



NTNU

Det skapende universitet

Norway's space industry and research

Space Technology I
Vendela Paxal

Figures

- Norway's space industry has a yearly income of almost 7BNok
- The income is mainly from the communication satellite industry
- The income is about 5 times the investment
- The investment is primarily through ESA, and then through the Norwegian Space Centre (Norsk Romsenter) and the Norwegian Research Council (Norges Forskningsråd)

Industrial players

In 1986, the Norwegian Forum for Space Activities, (NIFRO) was created. Members come from Industry and research institutes.

The aim of NIFRO is to promote Norwegian space industry, research and education.

NIFRO is a recognised "consultant" for Stortinget and Ministries in space matters.

NIFRO members

- Andøya Space Center
- CMR Prototech
- T&G Elektro
- Telenor Satellite
- Ideas
- Kongsberg-gruppen
 - Defence Systems
 - Satellite Services
 - Seatex
 - Spacetec
 - Norspace
- NAMMO
- Zaptec
- Indra Navia
- SINTEF

R&D members:

- Høgskolen i Narvik
- NAROM
- Validé
- Universitetet i Stavanger



Why is space industry important to Norway?

- Geographical position
 - Needs
 - Offer
- Low population density
- Large areas to cover
- Off-shore industry and shipping
- Increased interest in Arctic areas
- Increased interest in phenomena for which Norway is a perfect observation spot
- New satellite systems, new needs



Geographical position

Needs:

As we are sparsely populated we need satellites for broadcasting, communication, observation and navigation.

Our geographical coverage goes far beyond main land territorial Norway, far out into the sea, far to the north, even far to the south (Antarctica).

Special challenge due to topography and latitude, not always possible to use GEO satellites.

Geographical position

Offer:

Ideal position as an entrance to the arctic. "Civilisation" far to the north.

Ideal position for arctic studies; northern light, environmental changes, ozon layer, etc.

Ideal position for polar satellite systems house-keeping.

Up-coming fields of interest

More activity in the north, due to climatic changes, reports on large amounts of natural resources, increased political interest in northern regions.

Increased activity in the following areas is expected:

- Maritime traffic, north east and north west passages
- Oil industry, large oil fields have been discovered, or are expected
- Environmental studies, many of the "answers" are expected to be found in the arctic regions
- Atmospheric studies, prediction of space weather, important for GPS navigation
- Fishing industry
- Marine biology, access to new resources
- Mineralogy, access to new resources
- Tourism

Upcoming challenges

- Observation to predict weather, ice-berg drift, seasonal changes
- Surveillance to detect (environmental) criminal activity
- Security, rescue operations of personnel and handling of disasters as oil spill
- Transport, e.g. to and from oil platforms
- Navigation;
 - special problems in northern regions due to ionospheric activity
 - optimisation of maritime and air routes to reduce fuel consumption
- Secure communication to all parties

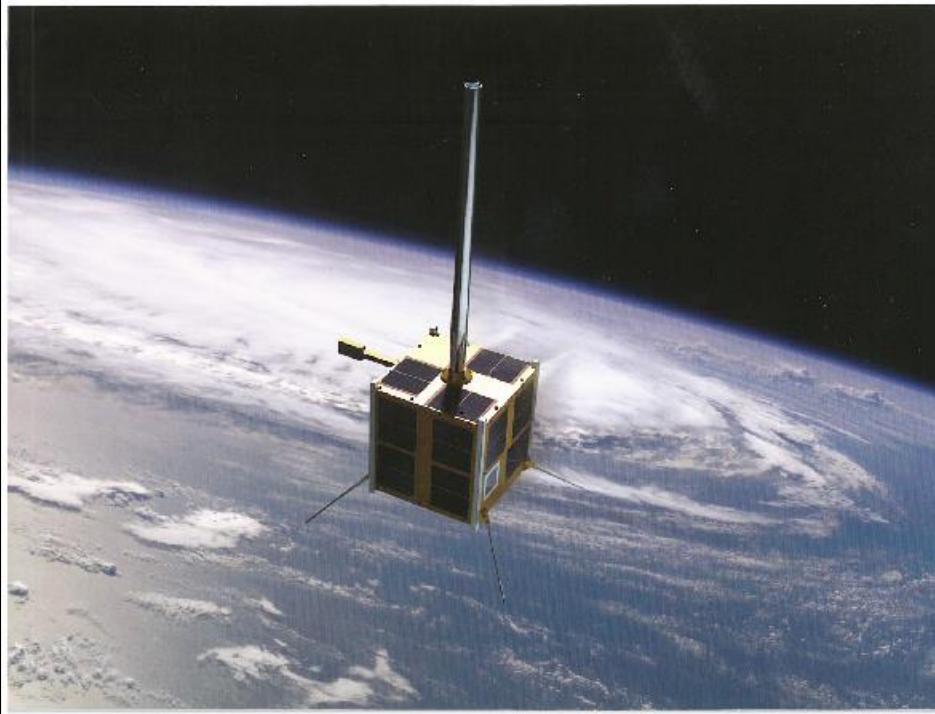


Meld. St. 32

(2012–2013)

