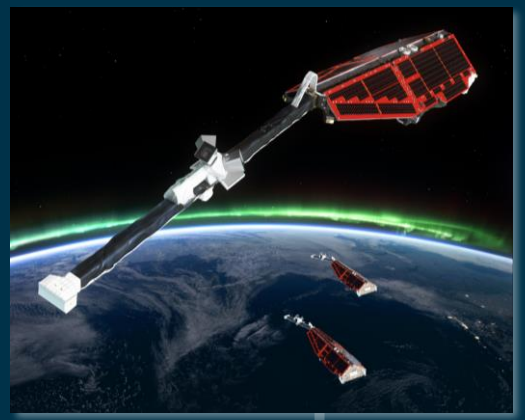
Magnetic characterization, IABG



2018

In-orbit constellation alignment (designed in Phase B) successfully applied by science team

Implementation Phase: competitions?

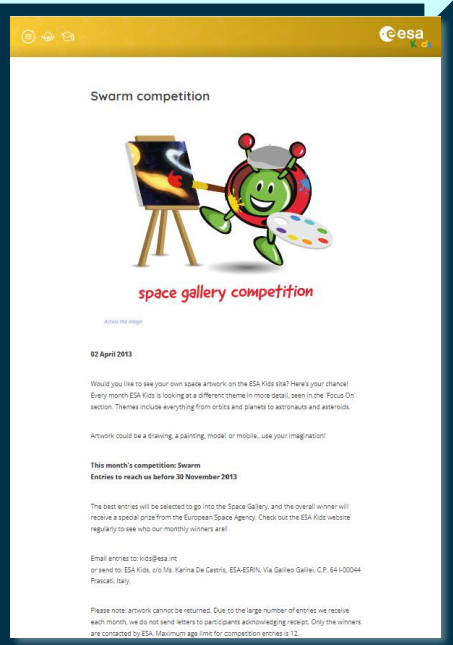


Feasibility

Implementation

2004

Kids Swarm art competition 2013

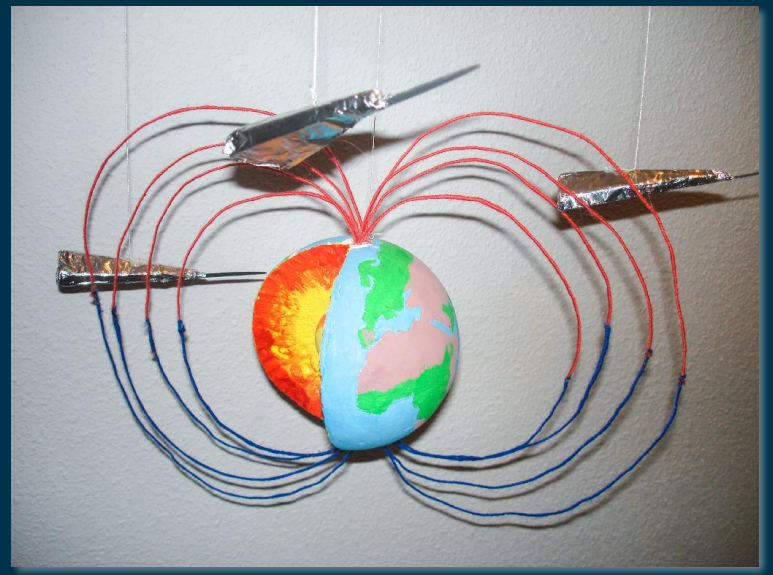


2013

Idea for a naming competition for the three satellites

Airbus proposed: Blood, Sweat and Tears

The winner is: Swarm A, B & C



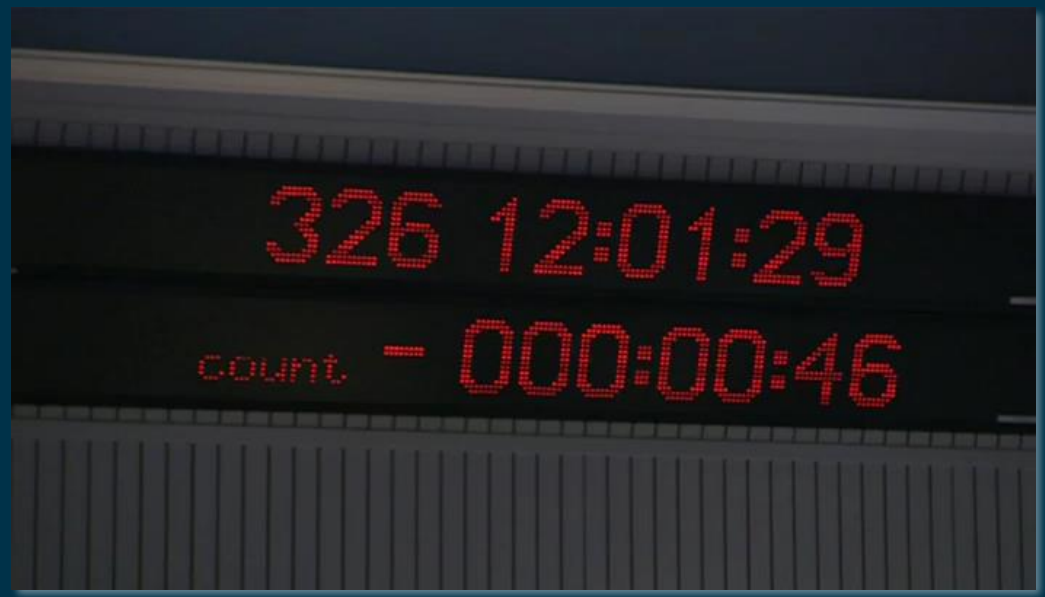
Winner: Claudia from Spain!

