4D Space
Conceptual Design Review

University of Oslo
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Mission Overview: Mission Statement

• The experiment will demonstrate the feasibility of multipoint high-resolution electron density measurement using our developed payload module:
  - Multipoint measurement will help to understand the ‘big picture’ of ionospheric plasma condition.
  - Characterizing the plasma density at kinetic scale.
  - Obtained data is used to study plasma turbulence and instability.
Mission Overview: Mission Objectives

• Successfully release six sub-payload modules, a.k.a. ‘daughters’, into space.
  - All daughter sub-payloads can communicate with the access point on the ‘mother’ payload section.
  - Daughters contact each other for localization purpose.

• Successfully measure small-scale electron density using Langmuir probe systems deployed on the daughters.
  - multi-Needle Langmuir probe (m-NLP) or single Needle Langmuir probe (NLP) systems are used to characterize plasma structures with high sampling rate up to several kHz.
  - Measure platform potential of the daughters after being released.
  - Electron emitter and/or strips of metal foil are successfully deployed to mitigate the sub-payload modules charging effect.
  - Measured data is transmitted to the control board on the mother payload section.

• Post-flight data analysis to study plasma turbulence and instability.
  - The in-situ measurement can then be compared with other indirect measurement.
Mission Overview: Theory and Concepts

• Attitude information of the six daughters is given by onboard gyro, magnetic field and acceleration sensors.

• Localization in a wireless network of the six daughters will be based on RSSI.

• multi-Needle Langmuir probe (m-NLP) system:
  - Has long been developed and deployed on more than 7 sounding rockets.
  - Measure absolute electron density at high sampling rates (several kHz) - high spatial resolution (up to meters)
  - Determine the spacecraft floating potential.

• Spacecraft charging mitigation by electron emitter and strips of metal foil.
  - The daughter platforms likely charge to a negative potential as a result of the current balance in ionosphere. The more collected electrons by the onboard probe system, the more negative the spacecraft floating potential, that deteriorates the electron density measurement performance.
  - Electron emitter is deployed to shoot out ‘redundant’ electrons, and/or strips of metal foil are used to increase the conductive area of the daughters.
Mission Overview: Concept of Operations

1. **Launch**
   - Power/Telemetry begins

2. **Launch to Apogee**
   - Power/Telemetry continues
   - Daughters released
   - Min release time ~ 3 s
   - Daughter flight time ~ 250 s
   - Max separation ~ 1200 m
   - Separation speed ~ 4.4 m/s

3. **Apogee**
   - Nose cone separation
   - Skin separation
   - De-spin to TBD rate
   - Power/Telemetry continues
   - Daughter separation at apogee ~ 500 m

4. **Descent**
   - Power off at TBD time
   - Telemetry continues

5. **Splashdown**
   - Telemetry terminates
Mission Overview: Expected Results

- We expect to see that all six daughter sub-payloads are released well.
  - Some daughter sub-payloads designed with strips of metal foil can deploy the strips successfully.

- If all works as designed, each of the daughter modules should execute its measurement mission and transmit data to the control board on the mother payload section, then all the data can be transmitted to the ground station via telemetry in real-time.
  - Transmitted data should include measured currents by the probe system (which then give ambient electron density and daughter platform potential), attitude information given by the gyro, magnetic field and acceleration sensors, and RSSI information for localization purpose.

- Multipoint electron density measurement would be able to provide the separation of temporal and spatial variations in electron density, as well as provide bases to study plasma turbulence and instability.
Design Overview: Science Design

• Payload:
  - Mother payload section consists of six sub-payload modules, a.k.a. daughters.
  - ‘Puck’ shaped daughters are released by the mother payload section to measure temporal and spatial variations of ambient plasma density.