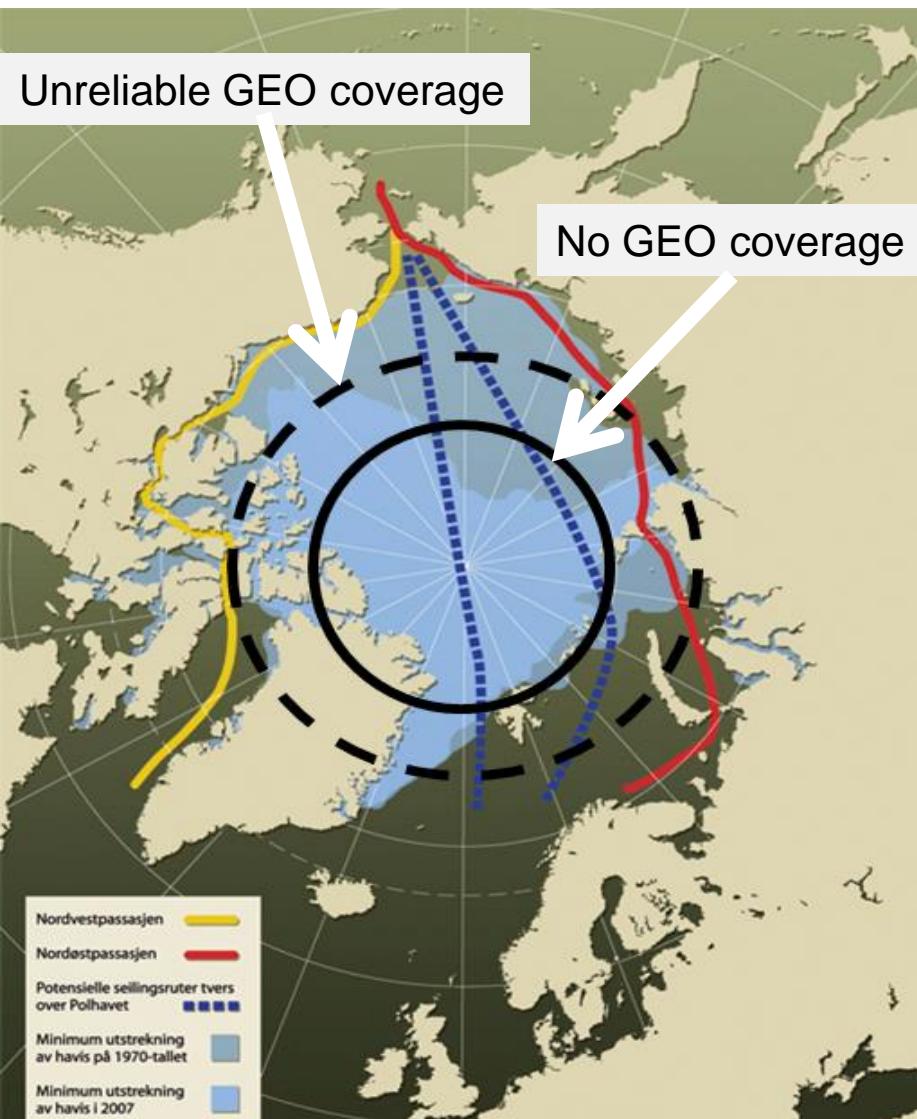
Melding til Stortinget

Mellan himmel og jord:
Norsk romvirksomhet for næring og nytte



Published April 2013

Activity in the arctic



Article in *Dagens Næringsliv* Friday 7th of September 2012:

Norsk romvirksomhet runder 50 år:

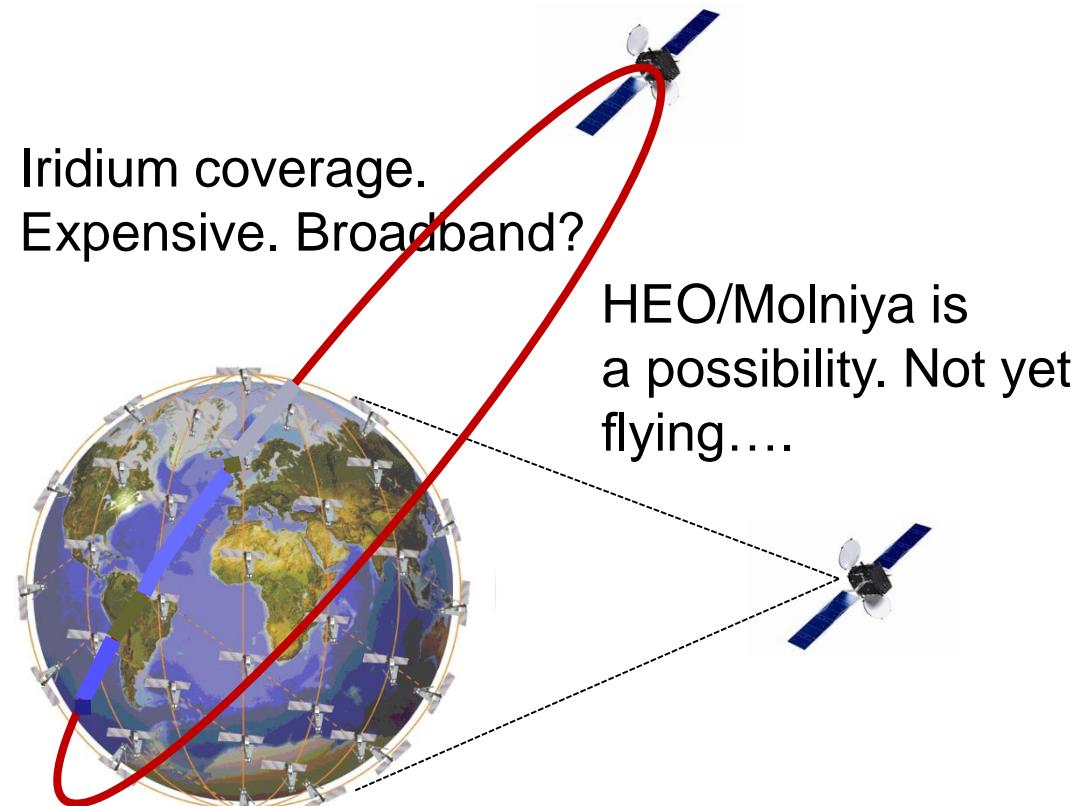
Kommunikasjon og navigasjon i Arktis er avhengig av satellitter–
vesentlig for sikkerheten, men gir også store industrielle
muligheter

*Professor Terje Røste, Professor Vendela Paxal,
Professor Odd Gutteberg, Institutt for elektronikk og
telekommunikasjon, Norges teknisk-naturvitenskapelige
universitet (NTNU)*

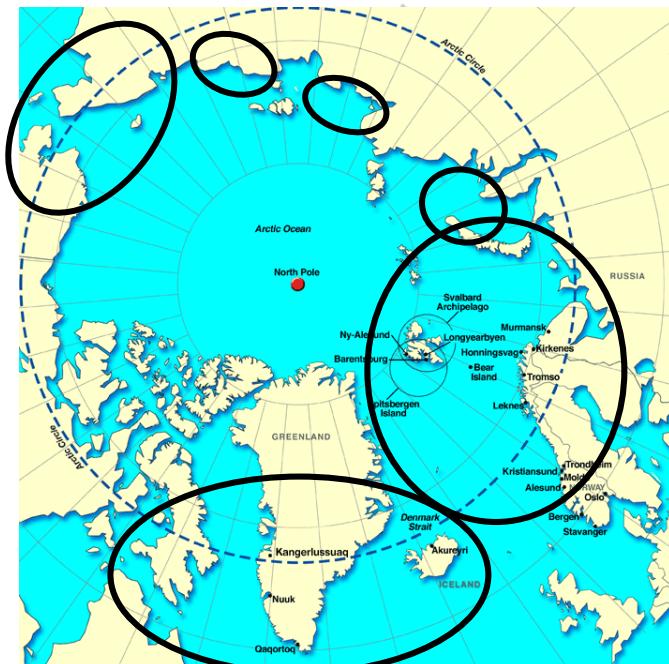
Main points:

Little coverage in the arctic for
communication and precise navigation.
This is a problem for activity depending
on large bandwidth, secure operation,
rescue operations, and surveillance.

Infrastructure in the Arctic - communication



Possible radio coverage from land based installations.
Broadband?



Infrastructure in the Arctic - Navigation

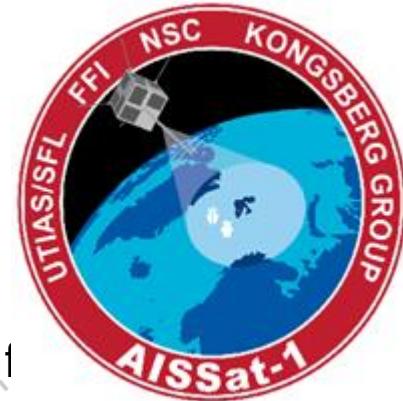
Low elevation may lead to loss of signal or loss of precision ~10m



- topography
- ionospheric distortions
- weather & darkness

AISSat

In 2013, StatSat was established, and has taken over the planning and operation of the existing and future Norwegian small satellite fleet.