Implementation Phase: towards launch 22 November 2013

2013

Feasibility

Implementation

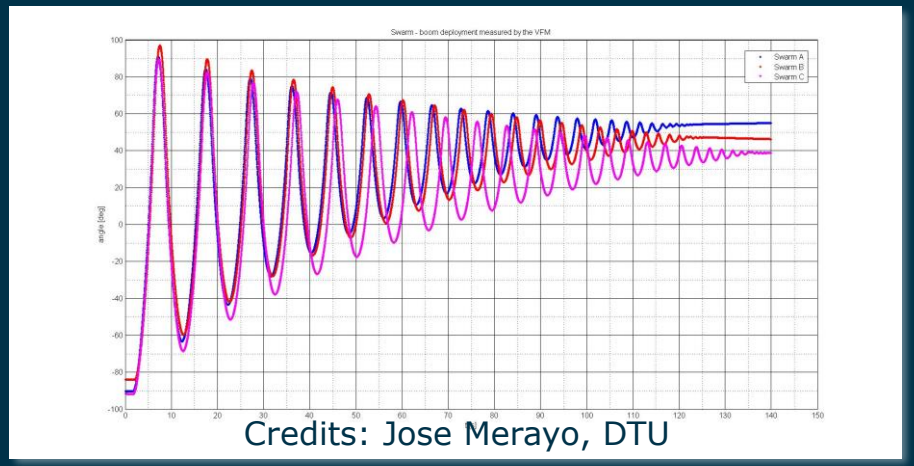


Implementation Phase: Just after launch

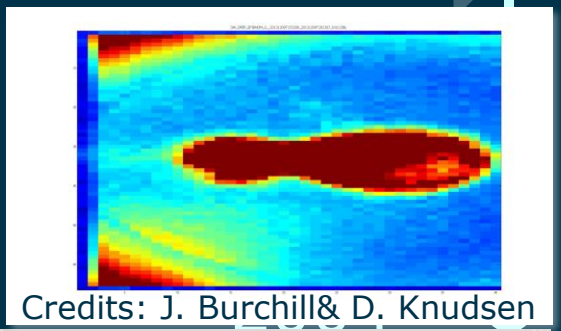
2013

Feasibility

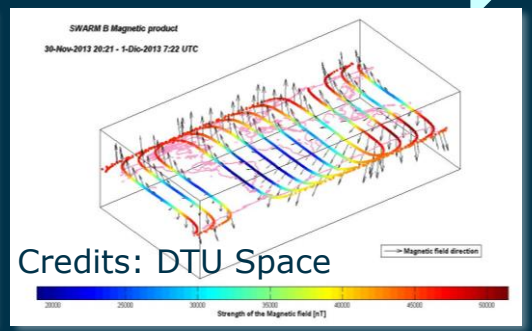
Implementation



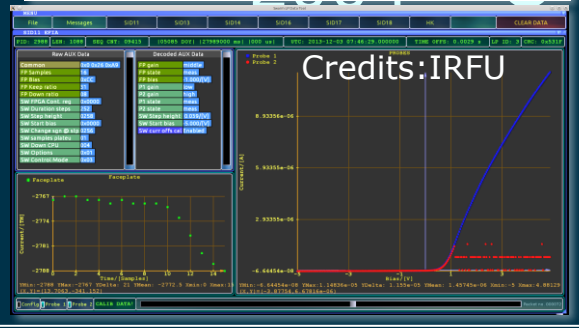
