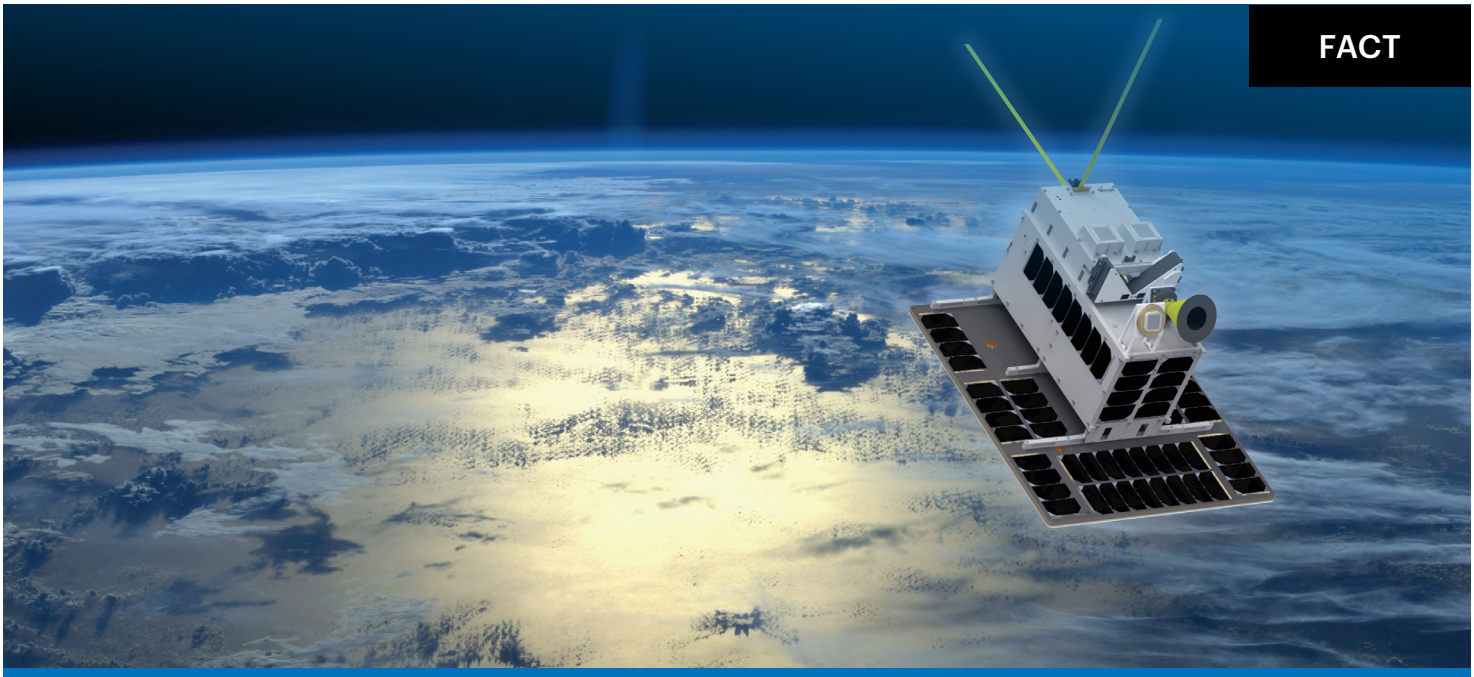
FFI Norwegian Defence Research Establishment

FACT



April 2021, v. 2 - Design /production: FFI, Photo: FFI, ESA, Roskosmos and UTIAS/SFL