- NRS (Norwegian Space Center) owns the project
- FFI (Norwegian Defense Research Establishment) is responsible for the technical implementation
- Kystverket (the Norwegian Coastal Administration) is the receiver of the information
- SFL (Space Flight Laboratory at the University of Toronto Institute of Aerospace Studies) has provided the spacecraft platform and the AIS VHF antenna
- The payload is being developed by Kongsberg Seatex AS with oversight from FFI.
- Kongsberg Satellite Services AS is providing the Earth station facility.

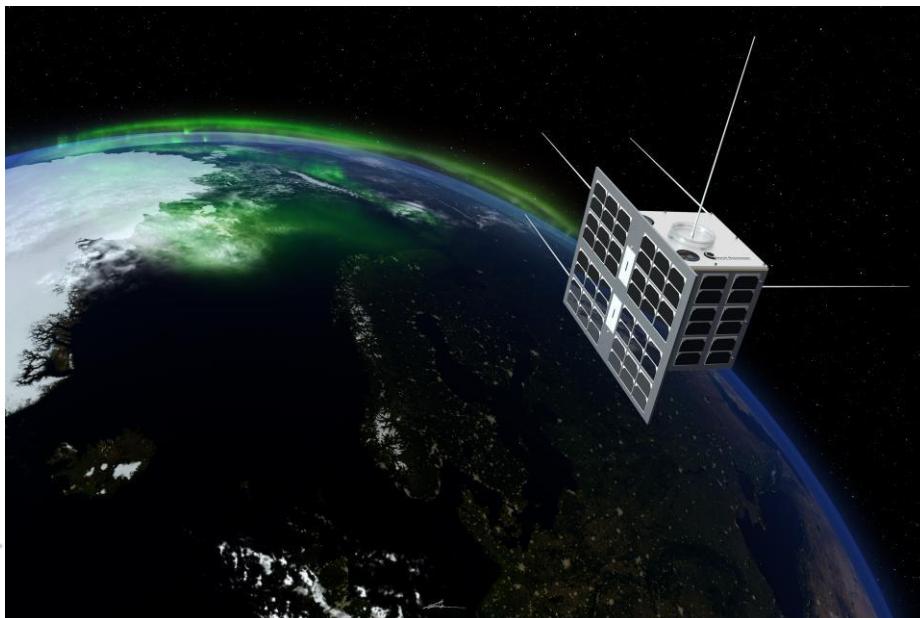


KONGSBERG SEATEX
KONGSBERG SATELLITE SERVICES



New Norwegian LEO satellites

- AISSat II launched 8th of July 2014 from Baikonur in Kazakhstan. Copy of AISSat I
- AISSat III planned
- Norsat-I is projected, will carry next generation AIS equipment and two scientific instruments (sun observation and space weather)



- Norsat-II will follow....

Research activities

- EISCAT
- Nordlysobservatoriet
- Andøya (ASC and Alomar)
- UiB, UiO, UiT, UNIS, NTNU





University of Bergen

Elves, sprites and jets

Published 17.10.2012

Space science receives supergrant

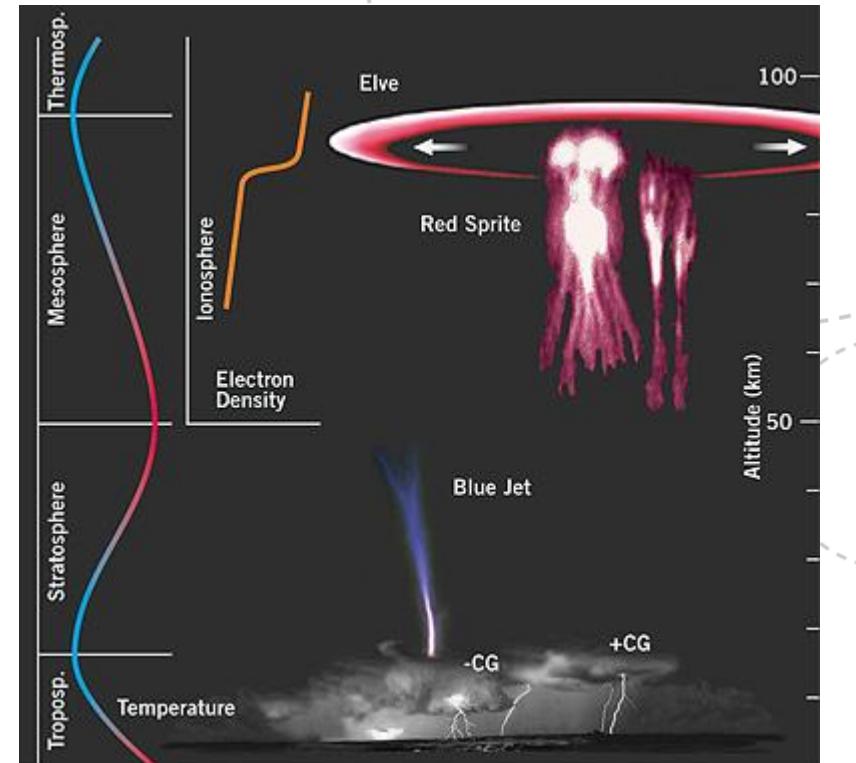
Space research at the University of Bergen has been awarded with one of the most prestigious grants in Europe. Nikolai Østgaard is the man looking for GRBs in thunderclouds.

Østgaard's project is pursuing earthly gamma ray bursts (GRB) that occur in thunderstorms. Electrically charged particles fly at the speed of light when there is thunder and lightning. A few years ago, both relativistic electrons and antimatter were measured from these phenomena.

– There are quite a few unknowns. We don't even know how often these phenomena occur. Perhaps it is in every strike of lightning. If so, we are talking about 45 times a second on Earth, he says.

