Norwegian participation in space and satellite activities
AGF-216

Pål Brekke

Norwegian Space Agency

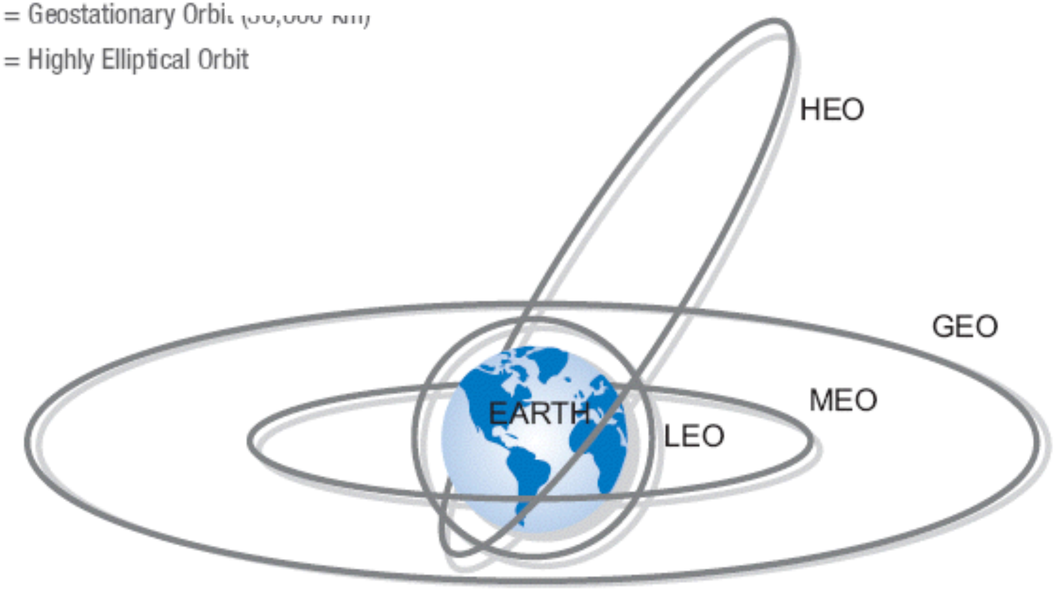
Satellite orbits

LEO = Low Earth Orbit (100-1,500 km)

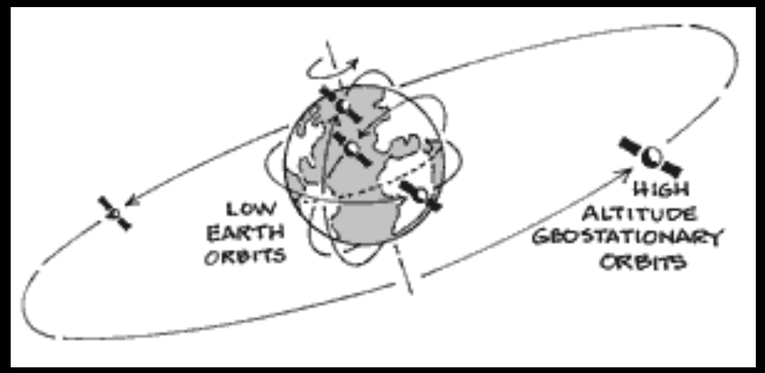
MEO = Medium Earth Orb (ca. 20.000 km)

GEO = Geostationary Orbi[illegible]

HEO = Highly Elliptical Orbit



Not to scale



Orbital Altitudes of many significant satellites of earth

Scale: 1 Pixel = 10 Km / 6.2 mi

2000 Km / 1243.7 mi

0 km / mi - Sea Level.

37.6 km / 23.4 mi - Self Propelled Jet Aircraft Flight Ceiling (Record Set in 1977).

215 km / 133.6 mi - Sputnik-1 The first artificial satellite of earth.

340 km / 211.3 mi - International Space Station.

390 km / 242.3 mi - Former Russian Space Station MIR.

595 km / 369.7 mi - Hubble Space Telescope.

[700 - 1700 km] - Polar Orbiting Satellites.
[435 - 1056 mi]

LEO Zone (Low Earth Orbit)

MEO Zone (Medium Earth Orbit)

2000 Km / 1243.7 mi

HEO Zone (High Earth Orbit)

600 - 800 km / 372.8 - 497.1 mi - Sun-synchronous Satellites
These satellites orbit the Earth in near exact polar orbits north to south.
They cross the equator multiple times per day and each time they are at the same angle with respect to the sun. Satellites on these types of orbits are particularly useful for capturing images of the Earth's surface or images of the sun.

20,350 km
GPS (Global Positioning System) Satellites
These Satellites are on a Semi-synchronous Orbit (SSO)
meaning that they orbit the earth in exactly 12 hours (twice per day).

35,786 km
Geosynchronous (GEO) and Geostationary (GSO) Satellites
Geosynchronous satellites orbit the Earth at the same rate that the Earth rotates. Thus they remain stationary over a single line of longitude.
A geostationary satellite will remain in a fixed location as observed from the earths surface, allowing a satellite dish to be aligned to them.
This particular altitude marks the border between the MEO and HEO Zones.

Scale: 1 Pixel = 100 Km / 62.1 mi

20000 Km / 12437.4 mi

MEO Zone (Medium Earth Orbit)

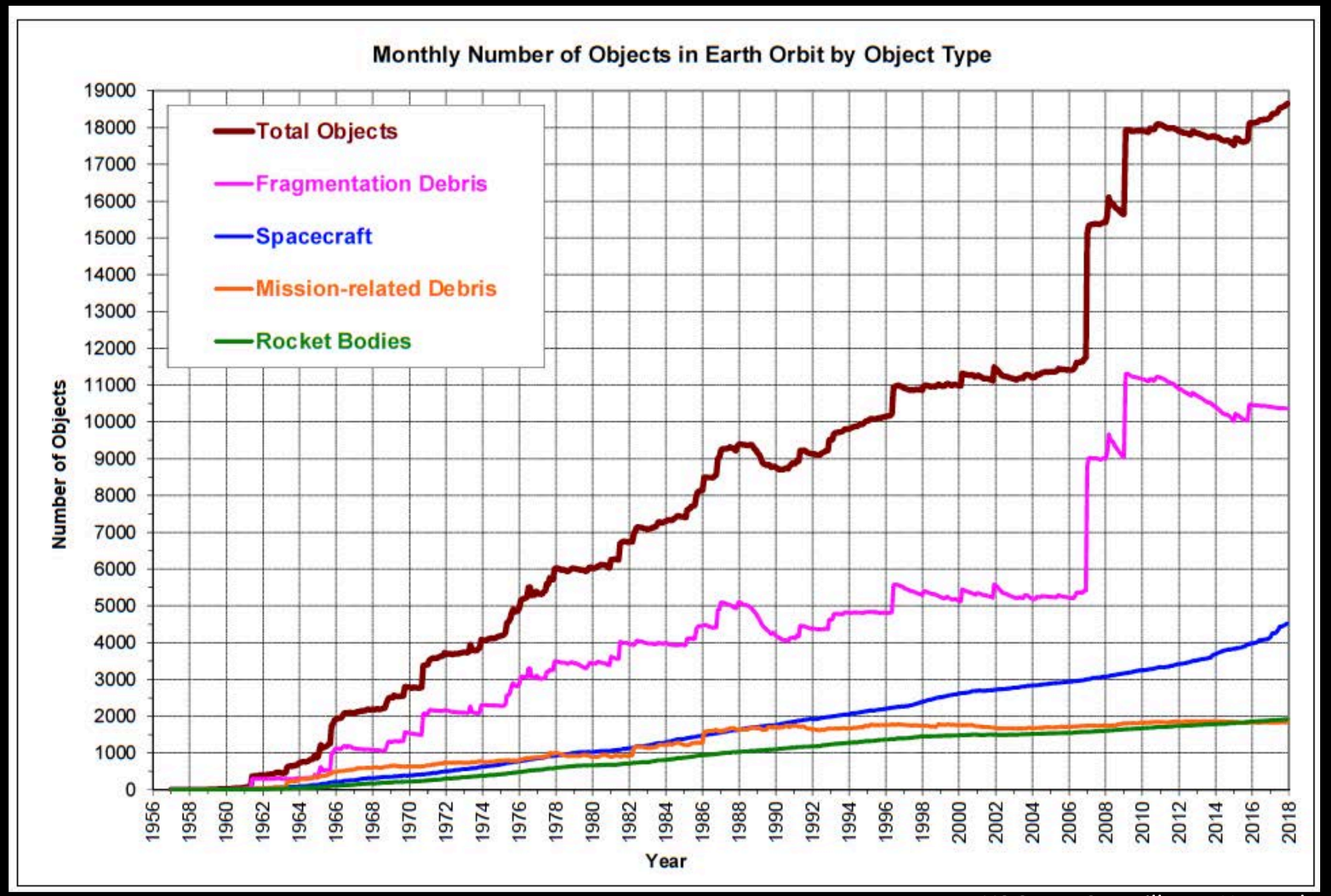
HEO Zone (High Earth Orbit)

LEO Zone (Low Earth Orbit)

384,000 km
The Moon

Satellites and Space Debris

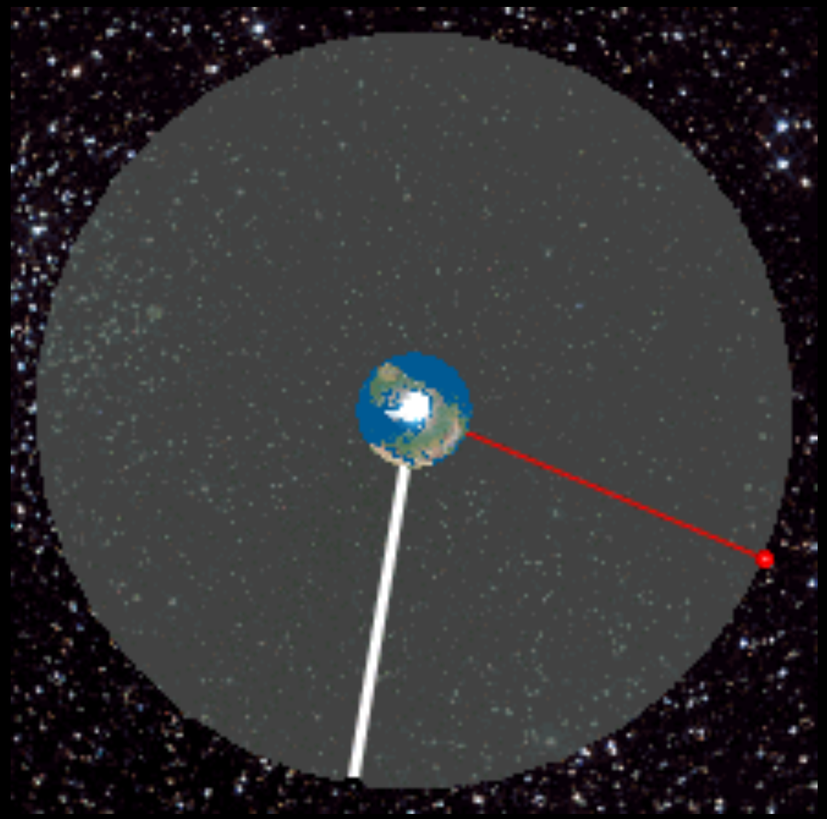
- 8000 satellites launched
- 4850 still orbiting
- 2000 are operating
- 20.000 objects > 10 cm
- 700.000 small objects



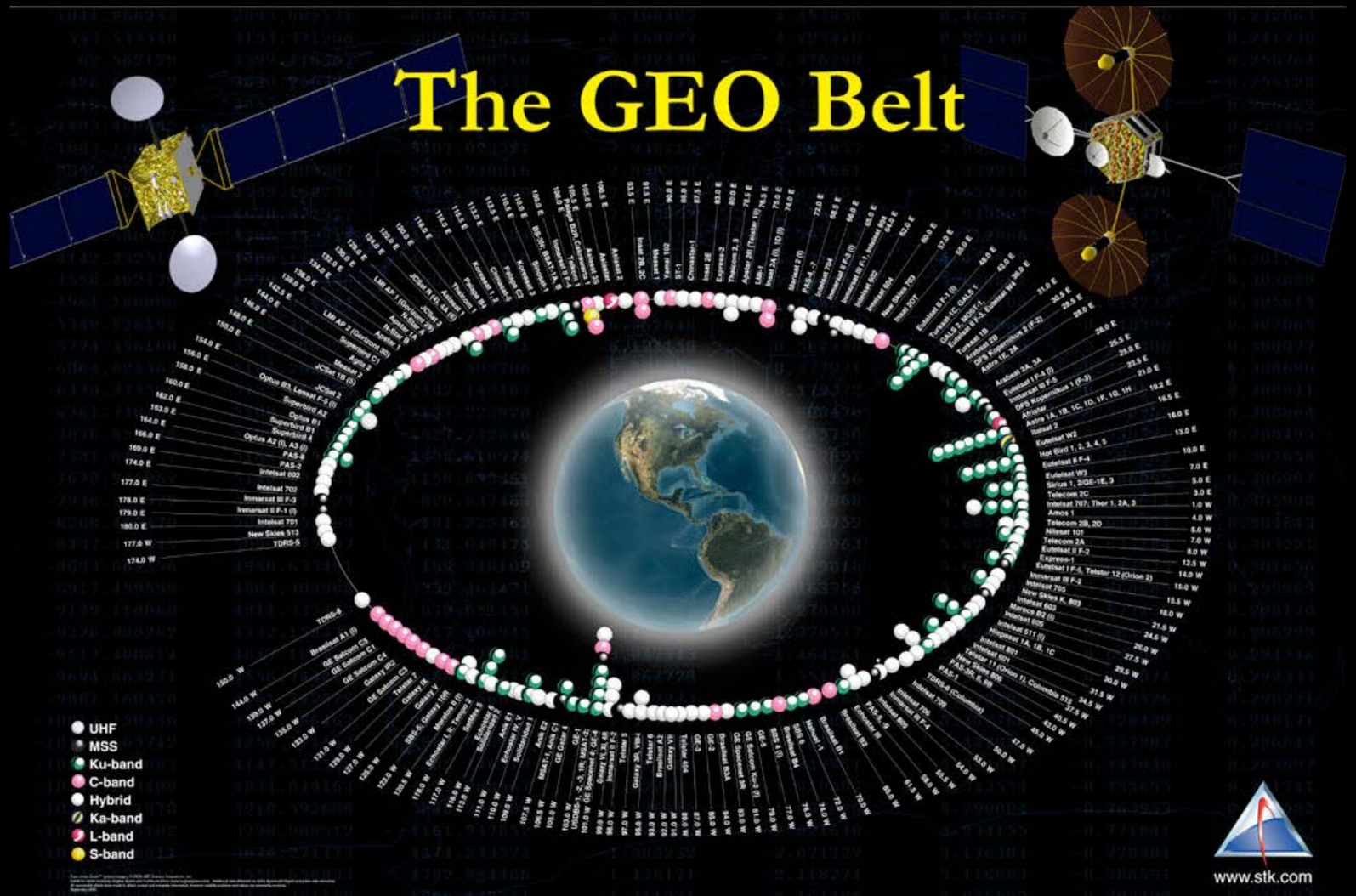
US Space Surveillance Network

Geostationary satellites (GEO)

- Telecommunication
- TV-satellites
- Weather satellites (GOES, Meteosat)

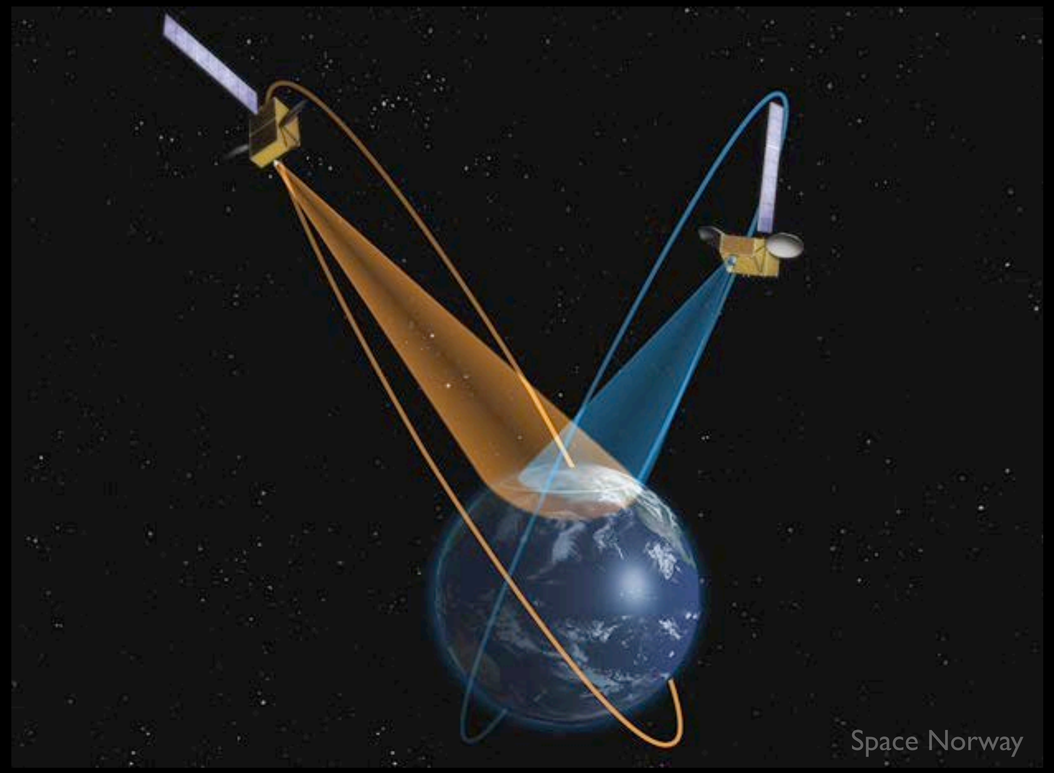


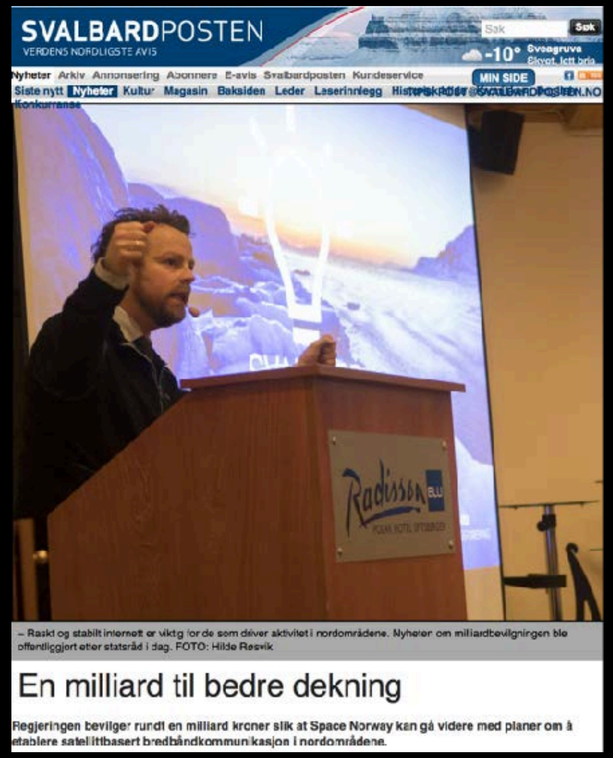
Wikipedia



High inclination orbits (HEO)

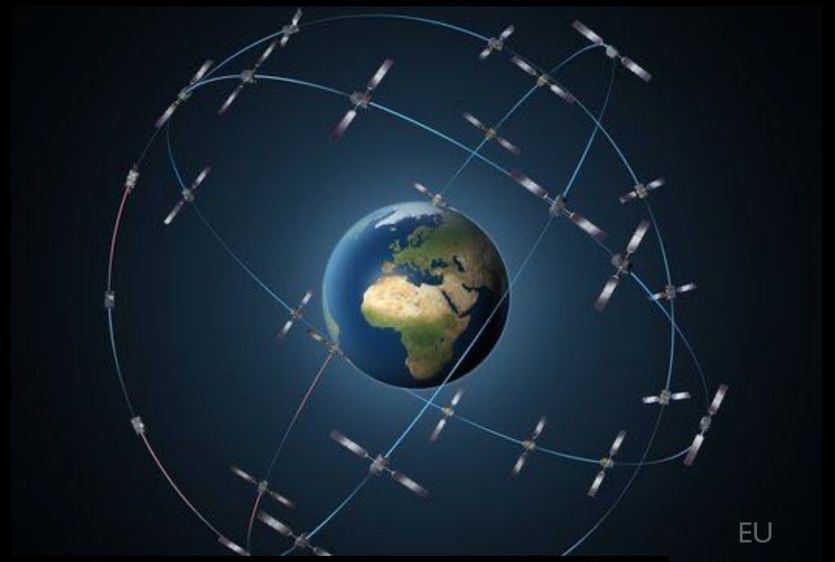
- Will make it possible to provide communication and broadband internet over the polar regions
- Space Norway is leading the development of this project.

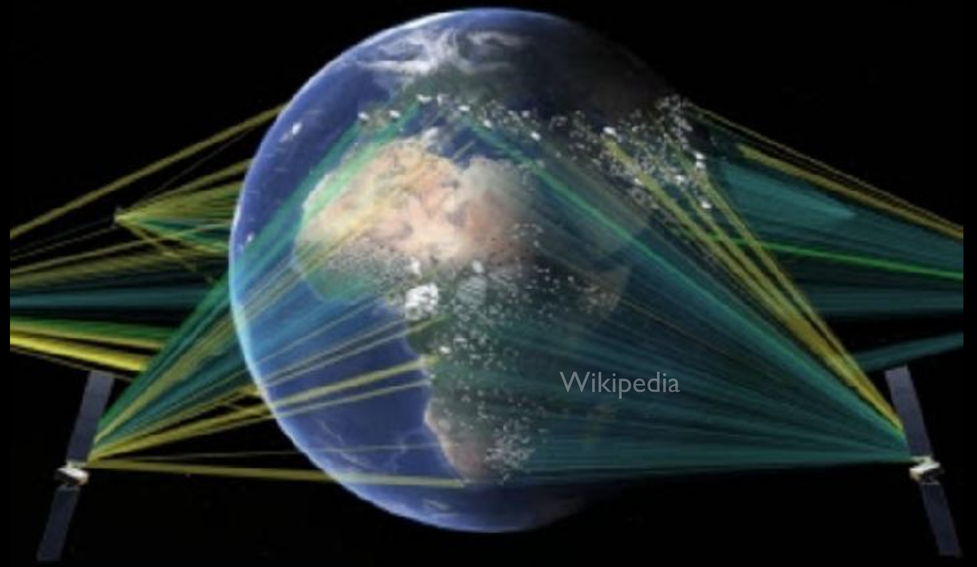




Medium Earth orbits (MEO)

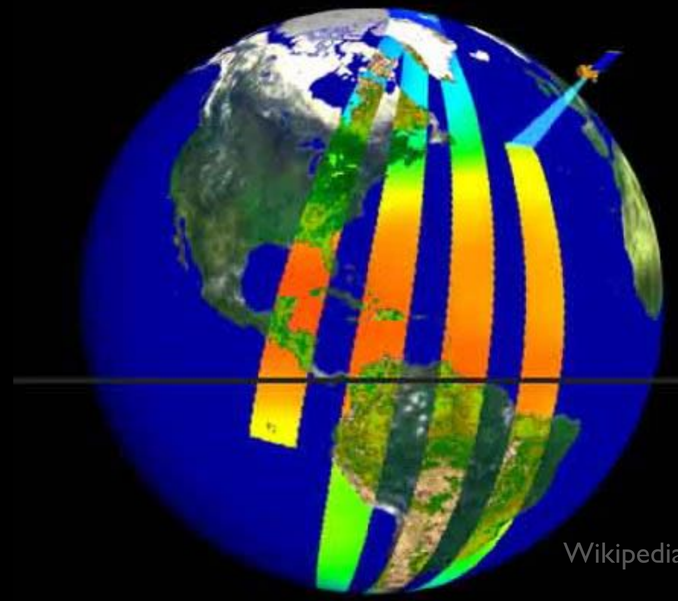
- GPS (20.200 km)
- Galileo (23.200 km)
- Glonass (19.100 km)





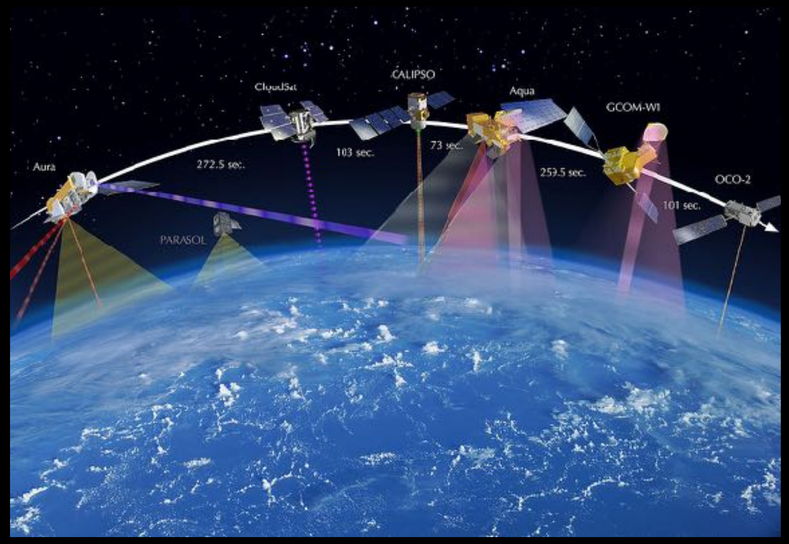
Low Earth Orbits (LEO) - polar

- Earth observation
- Astronomy/solar physics
- Spy satellites
- Some telecom (Iridium, Globalstar)



Wikipedia

KSAT

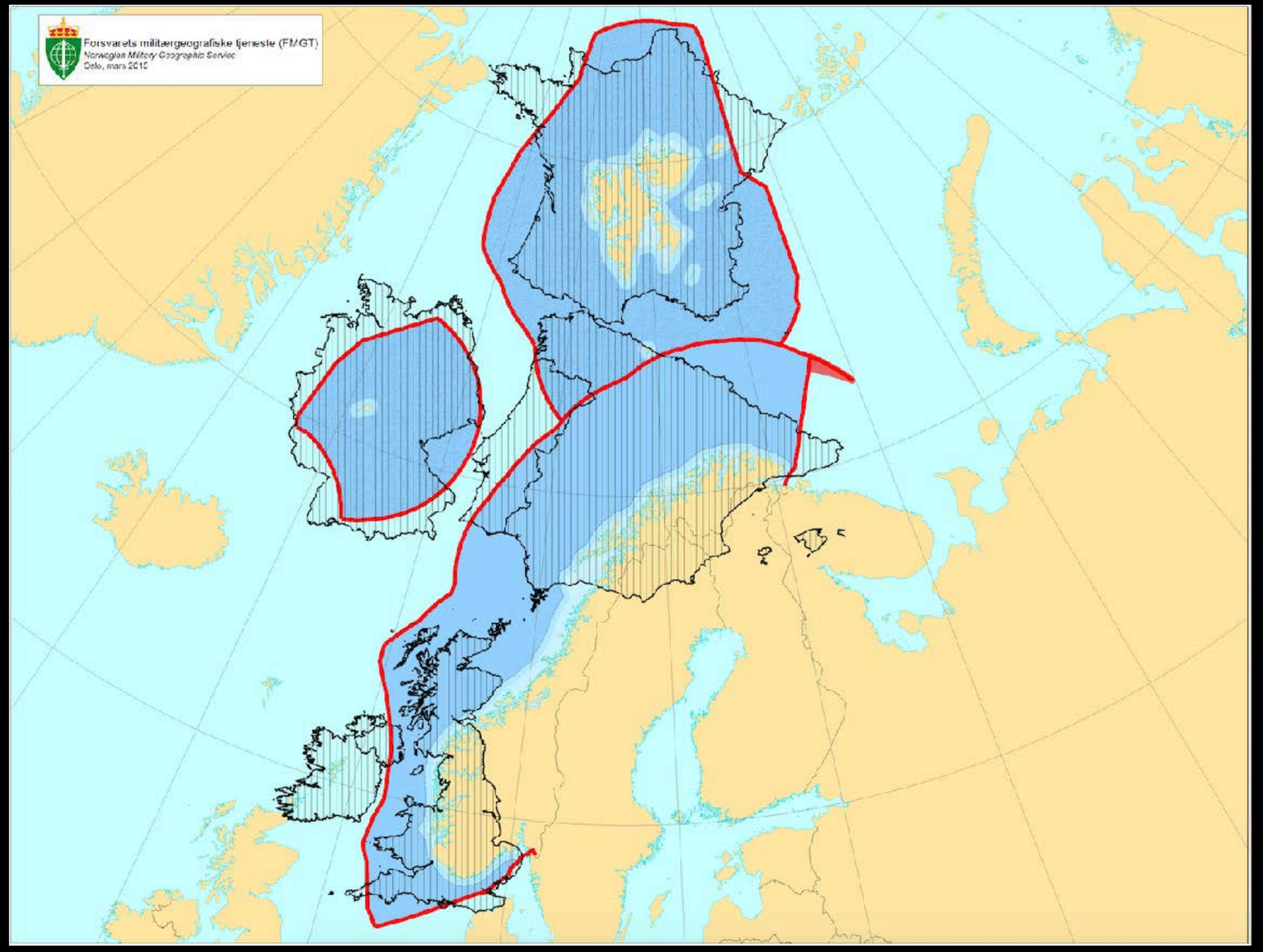


NASA

Norway - small space nation on top of the world

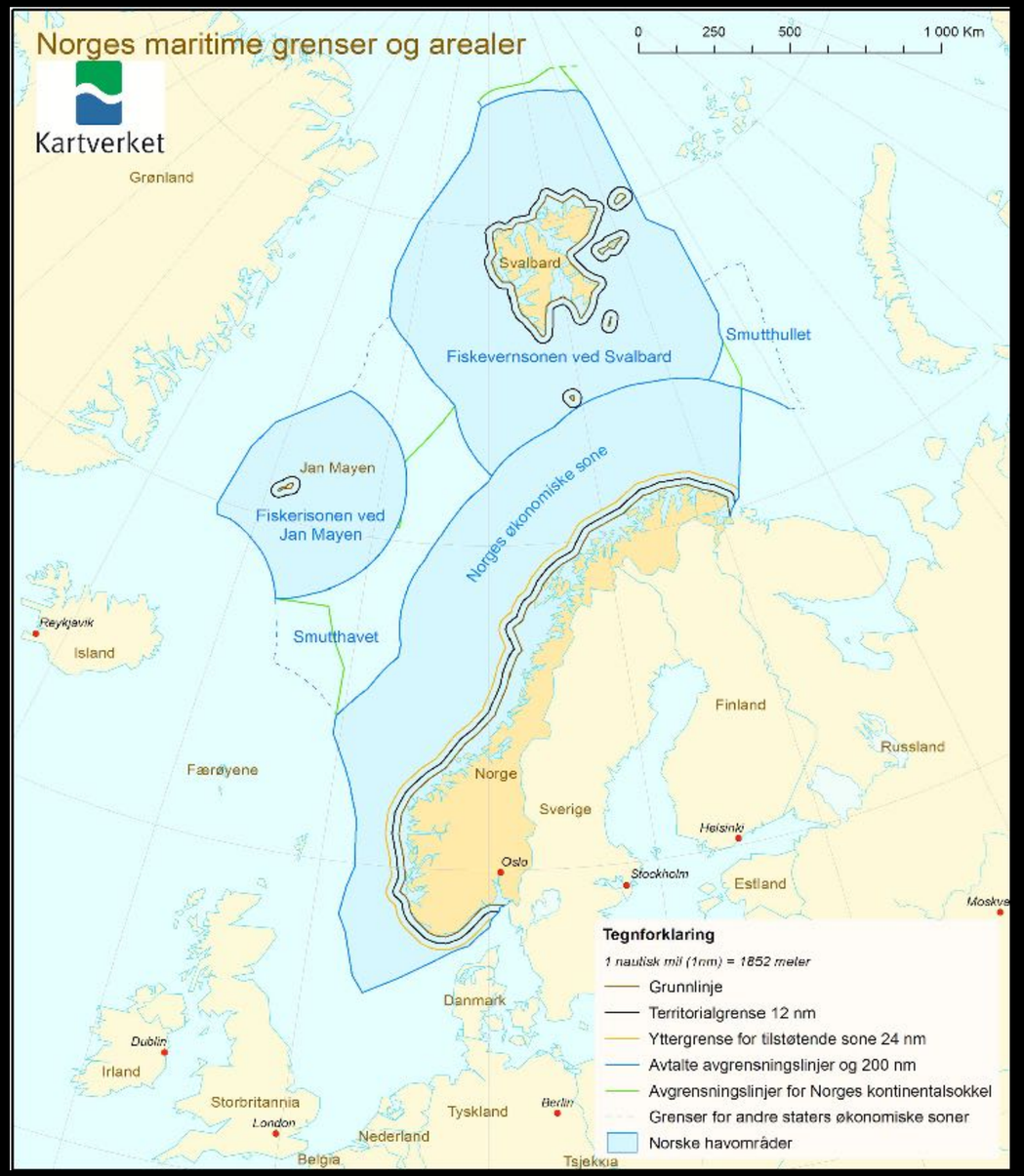

1 979 179 km²
OCEAN
to monitor

Corresponds to half EU



Why is the Arctic important to Norway?