# NorSat-3

## Ship Surveillance with a Navigation Radar Detector

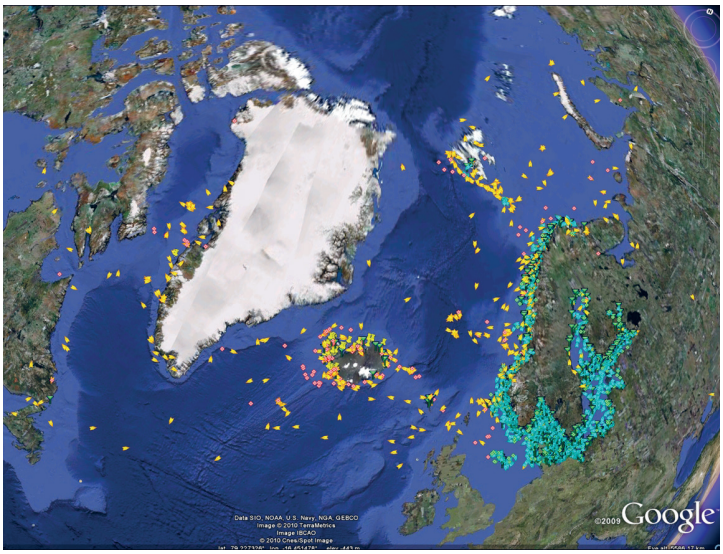
The NorSat-3 microsatellite will be launched into space during spring 2021 with a radar detector developed at the Norwegian Defence Research Establishment (FFI). It will provide improved surveillance capability of the shipping traffic in Norwegian national waters.

**Background**

Satellites have now become a very important tool to obtain situational awareness in the Norwegian sea territory and national waters. The first two Norwegian microsatellites AISSat-1 and AISSat-2 were launched in 2010 and 2014 respectively. They carry AIS receivers (Automatic Identification System) to intercept anti-collision transponder messages from ships.

AIS has been designed to prevent ship collisions by an exchange of transponder messages containing information about the position, course and speed of the ship. It is mandatory equipment for all ships above 300 tons and for ships carrying more than 12 passengers.

For Norwegian authorities, AIS is a useful source of information about the sea traffic. However, the AIS messages do not necessarily provide a complete picture. Technical faults with the equipment and willful manipulation have been observed to happen, or ships may simply switch off their AIS transmitters. A more complete picture can be built by intercepting other signals from the ships and then corroborate this information with the AIS data. It will then be possible to single out those ships that are not complying with proper use of AIS, and investigate them further.




*This illustrates the very first data received from the AISSat-1. The yellow and orange symbols are AIS observations from the satellite which came in addition to the existing AIS observations (green and blue) from the Coastal Administration ground based sensors.*


*The figure above shows examples (in red and green) of the size of the antenna coverage on the surface of the earth as observed from orbit at 600 km altitude over Greenland.*

## NorSat-3 requirements

- NorSat-3 will be able to observe globally with both the AIS receiver and the radar detector, but the radar detector will mainly be used in the northern areas.
- The satellite's radar detectors will only work in the navigational radar band.
- It will be possible to observe a ship a second time within 12 hours globally and within 3 hours if it is positioned north of 70 degrees N.
- The radar detector will be able to position ships with accuracy within 10 km CEP (Circular Error Probable – the radius which contains 50% of all positions).
- After launch the satellite will be used to investigate how suitable the received signals are to verify ship position and identity.
- Detected signals must be transmitted to the down link stations in Vardø or Svalbard on the same pass, or in subsequent passes.

*Conceptual sketch of the NorSat-3 from October 2017. The body has dimensions of 20x30x40 cm. The outer dimensions of the antenna are 56x62 cm. The satellite has a weight of less than 20 kg.*

