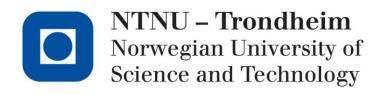
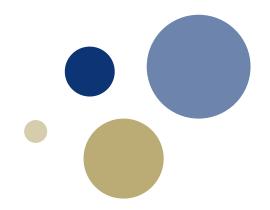
#### **Contact information**

- NUTS: http://nuts.cubesat.no
- NAROM: <a href="http://cubesat.no">http://cubesat.no</a>
- CAMOS: <u>www.ntnu.edu/camos</u>
- Norwegian Space Centre: <a href="http://.spacecentre.no/">http://.spacecentre.no/</a>
- CubeSats: <a href="http://cubesat.org/">http://cubesat.org/</a>
- ESA Education: <a href="http://www.esa.int/Education">http://www.esa.int/Education</a>
- Space Generation: <a href="http://spacegeneration.org">http://spacegeneration.org</a>
- Please contact me if you are interested.
- roger.birkeland@iet.ntnu.no





# **Space Technology Activities at NTNU**

Space Technology I 2016

Roger Birkeland – <u>roger.birkeland@iet.ntnu.no</u>

#### **Outline**

- My background
- The CAMOS project
- The NUTS student satellite project and CubeSats
- National and international trends and possibilities (my subjective view)
- Further possibilities for the space interested student

# My Background

- Started my studies in 2001 at electronics
- Co-funded a .com company in 2000 which still is up and running(!)
- Graduated in 2007, wrote my thesis on radio systems and CubeSats
- Worked for three years at FFI on under water sensor networks
- Project manager for the NUTS CubeSat project from 2010
- PhD-student on Arctic communications system from 2013







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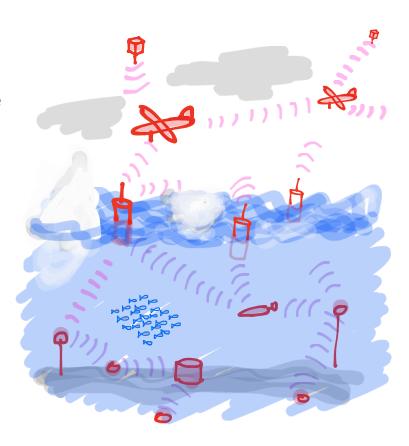
ner på

Ferdige med testen. Ingeniør Helge Buen og forsker Roger Birkeland heiser opp en relé-node etter avsluttet sjøtest.

# Part I – Costal and Maritime Operations and Surveillance (CAMOS)

# The CAMOS Project

- The CAMOS project
- Big project that studies several aspects of coastal and maritime operation sensor networks



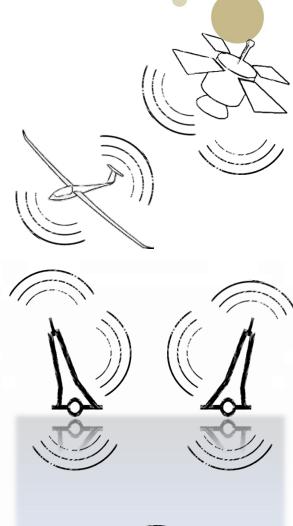
# **Heterogeneous Communication**

#### **Seamless routing between:**

- Anchored nodes/buoys
- Cyber-physical Systems (UAVs, AUVs, ...)
- Satellites
- Ships or other

