

The Norwegian Initiative for a Satellite Nano-launcher

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Introduction

- Norway is working on a family of sounding rockets based on hybrid propulsion: **the NorthStar Rocket Family**
- Initial focus has been on improving performance and upscaling of the hybrid technology (AIAA-2015-4044)
- Next step is performing a demonstration flight of a single stage sounding rocket
- The NorthStar Launch Vehicle is the ultimate goal
- The key elements driving the design are **responsiveness** and **cost effectiveness**.



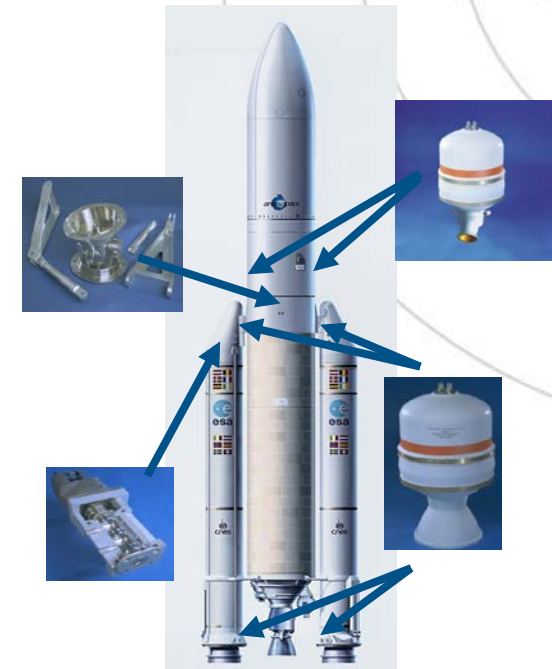
Nammo

Nammo's background

Nammo

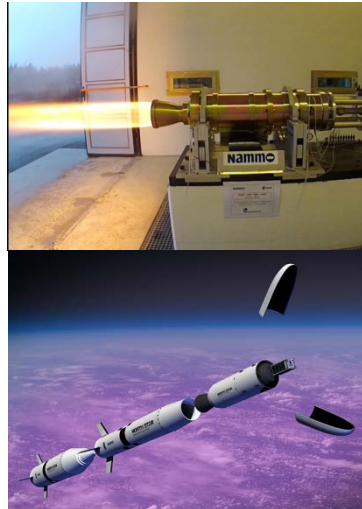
SECURING THE FUTURE

- Nammo designs, develops and manufactures rocket motors
- We test them, qualify and maintain them
- We have done so for over 50 years
- We serve customers from space and defense

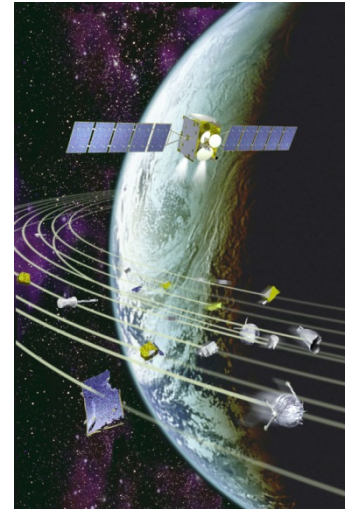
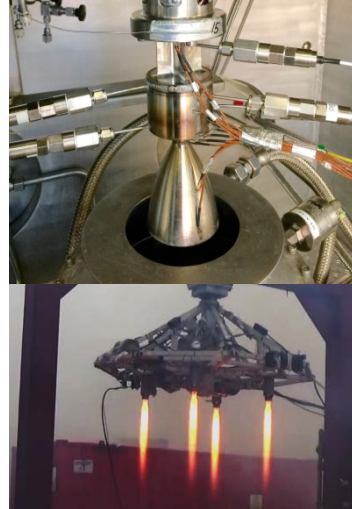


Nammo is an award winning producer of rocket motors in the international aerospace and defense market

Nammo Space Propulsion



Credits: Andeya Space Center



Credits: CNES/D. Ducros



Solid Rocket Motors & Igniters

- Ariane 5 acceleration and separation boosters
- Well established capabilities for rocket motors and igniters with propellant masses from 5 - 150kg