• Sub-payload Instrumentation:
  - Each of daughters accommodates instrumentation section, which includes either multi-Needle Langmuir probe (m-NLP) or single Needle Langmuir probe (NLP) system to characterize ambient plasma with high sampling rate up to several kHz.
  - A probe of m-NLP (4 probes) or NLP has a length of few centimeters, together with its bootstrap section.
  - Each probe is supported by a spring-loaded boom.
Design Overview: Engineering Design

• Payload:
  - Payload design will be done by Andøya Space Center.
  - The design has heritage from our previous Maxidusty project and will be adapted to G-Chaser project.
  - Each daughter sub-payload will be powered by a Lipo battery and have a transceiver system with around 2 Mbits data speed. Attitude information of the daughters will be given by onboard gyro, magnetic field and acceleration sensors.

• Sub-payload Instrumentation:
  - Probe system design has heritage from our sounding rocket and satellite versions of the probe instrumentation with some modifications to accommodate the requirement of available space and power consumption of the daughters.
  - Some daughters will employ electron emitter with tungsten filament taken from light-bulb to control the sub-payload potential.
  - In order to increase conductive area, some daughters will employ strips of metal foil which are preformed to roll up and then are deployed when the daughters are released into space.
Design Overview: Main payload
Design Overview: Sub-payloads
Design Overview: Sub-payload Instrument

Instrumentation

- Probe system
- Microcontroller
- Electron emitter/Metal strips module

To microcontroller board

SPI
Design Overview: Payload Layout

Daughter sub-payload

Neatly stacked on mother payload

- Payload deployment will be done by Andøya Space Center.

Released in pairs
## User Guide Compliance: Summary

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Status/Reason (if needed)</th>
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<tr>
<td>Center of gravity in 1&quot; plane of plate?</td>
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<tr>
<td>Weight 30.0+/- 1.0 (15.0 +/- 0.5) lbs?</td>
<td>40 lbs</td>
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<td>Max Height &lt; 10.75&quot; (5.13&quot;)</td>
<td>9&quot;</td>
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<tr>
<td>Bottom of deck has flush mount hardware?</td>
<td>N/A</td>
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<tr>
<td>Within Keep-Out Zone</td>
<td>N/A</td>
</tr>
<tr>
<td>Using &lt; 10 A/D Lines</td>
<td>Using 2 lines</td>
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<tr>
<td>Using/Understand Parallel Line</td>
<td>Yes</td>
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<tr>
<td>Using/Understand Asynchronous Line</td>
<td>Not using</td>
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<td>Using X GSE Line(s)</td>
<td>GSE-1 and GSE-2</td>
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<tr>
<td>Using X Non-Redundant PWR Lines (TE-1, TE-2, TE-3)</td>
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<tr>
<td>Using X Redundant Power Lines (TE-R)</td>
<td>Yes</td>
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<tr>
<td>Using &lt; 1 Ah (.5 Ah for half payload)</td>
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<tr>
<td>Using &lt;= 28 V</td>
<td>Yes</td>
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<tr>
<td>Using RF (If yes, list frequency and TX Power)</td>
<td>Yes, 2.5 GHz at &lt;130mW.</td>
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<tr>
<td>Using deployable?</td>
<td>Yes, 6 deployable circular «pucks»</td>
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<tr>
<td>Using ITAR and/or Export Controlled hardware</td>
<td>Holex 2800, provided by NSROIC</td>
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</table>
Management: Team Organization

Team supervisor
Ketil Røed

Technical support
UiO ELAB
Andøya Space Center

Senior engineer
Espen Trondsen

Team members
Fredrik Lindseth Winje
(*) Henrik Bjoner Lie
Andrei Costescu
Ole Martin Vister
Huy Minh Hoang
Tom Morgen Berge

(*) Team lead
## Management: Preliminary schedule

<table>
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<tr>
<th>Tasks</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
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RockSat-XN
CoDR
Management: Budget

- Funding has been secured from the Norwegian Space Center (NRS)
  - to cover engineering of payload module at Andøya Space Center
  - to cover the RockSat-XN program fee

- Funding to cover travel and material and component costs for instrument is not yet allocated
  - Students can apply for 50% coverage of travel and registration fee costs from NRS
  - Students may look for sponsoring options
  - Instrument expected to be covered by associated research projects at UiO. Strong overlap with parallel development for e.g. ICI5 and ongoing CubeSat activities.
### University of Oslo

CoDR RS-XN Team Availability Matrix

<table>
<thead>
<tr>
<th>May 22-26</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Norway</th>
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Please use Mountain Time Zone Times.