#### **Configurable routing**

- Context-aware centralised decisions
- Backup paths for robustness



# **Converging Communication**

#### Distinct access technologies

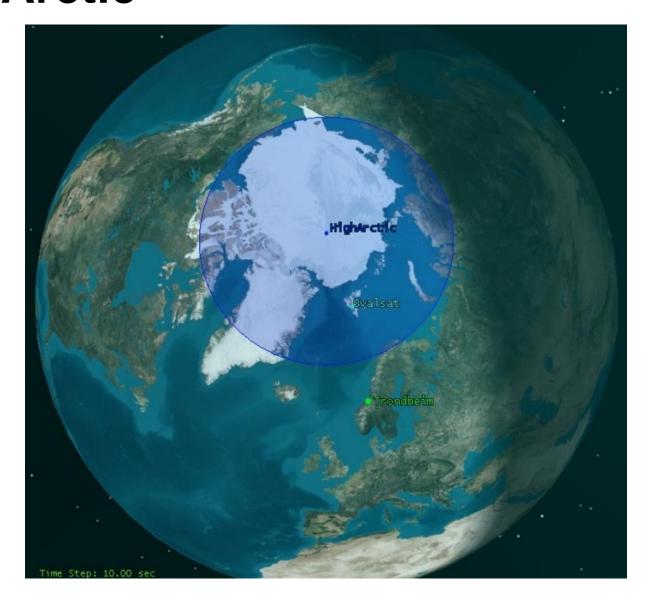
- Different performance
- Variable functionalities
- Diverse availability

• ...

#### Common identification scheme

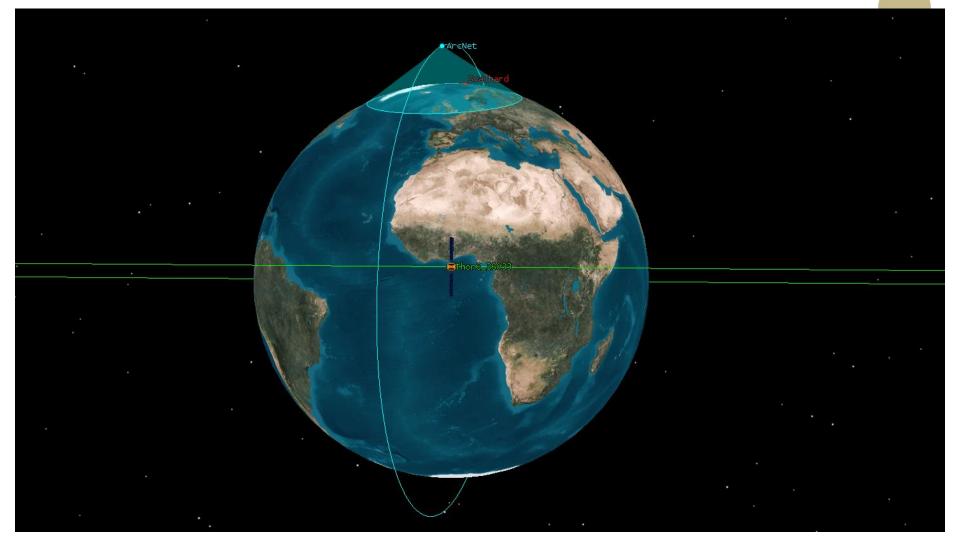
- Internet Protocol v6 for converging!
- 6LoWPAN handles constrained devices
- Compliance with existing technologies and protocols

# **The Arctic**



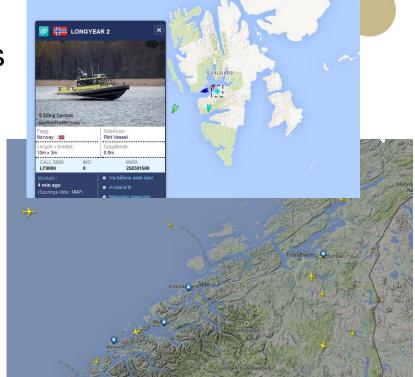
# Communication Challenges in the Arctic





# The Satellite Payload - Similar Systems

- Flight proven on small satellites
  - AIS
  - ADS-B



- The difference
  - We need a down-link for commands and polling
  - We will have with better interference conditions, less disturbance
  - We are worse off with respect to weather, waves and ice