Hybrid Rockets based on Clean Propellants

- Sounding Rockets
- North Star Launch Vehicle
- H2020 SMILE, small innovative launcher
- H2020 ALTAIR, air launched small launcher

Green In-Space Propulsion

- Mono-propellant ACS/RCS for Ariane 5ME, 6 and Vega
- FP7 SPARTAN - Hybrid Rocket with throttle capabilities

Topic of today

De-orbiting of decommissioned Satellites

- Development contract on particle-free Propellant Formulation for CleanSpace
- GSP with ESA on debris remediation based on hybrid technology
- De-orbit study for Norwegian Space Agency

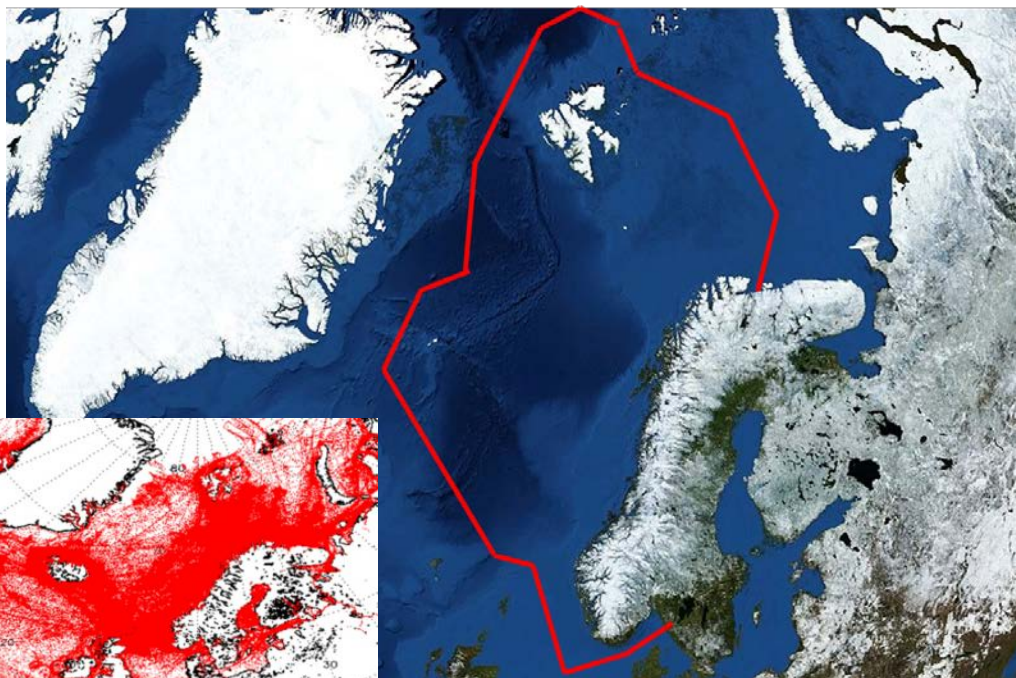
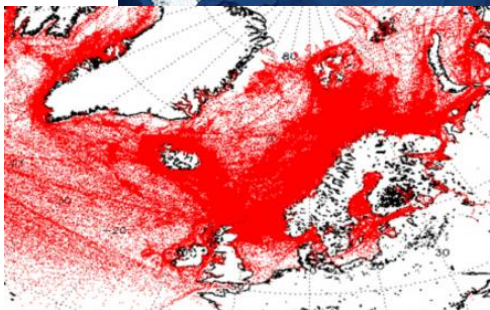
Development and Testing of Green Propulsion Solutions