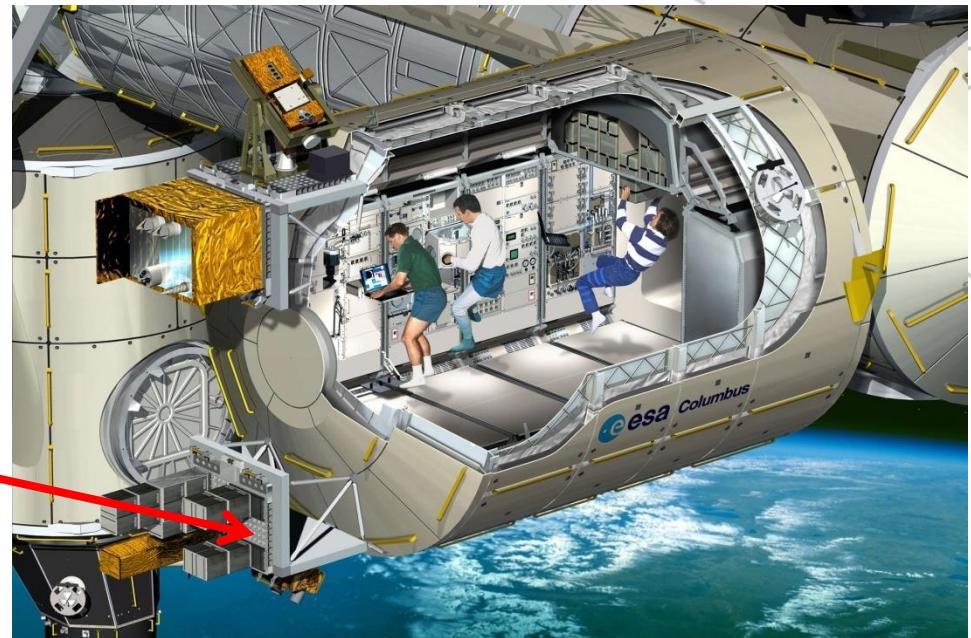
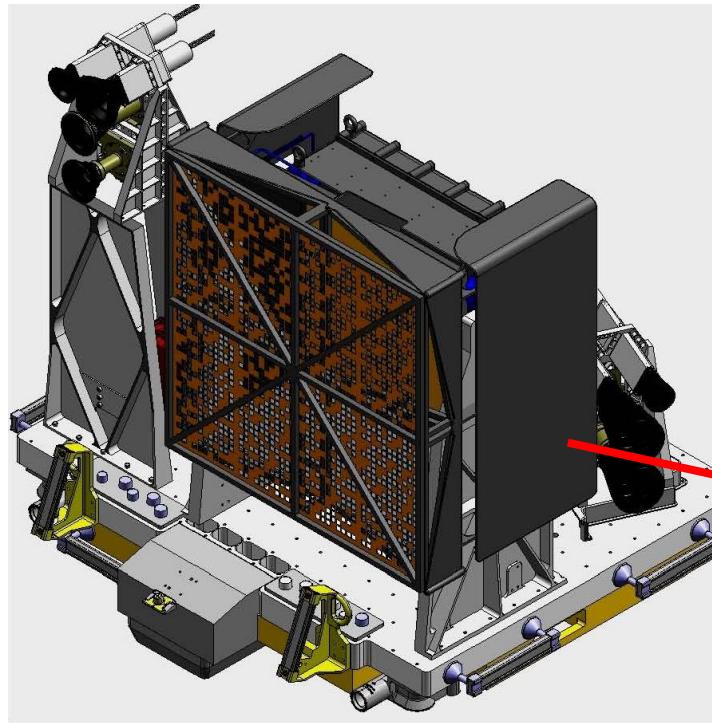
In their quest to find GRBs, Østgaard and his research team are building a large radiology instrument that will be sent to the International Space Station. They are also due to participate in a hot air balloon project across Central America. Future plans also involve flights above the thunderclouds.

The ERC funding will help the researchers reach these goals.





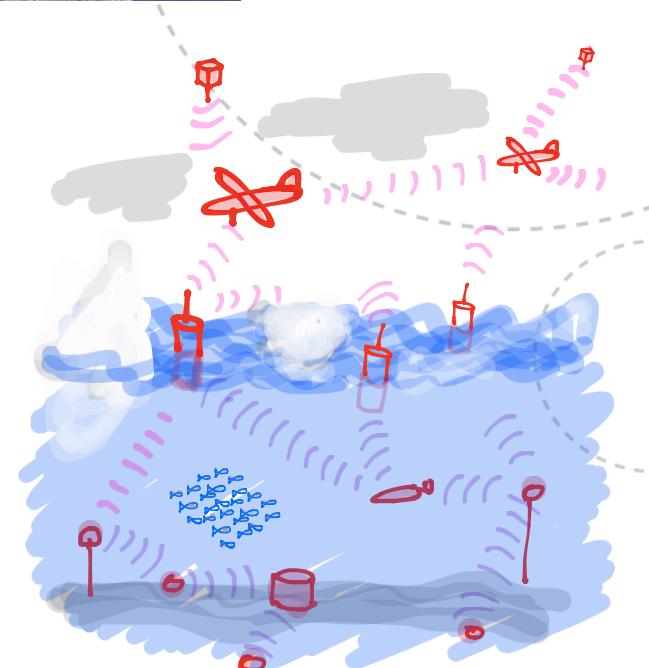
University of Bergen cont.



Atmosphere Space Interaction Monitor



- NUTS – the student satellite project
- CAMOS - Coastal and marine operations and surveillance - one of IMEs light house projects
- AMOS – Autonomous Marine Operations and Systems – including use of UAVs



NTNU- Plant Biocentre

A space research facility on ISS is controlled from Trondheim

By Tor-Henning Iversen, Nordicspace, 31st of March 2006

The European Modular Cultivation System (EMCS), which will be launched by the space shuttle Discovery for the ISS in July 2006, provides a fully controlled system dedicated primarily to experiments using plants, but also insects, amphibians, cell and tissue cultures. The EMCS is an experiment facility for biological investigations under microgravity, which allow the cultivation, stimulation, and crew-assisted operations of biological experiments under well-controlled environments. Conditions such as temperature, atmospheric composition, water supply, illumination, observation and acceleration on centrifuges will be controlled.

NRK 28.02.2011: Romfergestans forsinker "kjøkkenhage" på Mars

Forskere ved NTNU vil sende frø ut i verdensrommet for å finne ut hva som kan dyrkes på Mars og Månen i fremtiden. Men eksperimentene forsinkes av at de amerikanske romfergene nå settes på bakken for godt.



Vårskrinneblomsten er forskernes modellplante. Dersom den kan vokse i verdensrommet, er det grunn til å tro at også større planter kan klare seg.

Foto: NASA / NTNU

CIRiS – NTNU Dragvoll

Centre for Interdisciplinary Research in Space

- Human Spaceflight and Society
- International Space Station
- Regenerative life support systems
- Agricultural Research
- Integration and Operation – Norwegian User and Operations Centre

N-USOC

The N-USOC (Norwegian User Support and Operations Centre) – is one of ESA's seven Control Centers that are part of the ISS programme.





EISCAT (European Incoherent Scatter Scientific Association) operates three incoherent scatter radar systems, at 224 MHz, 931 MHz in Northern Scandinavia and one at 500 MHz on Svalbard, used to study the interaction between the Sun and the Earth as revealed by disturbances in the ionosphere and magnetosphere. At the Ramfjordmoen facility (near Tromsø, Norway), it also operates an ionospheric heater facility, similar to HAARP. Additional receiver stations are located in Sodankylä, Finland, and Kiruna, Sweden. The EISCAT Svalbard radar (ESR) is located in Longyearbyen, Norway. The EISCAT Headquarters are also located in Kiruna.