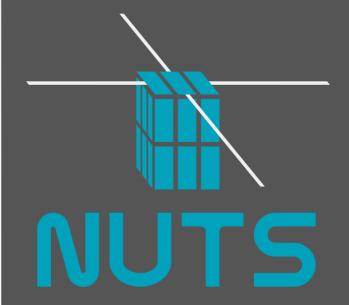
# Part I - NUTS



### The Norwegian student satellite program











#### What is a CubeSat? #1



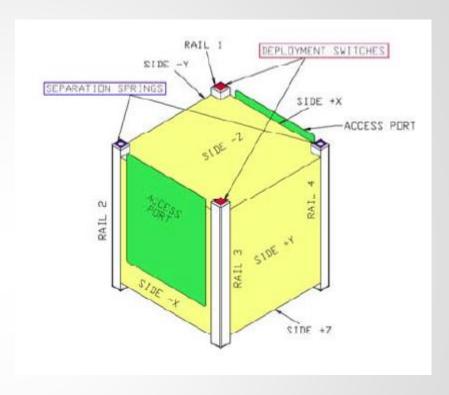
An easy way to space!

Designed and initiated at CalPoly and Stanford around year 2000

Provides a proven and known mechanical interface for small inexpensive satellites

Dimensions: 10 x 10 x 10 cm<sup>3</sup> Allows for 1U, 2U and 3U sizes

Max weight pr. U: 1.33 kg



Credit: CubeSat Standard - CalPoly



#### What is a CubeSat? #2 – How to launch?



Hitch-hike with other commercial payloads

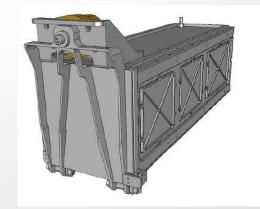
Stays within the known launch-pod until launch; the launch provider knows how the pod works and this masks your CubeSat so not every single CubeSat has to be individually approved to a great detail. If they adhere the CubeSat standard and its specifications we know they are "safe". (Some qualification testing and approving are necessary)



Credit: ISISpace.nl



Credit: CubeSat Standard – CalPoly





#### What is a CubeSat? #3 – Launchers











ESA – Vega VV01

Wikipedia – Falcon 1

VirginGalactic Launcher One

#### What is a CubeSat? #4 – Quality and lifetime



Around 100 or more launches so far 200 satellites (not all are student projects) Around 40% success-rate? (Uncertain number)

Observed life times: days to years (as CUTE-1 og XI-IV)

Mostly non-space qualified components

Lifetime usually limited due to radiation issues and electronics design

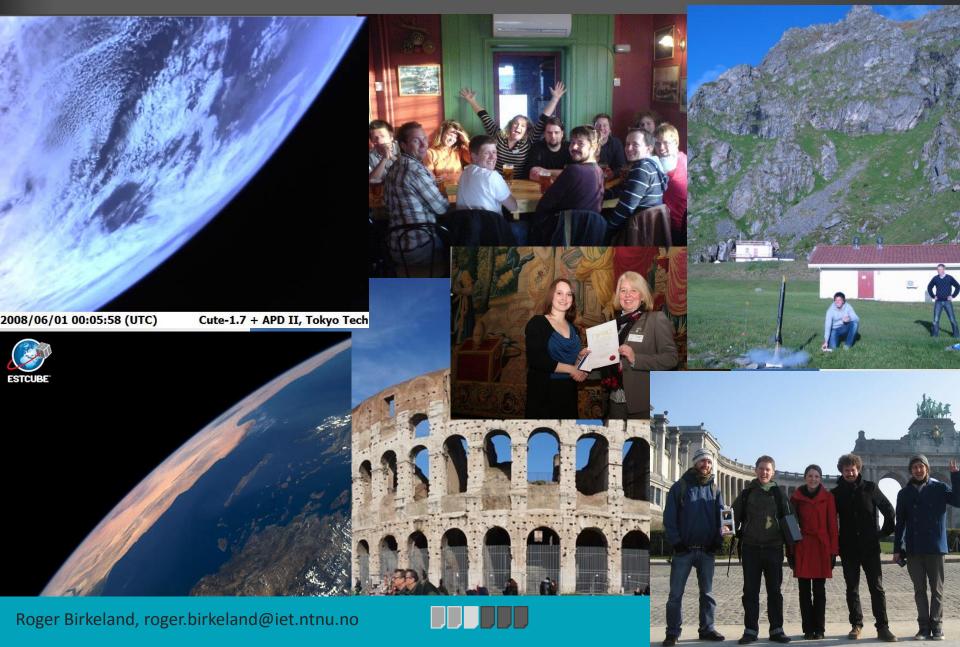
Orbit life time depending on orbit height, should be < 25 years (max 650 km)