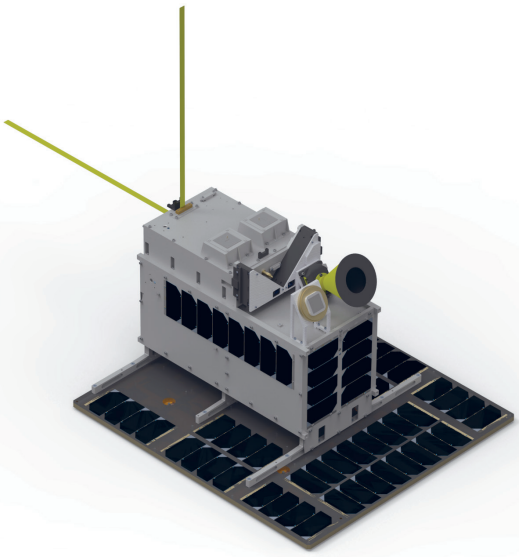
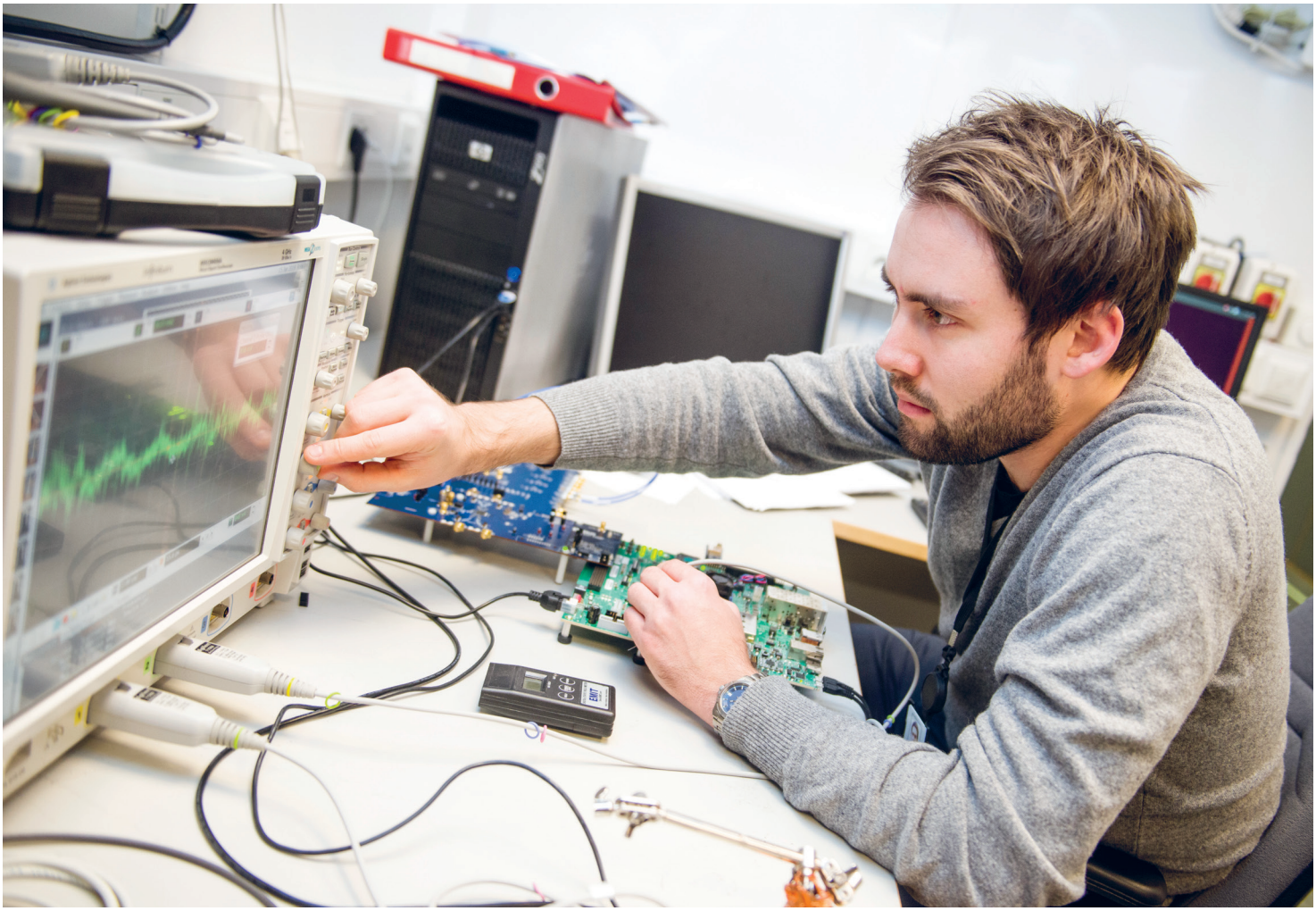


*Illustration: UTIAS/SFL*



*Scientist Eirik Grimstvedt at FFI (Norwegian Defence Research Establishment) at work on the radar detector prototype which will be payload on the NorSat-3. Photo: FFI.*

In 2001 FFI proposed to deploy a microsatellite that could detect the navigational radar signals – a Navigation Radar Detector (NRD). Now the Norwegian Space Centre has offered to include an experimental NRD on the NorSat-3 microsatellite which is due for launch during spring 2021.