- Norway has apart from Russia, Europe's largest area to manage, mostly in the Arctic or the High Arctic
- Norway and Russia manages one of the worlds largest well managed fish stocks in the Barents Sea
- Exploitation of oil- and gas resources
- More traffic through the Northern Sea Route increases traffic in Norwegian waters
- Opening of new sailing routes across the Arctic basin creates issues concerning safety and rescue



Norsk Romsenter
NORWEGIAN SPACE CENTRE

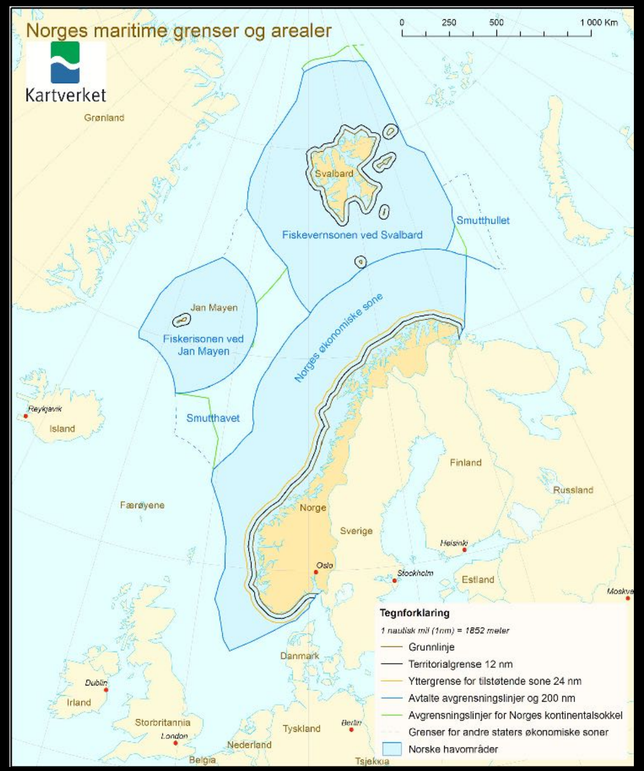
Norwegian Space Agency in brief

- The Norwegian Space Agency is a government agency under the Ministry of Trade and Fisheries
- Established in 1987 when Norway joined the European Space Agency
- Coordinates Norwegian space activities internationally, with focus on ESA and the EU
- Coordinates national space activities
- 40 employees at Skøyen, Oslo
- Budget 2021: NOK 1563 million (≈ € 156 million)

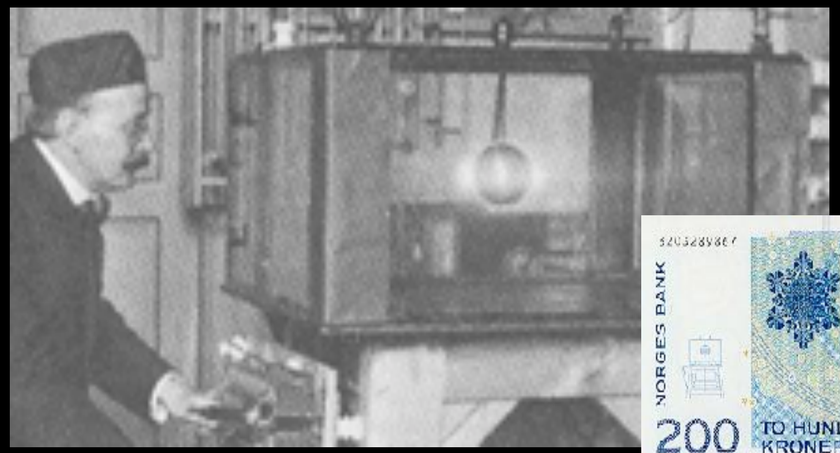
www.romsenter.no

National priorities

- Telecommunication
- Navigation
- Earth observation
- Industrial development based on ESA and EU programmes
- Ground infrastructure
- Space research and space related basic research



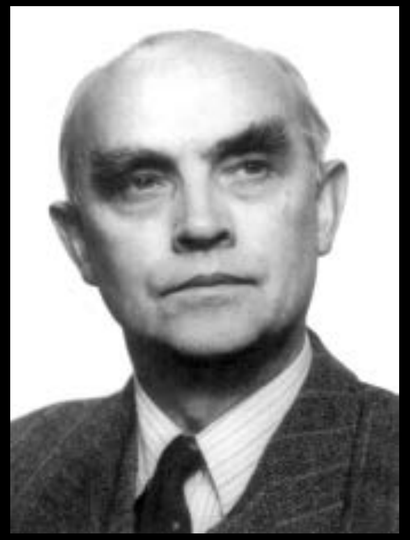
Historic traditions



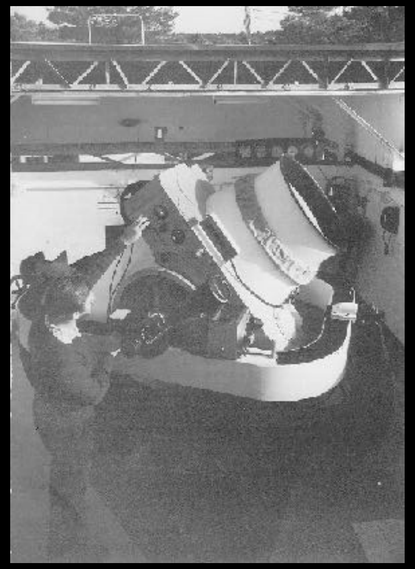
Long traditions within space research due to our location far north :

- Scientific observations of the aurora before 1900
- Birkelands innovative experiment in 1896
- National solar observatory in 1957
- First rocket launch in 1962

Solar Physics in Norway



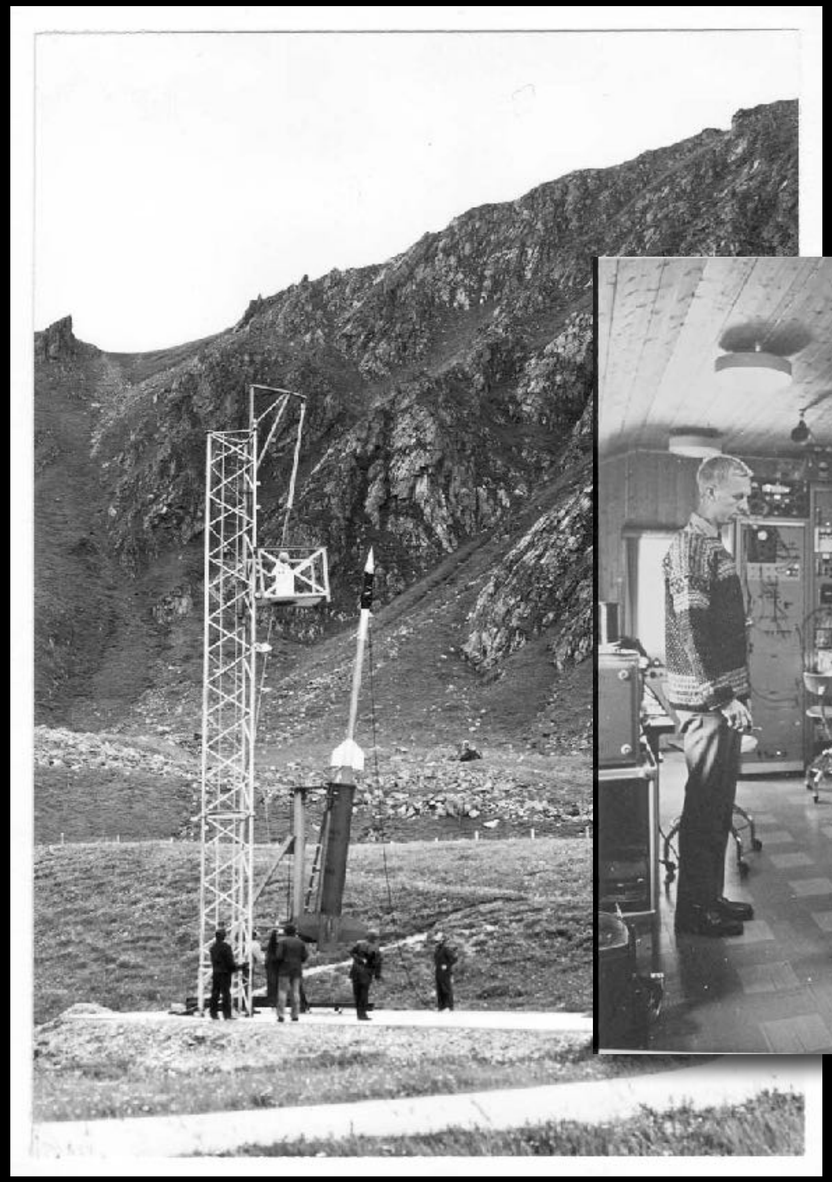
Institute of theoretical astrophysivs was established by Professor Rosseland in 1934 and built with help from the Rockefeller Foundation.

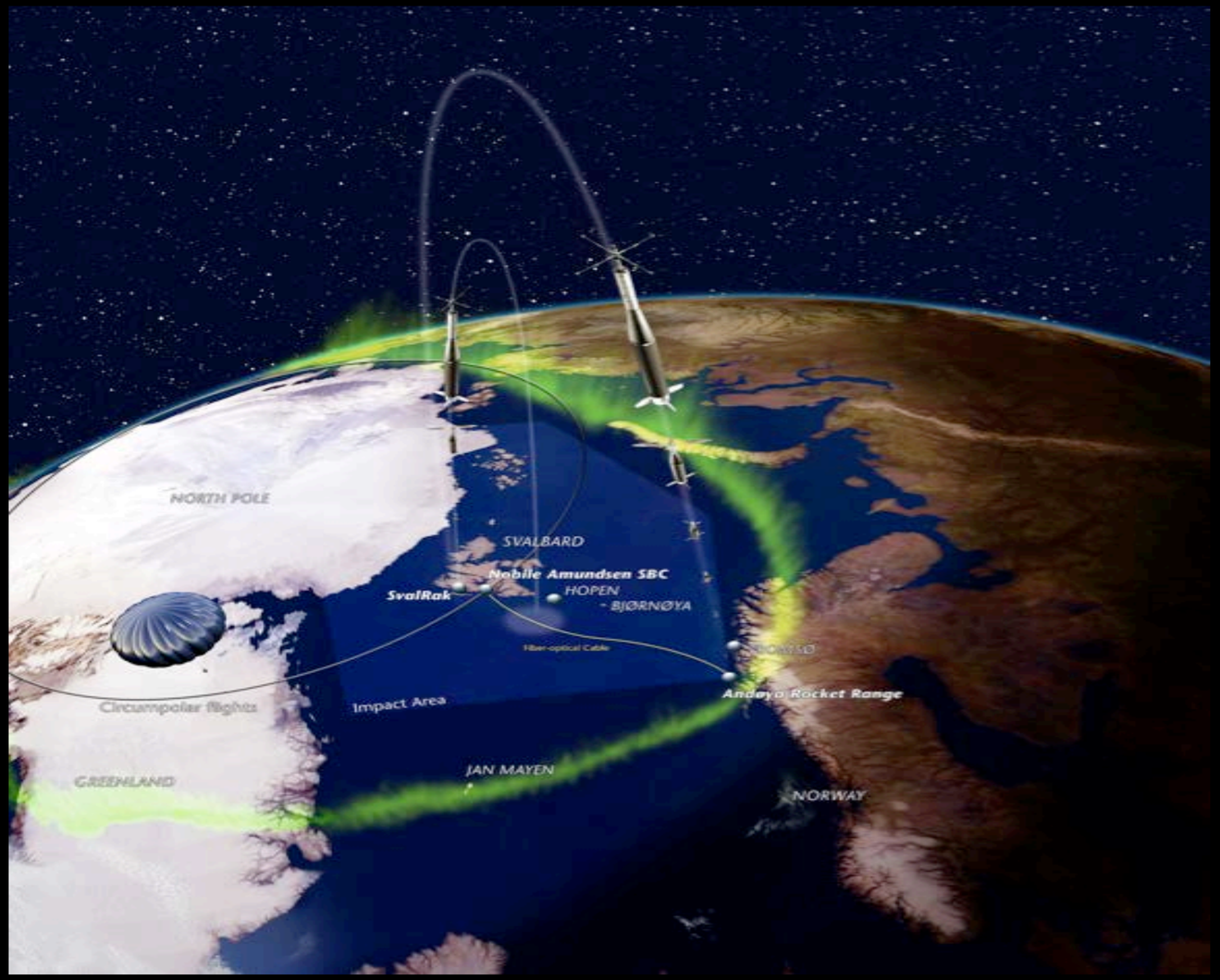


The National Solar Observatory was opened in 1957. Provided satellite tracking for US Airforce in the 50s and 60s.

The very start of space research.

Andøya Rocket Range

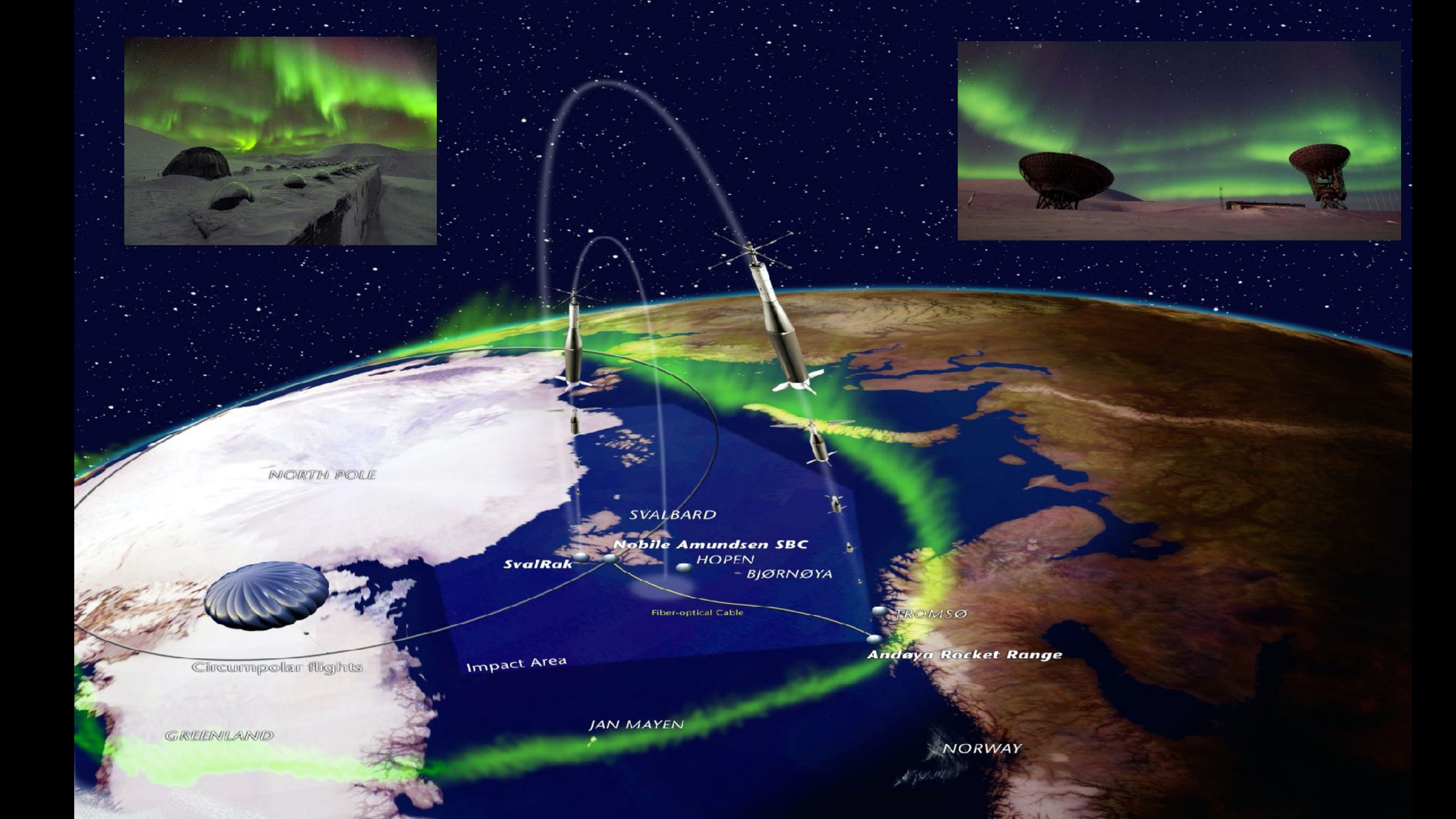




Ferdinand from Oksebåsen, Andøya 18 august 1962

ANDØYA SPACE CENTER

The Cost Effective Entrance to Space


NORTH POLE
SVALBARD
Nobile Amundsen SBC
SvalRak
HOPEN
BJØRNØYA
Fiber-optical Cable
TROMSØ
Andøya Rocket Range
Circumpolar flights
Impact Area
JAN MAYEN
GREENLAND
NORWAY

Launches

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Thursday, January 21, 1999 Published at 19:12 GMT

Sci/Tech

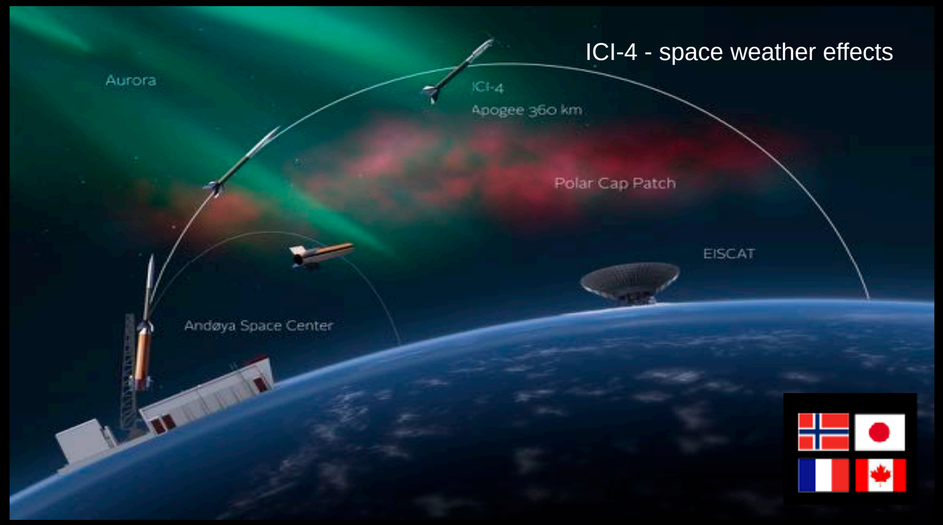
Successful Caper in Norway

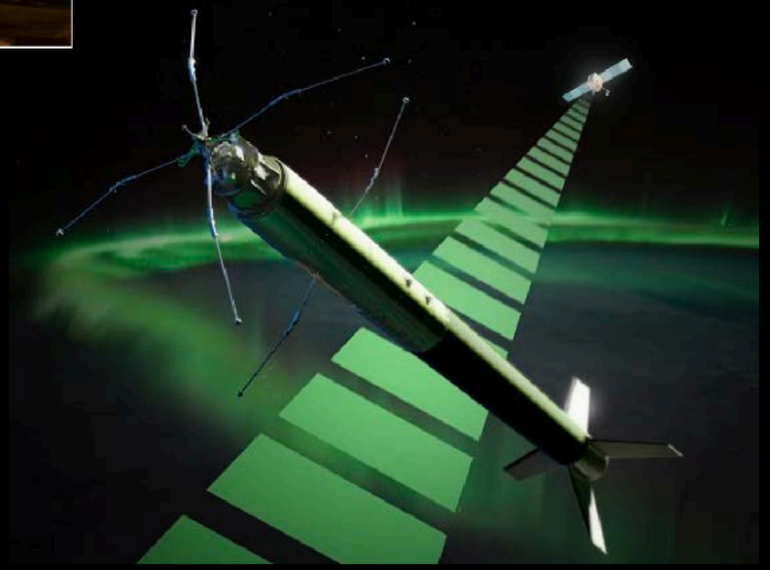
Poor conditions had delayed the launch

A rocket designed to investigate the "space weather" responsible for the Northern Lights blasted off from a rocket range in Norway on Thursday.

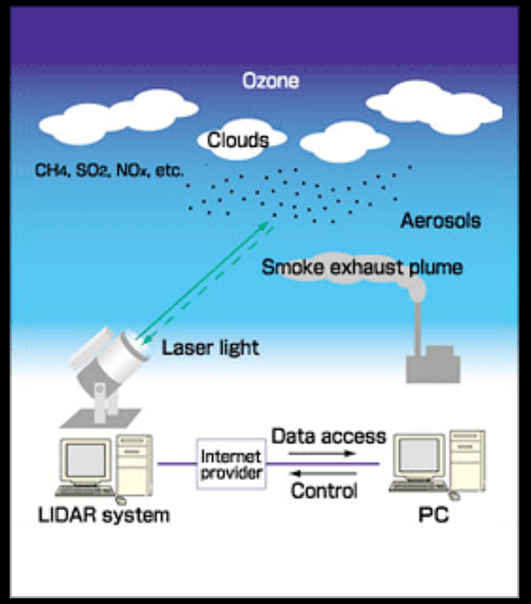
The Caper (Cleft Accelerated Plasma Experimental Rocket) was part of a joint US-Norwegian research project.

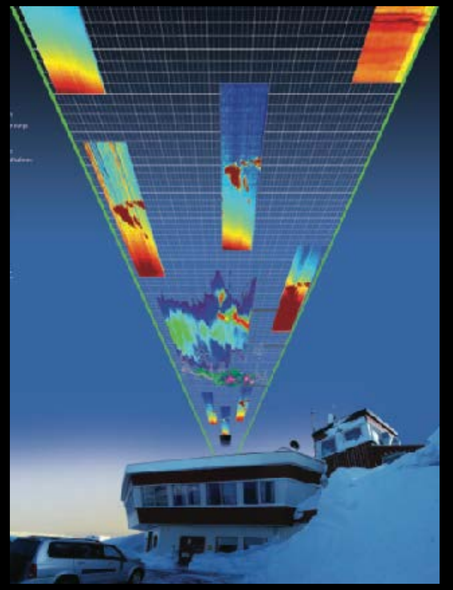
Launch of the NASA Charged Aerosol Release Experiment (CARE II) from Andoya Space Center in Norway, Sept. 16, at 19:06 GMT. -



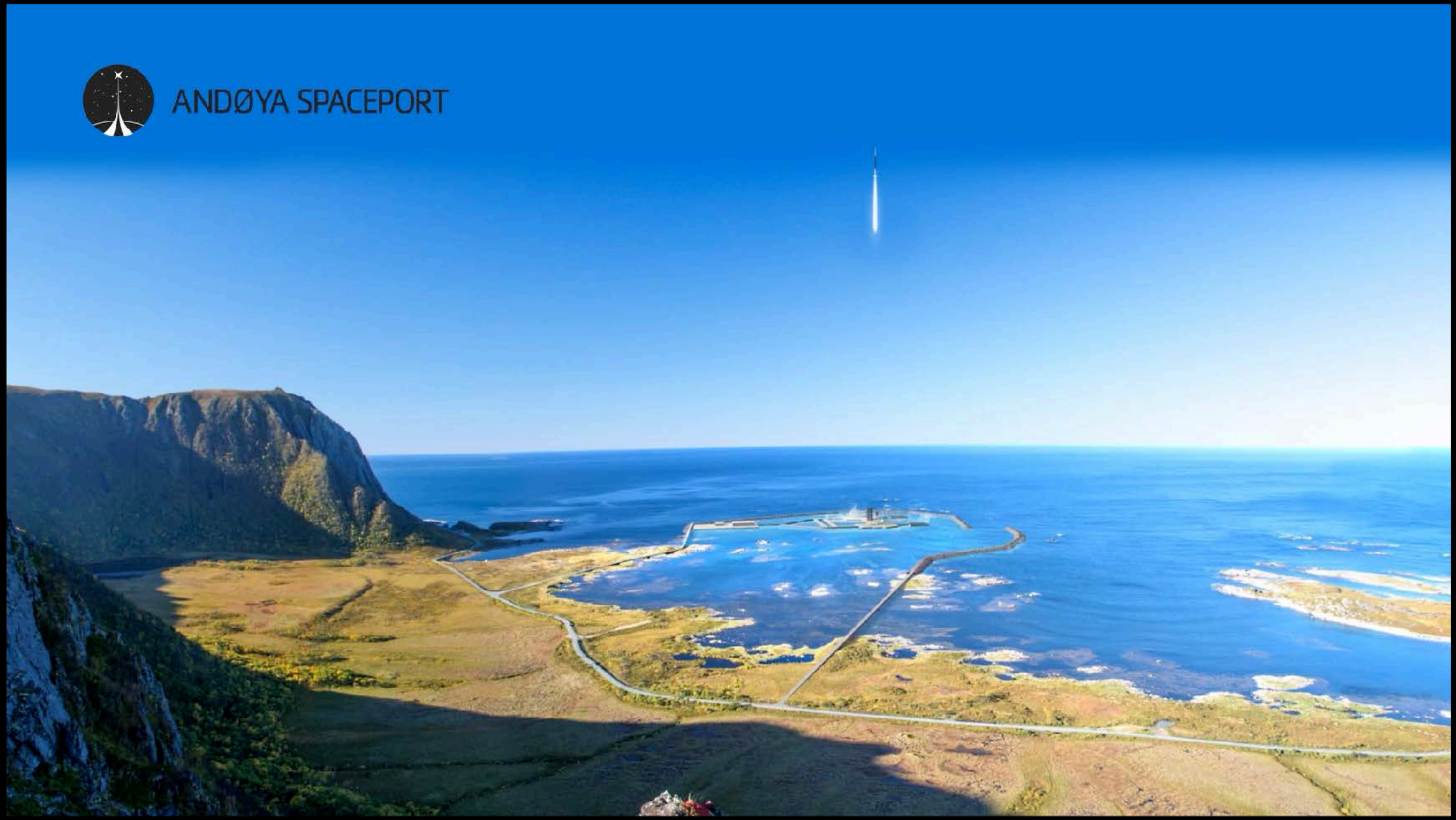


ALOMAR

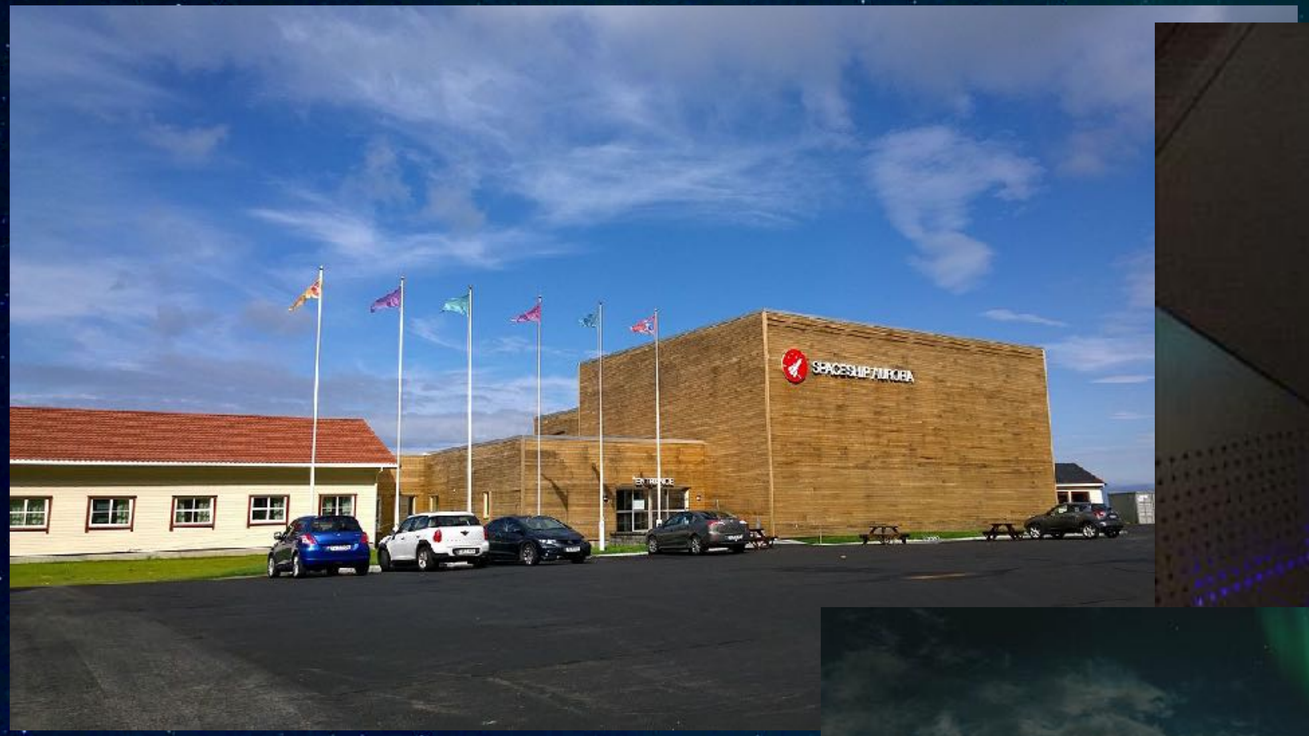

Ozone
Clouds
CH4, SO2, NOx, etc.
Aerosols
Smoke exhaust plume
Laser light
Internet provider
Data access
Control
LIDAR system
PC