### Motivation – for us and the students



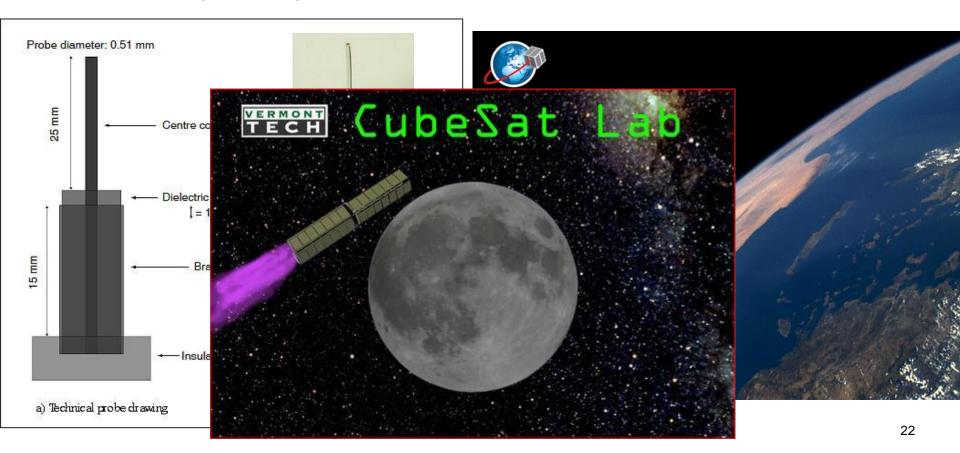


# Part II – The Useful CubeSats



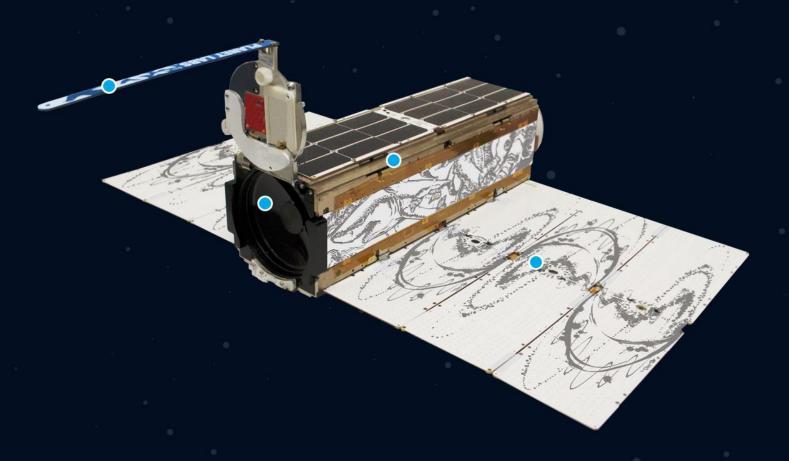
## Transition From Fun to also Useful

- CubeSats has been viewed upon as toys
- HUGE growing interest in their capabilities over last 3 y



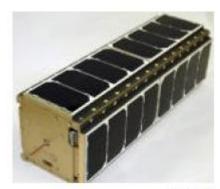
## **Planet Labs**

The world's largest constellation of Earth-imaging satellites, comprised of 28 Dove satellites. Deployment of Flock 1 marked a number of first-time achievements in the space industry, and provides a whole-Earth dataset that is unmatched in its breadth and freshness.