Ramnfjorden, Tromsø



Adventdalen, Svalbard

University of Svalbard



Department of Arctic Geophysics - Research projects, Middle- and upper atmospheric processes :

- Kjell Henriksen Observatory instrumentation.
- The Birkeland Centre for Space Science (Asymmetric Aurora, Dynamic ionosphere, Particle precipitation, Gamma-ray flashes)
- PROEM (Plasma physics Research using Optics, EISCAT and Modelling).
- NORUSCA (Norwegian-Russian research Collaboration in the Arctic)
- POLARLIS (POLarization of the Oxygen thermospheric Red Line In Svalbard):
 - Air-Ice-Sea interaction
 - Local scale climate
 - CRYOSLOPE Svalbard (Climate change effects on high Arctic mountain slope processes and their impact on traffic in Svalbard)



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Plasma physics, ionosphere studies

- Research on the Geminids meteor shower
- Every year in December, the Geminids meteor shower

with its many shooting

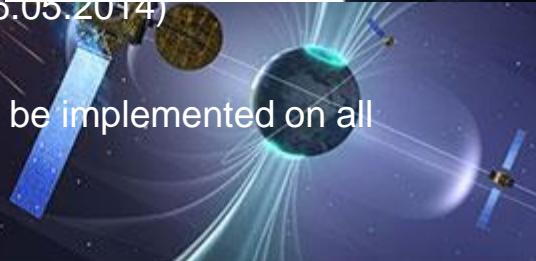
Northern Norway has given

CubeSTAR, Space weather Micro satellite



Space weather

- Industrialisation of space with Eidel (published 26.05.2014)
- Financed by ESA
- An instrument that may be implemented on all satellites in LEO orbit





University of Oslo

The UiO, physics department has had many projects with sounding rockets launched from Andøya and Ny Ålesund over the years.

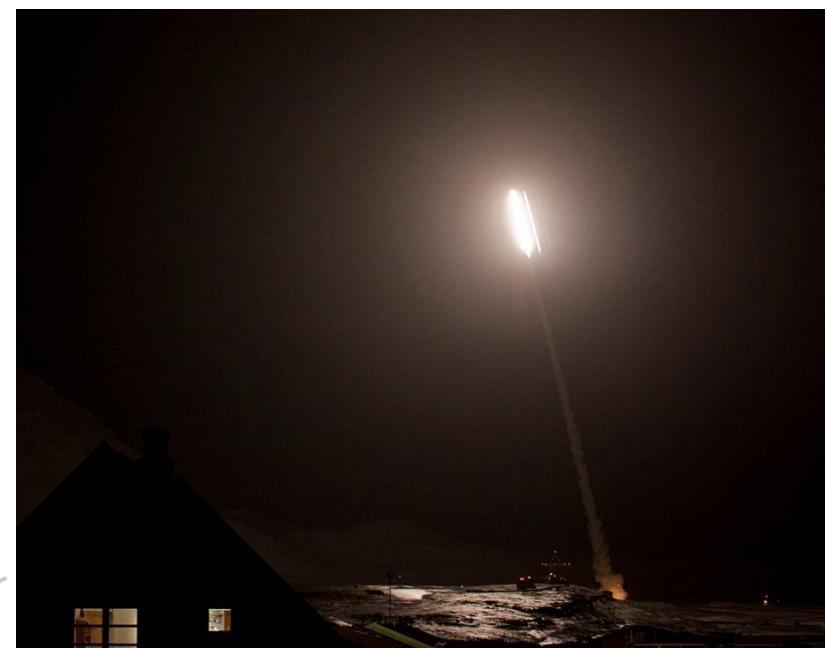
Examples are:

The ECOMA (Existence and Charge State of Meteoric Dust Grains in the Middle Atmosphere) project is a bilateral project between Germany and Norway involving a total of 9 sounding rockets distributed over four campaigns from Andøya Rocket Range from 2006 to 2010.



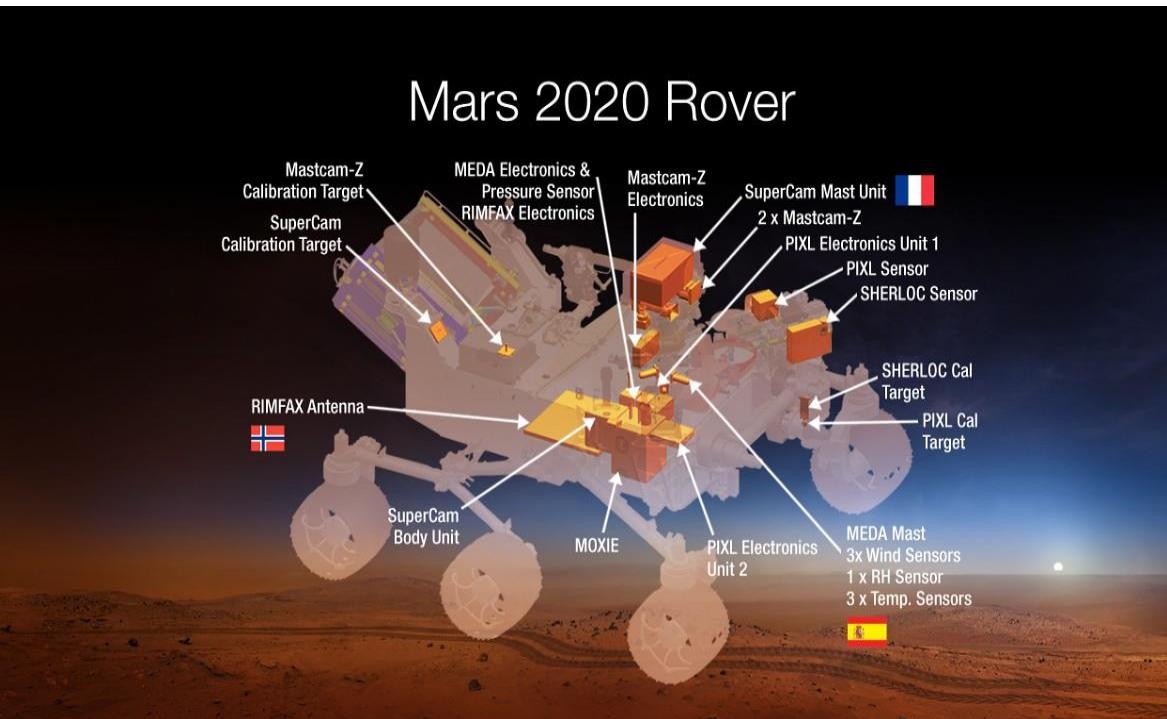
The ICI missions: “The ICI-3 sounding rocket launched from Ny-Ålesund today at 07:21:31 UT, intercepted an aurora and reached an altitude of about 354 kilometers.... The research from this and the previous ICI-2 flight will enable scientists to understand how space weather affects all types of radio communications.”

“ICI-4 is a scientific sounding rocket campaign that launched from the Andøya Space Center in February 2015”





- Study and design of own military satellites
- AIS satellite
- Recent achievement; a radar component developed by FFI will be on board the next rover going to Mars



See: <http://www.nrk.no/viten/norsk-utstyr-pa-mars-1.11858687>

- En stor ære

NASA offentliggjorde i går de sju instrumentene som skal være med roveren til Mars. De sju er utvalgt blant 58 instrumenter som har blitt foreslått av forskere og ingeniører verden over. Ett av de sju instrumentene er norskutvikla **RIMFAX - en georadar som skal sørge for data på den geologiske strukturen som ligger under overflata** på Den røde planet. Målet er å finne steder hvor det har vært vann på planeten, og NASA-forsker Michael Meyer sa på gårdsdagens pressekonferanse at RIMFAX vil gjøre det mulig å for første gang i historien se under bakkenivå på Mars.