Launch facility for small satellites



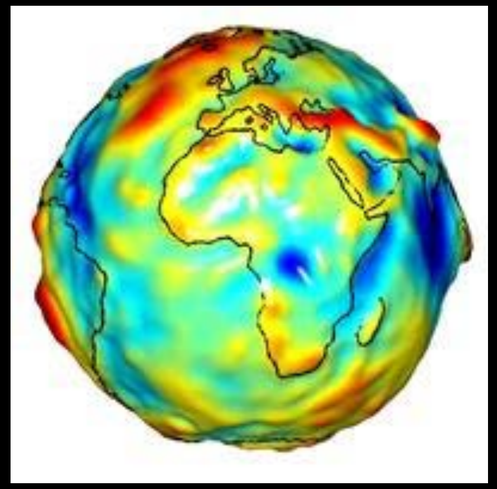
Spaceship Aurora

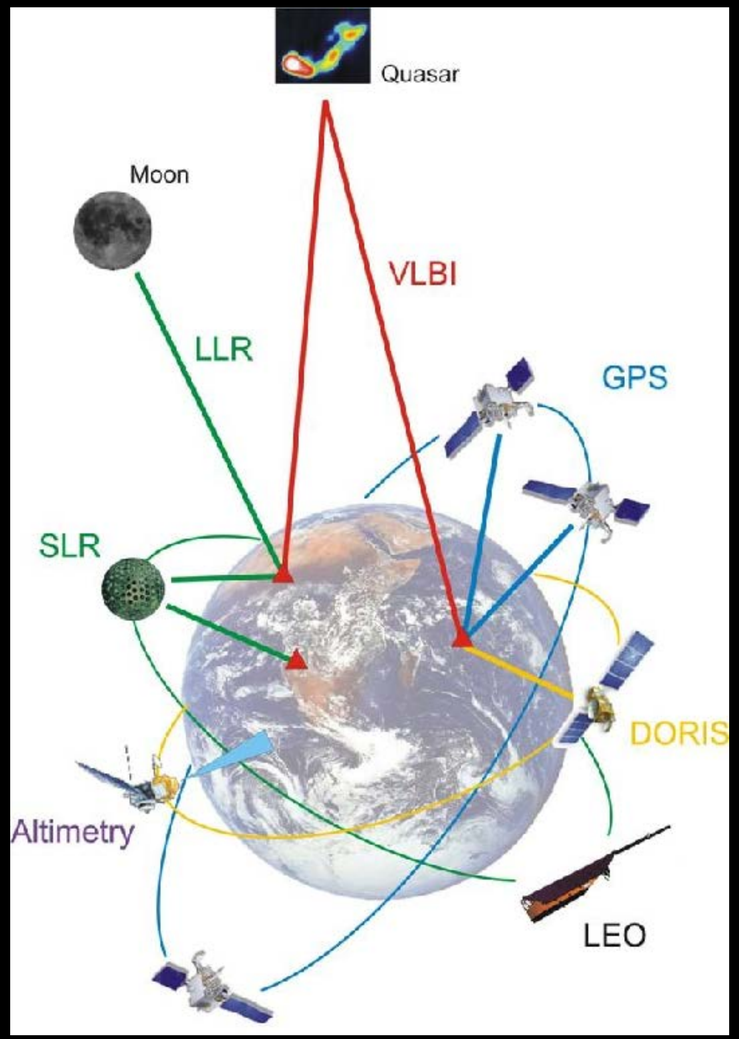


Space Geodetic Research Facility

Space Geodetic Research Facility of the Norwegian Mapping Authority is part of an international network of stations measuring small displacements in the Earths crest.

- Basis for Earth Observations
- The Science of the Earths's shape, motion, gravitational field and changes of these
- Fundamental for monitoring climate change, sea level an all mapping.





Planetary Exploration

- AMASE – Arctic Mars Analoge Svalbard Expedition is a Norwegian run cooperating project (ESA, NASA/JPL and Carnegie Institution of Washington) where future Mars rovers and instruments are being tested at Svalbard every summer.

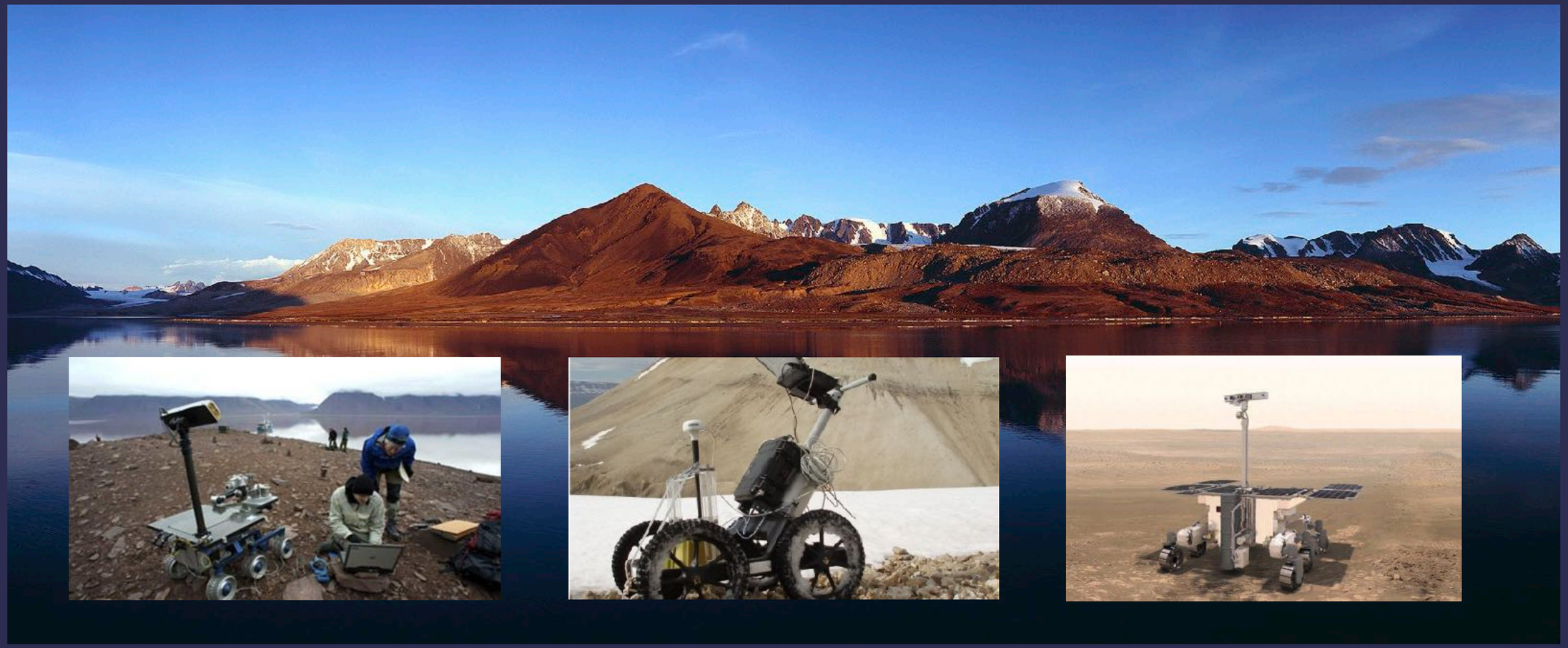
Norsk Romsenter
Norwegian Space Agency

AMASE

Arctic
Mars
Analog
Svalbard
Expedition

Wisdom on ExoMars

- The radar, named WISDOM (Water Ice and Subsurface Deposit Observations on Mars), is able to detect geological structures under the surface, and is able to create high resolution pictures from down to 2-3 metres.



Norsk Romsenter
Norwegian Space Agency

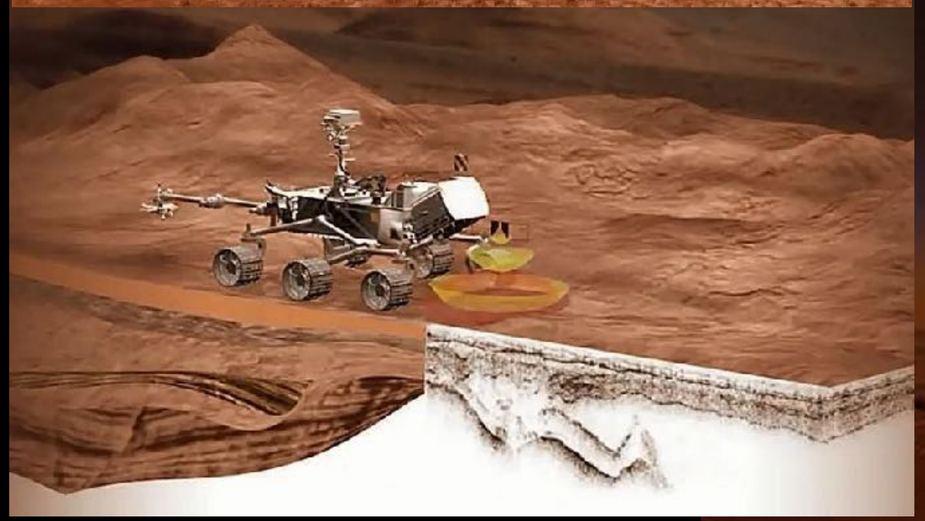
Instruments on Curiosity tested at Svalbard

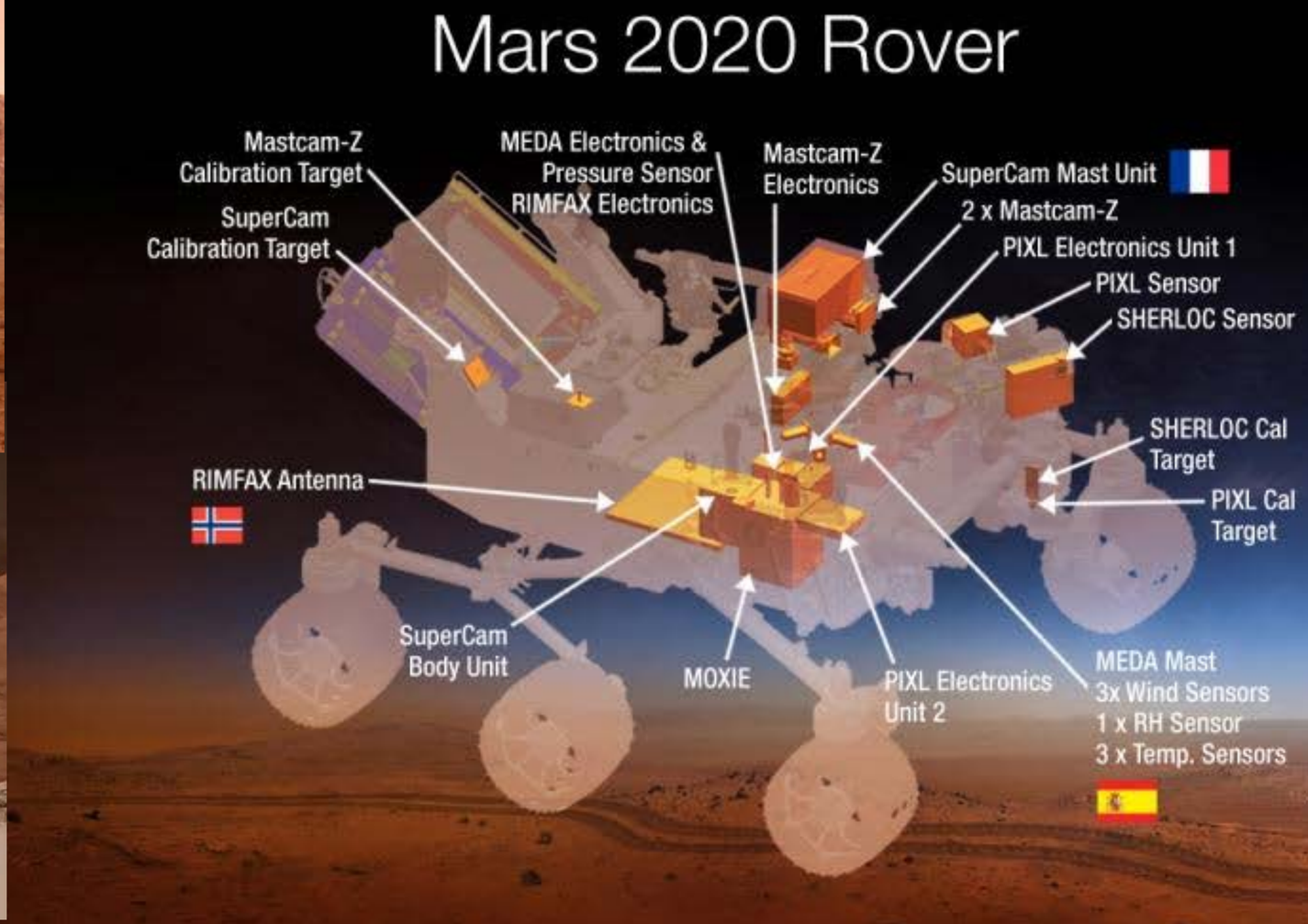
- Two of the instruments on Curiosity was testes at Svalbard.
- Memscap in Horten provided pressure sensors to Curiosity

Norsk Romsenter
Norwegian Space Agency

Norwegian Georadar on Mars

RIMFAX (Radar Imager for Mars Subsurface Exploration), was selected as one of the seven instruments on the MARS Perseverence rover. RIMFAX will investigate the geology under ground and find areas where there as been water.





Norwegian Georadar on Mars

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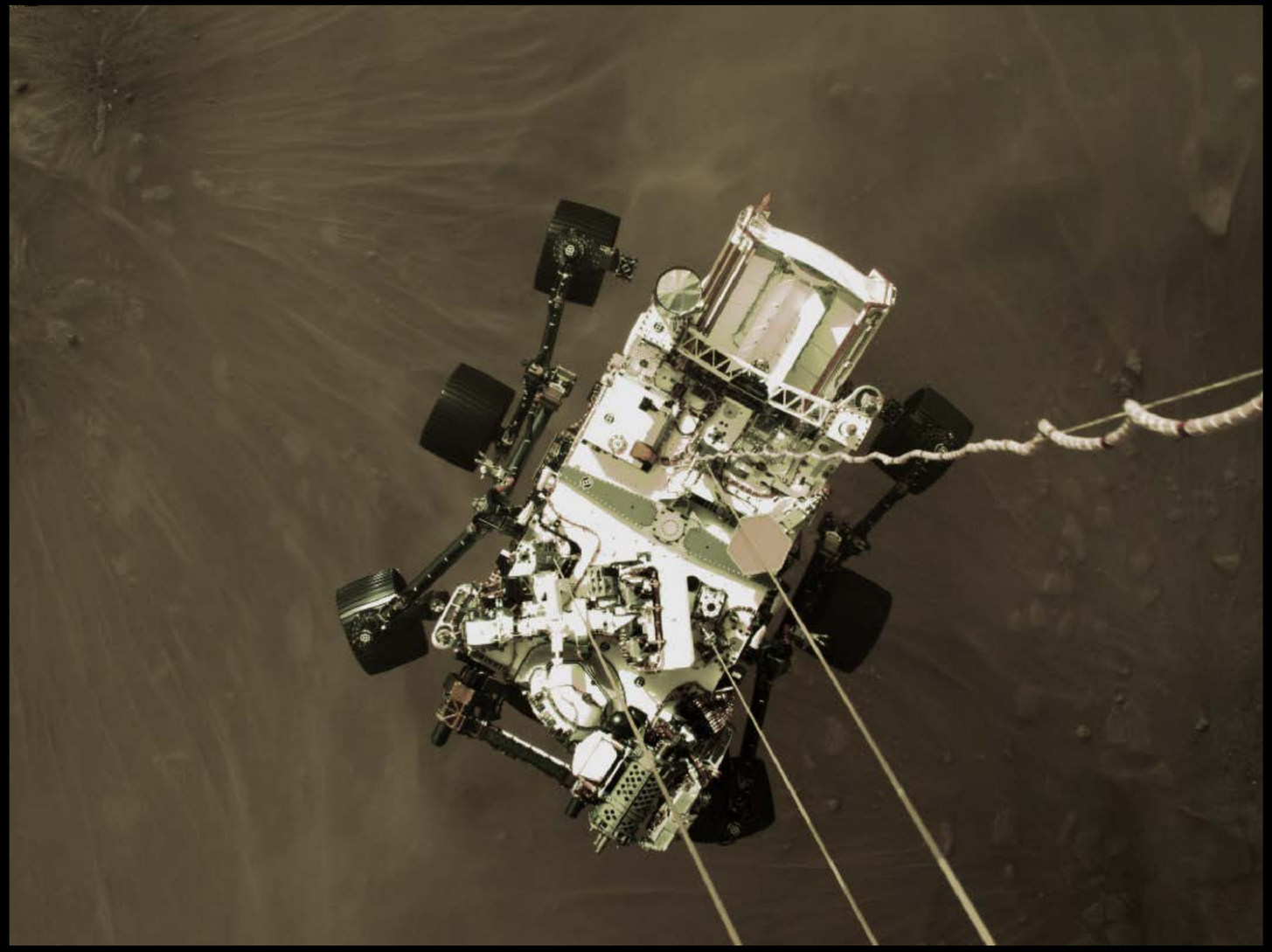
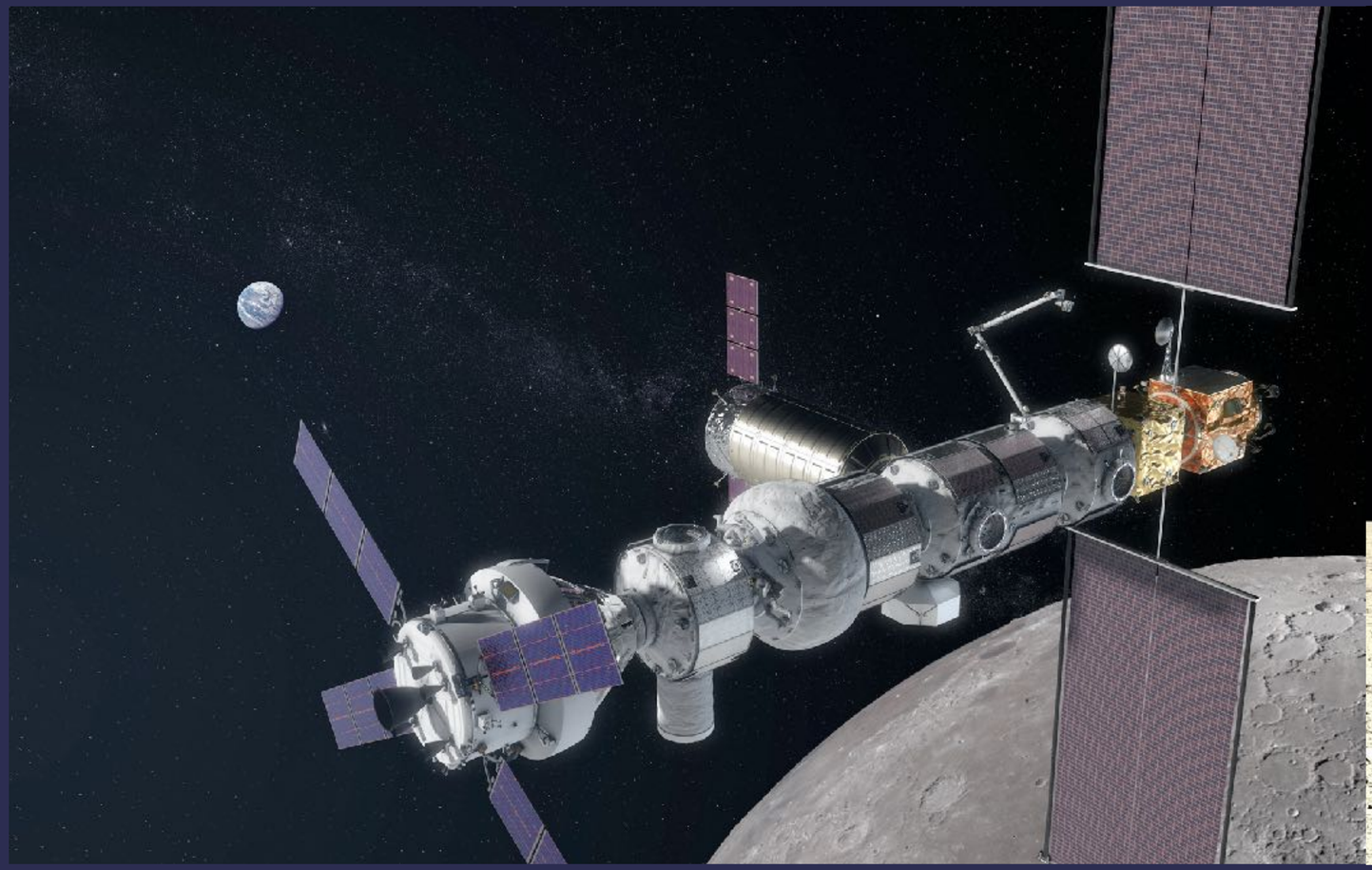
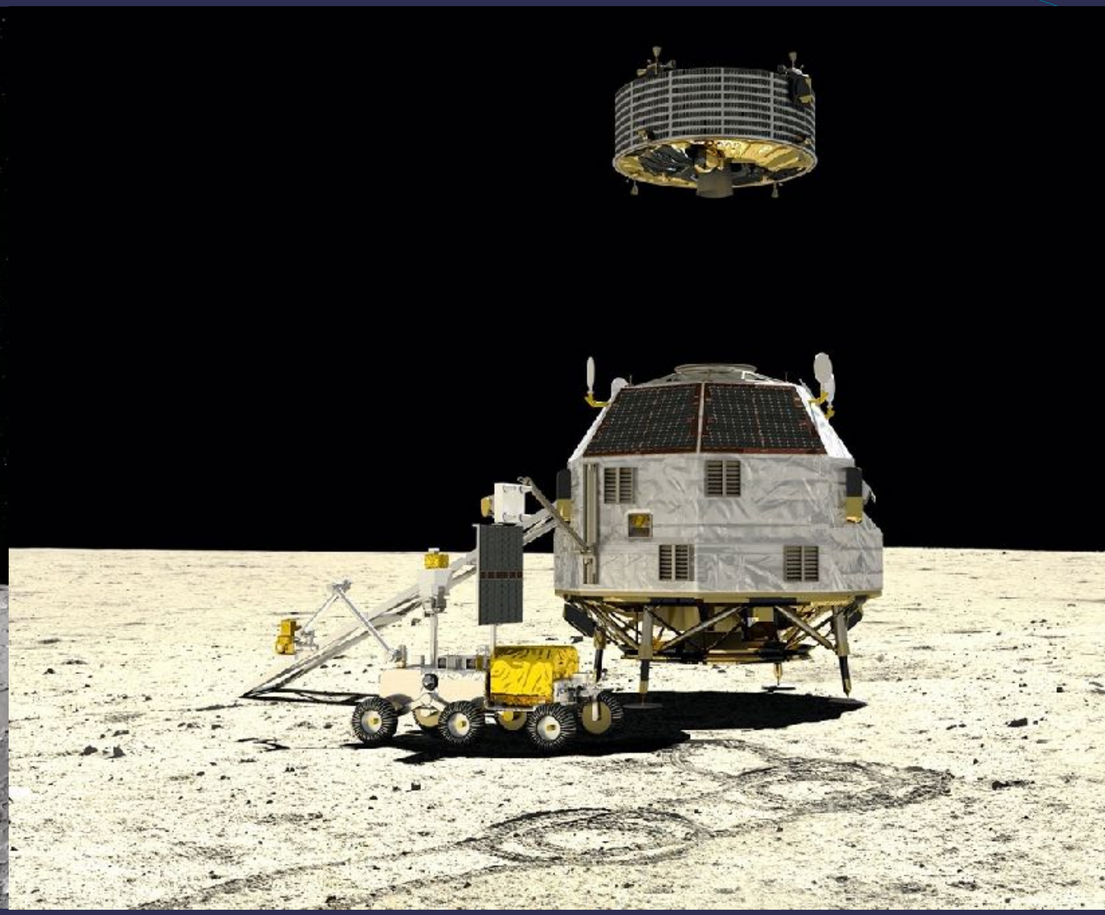


Perseverence landing

Lunar Gateway

- Norway will participate in Lunar Gateway through ESA industry contracts. E.g. Nammo with rocket engines for the Heracles lander





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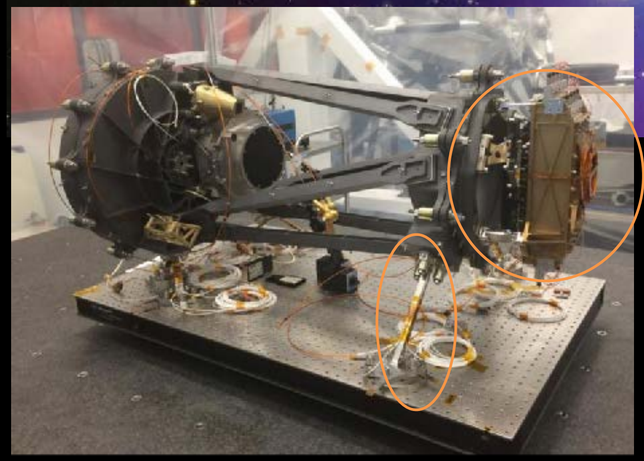
Norwegian Space Agency

Norwegian participation in Euclid

Euclid is an **ESA** mission to map the geometry of the dark Universe



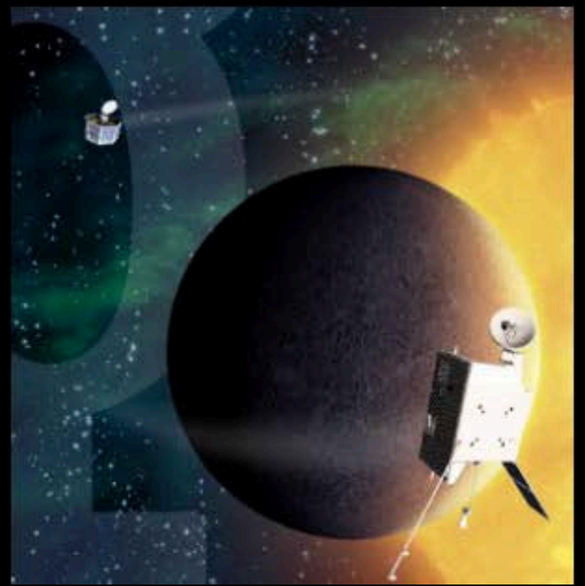
CMR Prototech delivers to the NISP instrument:
- NI-SSS, a mechanical structure holding the detector electronics
- the feet holding the NISP instrument in place on the space telescope.