**Please Place priority levels for times you are available. This is done by simply typing a 1, 2, 3, or 4 in each clear box. Hashed boxes are not available.**

**Example:**

- **Highest Priority:** 1, 2, 3, 4
- **Lowest Priority:** 1, 2, 3, 4

---

**RockSat-XN**

CoDR
## Management: Contact Matrix

### University of Oslo

#### RS-XN Contact Matrix

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
<th>Day Phone</th>
<th>Cell Phone</th>
<th>Receive Texts?</th>
<th>Email</th>
<th>Citizenship</th>
<th>Add to mailing list?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervisor</td>
<td>Ketil Roed</td>
<td>+4722858632</td>
<td>+4798865163</td>
<td>Yes</td>
<td><a href="mailto:ketil.roed@fys.uio.no">ketil.roed@fys.uio.no</a></td>
<td>Norway</td>
<td>Yes</td>
</tr>
<tr>
<td>Senior Engineer</td>
<td>Espen Trondsen</td>
<td>+4722857371</td>
<td>+4793249035</td>
<td>Yes</td>
<td><a href="mailto:espen.trondsen@fys.uio.no">espen.trondsen@fys.uio.no</a></td>
<td>Norway</td>
<td>Yes</td>
</tr>
<tr>
<td>Student</td>
<td>Fredrik Lindseth Winje</td>
<td></td>
<td></td>
<td>Yes</td>
<td><a href="mailto:fredrilw@gmail.com">fredrilw@gmail.com</a></td>
<td>Norway</td>
<td>Yes</td>
</tr>
<tr>
<td>Student</td>
<td>Henrik Bjoner Lie</td>
<td></td>
<td></td>
<td>Yes</td>
<td><a href="mailto:henrikbjonerlie@hotmail.com">henrikbjonerlie@hotmail.com</a></td>
<td>Norway</td>
<td>Yes</td>
</tr>
<tr>
<td>Student</td>
<td>Andrei Costescu</td>
<td></td>
<td></td>
<td>Yes</td>
<td><a href="mailto:ancostescu@gmail.com">ancostescu@gmail.com</a></td>
<td>Romania</td>
<td>Yes</td>
</tr>
<tr>
<td>Student</td>
<td>Ole Martin Vister</td>
<td></td>
<td></td>
<td>Yes</td>
<td><a href="mailto:o.m.vister@fys.uio.no">o.m.vister@fys.uio.no</a></td>
<td>Norway</td>
<td>Yes</td>
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<tr>
<td>Student(PhD)</td>
<td>Huy Minh Hoang</td>
<td></td>
<td></td>
<td>Yes</td>
<td><a href="mailto:huy.hoang@fys.uio.no">huy.hoang@fys.uio.no</a></td>
<td>Vietnam</td>
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<tr>
<td>Student(PhD)</td>
<td>Tom Morgen Berge</td>
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<td>Yes</td>
<td><a href="mailto:t.m.berge@fys.uio.no">t.m.berge@fys.uio.no</a></td>
<td>Norway</td>
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</tr>
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</table>
Risks/Worries:

- Our biggest worry is about the communication between the six daughter payloads and the mother payload section. If the communication link fails to establish, we would not get any measurement data made by the daughters.
Conclusion

• Multipoint high-resolution electron density measurement is significantly needed to understand the ‘big picture’ of ionospheric plasma condition by providing the separation of temporal and spatial variations in ambient electron density.

• Success of the program will enable us to deploy constellations of even more sub-payloads for multipoint scientific studies of ionospheric plasma, as well as to provide viable solutions to deal with spacecraft charging effect in tiny spacecraft.

• Looking forward toward the PDR, the team’s next step will be:
  • Create full design of daughter payload with electron emitter/strips of metal foil.
  • Verify and improve localization accuracy based RSSI.