- New test facilities and equipment dedicated to Green Propulsion

Norwegian interest for SmallSat's

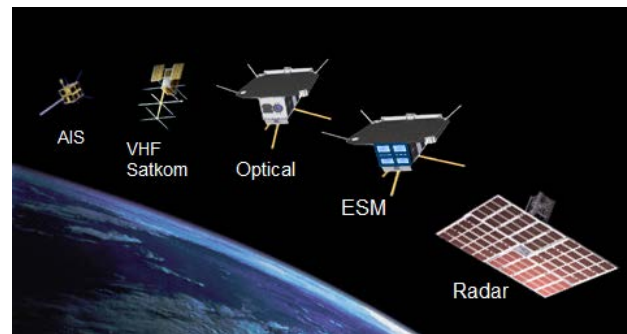
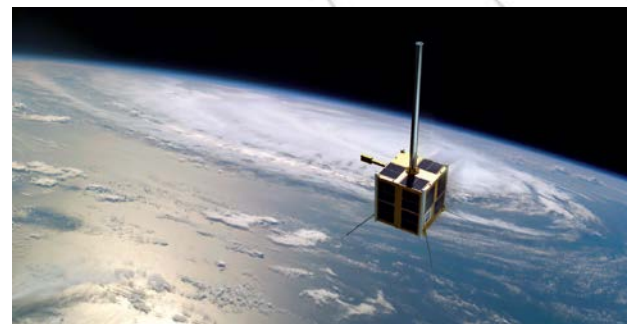
- Norwegian authorities have a keen interest in monitoring activities in their Northern territories
 - Ship traffic, fisheries, offshore petroleum and patrolling of territorial waters
 - An active and growing SmallSat program exists (navigation, communication, earth observation and security) in support of those activities.

Ship traffic as monitored by AISat-1



Approximate Norwegian territorial waters

AISat-1, AISat-2, AISat-3



Several other SmallSat's under evaluation

Territorial advantages and existing infrastructure

- Network of **ground stations** to supervise the launch, the orbital insertion and the life-time of the satellite.
 - **SvalSat** (78°N), world's largest ground station for polar orbit on Svalbard
 - **TrollSat** (72°S), its twin ground station in Antarctica
- **Andøya Space Center** ideally placed for high inclination launches
 - Existing Sounding Rocket Launch Base with supporting Scientific Research Facilities



SvalSat Control Station



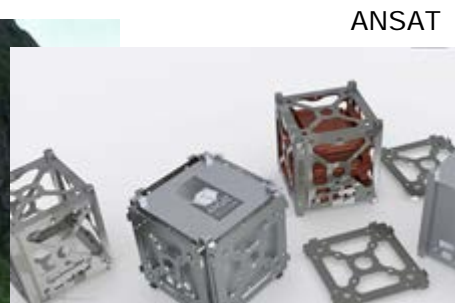
Rocket Range and Science Center at Andøya Space Center

What is the NorthStar Rocket Family?

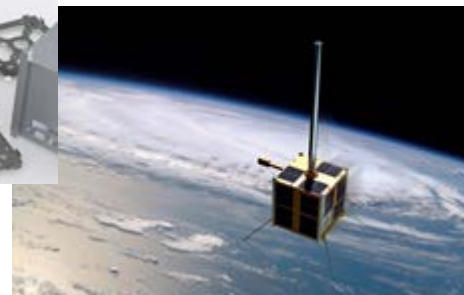
- A **Norwegian** initiative to establish a reliable source of **rocket motors**
- Based on a **modular concept** of hybrid rocket motors clustered together to form 2-stage sounding rockets for scientific research
- **Safe and environmentally friendly** hybrid rocket motors using standard elements in various configuration to keep the cost down
- Ultimately, these “launcher elements”, will form the basis of a **cost-effective** Nano-launcher



Dual launch from Andøya Space Center



ANSAT



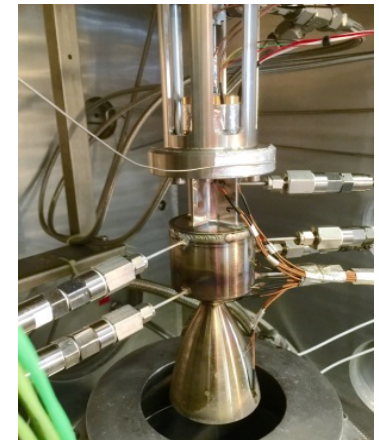
AISSat-1,2 & 3



Black Brant XII launch

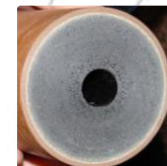
Propulsion is key to nanolauncher success

- Main propulsion based on **environmentally friendly** and **safe** hybrid engines
- **Mission flexibility** through
 - Unlimited stop/restart
 - Throttleability
 - Propellant loading
- ACS/RCS for **accurate orbit insertion** based on green mono-propellant
- **Affordability** through clustering of standard engines, common propellants for all stages and overall low life cycle costs.