Andøya Space Center & Alomar



- Service institute
- Rokets
- Lidars
- Primarily different studies of the atmosphere



Indra Navia

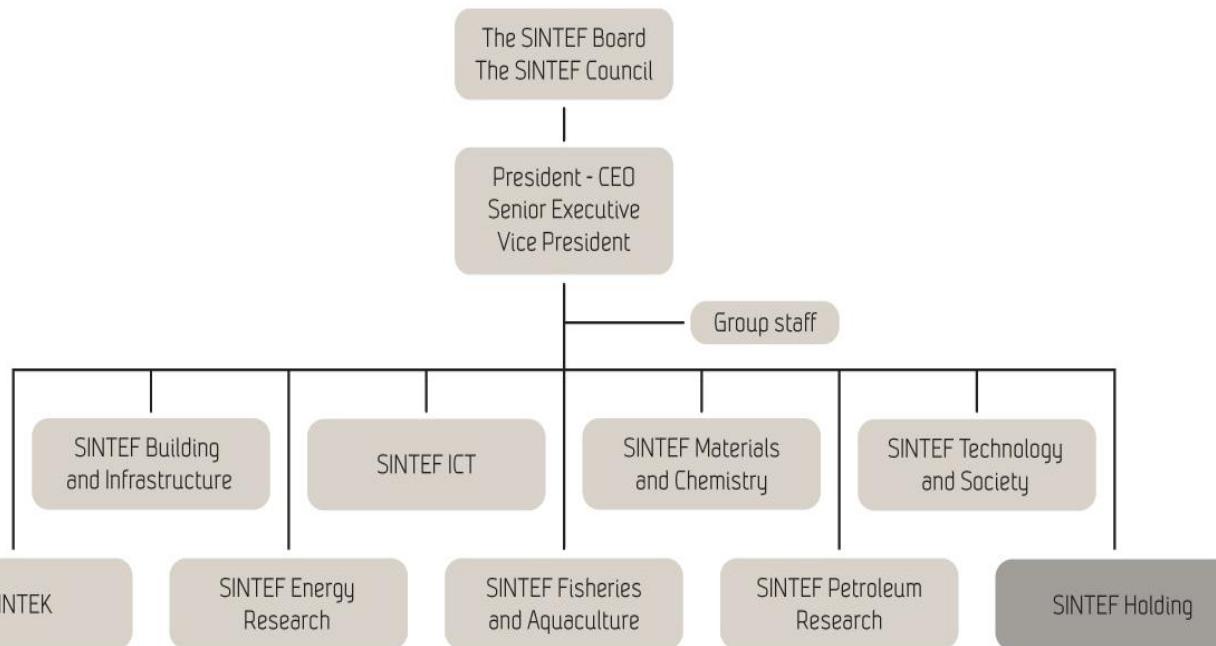


The Indra Navia Navigation department delivers NORMARC landing systems worldwide, and is the world leader on ILS systems. Indra Navia has also developed the GPS based approach and landing system SCAT-I, and is currently working on another system called GBAS, that will be able to land in CAT II/III conditions based on GPS and Galileo signals. This project is part of the EU financed SESAR program and also receives funding from NRS and NFR.





SINTEF is Scandinavia's largest independent research organisation, and sells research and consultancy services within technology, natural science, medicine and political science.





Snake robots in space:

SINTEF ICT (Applied Cybernetics), CIRiS (Centre for Interdisciplinary Research in Space), and NSC (the Norwegian Space Centre) are cooperating in the SERPEX project, which aims at investigating the feasibility of employing snake robots in future planetary exploration missions. The project is funded by ESA (the European Space Agency).



VG 14.10.2014

Forskere laget slangerobot

[http://www.vg.no/nyheter/
utenriks/forskere-laget-
slangerobot/a/23315298/](http://www.vg.no/nyheter/utenriks/forskere-laget-slangerobot/a/23315298/)



EMC SATCOM



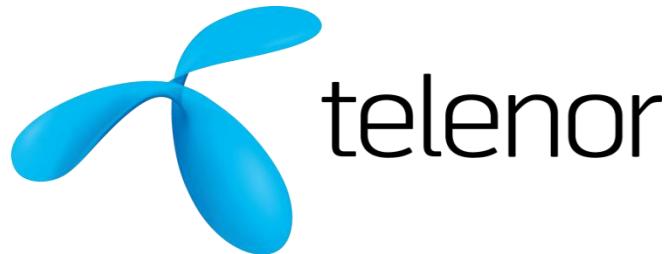
Research and development company delivering satellite equipment for two-way communication of voice, broadcast, video and internet services. The company is based on DVB-RCS broadband technology from Nera Satcom.

SatLink 2000

High Performance
VSAT Indoor Unit

DVB-S2® DVB-RCS2®

A photograph of the SatLink 2000 VSAT Indoor Unit. It is a rectangular, silver-colored device with a perforated front panel. On the left side, there are several small circular ports labeled "Power", "Error", "Status", "Receive", "SATLINK", "Transmit", "ETHERNET", and "LINK/ACT". On the right side, there are two small circular ports labeled "DVB-S2" and "DVB-RCS2".



Telenor is the market leader on providing satellite communication in the Nordic and Baltic countries. The coverage area is Europe and the Middel East.