This satellite will also carry an AIS receiver. The combination of the two systems will provide an improved maritime situational picture to the Norwegian Coastal Administration, the Armed Forces and other national institutions.

**How the navigational radar on NorSat-3 works**

The experimental NRD has an antenna with an approximate circular detection beam some 10 degrees in width. When the antenna is directed towards the horizon from an altitude of about 600 km, it will observe an elliptical area along the surface of the earth out to a distance of 2800 km. This area is about 1400 km long and 450 km wide. The trajectory that this area covers on earth will thus be 450–1400 km wide depending on whether the antenna is pointing straight ahead or out to one side. The antenna will be pointing straight ahead when the area of interest is directly under the satellite orbit, and out to one side when the area of interest is near the horizon on one of the sides of the satellite orbit.

The positioning of the ships is based on measuring the direction of the radar that the NRD is intercepting signals from. The position this radar will get, is where the line of sight from the satellite intercepts the surface of the earth. More accurate positions can be found by triangulating multiple observations of the same ship during the same satellite pass. Data from the NRD and AIS is transmitted to the ground when the satellite is within communication range of Vardø or Svalbard, the two receiving stations situated well to the north.

A satellite at 600 km altitude will make approximately 15 passes per 24 hours, which works out to about 90 minutes per pass. Such orbits are often placed close to the North Pole, typically 82 degrees N. Consequently, ships north of 75 degrees N (which is just south of Svalbard) will be within the satellite's detection area on all of its 15 passes within 24 hours. Similarly, the North Cape will be visible during 12 consecutive passes per 24 hours, while areas further south will be seen by the satellite in 10–11 consecutive passes per 24 hours.

*AISSat-2, NorSat-1 and NorSat-2 were launched from Bajkonor in Kasakhstan. NorSat-w will be launched from Kourou, French Guiana. Photo: Roskosmos*

## Norwegian microsatellites

- AISSat-1 was the first domestic Norwegian micro satellite. It was launched from India on 12 July 2010. It has a weight of six kilograms and a dimension of 20x20x20 cm.
- AISSat-1 demonstrated the feasibility of receiving AIS signals from space. It was so successful that it has remained in service as an operational satellite since launch.
- The identical AISSat-2 was launched on 8 July 2014. AISSat-3 followed, but was unfortunately lost after a failed launch from Russia in November 2017.
- NorSat-1 and -2 was launched during the summer of 2017. In addition to the AIS receivers they have other payloads. These include solar instruments and Langmuir probes for northern lights research (aurora borealis). NorSat-2 is also testing the VDES international standard for two-way communication at sea.
- NorSat-3 is scheduled to be launched during spring 2021 and will be equipped with an AIS receiver and a radar detector. It will be able to detect anomalies in the use of AIS and will provide a significant boost in maritime traffic surveillance.
- The NorSat-4 is next in line. This satellite will be equipped with both an AIS receiver and an electrooptical camera, which will further enhance the surveillance capability of the maritime traffic.

**Contributors**
The microsatellites in the NorSat series are a collaborative effort between the Norwegian Coastal Administration and the Norwegian Space Centre. All of the satellites so far have been constructed by the University of Toronto Institute of Aerospace Studies/Space Flight Laboratory (UTIAS/SFL). Several companies and institutions have contributed with payloads. The NRD for the NorSat-3 is constructed by the Norwegian company Kongsberg Seatex based on prototypes developed at FFI. Kongsberg Seatex has also provided the AIS receiver on all Norwegian microsatellites. FFI delivers the NRD antenna and the subsystem for the signal processing from the antenna to the end-user. The Norwegian Ministry of Defence is financing the NRD payload.

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