Credits: Jose Merayo, DTU



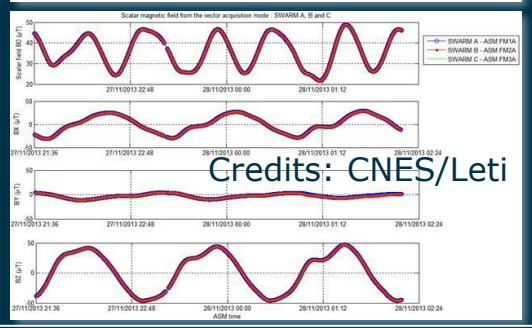
Credits: J. Burchill& D. Knudsen



Credits: DTU Space



Credits:IRFU

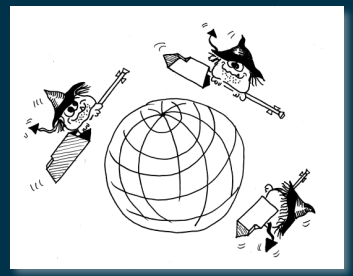


Credits: CNES/Leti

Swarm science meetings

1st science meeting, Nantes,2006

Feasibility



Credits: Charles Barton

2004

Implementation

2nd science meeting, Potsdam,2009

2013

Exploitation

3rd science meeting, Copenhagen,2014

2018

Extension

2024

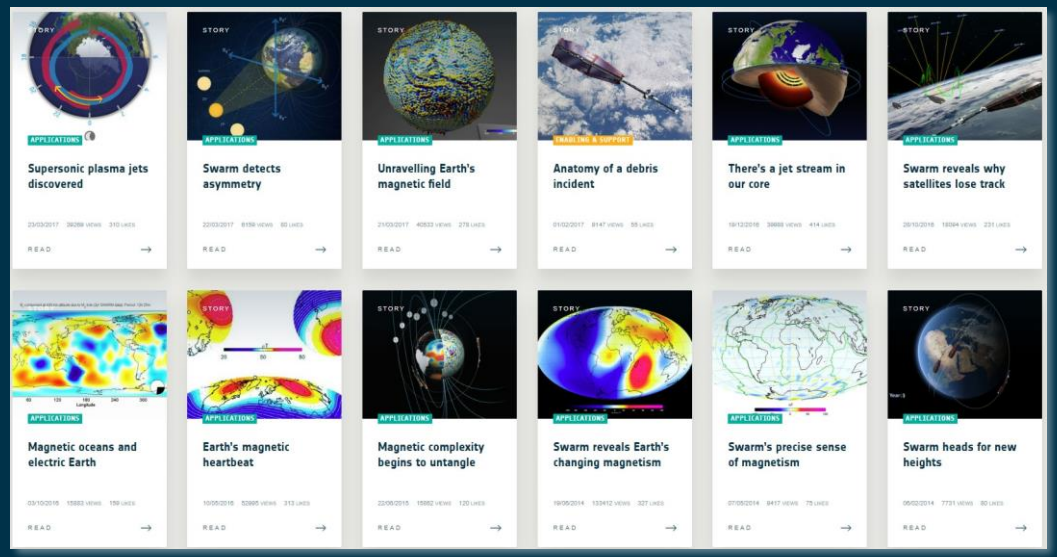
Continuation

Now, Copenhagen, 2024

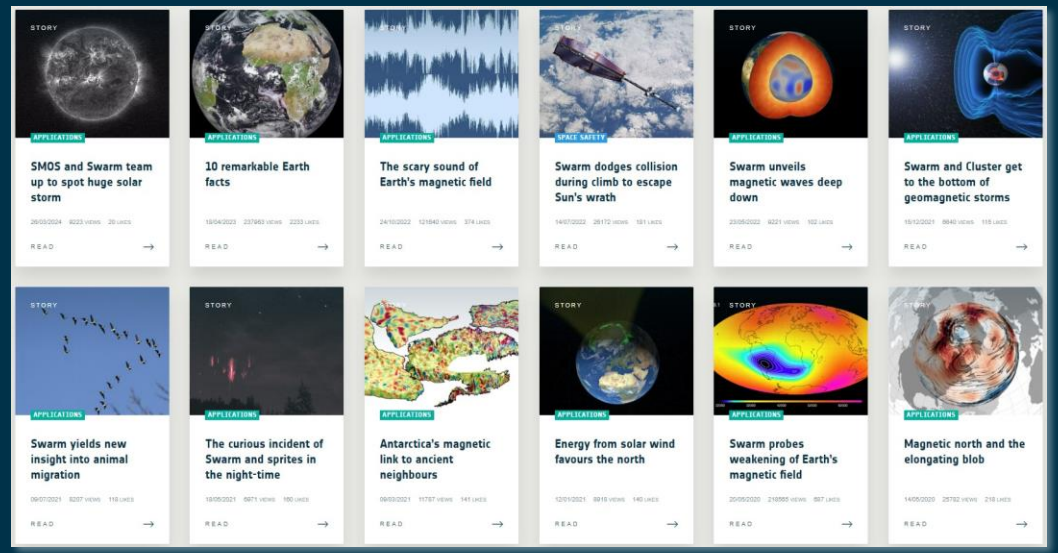
4th science meeting, Banff,2017

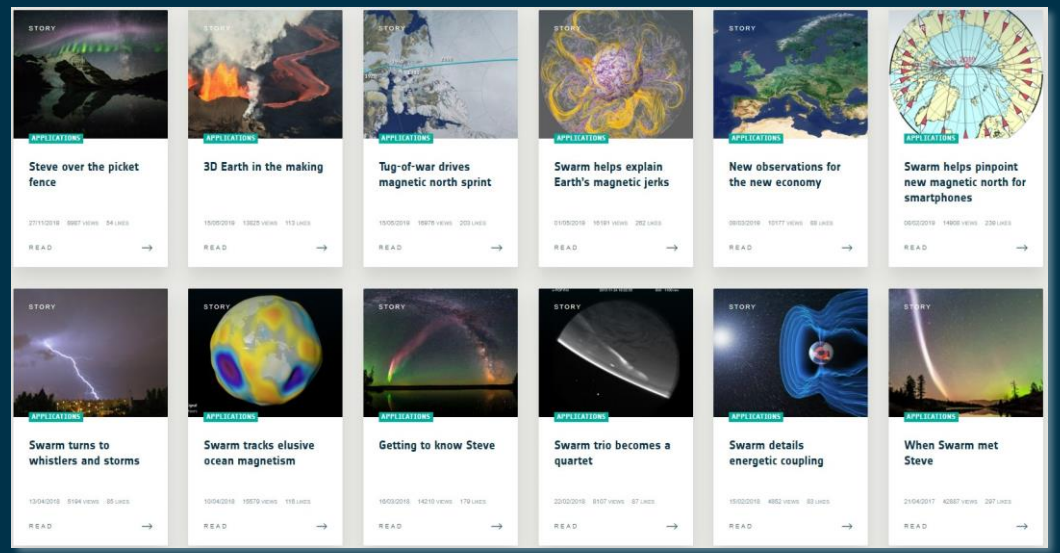
Swarm science selected highlights on ESA webpages