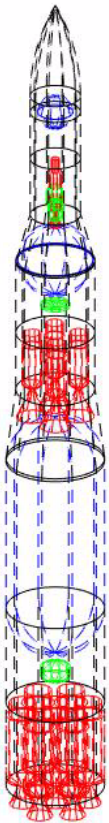
Hybrid Propulsion: The Heart of NorthStar

- **Cheap** and **readily available** propellant ingredients (H₂O₂/HTPB)
- **Simple** architecture, **robust** combustion without complex control algorithms
- **Clustering**: many identical parts are cheaper to manufacture reliable than once in a while a unique and delicate part
- Inherently **non-hazardous** until pressurized on the launch pad
 - Manufacturing, handling, storage and transportation are made affordable
- **Performance** already successfully scaled-up to 30kN (AIAA-2015-4044)
 - More details about the motor and the hybrid technology in the paper!

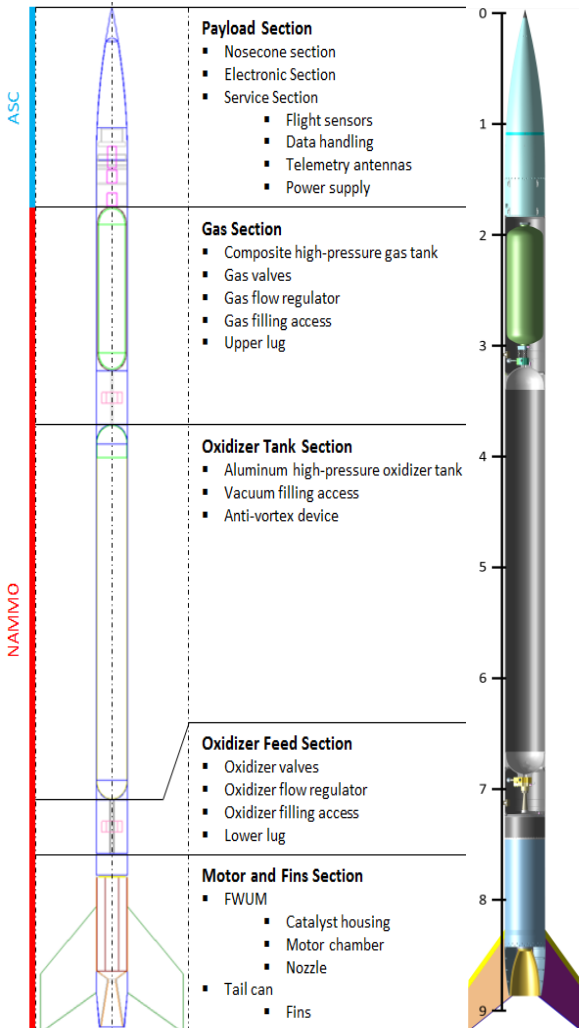


Well recognized hybrid technology

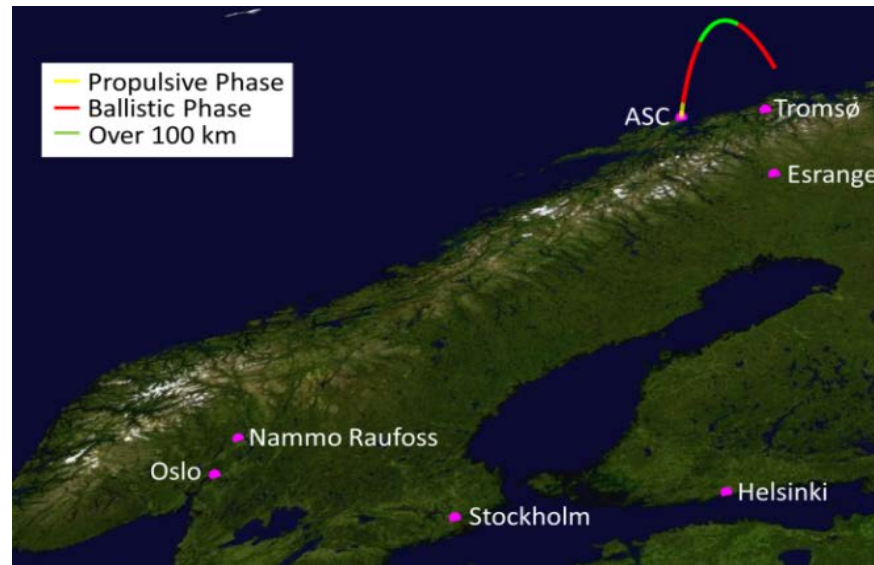
- Nammo has been selected by two European consortia to look at a European dedicated launcher capability
 - Funded by the European Commission under S&T program: **H2020**
 - Both projects started in 2016 and run for 3 years
- **ALTAIR** is focused on an air-launch system
 - Prime: ONERA, the French Aerolab.
 - Use of an autonomous reusable aircraft and a expendable rocket using Nammo's hybrid technology.
 - Development of a dedicated ground segment.
- **SMILE** is focused on a ground based system
 - Prime: NLR, the Netherlands Aerospace Center
 - Two competing technologies on the propulsion: Liquid engine from DLR (German Aerospace Center) and Hybrid technology from Nammo.
 - Trade-off between higher performances and reusability of the liquid engine and simplicity and low-cost of the hybrid motors.