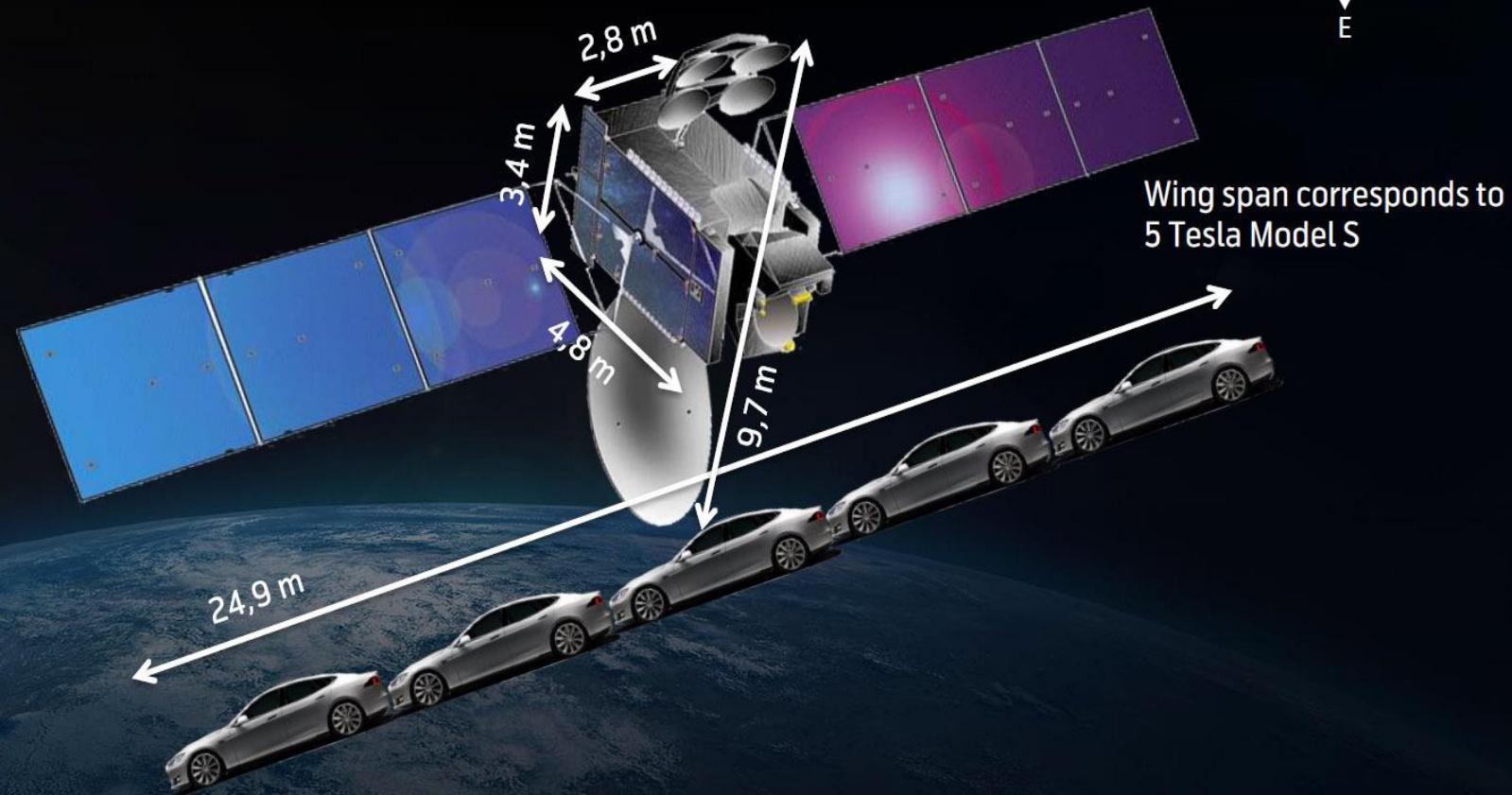


Thor 5 and 6 are the two operating satellites owned by Telenor currently, but Telenor also owns capacity on Intelsat 10-02. Thor 7 was launched in April 2015 from Kourou.

Thor 7

Ariane 5 sends Thor 7 and Sicral 2 satellites into orbit, 26th of April 2015

THOR 7 dimensions



Norspace

Kongsberg Norspace is a world leading supplier of on-board electronic equipment and components for satellites and launchers.

Our primary market is commercial telecommunications satellites.

We are specialised in analogue signal processing equipment, including frequency converters, frequency generator modules and related building blocks.

Other major products are Telemetry, Tracking and Command (TTC) equipment.

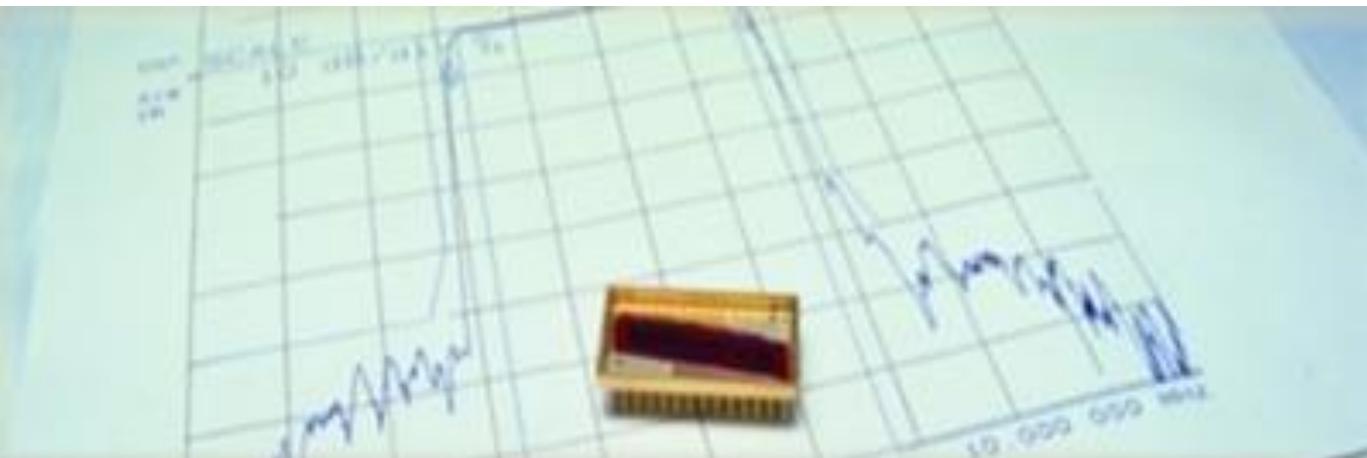
In addition, Kongsberg Norspace is a world leading supplier of Surface Acoustic Wave (SAW) components for satellites.

Examples of two large contracts:

- They provide search and rescue equipment to be installed in the new Galileo satellites.
- Twenty new devices for frequency conversion ordered from the European giant Astrium.



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Kongsberg Satellite Services, KSAT

KSAT operates four satellite earth stations that can download huge amounts of data: Grimstad, Tromsø, Troll and Svalsat. Troll and Svalsat are the only earth stations in the world that have contact with all satellites in a polar orbit at every pass. It is therefore perfect for downloads and housekeeping operations.



Kongsberg Spacetec



KONGSBERG

“Kongsberg Spacetec is the world leading provider of turnkey satellite ground stations for Earth observation satellites and processing software for remote sensing applications.”

Meteorological data,
Satellite testing,
Satellite house-keeping,
Copernicus,
Surveillance.



Ground stations: Vardø, Kangerlussuaq, Lannion, Moscow, Novosibirsk, Rome, Bangkok....



KONGSBERG

Kongsberg Seatex

Global source for marine and offshore electronics

Kongsberg Seatex is a marine electronics manufacturer with products for precision positioning and motion sensing. Our commitment is to provide quality products and solutions for safe navigation and operations at sea. We provide innovative and reliable precision positioning and motion sensing systems. As part of Kongsberg Maritime we can provide complete ship and offshore systems.

Product areas

Kongsberg Seatex provides the following range of products:

- **Attitude Determination Systems**
Motion Reference Units
Helideck Monitoring Systems
High-end solutions for precision positioning
- **Surface Positioning Reference Systems**
Relative positioning
Absolute positioning
High end GPS/Glonass solutions
- **Automatic Identification Systems**
AIS - Infrastructure for coastal surveillance
AIS - Mobile Stations for onboard use
- **Global Navigation Satellite Systems**
Project oriented development of today's and future navigation systems



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North Star Rocket System
Three sounding rockets
One satellite launcher:
10kg/650km polar orbit

Hybrid Rocket Propulsion

Nammo hybrid rocket propulsion work

Nammo Raufoss has since 2004 invested and actively worked on the development of hybrid rocket propulsion systems. A hybrid rocket engine has several interesting and advantageous capabilities that solid propellant based rockets often lack:

- 1) Inherent safety -> no explosives since the liquid oxidizer and fuel is separated in two tanks
- 2) Throttling capability -> broad range of thrust throttling which provide on demand impulse management
- 3) On demand termination -> a hybrid rocket motor can if needed be terminated on demand
- 4) Re-ignition -> a hybrid rocket motor can if needed be re-ignited on demand multiple of times
- 5) High-performance -> several hybrid rocket propellants produces specific impulse levels superior to that of solid propellants



Nammo state-of-the-art hybrid rocket propulsion technology has demonstrated all the above listed capabilities within a compact and non-toxic (green) propulsion package.