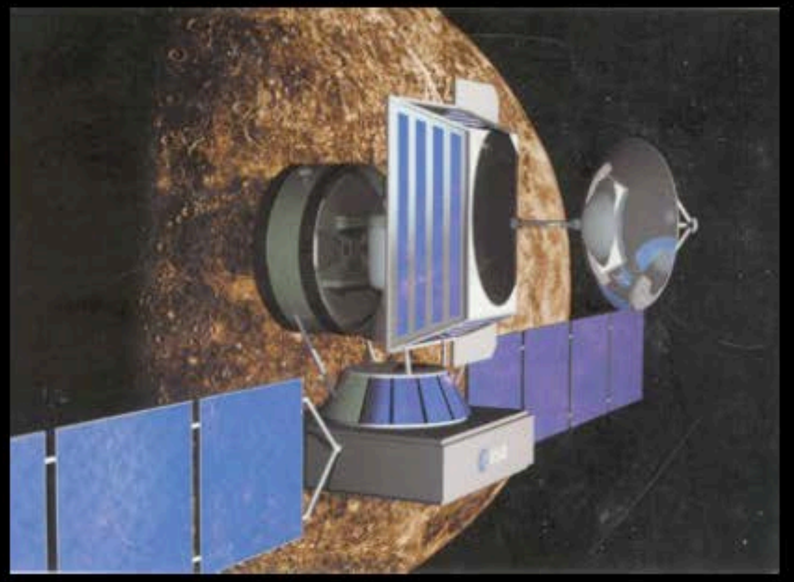
University of Oslo /ITA
- Science Ground Segment

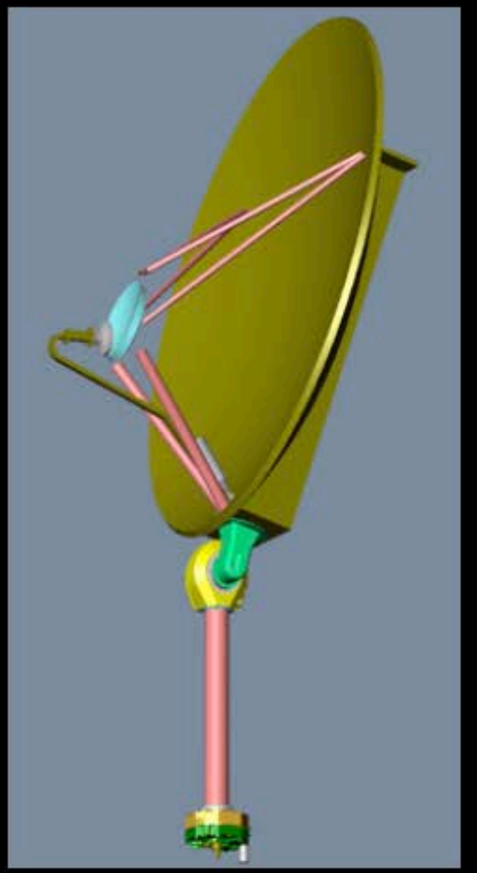
BepiColombo - studere Merkur

- BepiColombo is an interdisciplinary mission to the planet Mercury. The planetary orbiter (MPO) carries instruments for close range studies.

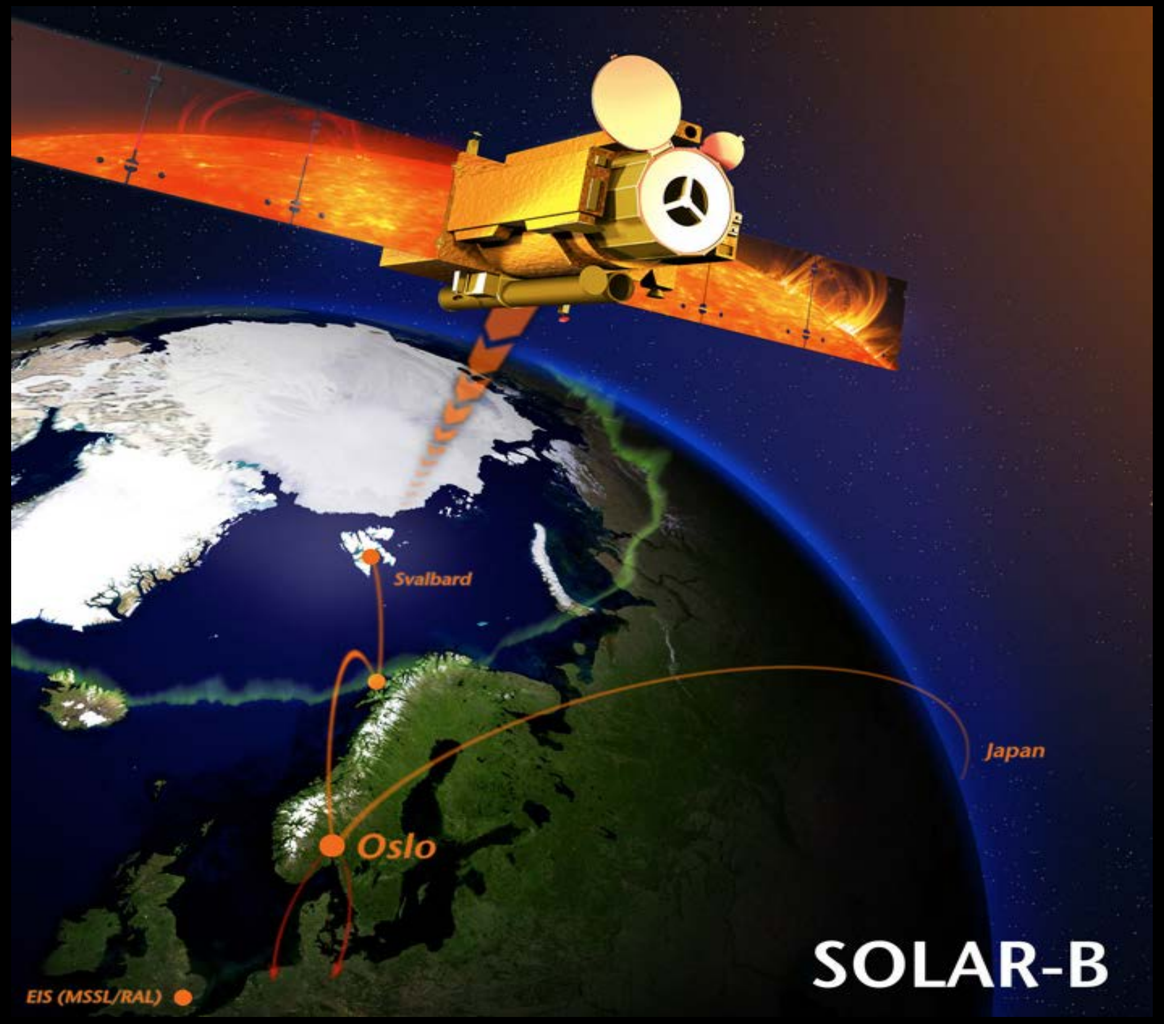
- Konsgberg Defence & Aerospace: Material selection and development of the High Gain Antenna assembly + dish for operating in high temperature environment.







Norway Central partner in HINODE

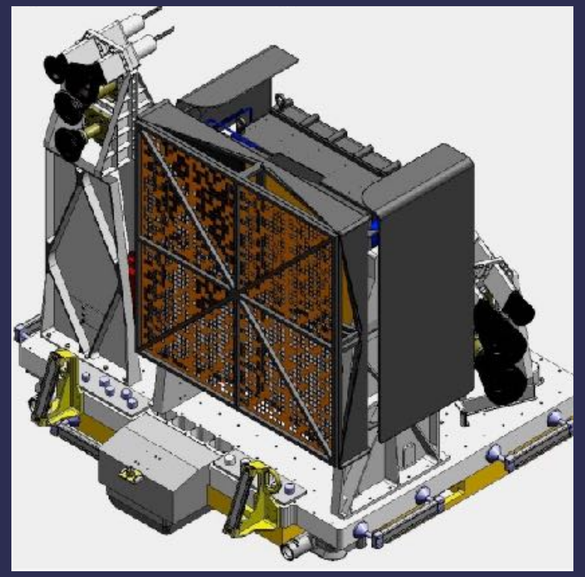


Led by the Japan Aerospace Exploration Agency (JAXA), the Hinode mission is a collaboration between the space agencies of Japan, the United States, the United Kingdom and Europe.

EIS Software, data downlink at Svalbard and the European Data Centre in Oslo (a 20 MEuro contract with ESA)

Birkeland Centre for Space Science

- ASIM on ISS



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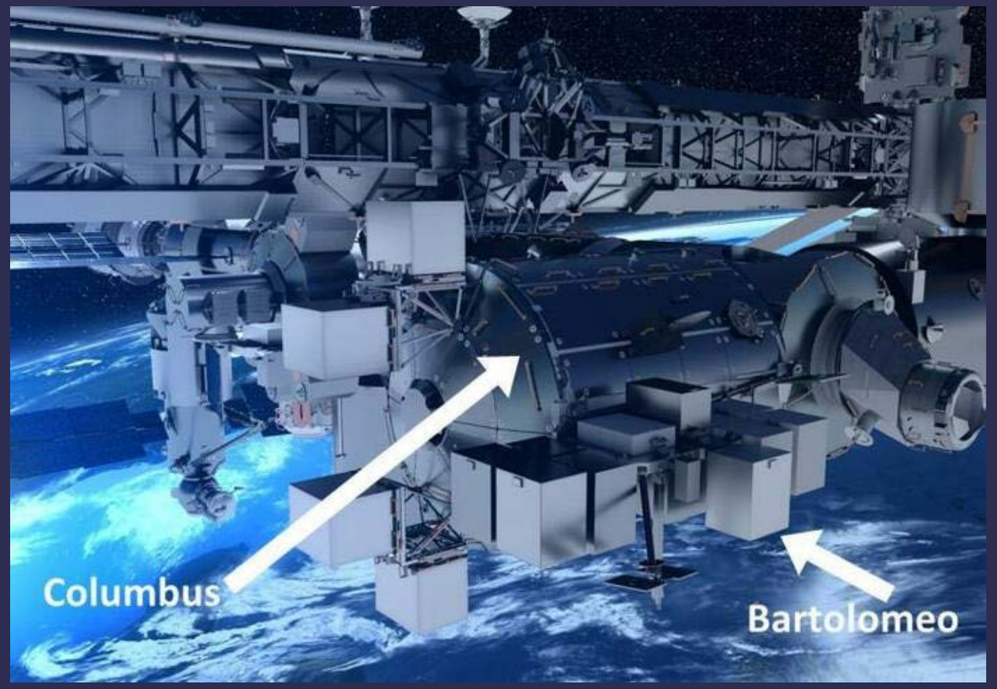
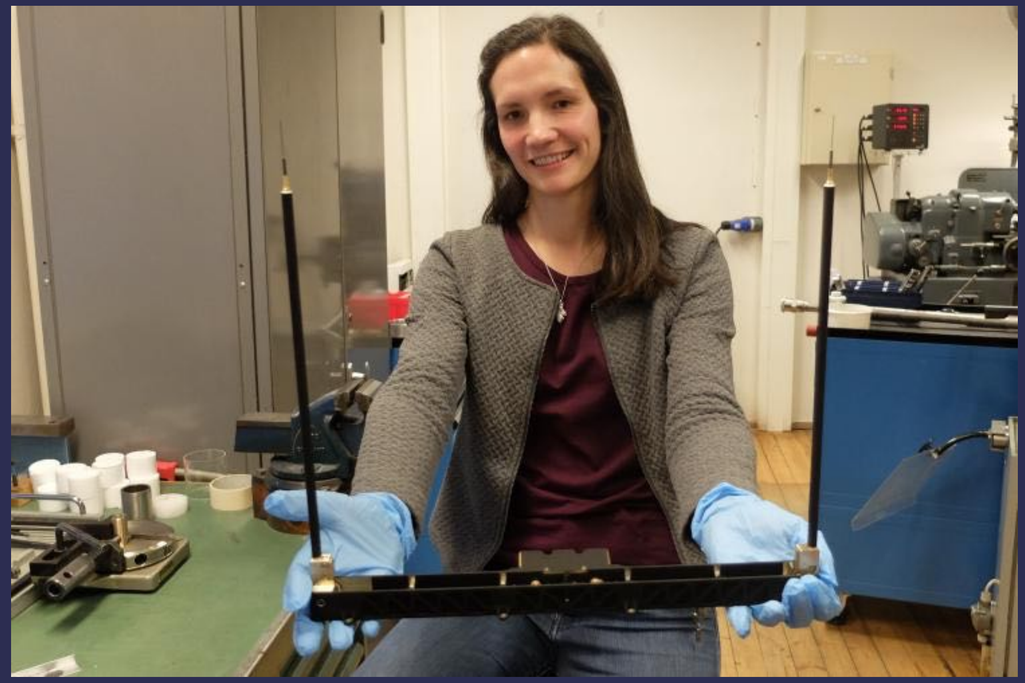
Norwegian Space Agency

ASIM - front page in Nature

m-NLP - multi-needle Langmuir probe system

- UiO and Eidel: Plasma diagnostic around ISS - and space weather





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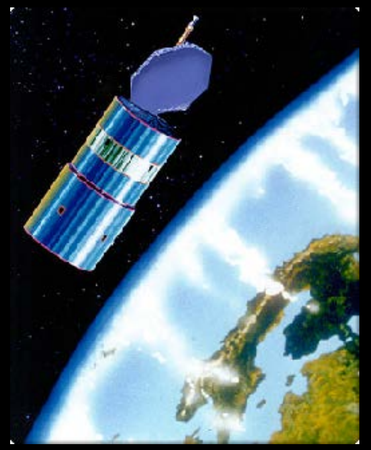
Norwegian Space Agency

Plants in space

- **CIRiS - Centre for Interdisciplinary Research in Space** has been selected as the operation center (N-USOC) for European Modular Cultivation System (EMCS) on the International Space Station.
- Plant cultivation chambers developed by Prototech in Bergen

Norway - early to utilise satellite communication

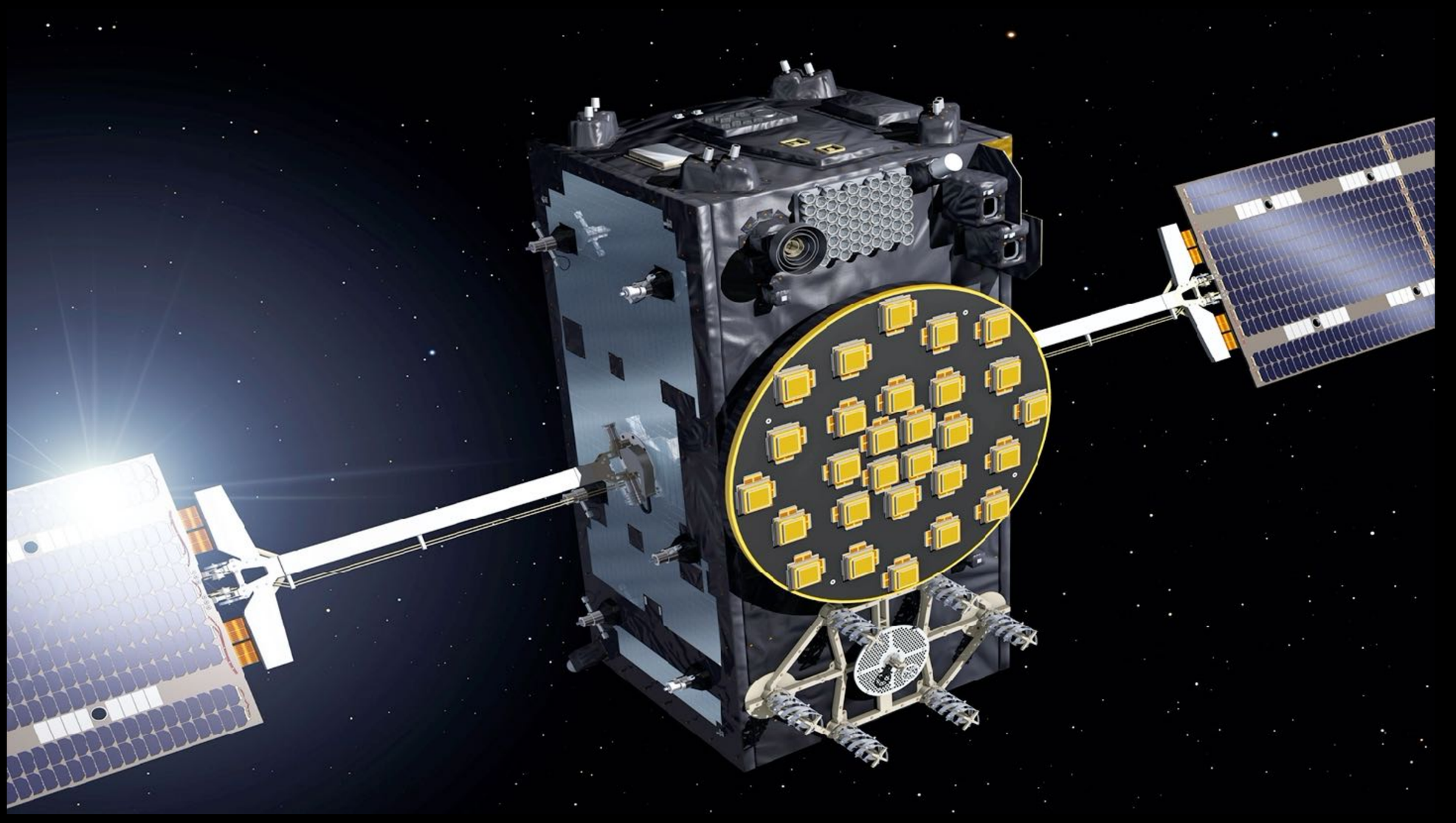
- Norway - first country in the world to use sat-com to localise emergency beacons
- Telenor - one of the biggest telecom-companies in the world



Norway - leading in satellite phone systems

- Satellite phones important for rescue workers, human aids personnel, journalists etc. in war zones or disaster areas.
- First broad-band satellite phone developed in Norway 2 years ago

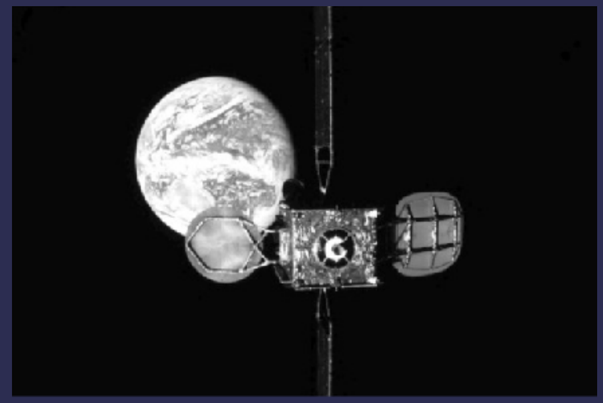
Kongsberg Norspace

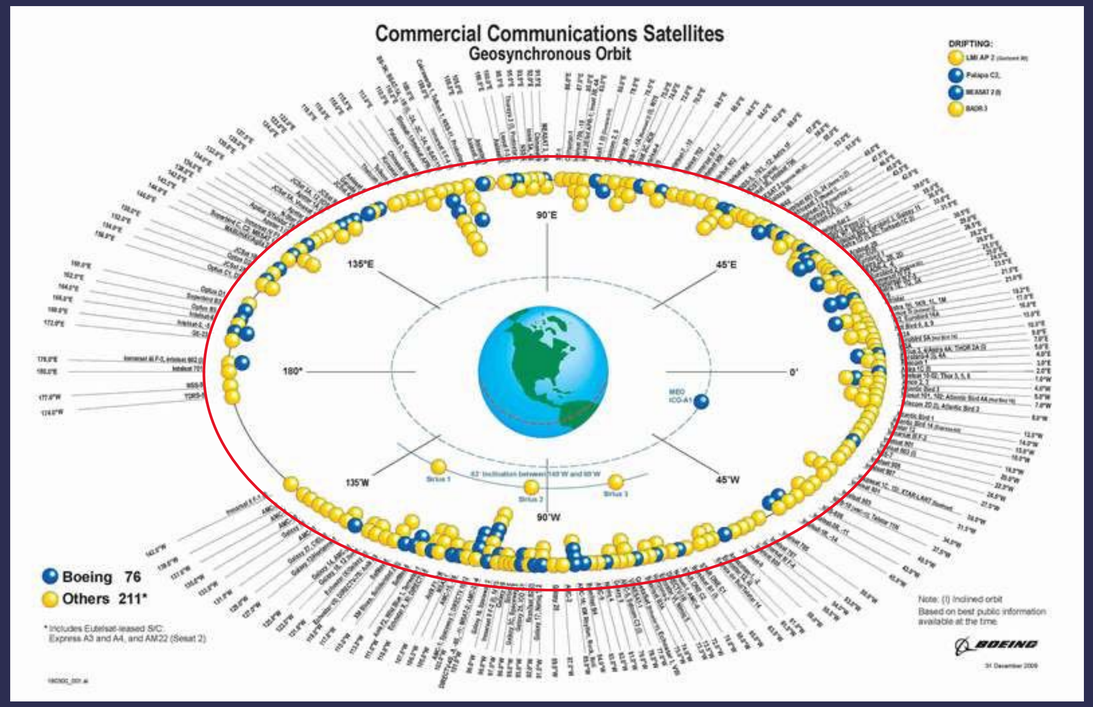


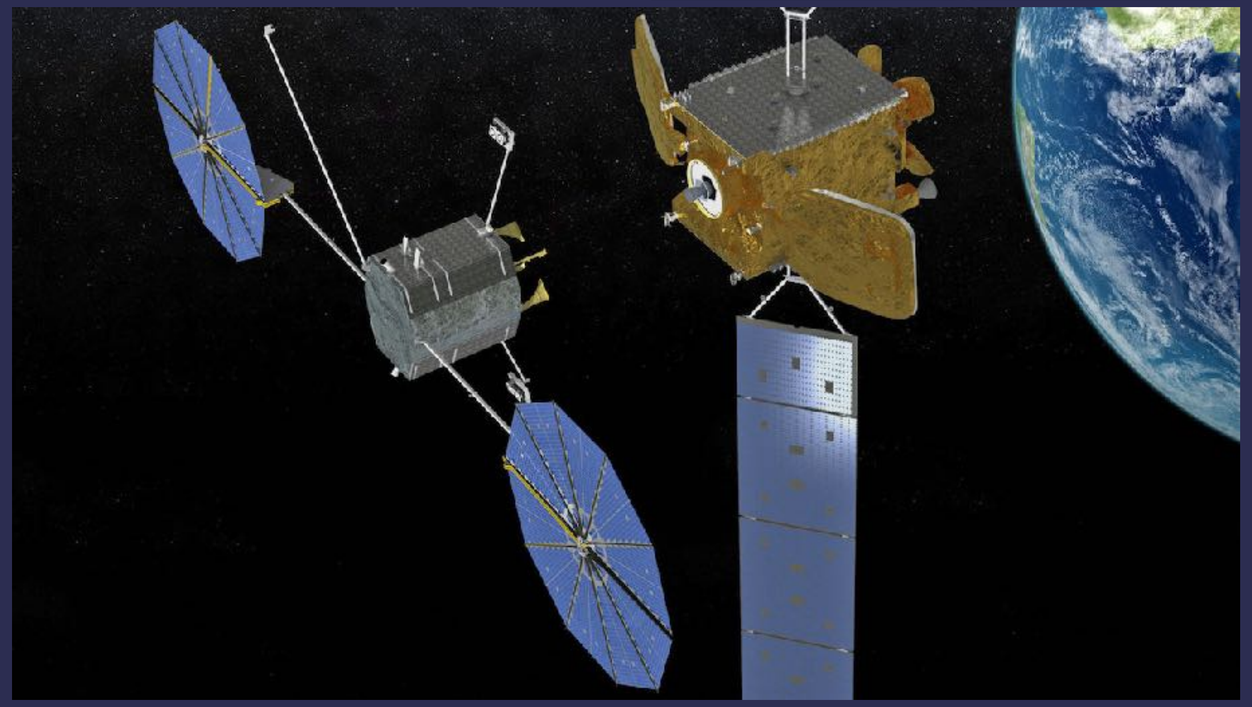
Most communication satellites launched today includes 100 kg of electronics from a small company in south Norway (NORSPACE).

Kongsberg supports MEV-1/2 to extend lifetime of satellites

- Mission Extension Vehicle (MEV) designed to extend the functional lifetime of geostationary satellites.
- First time another satellites in geostationary orbit has been serviced.
- Kongsberg Space Electronics has delivered TTC (Telemetry, Tracking and command-system) Transmitters and Receivers that made it possible for MEV to safely approach the oter satellite. Thus, all commanding, control, telemetry and images goes through their electronic boxes



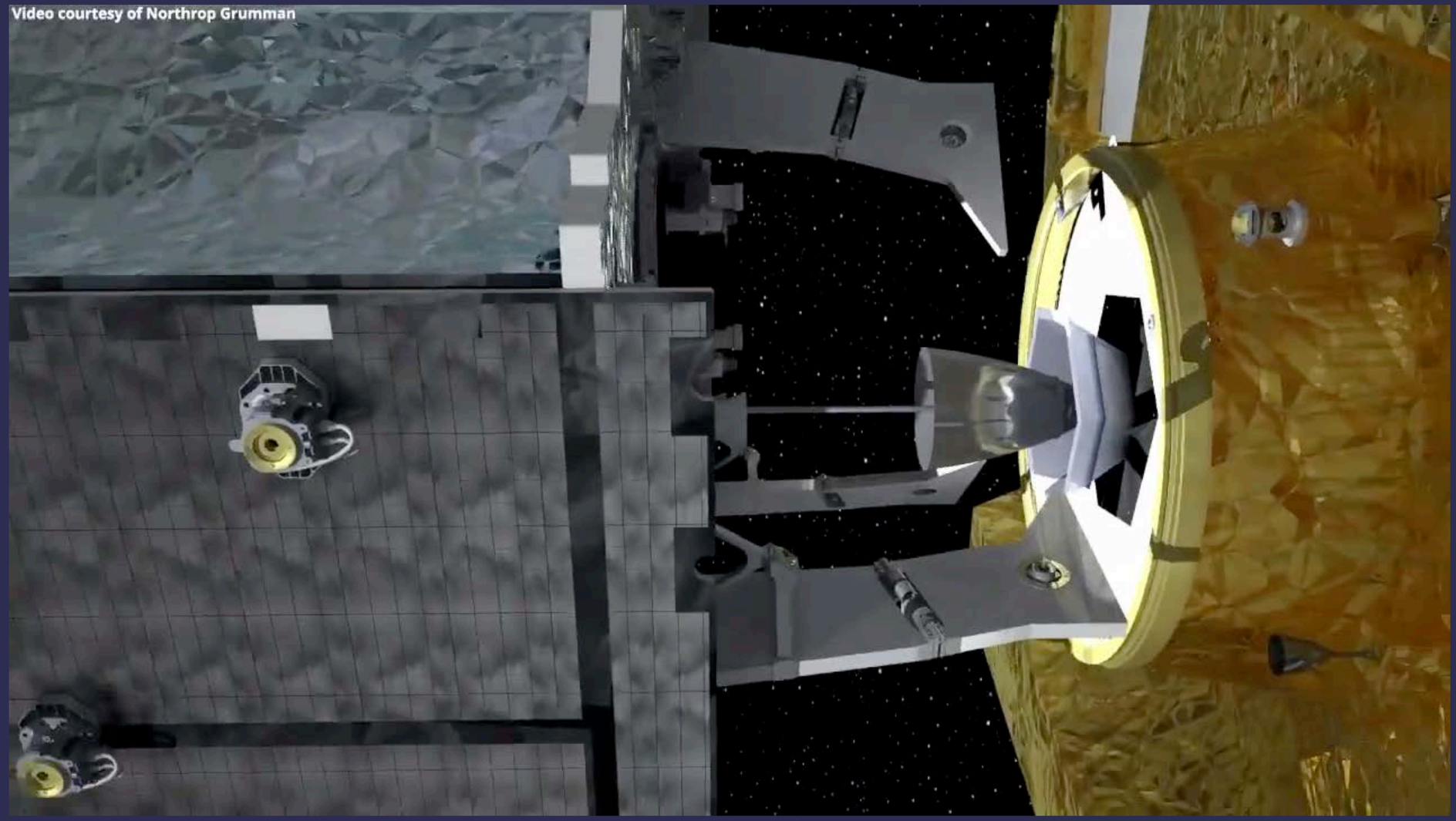




MEV-2 - also launched and on its way to Intelsat/Thor 1002 - partly owned by Telenor