First live test of Nammo's technology: Nucleus Launch in spring 2017

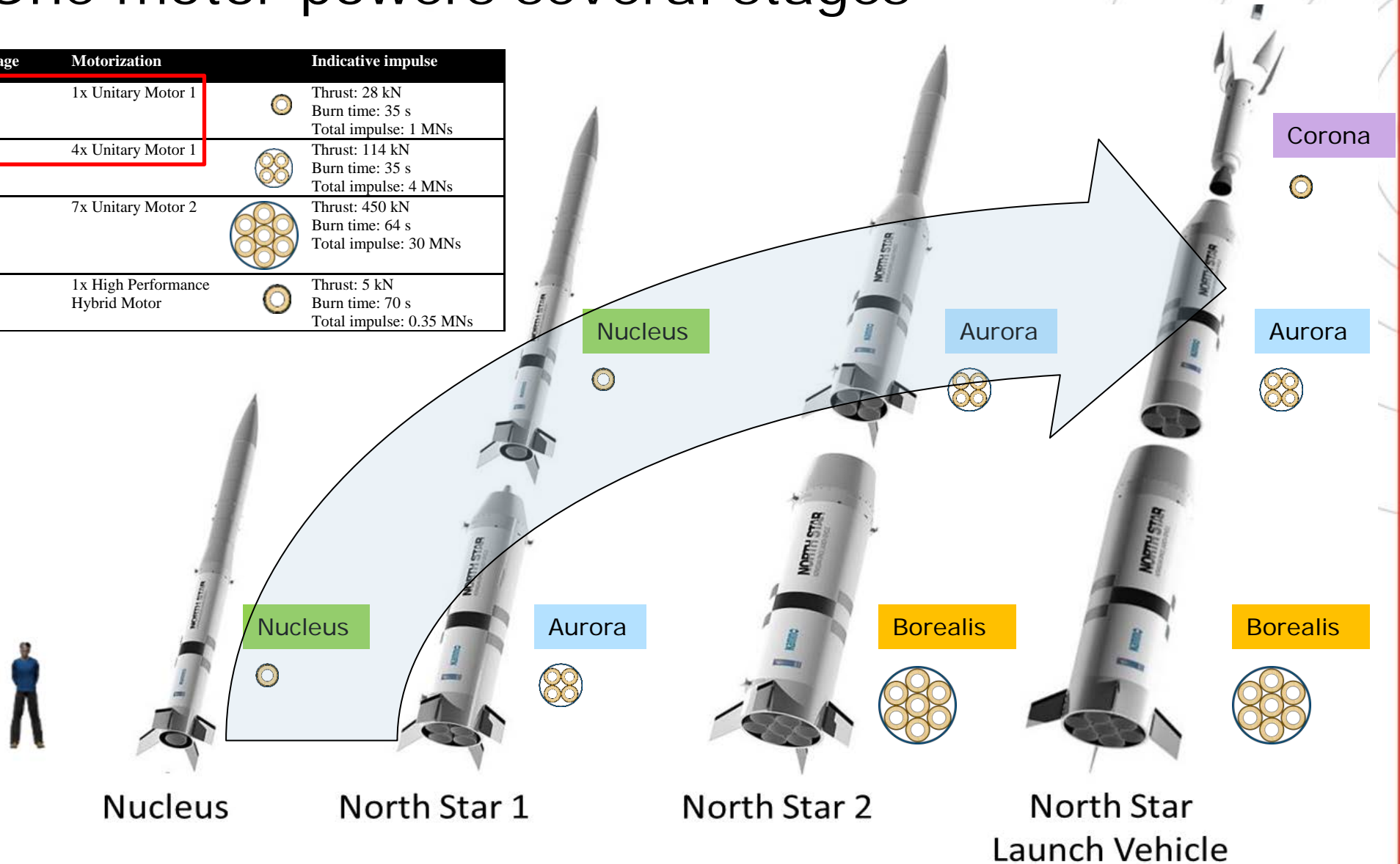


- Nammo will demonstrate the technology in flight on board the single stage sounding rocket: the Nucleus.
- The goal of the flight demonstration is to reach the limit of Space (> 100 km) proving the abilities of the hybrid technology
- The project is funded under the Future Launcher Preparatory Program (FLPP) of ESA.



One motor powers several stages

Rocket stage	Motorization	Indicative impulse
Nucleus	1x Unitary Motor 1	 Thrust: 28 kN Burn time: 35 s Total impulse: 1 MNs
Aurora	4x Unitary Motor 1	 Thrust: 114 kN Burn time: 35 s Total impulse: 4 MNs
Borealis*	7x Unitary Motor 2	 Thrust: 450 kN Burn time: 64 s Total impulse: 30 MNs
Corona*	1x High Performance Hybrid Motor	 Thrust: 5 kN Burn time: 70 s Total impulse: 0.35 MNs



Phase 1

Small Booster


Phase 2

Large Booster

Phase 3

Launch Vehicle

North Star Development Process

 = Incremental improvements

Will be launched in spring 2017



Small Sounding Rocket

Nucleus



Unitary Motor 1



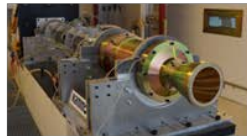
Two Stage Sounding Rocket

Nucleus
Aurora



Large booster

Borealis



Unitary Motor 2

Large Two Stage Sounding Rocket

Aurora
Borealis



Third Stage

Corona

Three Stage Nano-Launcher

Corona
Aurora
Borealis



High Performance Hybrid Engine Development

Summary

Motivation for a dedicated launcher

- Commercial space is a growth area
 - Large part of the growth is through Nano/Micro-Satellites
- Norwegian interest is in small satellites
 - Maritime, Defense, SAR, Remote-Sensing
- Dedicated launch opportunities are missing
 - Piggy-back launch as secondary pay-load with large satellites results in unpredictable launch dates
- Norway has strategically placed resources
 - Exploitation of existing launch site
 - Exploitation of existing satellite ground stations
- Nammo has developed Hybrid Rocket Motors
 - Affordable and scalable
 - Inherently safe and environmentally friendly
 - Providing thrust modulation and on/off capabilities
 - ACS/RCS based on common (mono-) propellant



Thank you for your attention



Acknowledgements:
European Space Agency
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Andøya Space Center