#### Other Missions

- Biological research
  - Genesat carried E. coli bacteria to monitor genetic changes



Genesa

- Space debris mitigation
  - Several drag sail missions:
     <a href="https://www.youtube.com/watch?feature=player\_embedded&v=STeYfG-8671">https://www.youtube.com/watch?feature=player\_embedded&v=STeYfG-8671</a>



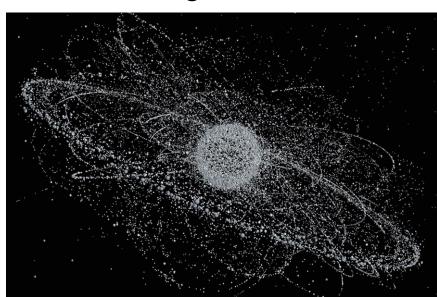
Thrusters and propulsion

# Part IV – Possibilities and Outlook



#### **National and International Trends**

- Small and big!
  - Cheaper pre-cursor flights, tech demos, new services ->
     CubeSats and small satellites
  - Testing the limits (Planet Labs, SAR-missions)
  - Increase of flight heritage. And it works (if you can afford the risk)
- Space debris will always be an issue → Regulations
- Access to space (driving cost)
  - → New and smaller launchers
- The sky is NOT the limit



# Commercialization and Competition

- Private companies: SpaceX, Virgin, Sierra Nevada, Boeing, Lockeed, Airbus, Blue Origin, Bigelow ++++ > Launch services and near-Earth space
- Space tourism, ISS and much more

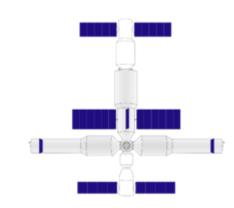
Provide services for the agencies (example: Launch to ISS)





# The Big Agencies

- China and India is coming
  - New "space race"?
- Exploration of "deep" space
  - New Horizon (Pluto)
  - Rosetta
  - Mars
- Science missions
  - Copernicus (ESA, EU)
  - Many more!



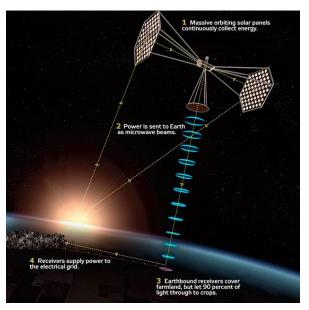


# The "Crazy" Ones...

- Mars One
- Moon/asteroid mining
- Space Power Stations
- Private (meaning commercial) space stations