Norsk Romsenter
Norwegian Space Agency

Kongsberg supports MEV-1/2 to extend lifetime of satellites



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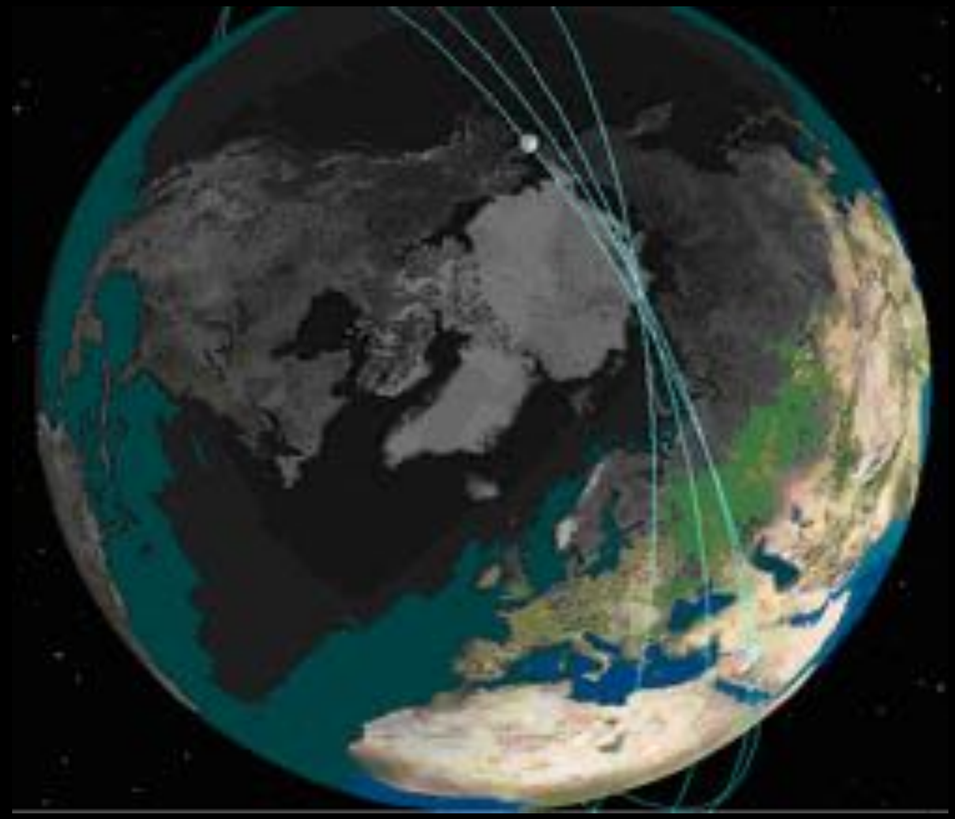
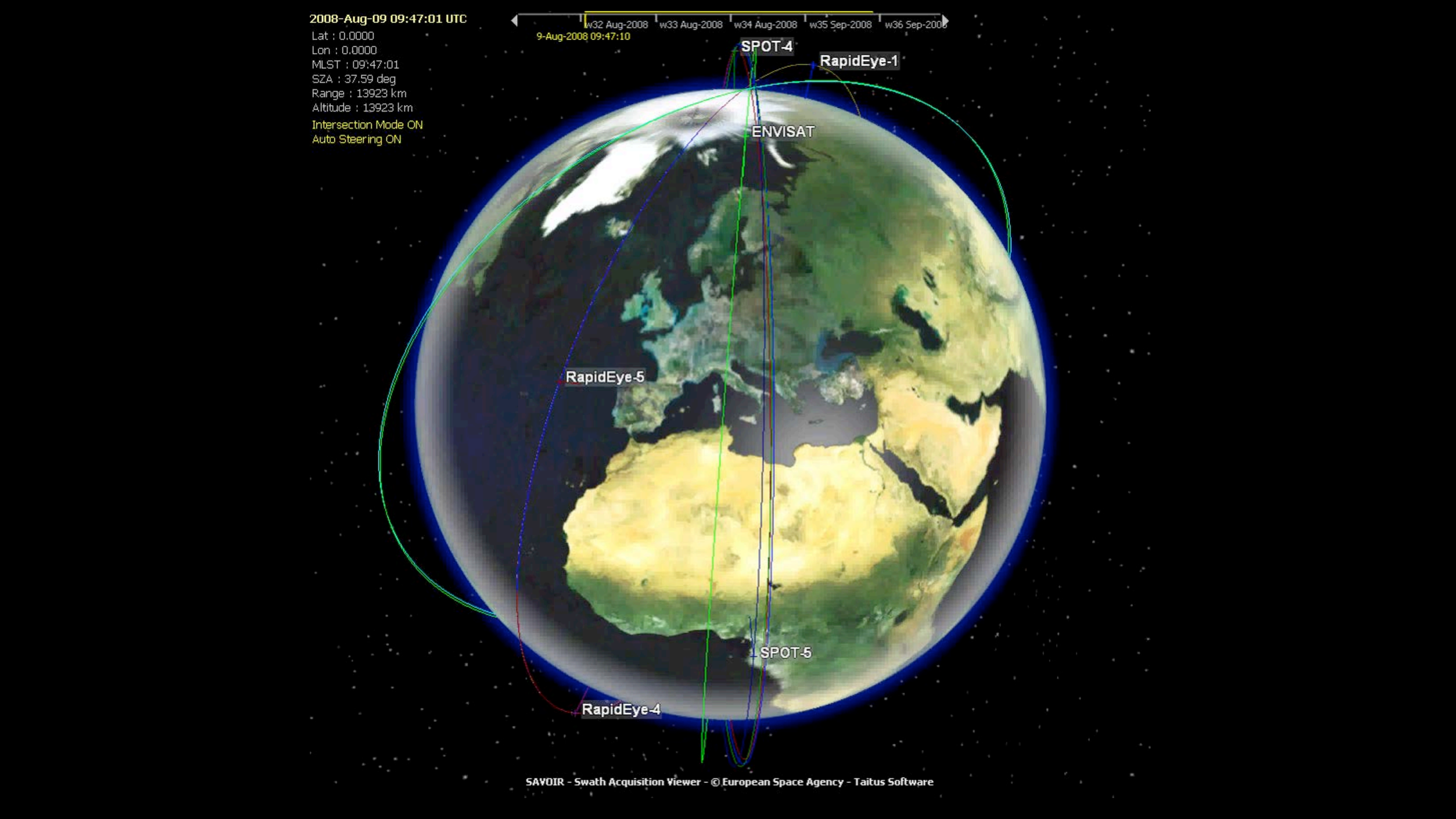
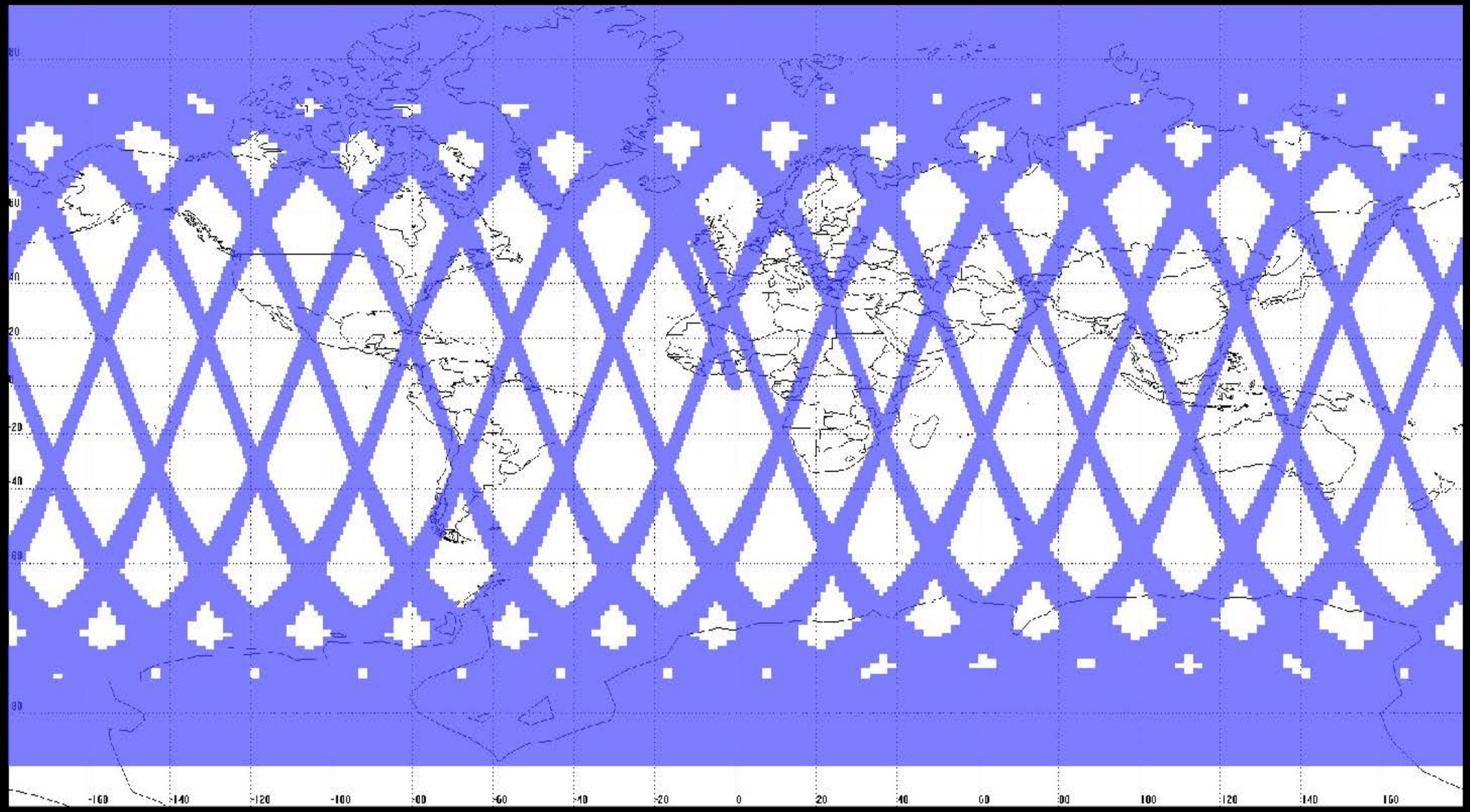
Earth observing satellites




2008-Aug-09 09:47:01 UTC
Lat : 0.0000
Lon : 0.0000
MLST : 09:47:01
SZA : 37.59 deg
Range : 13923 km
Altitude : 13923 km
Intersection Mode ON
Auto Steering ON
w32 Aug-2008
w33 Aug-2008
w34 Aug-2008
w35 Sep-2008
w36 Sep-2008
9-Aug-2008 09:47:10
SPOT-4
RapidEye-1
ENVISAT
RapidEye-5
SPOT-5
RapidEye-4
SAVOIR - Swath Acquisition Viewer - © European Space Agency - Taitus Software

Why Space in the Arctic?



Norway has best coverage over own areas

KSAT - The World Leader in Ground Station Networks

Kongsberg Satellite Services AS

World leading commercial satellite services

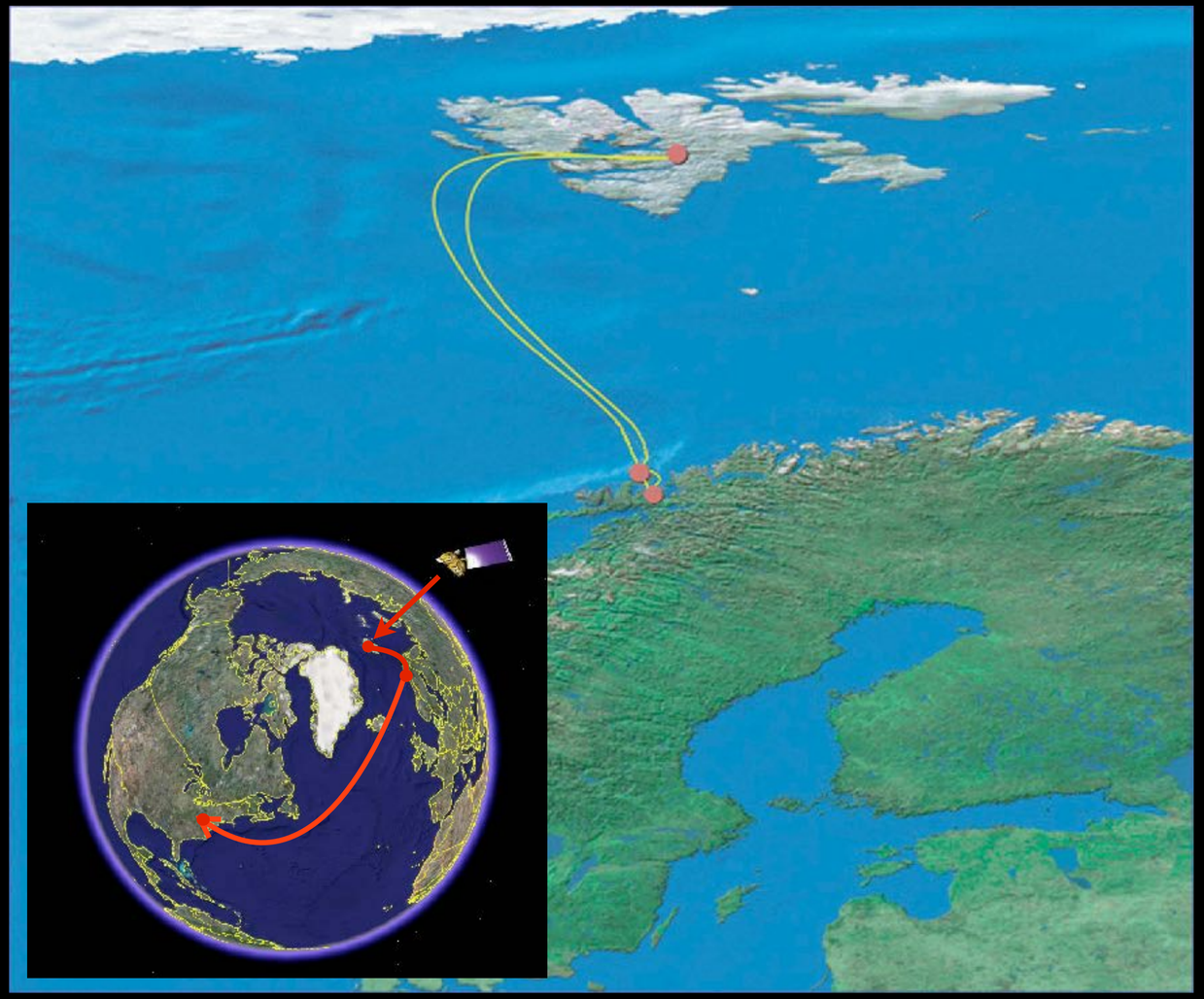
- Owned 50% by the Space Norway og 50% by Kongsberg Defence & Aerospace AS
- Satellite stations in Tromsø, Grimstad, Svalbard (SvalSat) and in Antarctica (Troll station), Bangalore, Mauritius, Alaska ++

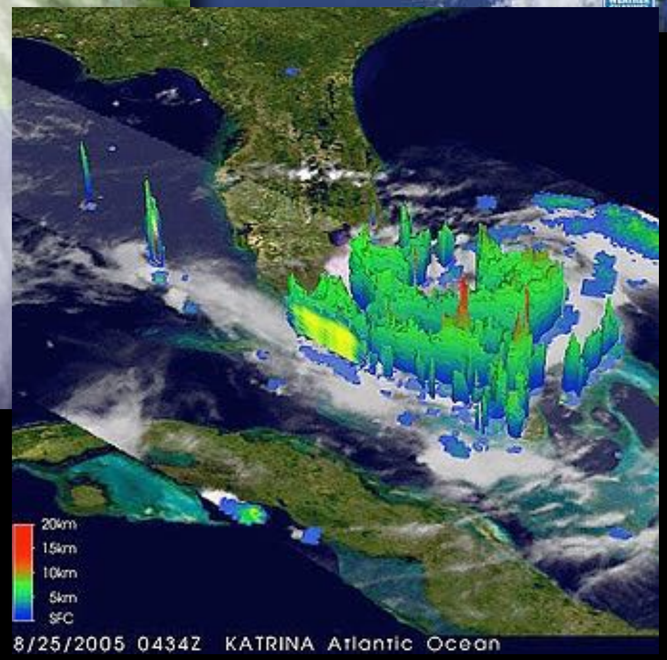
Total about 105 antennas

Supports over 100 satellites - 35.000 passes per month

Norsk Romsenter
Norwegian Space Agency

Svalbard Fiber Optical Cable





20 Gbit Fiberoptical cabel, 1,400 km lang,
Price: NOK 300 millioner.
FInaced by NASA og NOAA/IPO

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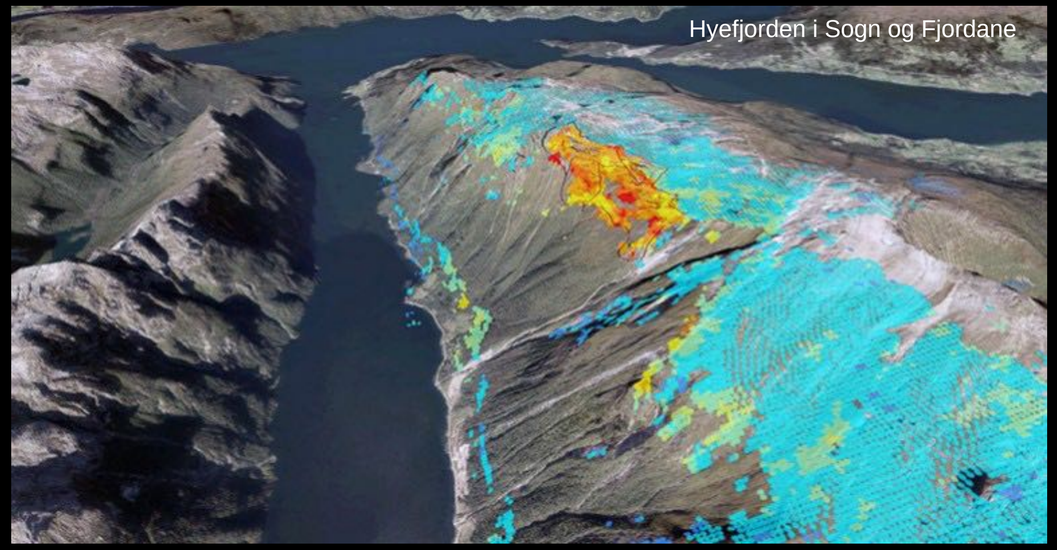
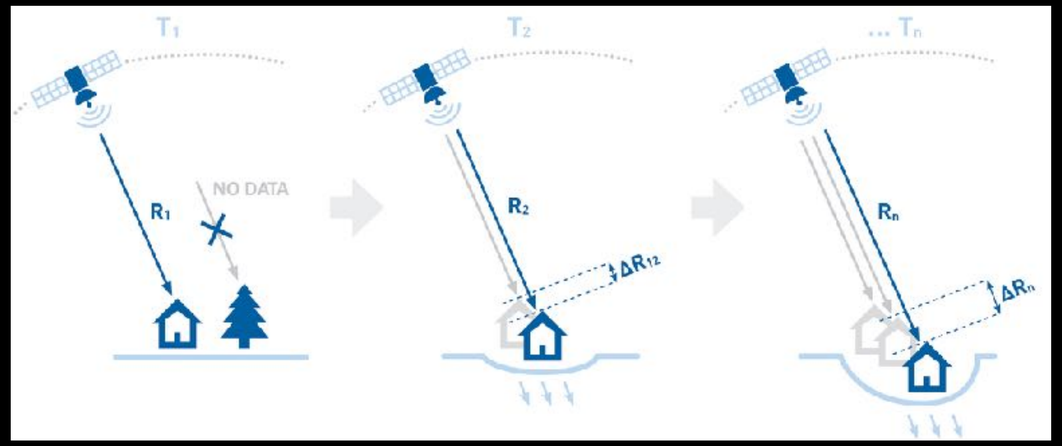
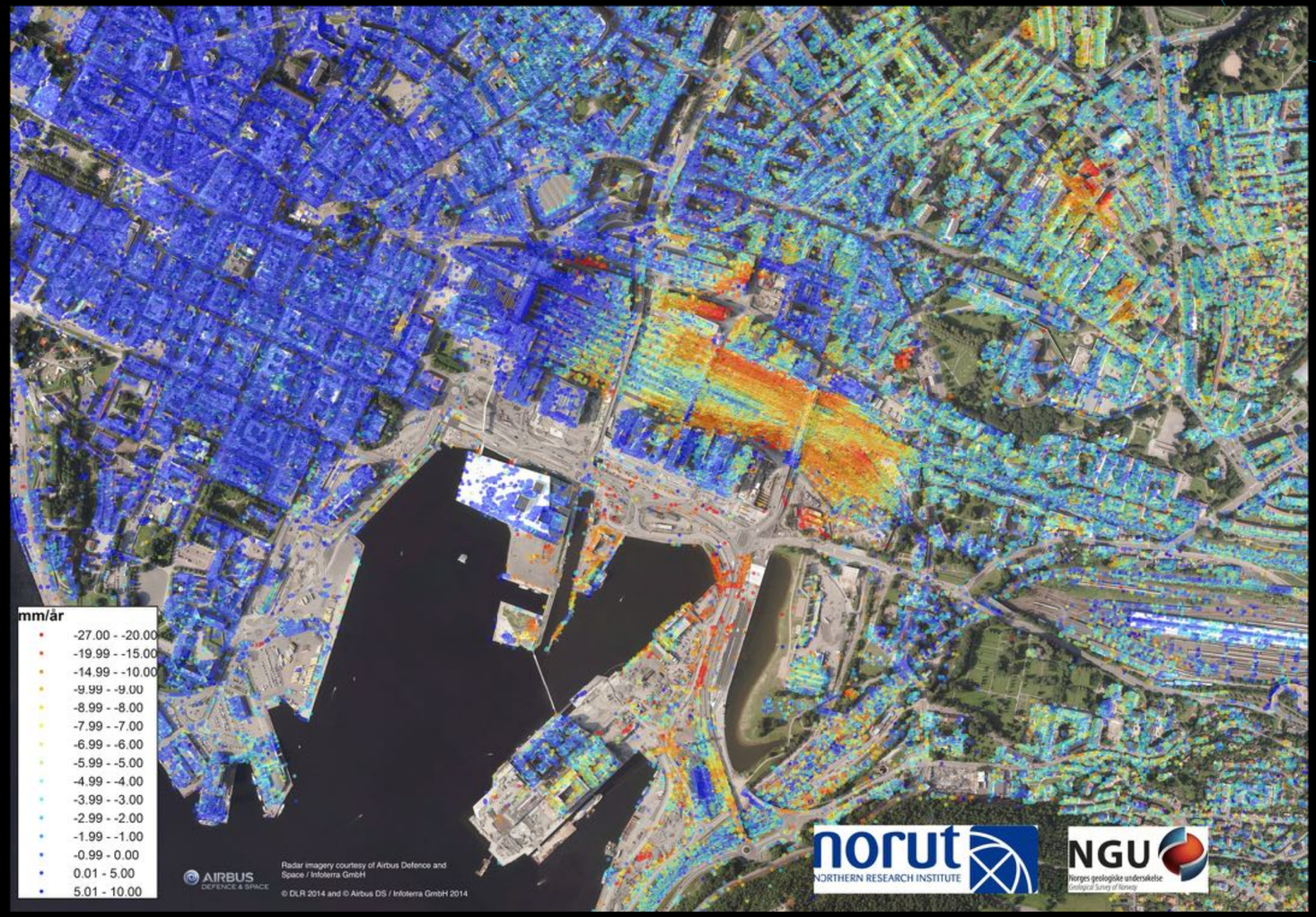
Norwegian Space Agency

Surface Displacement using inSAR observations







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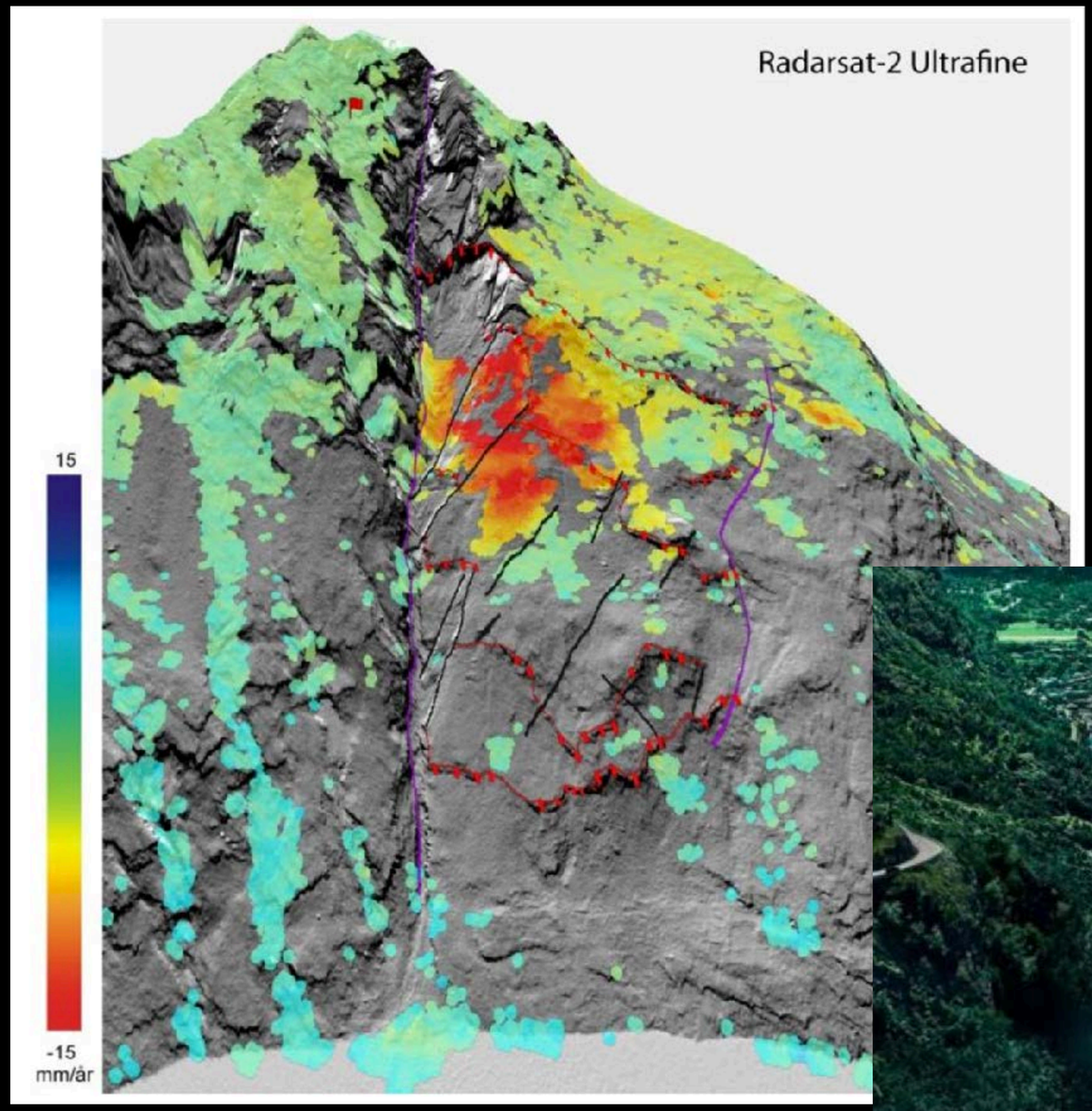
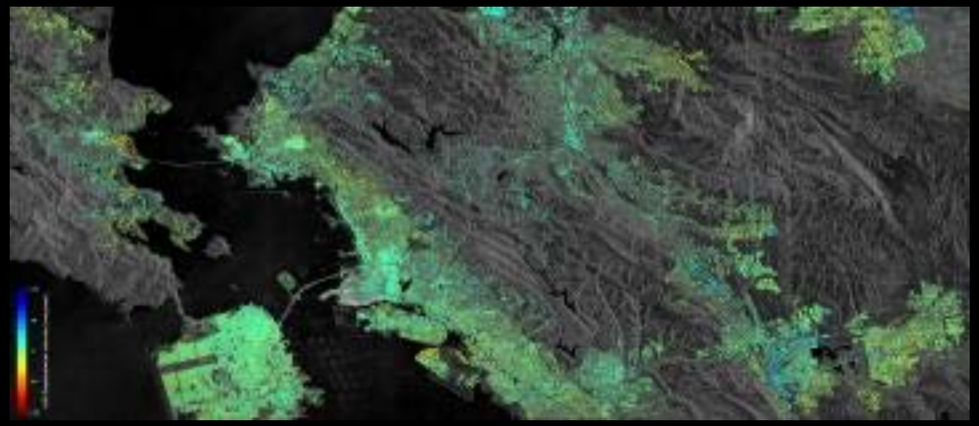
InSAR Norway
Norwegian Ground Motion Service
insar.ngu.no

Monitoring Rockslide with SAR imagery



Fjellet fra "Bølgen": InSAR-kart av Åkneset basert på data fra Radarsat-2. De røde stiplede linjene viser sprekker som forskerne har tegnet inn, mens de oransje og røde flekkene viser hvor utglidningen er størst.