Hybrid rocket demo at Andøya. By Jan Erik Rønningen.

T&G Elektro – fibre in space



The requirements on components and cable systems for usage in space are very unique and demanding and need to achieve highest scores for:

- Highly variable temperatures
- Vibration resistant
- Shock resistant
- Low insertion loss
- Low mass and small size
- Low mass loss due outgassing
- Irradiation resistant

ESA PROJECT

To develop, test and qualify fiber optical cable assemblies with European components which shall be suitable for future space missions. The project is one of several partial development projects within ESA for qualification of fiber optical technologies for the next generation of space equipments.

Norwegian Space Centre

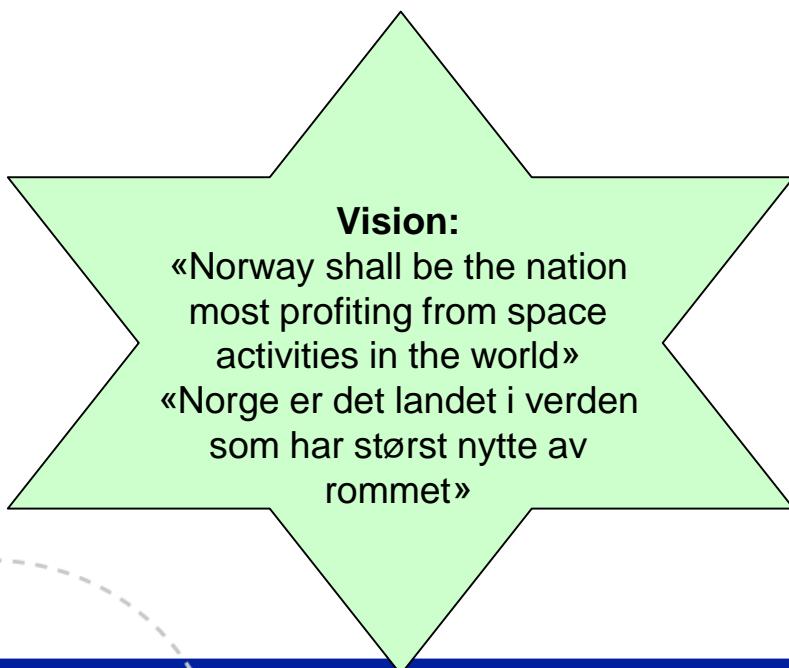


The principal goals of NSC are to:

- create 10 % annual growth in the space sector,
- meet national user needs,
- attain a leading international position in space research and
- maintain a leading role in space-related ground infrastructure.

Norwegian Space Centre:

- is the Norwegian "member" of ESA
- owns 90% of Andøya Space Center



SPACE NORWAY

Space Norway as (formerly Norsk Romsenter Eiendom as) was established in 1995 as a subsidiary of the Norwegian Space Centre to act as a vehicle for the Centre's operational activities. The company owns the fibre optic cable between Svalbard and mainland Norway. The cable is a key element of Norway's infrastructure in the Arctic. Space Norway owns a 50 % stake in Kongsberg Satellite Services (KSAT). KSAT was established by the Norwegian Space Centre, Space Norway, and the Kongsberg Group in 2001. KSAT reads data from satellites that are observing the Earth from space. The company is the largest of its kind in the world and has enjoyed excellent growth in the international market.

From 2015, Space Norway will have at its disposal satellite-based communications capacity providing coverage of the Troll Research Station in Antarctica. The solution on board the Thor 7 satellite has been developed in cooperation with Telenor. Space Norway is also the owner of Statsat AS, a company that will manage small satellites owned by the Norwegian state, such as AISSat. Space Norway will investigate the possibility of establishing new projects in space-related activities based in Norway, whether alone or in cooperation with others.



Space Norway created StatSat in 2013



The aim for StatSat is to define, develop and purchase space infrastructure for the Norwegian State.

Et ledende mikrosatellittmiljø

For å sikre allmenne hensyn har Statsat AS som formål å definere, utvikle og anskaffe rominfrastruktur for norske statlige formål. Selskapet skal være et lite, men ledende kompetansemiljø. I første omgang vil selskapet overta ansvaret for eksisterende og planlagte AIS-satellitter på vegne av Kystverket og Norsk Romsenter. Ved utgangen av 2014 vil det være inntil 3 satellitter i bane. Statsat AS vil ha ansvar for satellittene og for at Kystverket får AIS-dataene som samles inn. På sikt vil Statsat AS også ha ansvar for koordinering og utvikling av en serie mikrosatellitter, som skal være verktøy for teknologisk, industriell og vitenskapelig utvikling innen norsk romvirksomhet.

European Space Agency



The European Space Agency (ESA) is Europe's gateway to space. Its mission is to shape the development of Europe's space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe and the world.

ESA is an international organisation with 20 Member States. By coordinating the financial and intellectual resources of its members, it can undertake programmes and activities far beyond the scope of any single European country.

What does ESA do?

ESA's job is to draw up the European space programme and carry it through. ESA's programmes are designed to find out more about Earth, its immediate space environment, our Solar System and the Universe, as well as to develop satellite-based technologies and services, and to promote European industries. ESA also works closely with space organisations outside Europe.

Who belongs to ESA?

Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Romania, Spain, Sweden, Switzerland and the United Kingdom. Canada takes part in some projects under a Cooperation agreement. Poland exchanged Accession Agreements with ESA in September 2012 to become our 20th Member State.

Hungary, Estonia and Slovenia are 'European Cooperating States'. Other countries have signed cooperation agreements with ESA.



ESTEC

- ESA has sites in several European countries, but the European Space Research and Technology Centre (ESTEC) in Noordwijk, the Netherlands, is the largest. ESTEC is our technical heart - the incubator of the European space effort - where most ESA projects are born and where they are guided through the various phases of development.
- Developing and managing all types of ESA missions: science, exploration, telecommunications, human spaceflight, satellite navigation and Earth observation.
- Providing all the managerial and technical competences and facilities needed to initiate and manage the development of space systems and technologies.
- Operating an environmental test centre for spacecraft, with supporting engineering laboratories specialised in systems engineering, components and materials, and working within a network of other facilities and laboratories.
- Supporting European space industry and working closely with other organisations, such as universities, research institutes and national agencies from ESA Member States, and cooperating with space agencies all over the world.



Arianespace



Arianespace was founded in 1980 as the world's first satellites launch company. Its shareholders are French space agency CNES, Astrium and all the European space companies, representing 10 European countries.

At 1st October 2012, the company had 315 employees, at corporate headquarters in Evry, at the Guiana Space Center (CSG), launch site for Ariane 5, Soyuz and Vega, and at local offices in Washington DC, Singapore and Tokyo.

Since its creation, Arianespace has signed contracts with 80 customers and carried out 210 Ariane launches, launching more than half of the commercial satellites now in service worldwide, 28 Soyuz launches (3 at CSG and 25 at Baikonur via its subsidiary, Starsem) and the first launch of Vega.



Conclusion

Space related activities in Norway and in Europe are increasing.

There will probably be many interesting work opportunities within research, development, service provision, education,..... in the years to come.