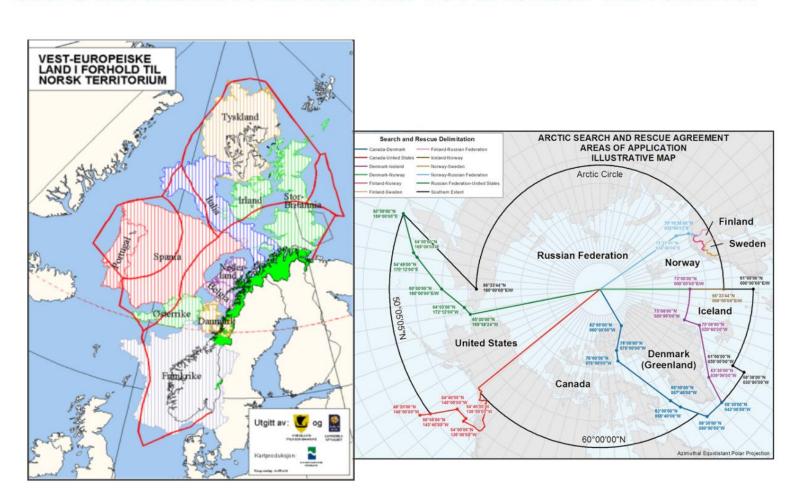






# Norwegian territories and responsebilities

#### Store norske havområder må «overvåkes» fra rommet



#### Økende aktivitet i Arktis

GASS

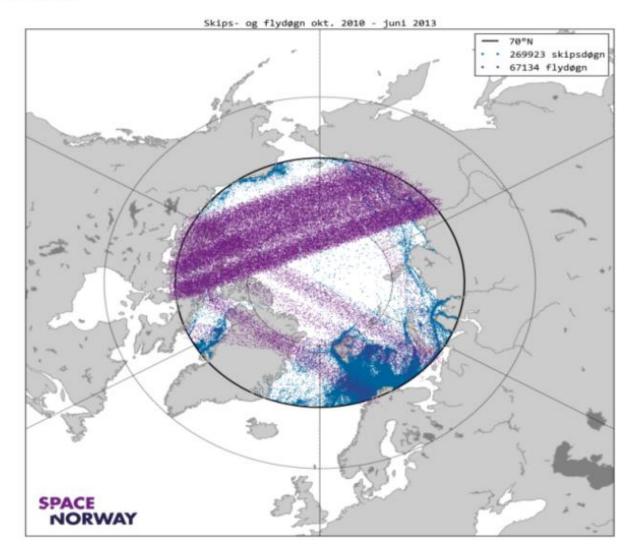
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#### Økende behov for kommunikasjon (og navigasjon)



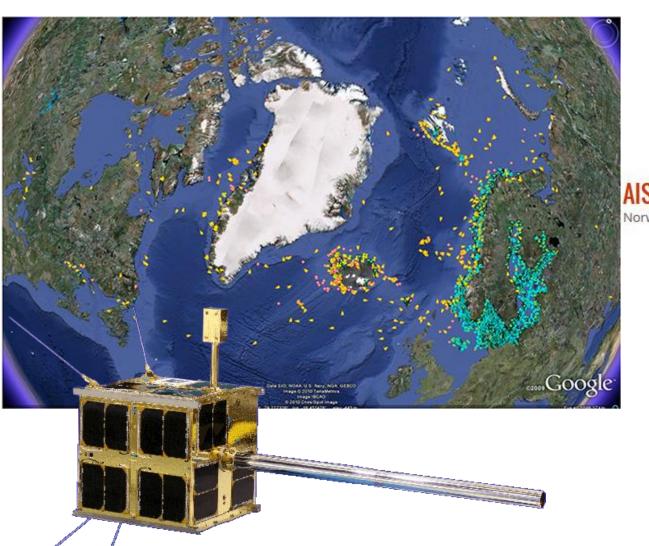
#### Økende aktivitet over Arktis

### **Flytrafikk**



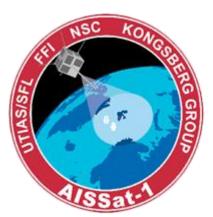


# In Norway – AiS-Satellites





AISSat-2 Norway's next AIS satellite.



# **In Norway – Future Missions**

- Costal Authorities is getting "too used" to AIS data?
- The Norwegian Space Centre is planning several small satellites
  - NORSat-1 (2016)
    - AIS receiver
    - Total Solar Irradiation instrument
    - Langmuir probes
  - NORSat-2 (2016/17)
    - AIS receiver
    - VDES (M2M VHF data communication for ships)
  - Future series of satellites
    - NRS?
    - FFI?
    - NTNU?!



# Part IV – How to meet other students like yourself?

# At NTNU/in Norway

- Space Technology courses
- Experts in team Romteknologi
- Join the student satellite project
  - − → Conferences/publications!
- Project and master theses
  - − → Conferences/publications!
- Your own project or idea?
  - Example: CPT-Scope → Rexus/Bexus balloon campaign
  - − → Conferences/publications!
- Work at a space related company
- Internship at the Space Center







### International activities

- ESA Drop/fly/spin/launch your thesis
- Summer schools (many!)
- ISU International Space University (9 weeks during summer...)
- Space Generation
  - Working groups (maybe hard to get introduced to...)
  - Space Generation Congress every year in Sept/Oct
- ESA internships (after graduation)
- Other universities





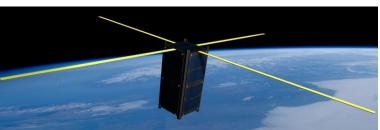


# Flight Opportunities for Your Payload

- Norwegian governmental satellites
  - Launch opportunity for payloads!
  - CubeSats!
  - Current and future satellite projects at NTNU
- Sounding Rockets from Andøya
  - CaNoRock/Sat
- Balloons (your own, Rexus/Bexus)







#### **Questions?**

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