Surface Displacement using inSAR observations



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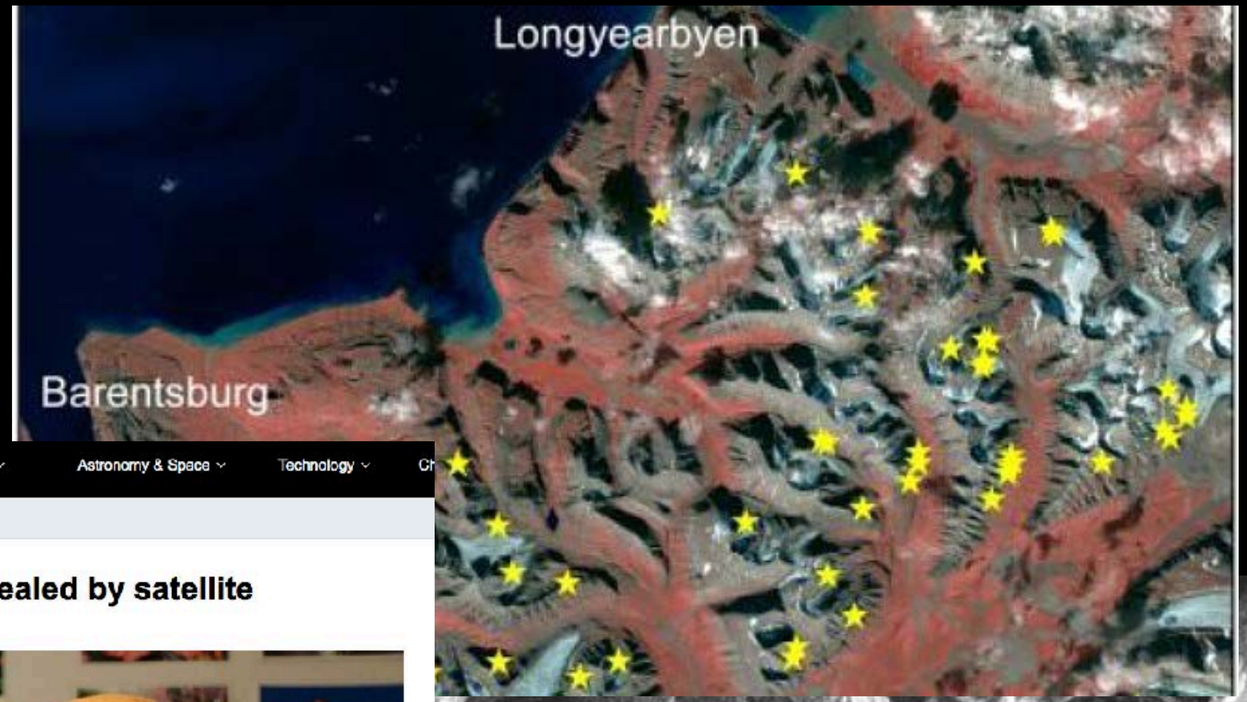
Norwegian Space Agency

Satellite images shows 50 avalanches on Svalbard

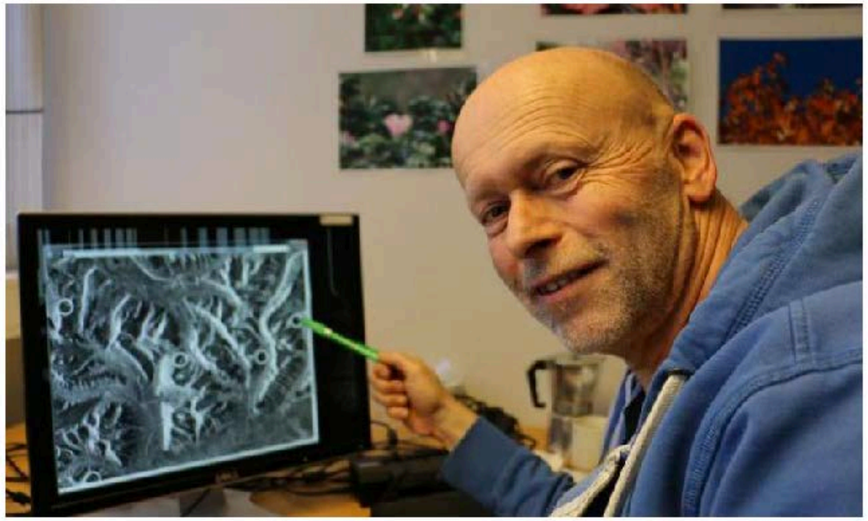


PHYS.ORG Nanotechnology Physics Earth Astronomy & Space Technology

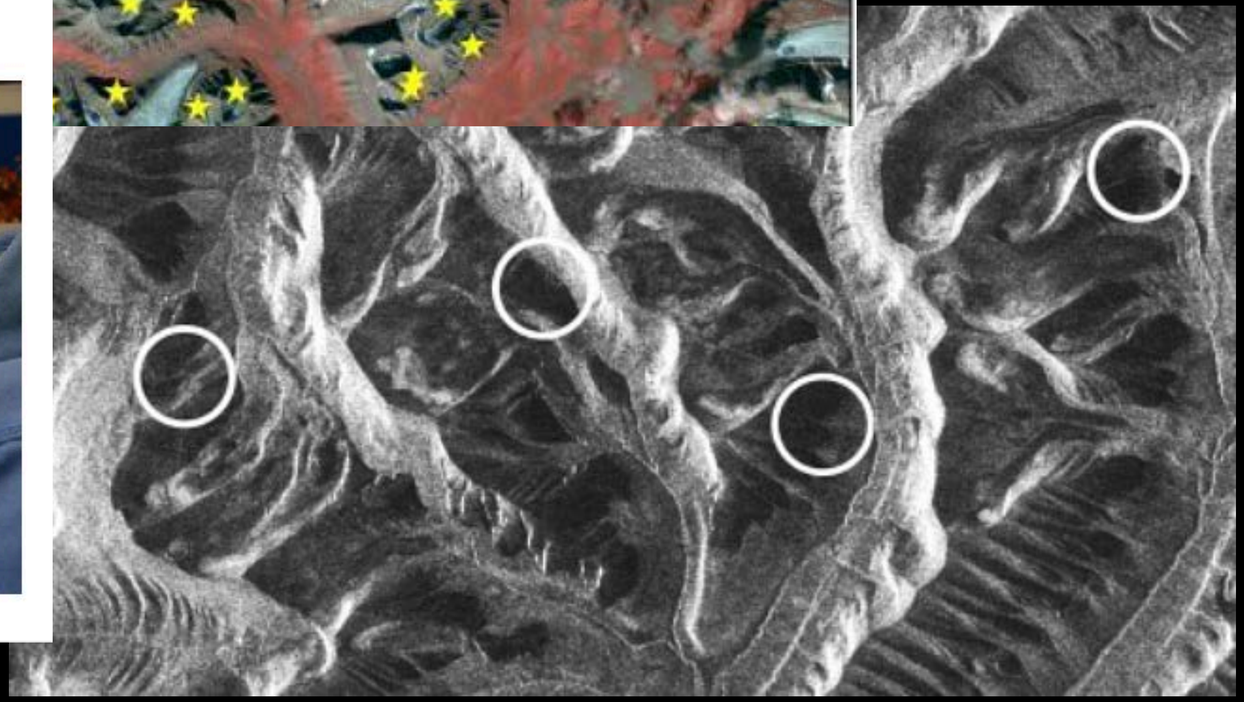
Home › Astronomy & Space › Space Exploration › January 4, 2017

New Svalbard avalanches revealed by satellite

January 4, 2017

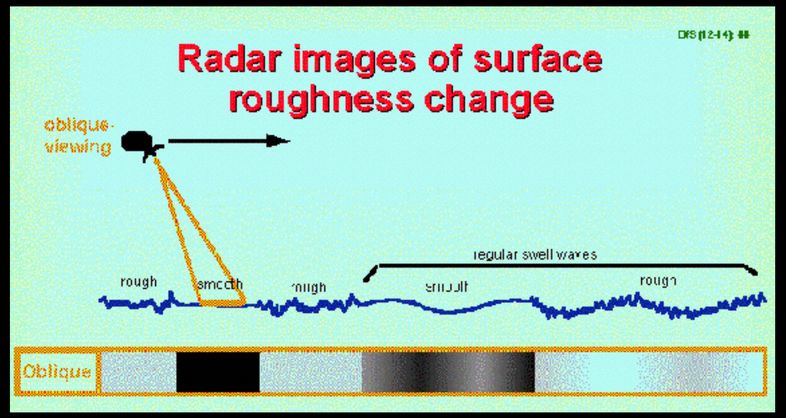


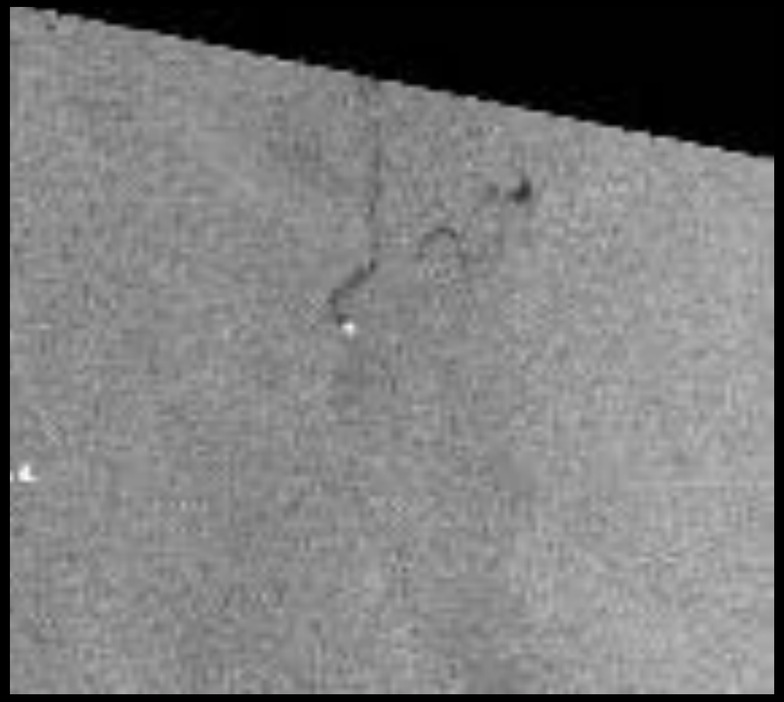
Bernd Etzelmüller explains satellite images revealing new landslides triggered at Svalbard lately. Andreas Max Kääb points out the importance of further satellite investments to keep a safe surveillance at Svalbard. Credit: Gunhild M. Haugnes



First operational oil spill detection from satellites

Radar satellites can "see" oil spills day and night and through clouds



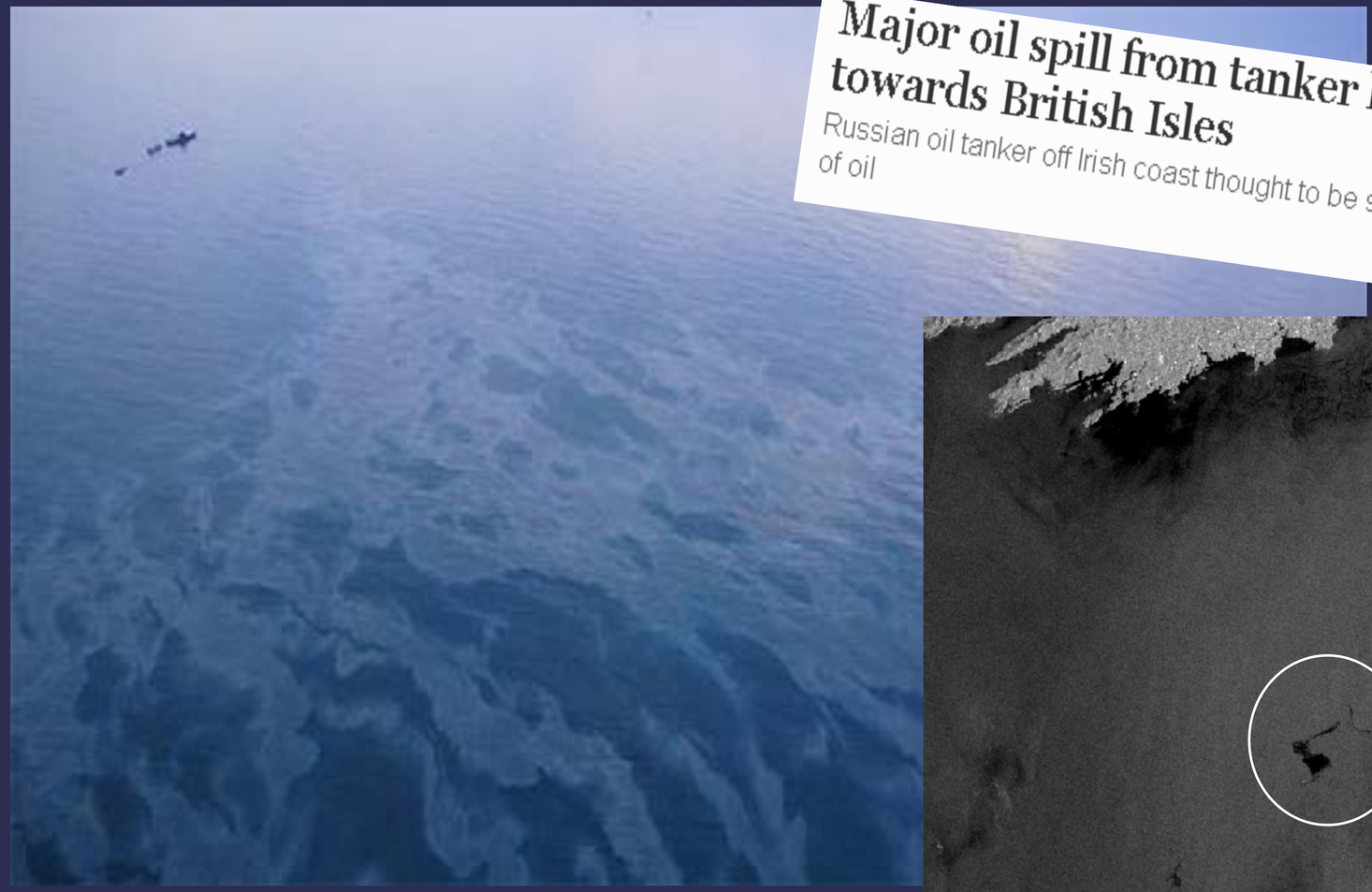


Oil spill from a Norwegian platform in 2004

KSAT detects oil-spills in the British Channel

EMSA CSN Detection Example

Oil spill detected by KSAT, alert through EMSA



Major oil spill from tanker heads towards British Isles

Russian oil tanker off Irish coast thought to be source of 500 tonnes of oil

Oil spill detected by KSAT, alert through EMSA,
Verified by Coastguard airplane. 14.02.2009

ESA2009/processed by KSAT

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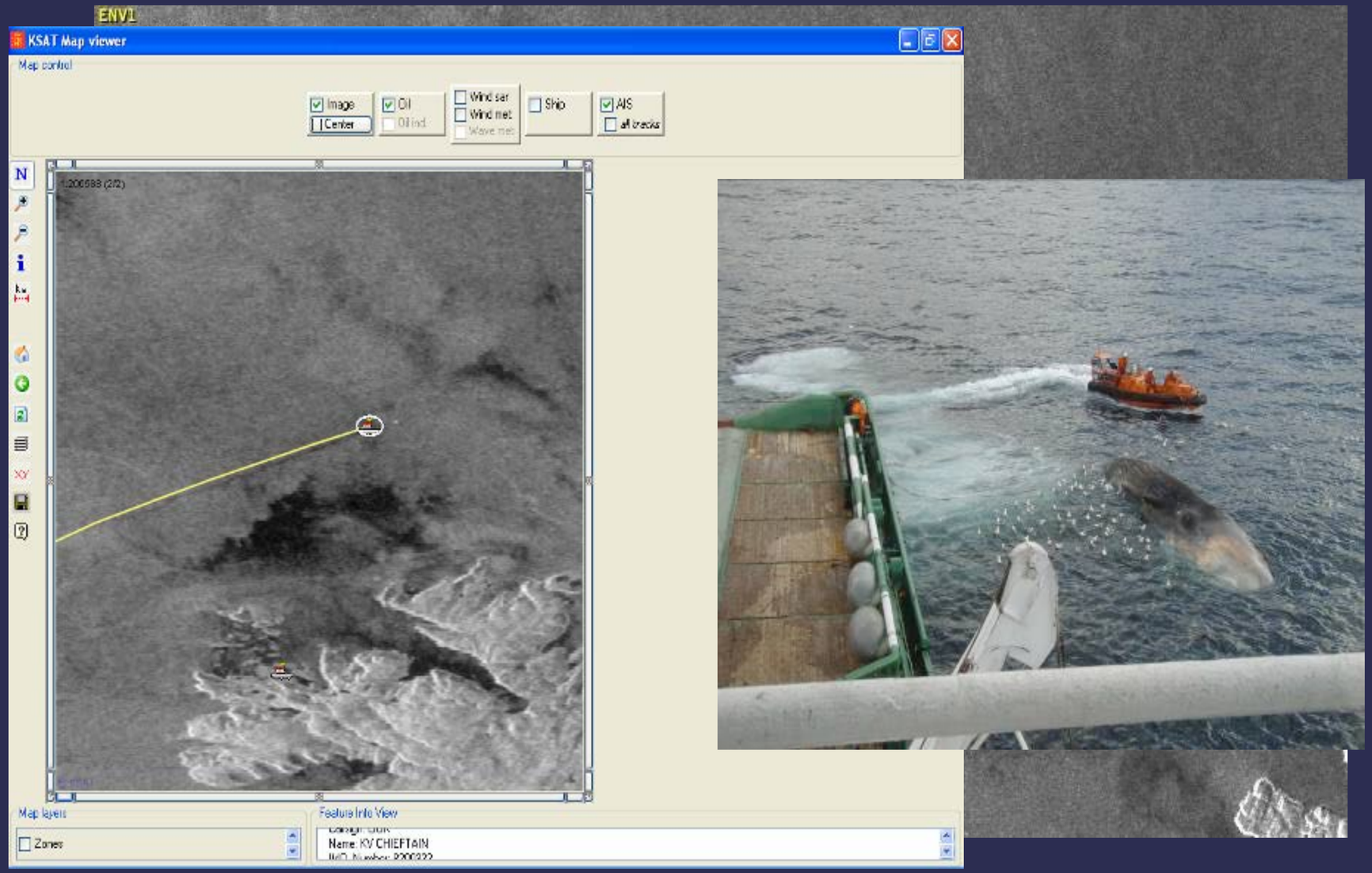
Norwegian Space Agency

Service – but always not real pollution



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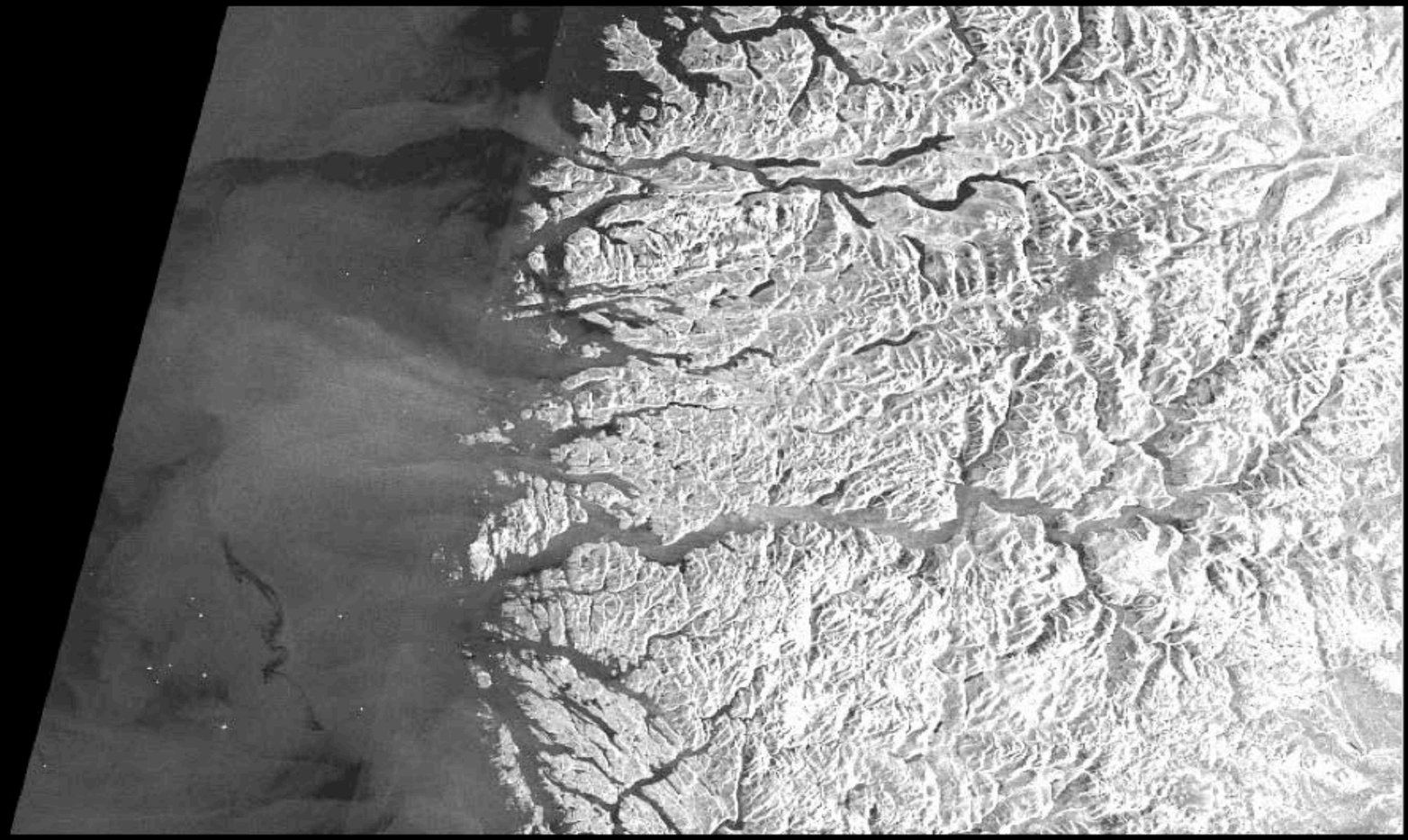
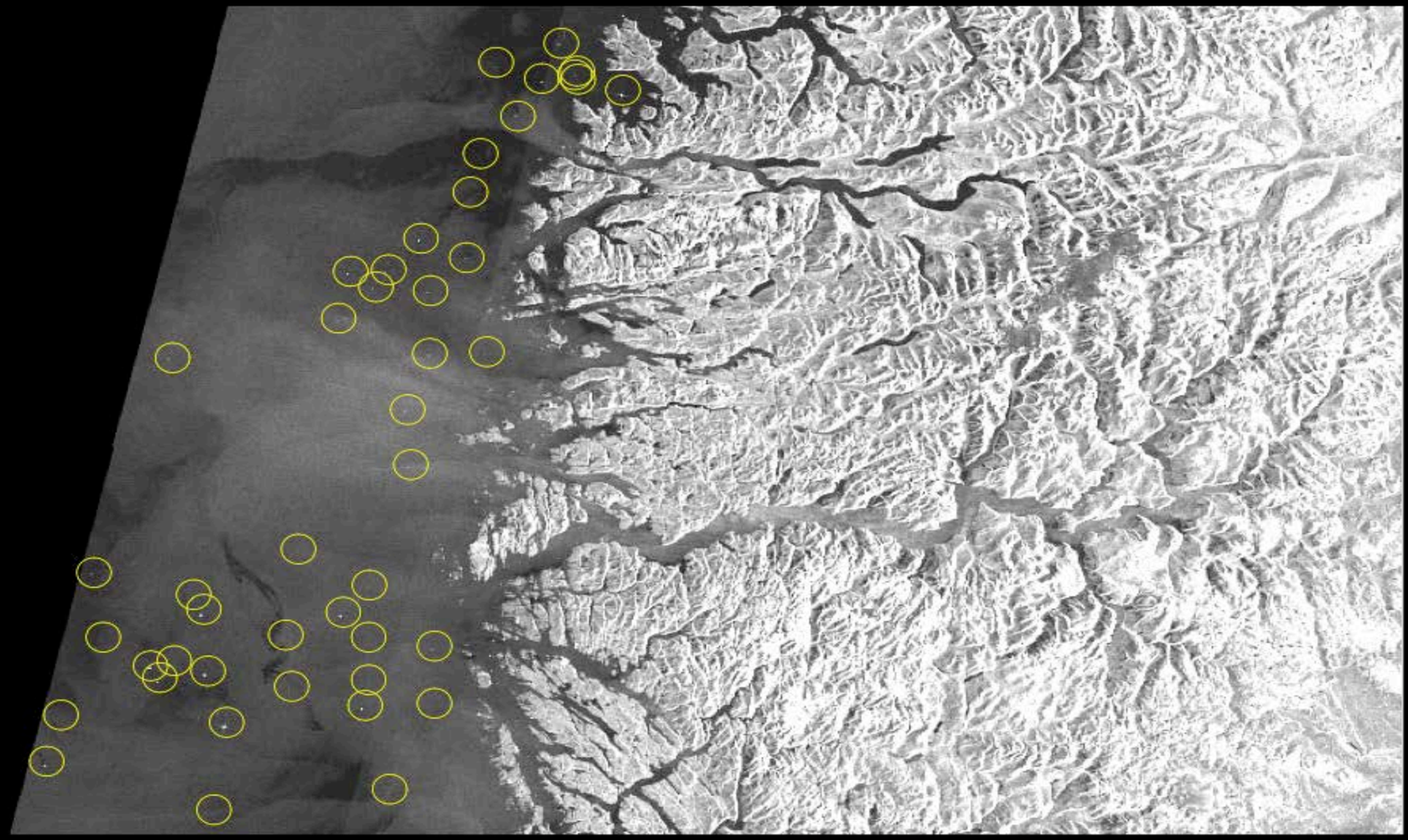
Norwegian Space Agency