Big success due to the science and applications community

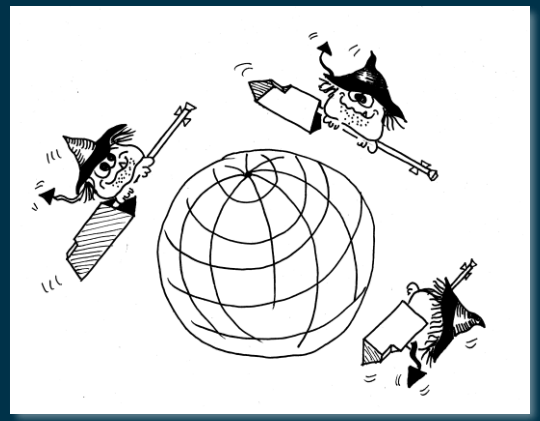


Inclusive mission:
From Core to Space
From Compass to Animal migration

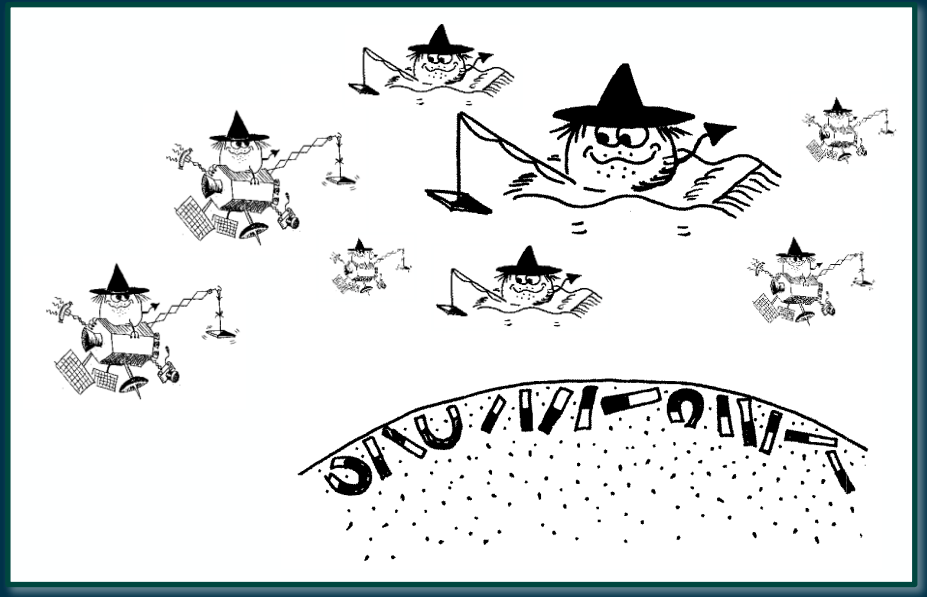




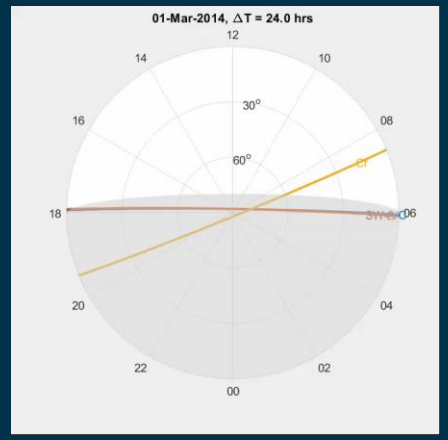
Swarm, other satellites, mini follow-on and Sentinel?



+ e-POP, Cluster, platform magnetometers, CSES ….



2013



Credits: Nils Olsen

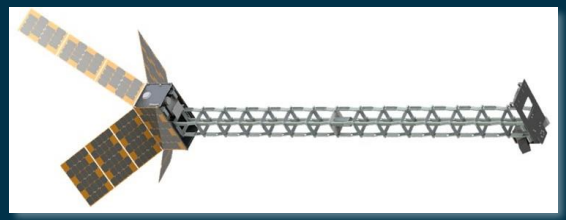
2024

Exploitation

Extension

Continuation

+ NanoMagSat constellation



2018

Pre-cursor for a "cheap" Sentinel continuation of a key Earth observable

How *swarm* became *Swarm*

My training period
experience in Finland 1986

A real swarm

Before going to bed you kill most of the swarm in the cabin, so 3 become the swarm remainder which was given the name Swarm

Congratulations to all Swarm teams in the Swarm community, industry and ESA with one of the most exiting, mysterious, intriguing and useful missions of ESA