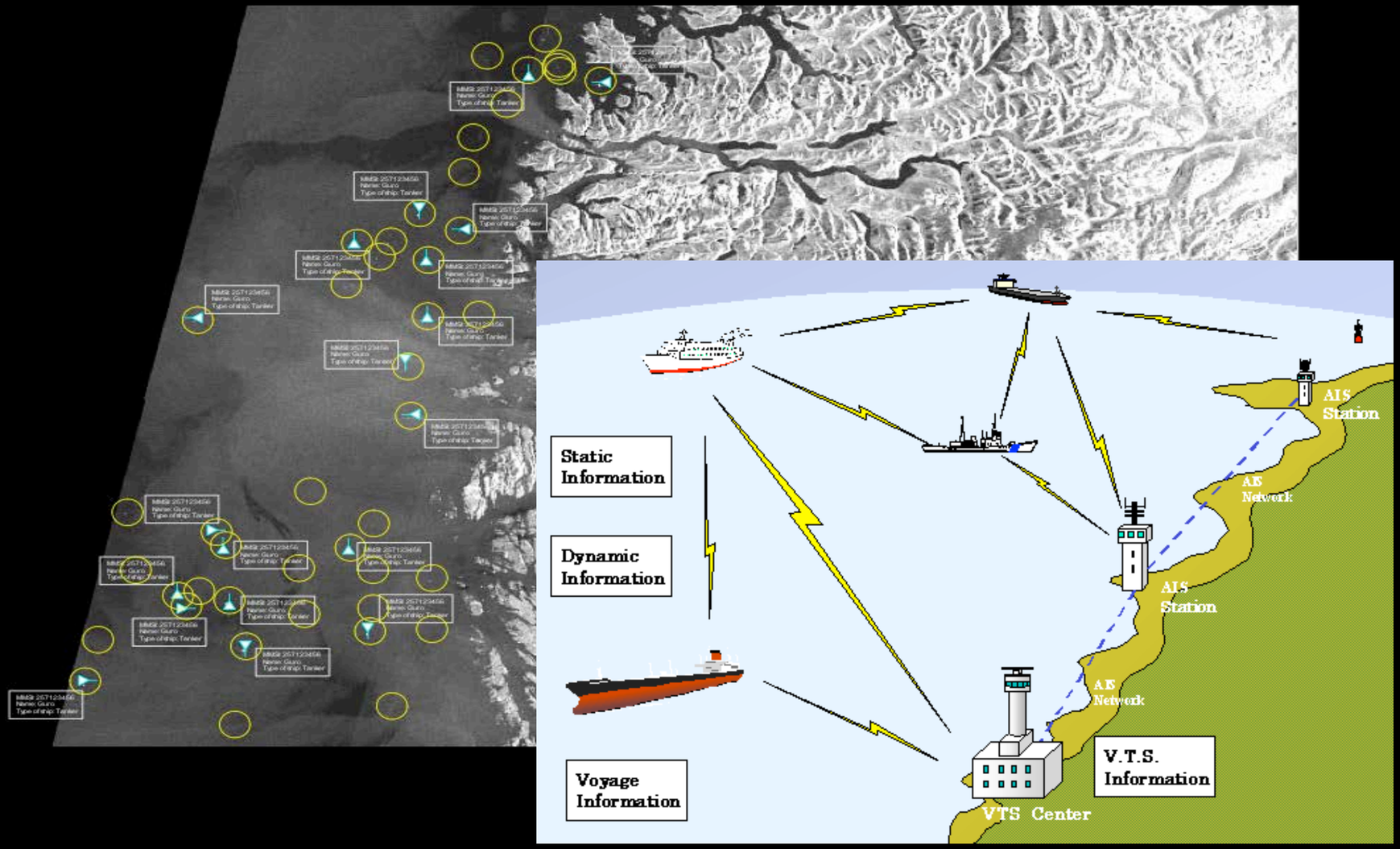
Surveillance of ship traffic



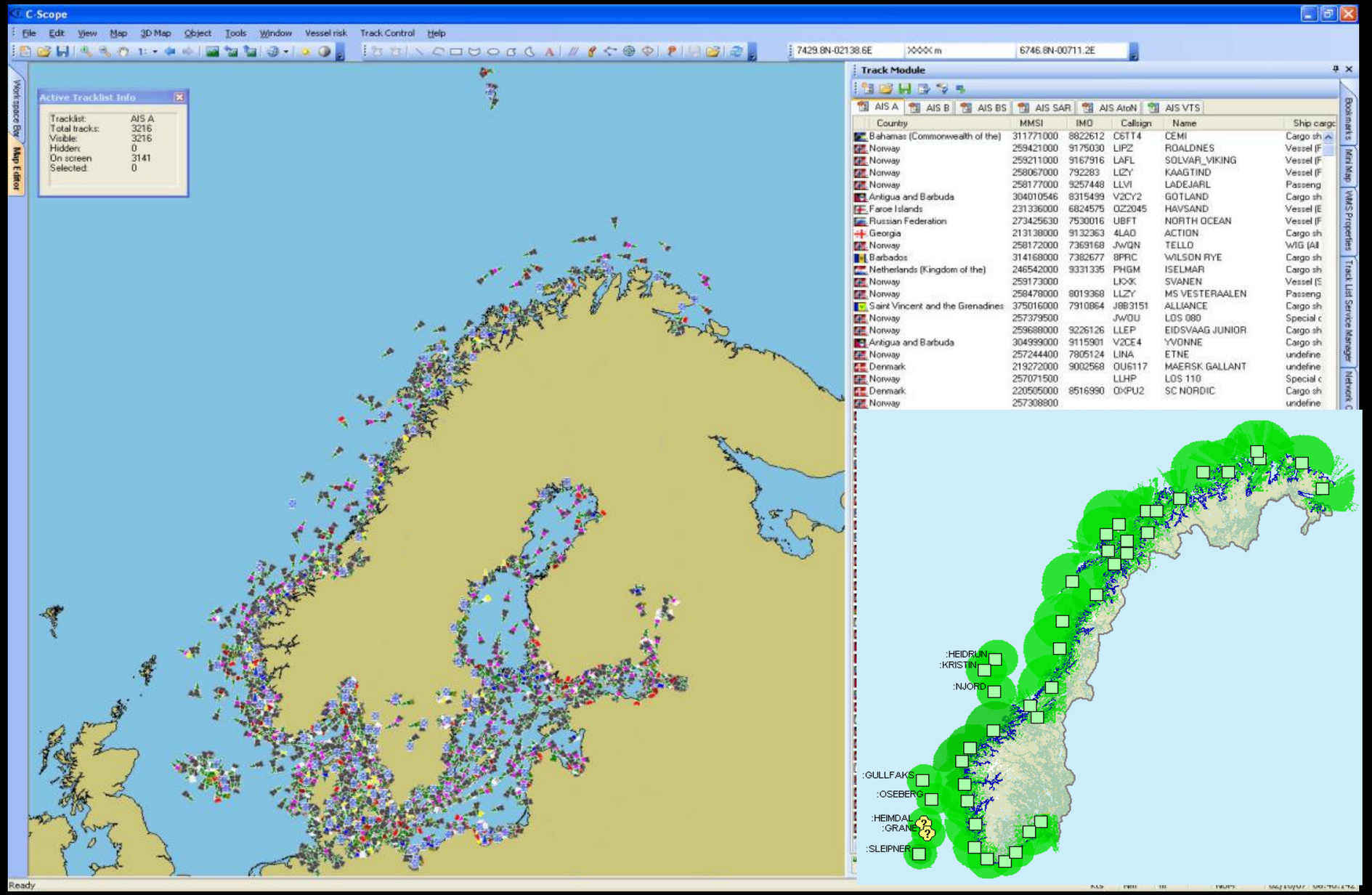
Detecting ships with RADARSAT



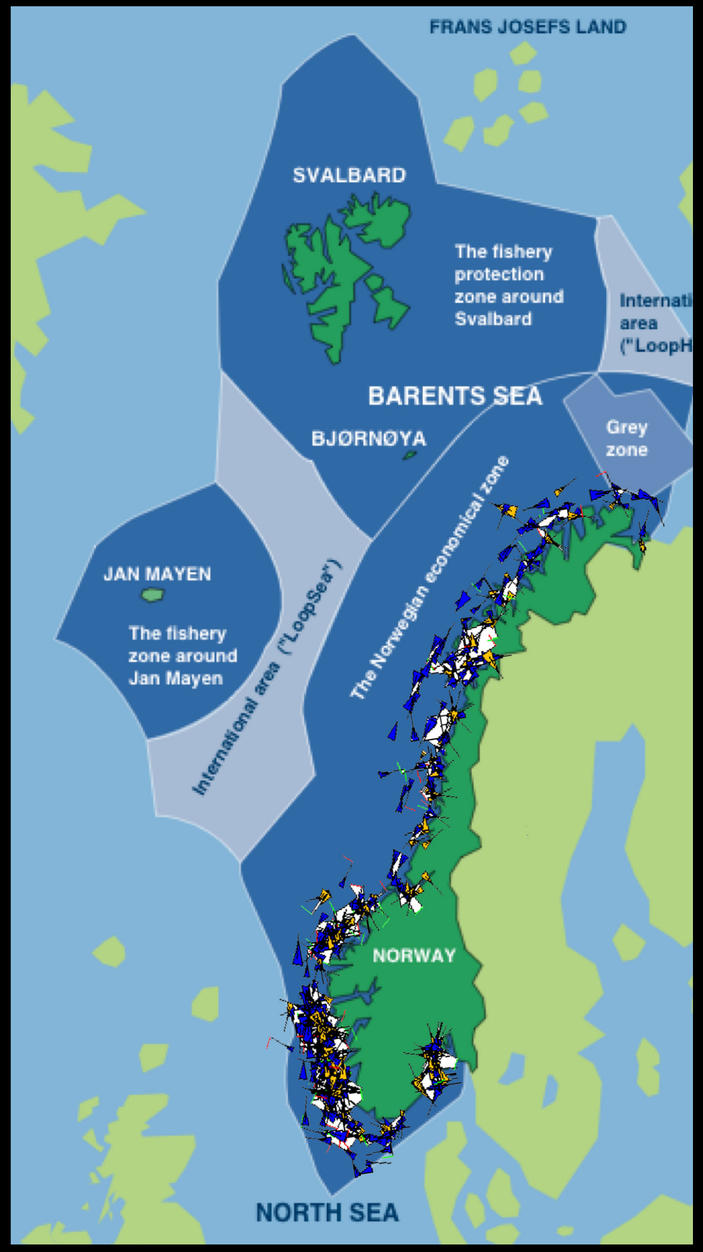
Identification of ships using AIS signals



Coast guards AIS monitoring system

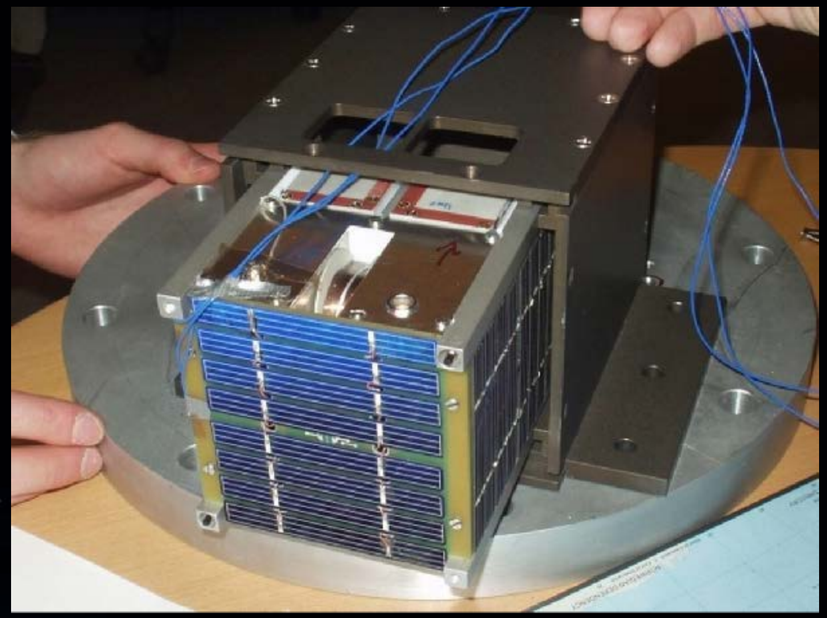


Coast guards monitoring system not enough!



The Rudolf-satellite (NCUBE)

Can AIS signals be received from space?
Can we track a reindeer?



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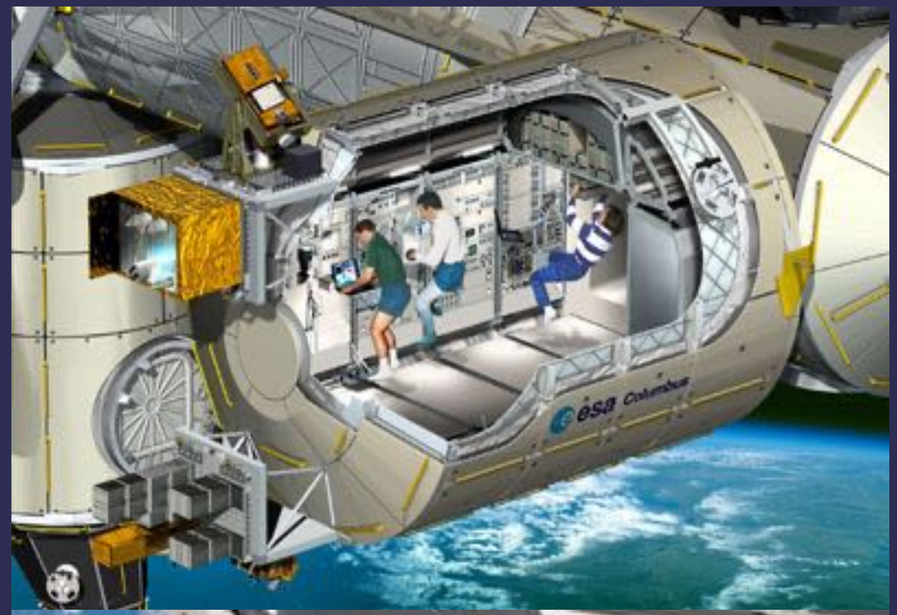
NORWEGIAN SPACE CENTRE

Test version of AISsat (NORAIS) was installed at ISS

- Launch: NORAIS was launched in September 2008, antenna late 2009
- Start of experiment: Early 2010
- Main goal: AIS signal tests in crowded areas



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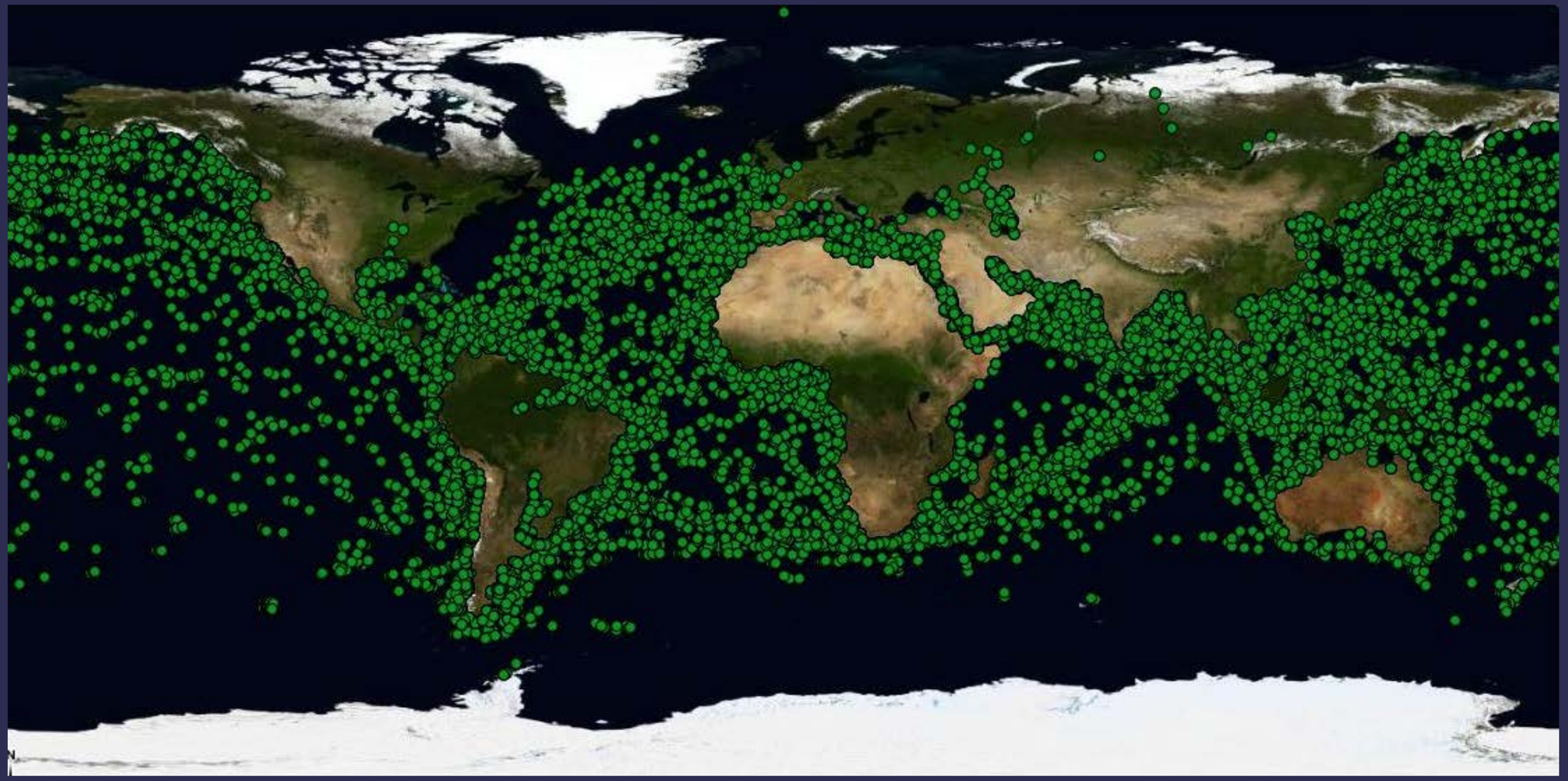
Norwegian Space Agency

World ship traffic from ISS



Norsk Romsenter
Norwegian Space Agency

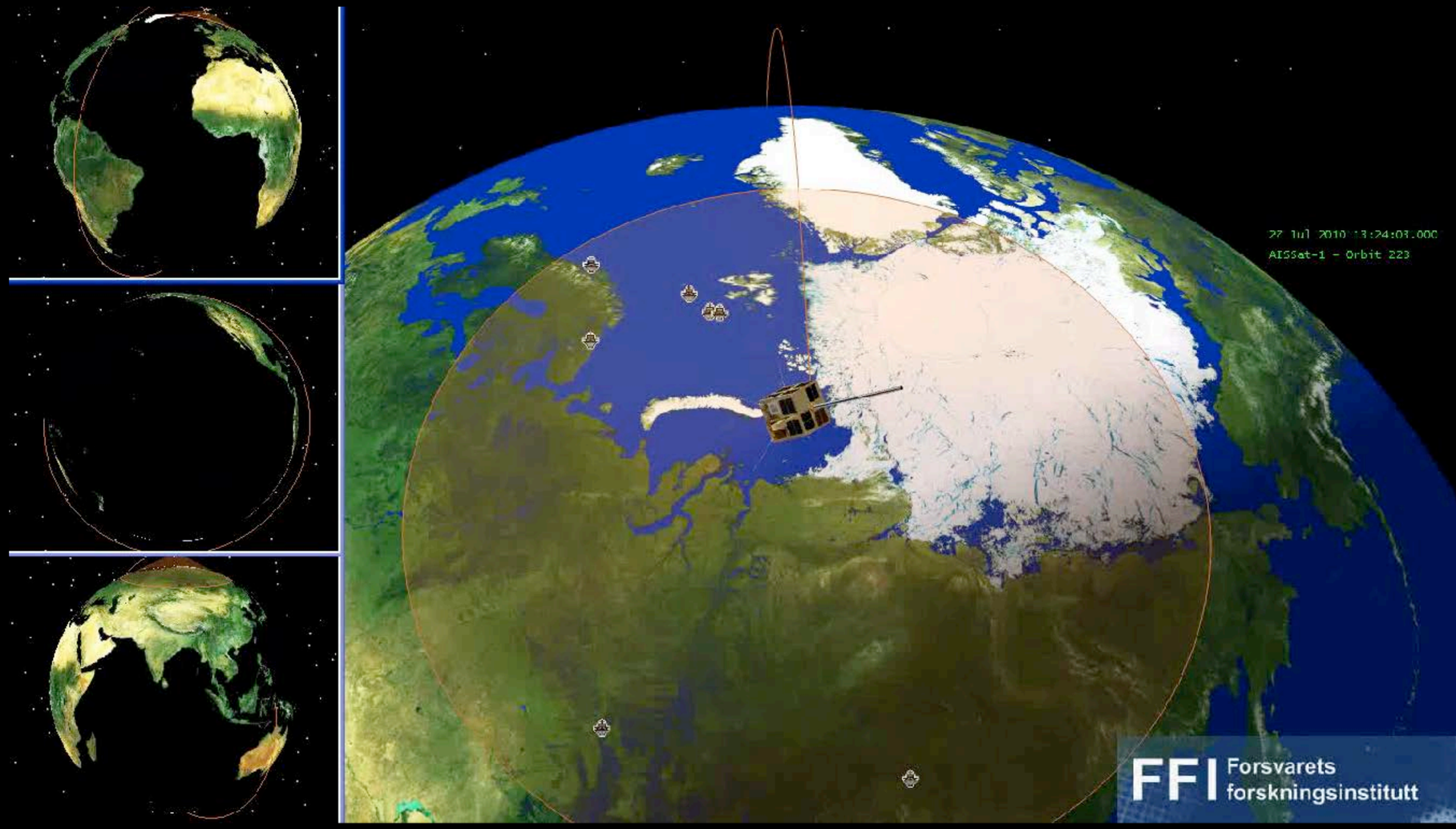
Norwegian AISsat-1

- Total cost ca. 30 million NOK.
- Launched summer 2010 from India
- Norwegian Space Centre and includes funding from NHD.
- Developed by Forsvarets Forskningsinstitutt (FFI), with contribution from Kongsberg Defence & Aerospace og Kongsberg Seatex

Norsk Romsenter
Norwegian Space Agency

AisSat-2

Today, the Norwegian Coastal Administration and other governmental institutions are using the data from AISat-1 and 2 for a variety of purposes, including monitoring fisheries, oil spills, and maritime traffic, to support anti-piracy operations along the coast of Africa, and other areas of interest to Norway.



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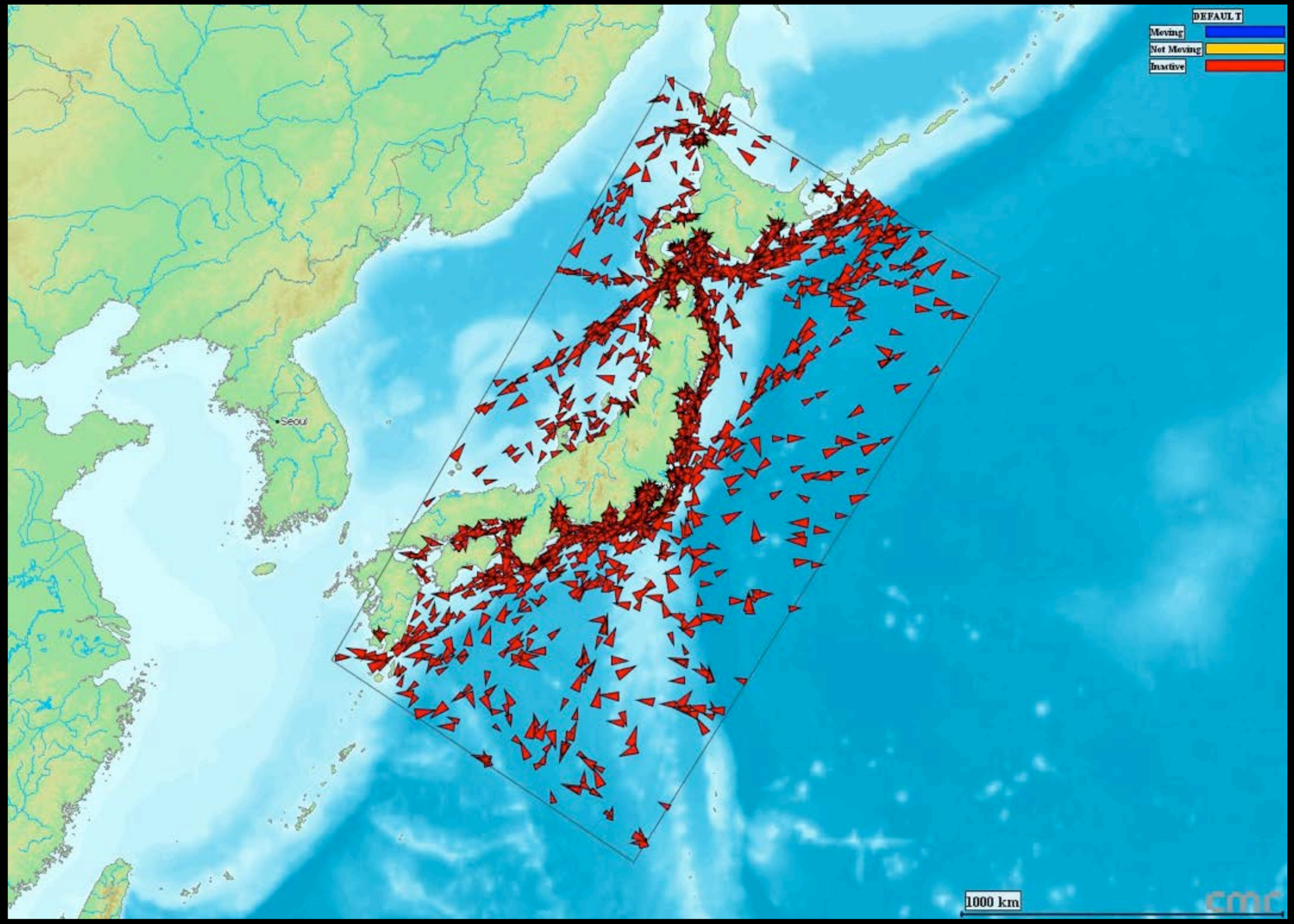
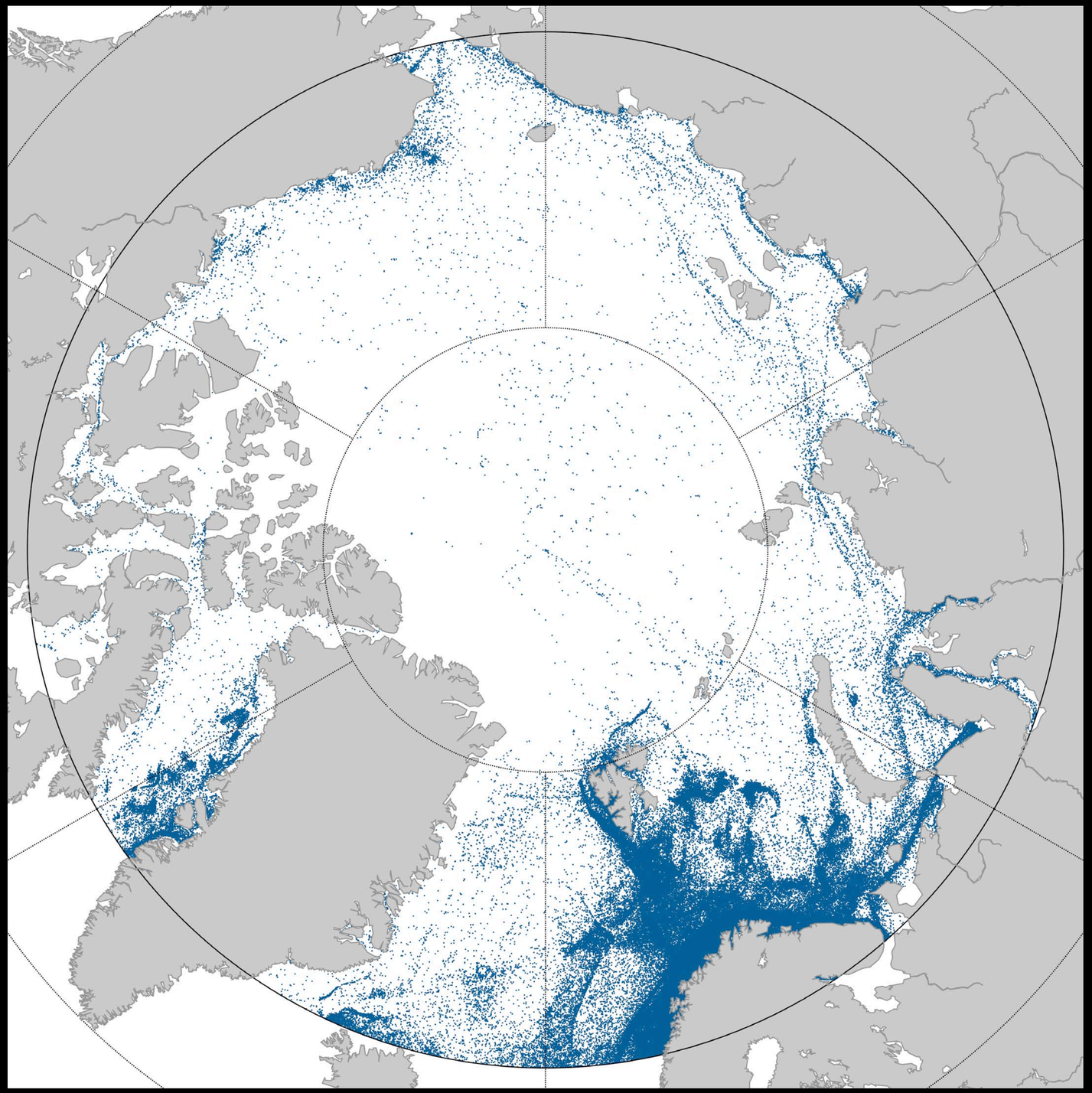
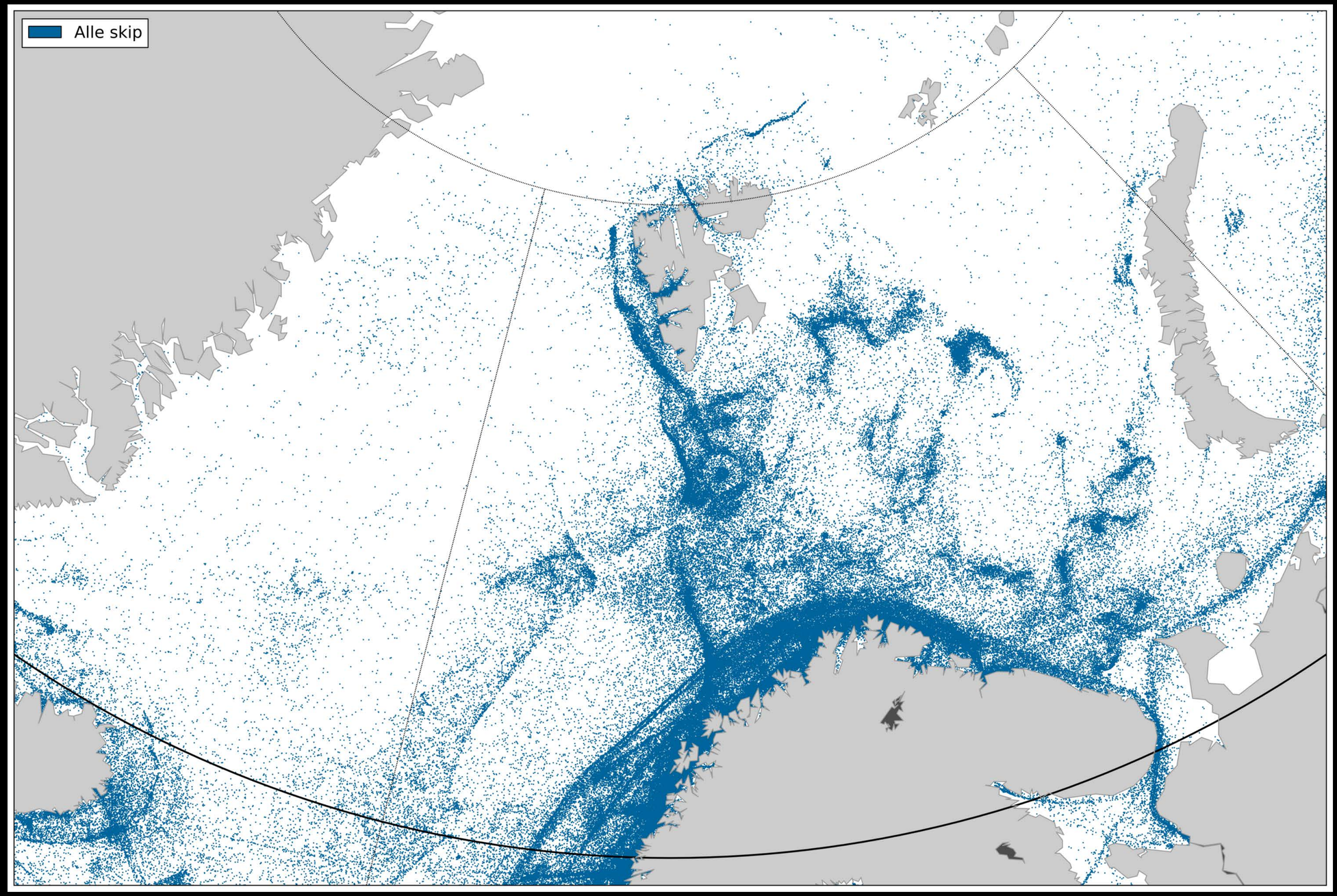
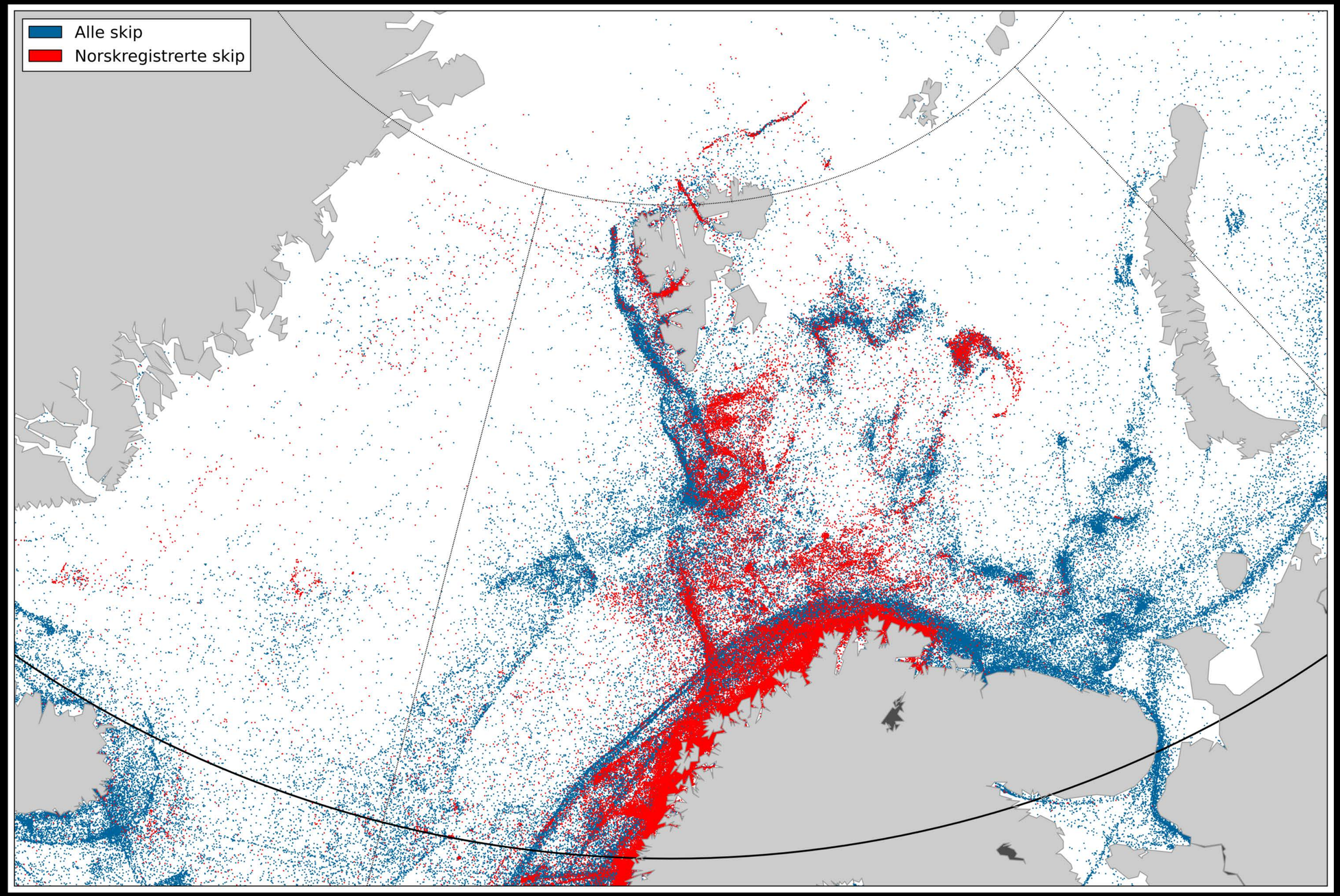
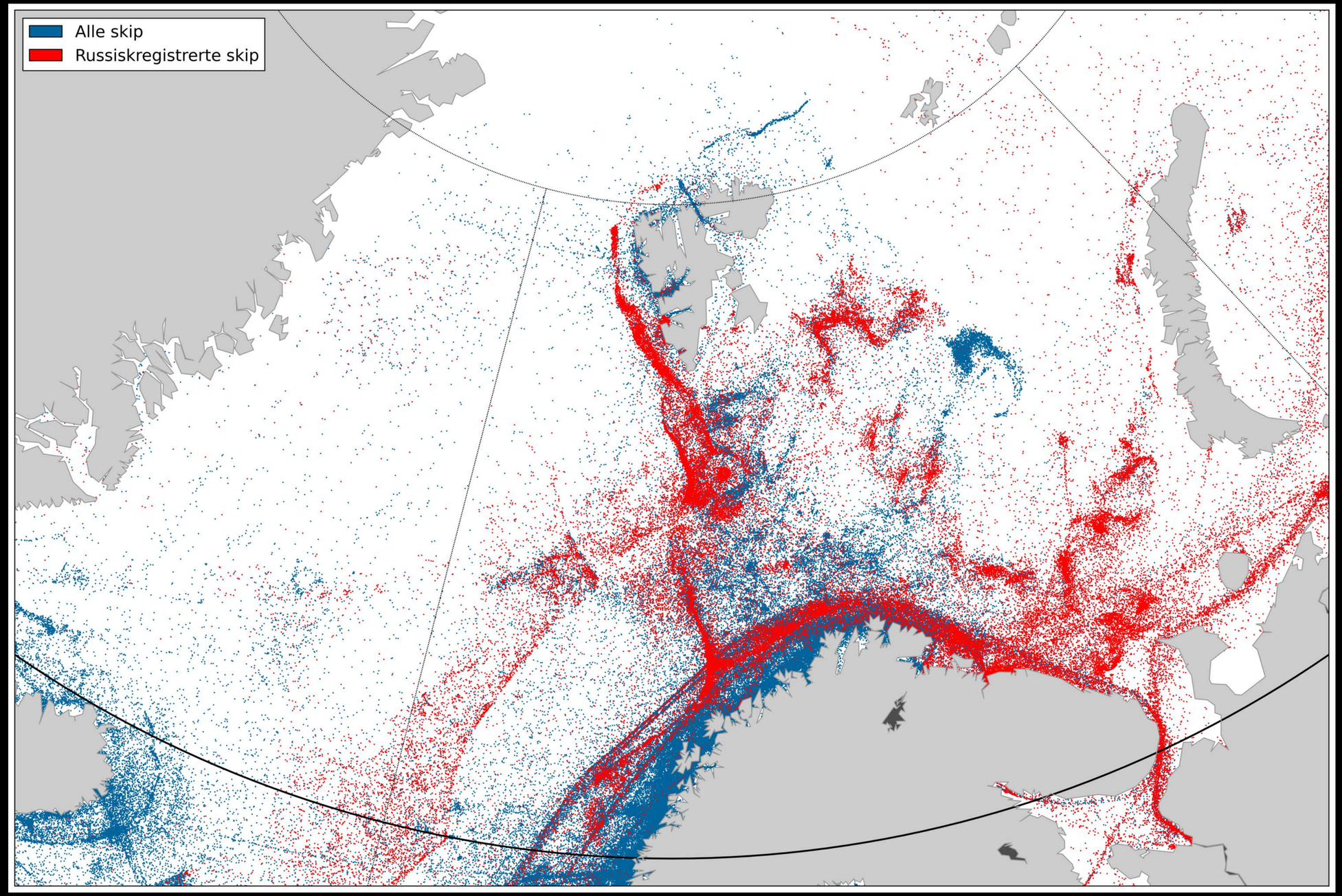
AisSat-1 supports Japan



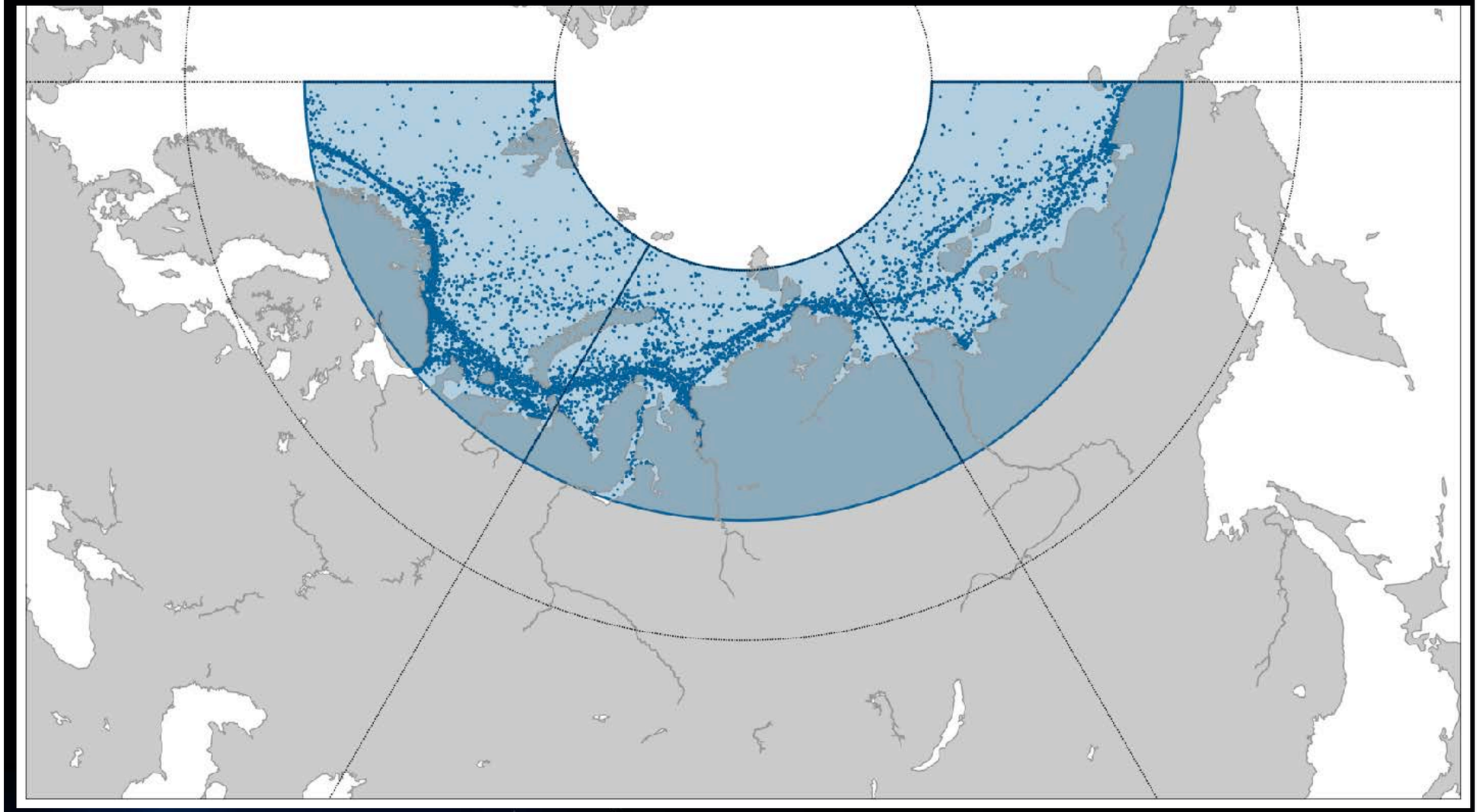



Alle skip


Alle skip
Norskregistrerte skip


Alle skip
Russiskregistrerte skip

Northern sea route (46 vessels in 2012)



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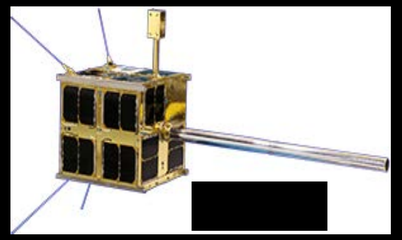
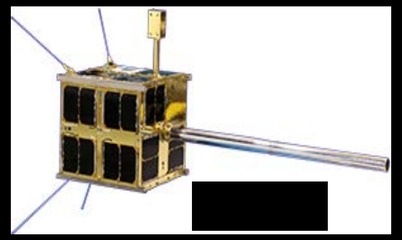
NORWEGIAN SPACE CENTRE

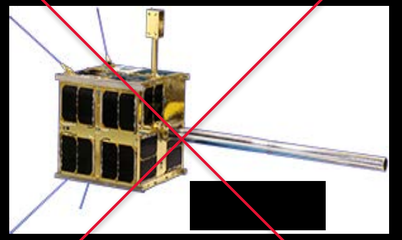
Norwegian small satellites



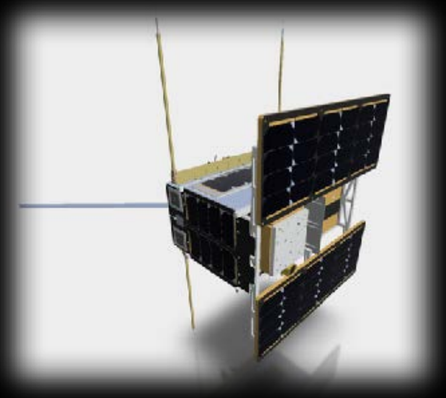
AISSat-1 (2010)
(2010)



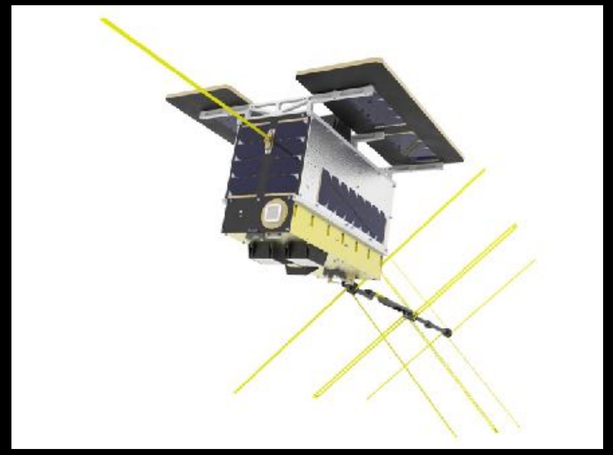
AISSat-2 (2014) (2014)



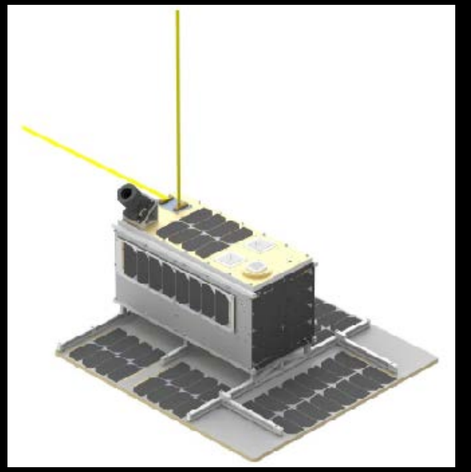
AISSat-3 (Q4 2017)



Norsat-1 (Jul. 2017)
- AIS
- Space weather
- Solar TSI



Norsat-2 (Jul. 2017)
- AIS
- VDES demonstrator (VHS Data Exchange System)

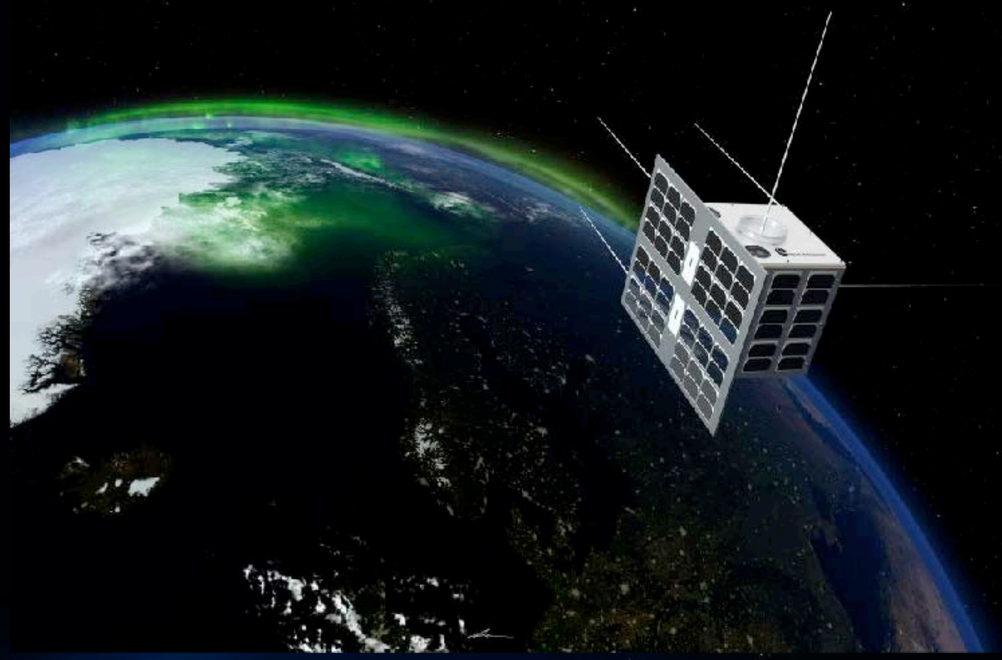


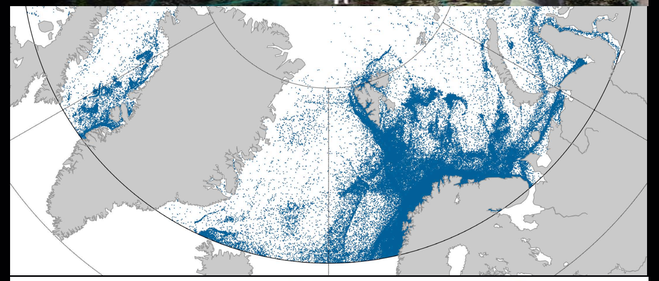
Norsat -3 (Q2 2019)
- AIS
- Navigation radar detector

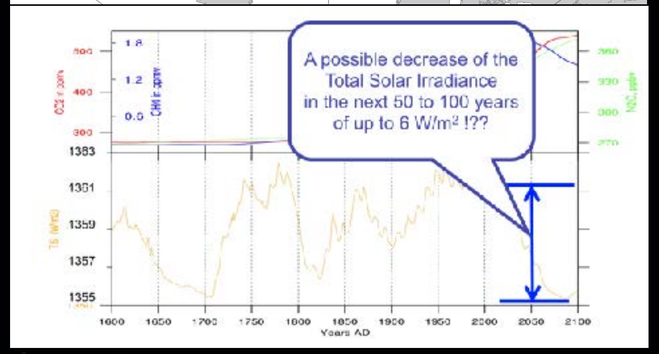
NORSAT-1

NORSAT-1 is a small Norwegian satellite designed to carry three scientific payloads

- AIS-receiver - Ship detection - to test new algorithms
- CLARA - Solar Total Irradiance monitor (Sun-Climate)
- Mini-Langmuir probes (Space Weather)



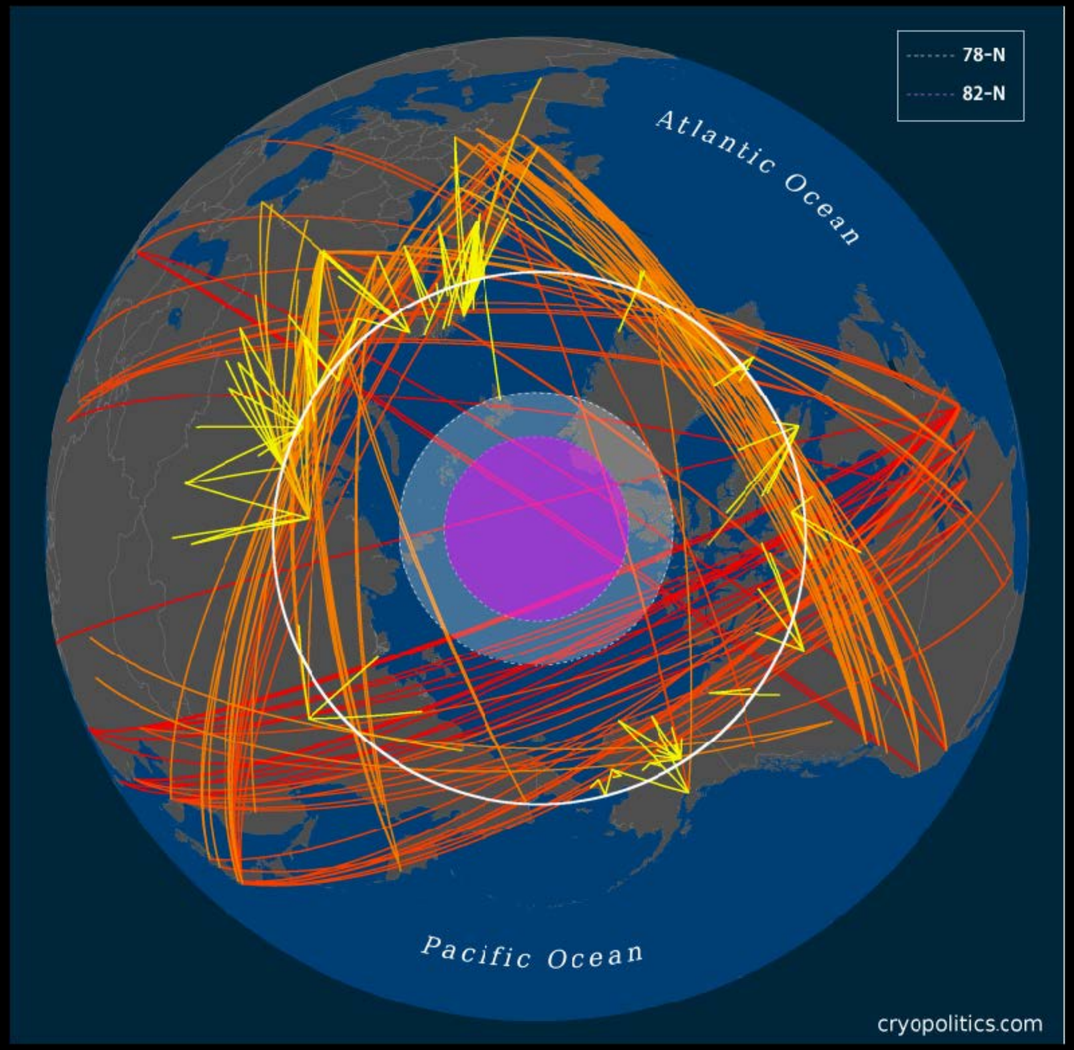


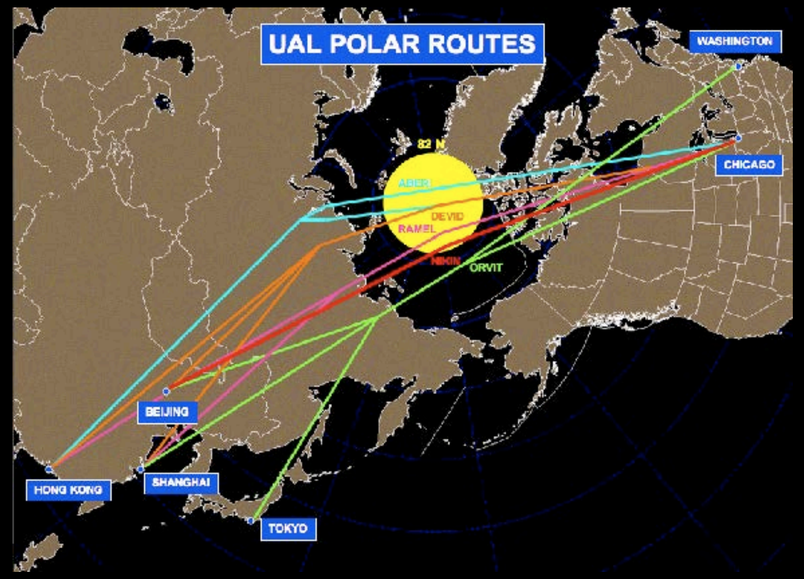


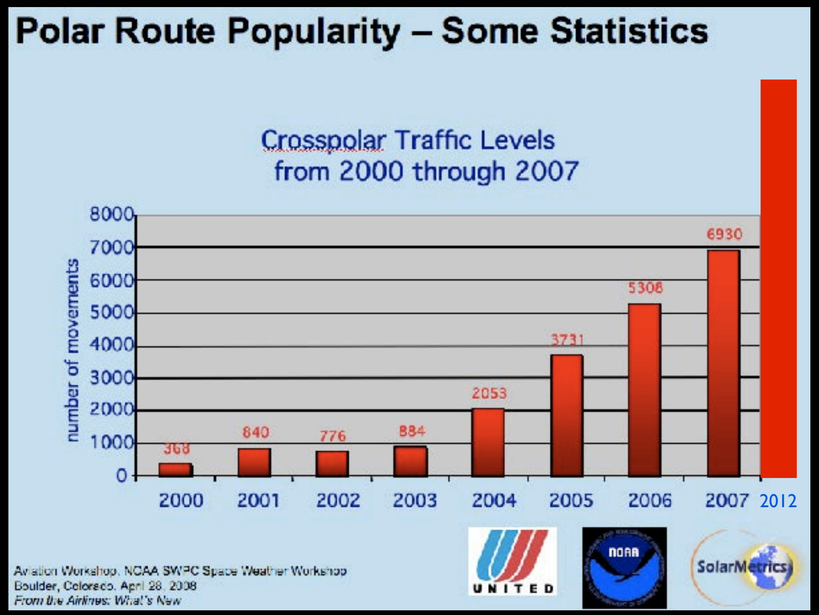
Norsk Romsenter
NORWEGIAN SPACE CENTRE

Polar routes

- Polar routes : 11.214 flights in 2012 (3,365,000 passengers)
- No satellite communication north of 82 degree

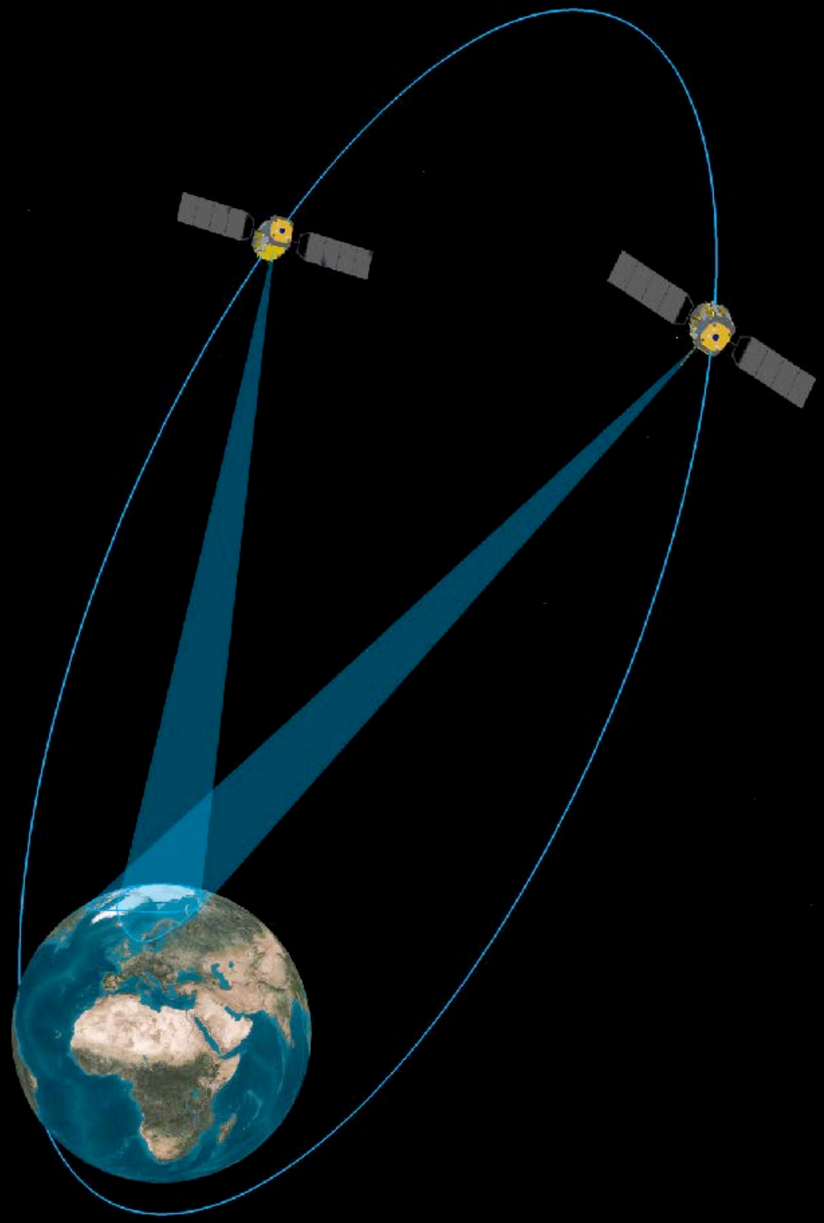






Broadband - Telecom in polar regions

Highly Elliptical Orbit (HEO)



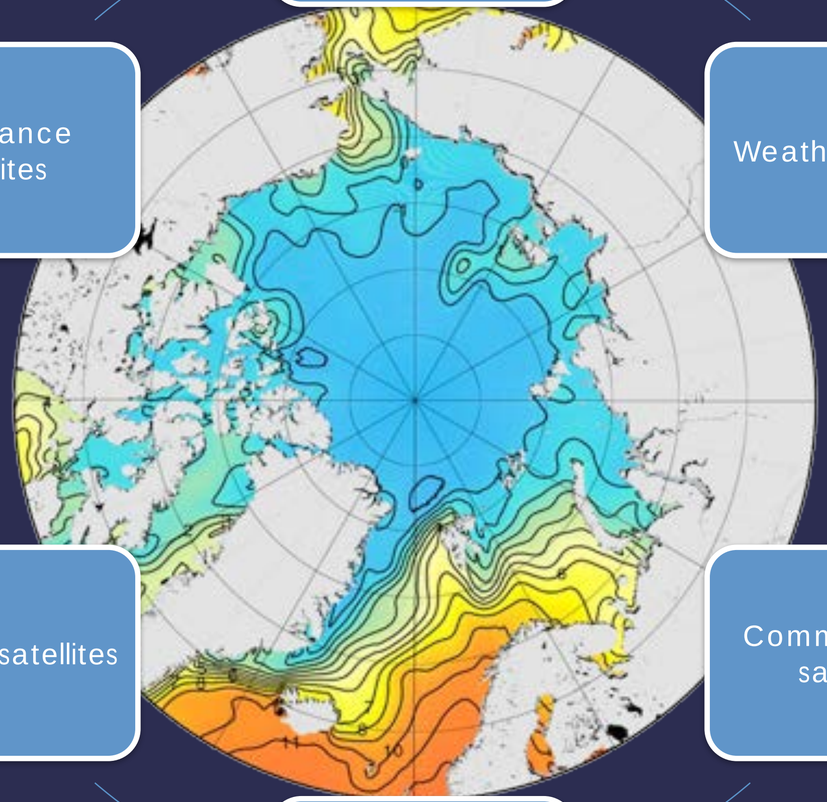
Wy Space Activities in the Arctic

Space technology is perfect for use in the Arctic since **satellites can cover vast areas with relatively small amount of infrastructure and without harming the environment.**

- Earth observations
- Navigation
- Communictaion
- Research

Norsk Romsenter
NORWEGIAN SPACE CENTRE

Arctic – an new Space Arena



Earth observing satellites

Weather satellites

Communication satellites

Navigation satellites

Research satellites

Surveillance satellites

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Space is not the solution to all our challenges

But few - or none - of our challenges in the Arctic can be solved without secure access to satellite systems

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