SIRONA-1
- a low-cost platform for lunar exploration – P5L101

Students:
Eve Pachoud, Barry Eich, Emmanuel Jehanno, Tarik Errabih, Florent Clouvel, Jean Michel Klein, Fernando Hübner, Elena Kostaropoulou, Quentin Paletta, Marcus Hott, Eliott Lindsay, Etienne Rouanet-Labé, Thomas Hancock, Romain Bossis, Rémy Derollez.
Overview

- Introduction
- Mission Objectives
- Scientific Specifications
- Mission Analysis
- System Dimensioning
- Mass Budget
- Conclusion
# Presentation CS³ – Project Team

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eve Pachoud</td>
<td>Lead WP1 (Trajectory)</td>
</tr>
<tr>
<td>Barry Eich</td>
<td>WP1 (Trajectory)</td>
</tr>
<tr>
<td>Tarik Errabih</td>
<td>Lead WP2 (Payload)</td>
</tr>
<tr>
<td>Florent Clouvel</td>
<td>WP2 (Payload) Logistics</td>
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<tr>
<td>Elena Kostaropoulou</td>
<td>WP3 (Deployable Structure)</td>
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<tr>
<td>Romain Lhotte</td>
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<tr>
<td>Jean-Michel Klein</td>
<td>Lead WP3 (Structure) I.T.</td>
</tr>
<tr>
<td>Fernando Hübner</td>
<td>WP3 (Thermal Structure) I.T.</td>
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<tr>
<td>Marcus Hott</td>
<td>Lead WP4 (EPS) I.T.</td>
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<tr>
<td>Eliott Lindsay</td>
<td>Lead WP5 (Communication)</td>
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<tr>
<td>Emmanuel Jehanno</td>
<td>WP1 (Trajectory)</td>
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<td>Maxime Carpentier</td>
<td>Electronics</td>
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<td>Etienne Rouanet-Labé</td>
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<td>Thomas Hancock</td>
<td>Lead WP6 (ADCS)</td>
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<td>Rémy Derollez</td>
<td>Lead WP7 (SE) Communication</td>
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<td>Romain Bossis</td>
<td>Lead WP7 (SE) Reporting</td>
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<tr>
<td>Quentin Paletta</td>
<td>WP3 (Thermal Structure)</td>
</tr>
<tr>
<td>Jean-Baptiste Latil</td>
<td>Stagiaire CS³</td>
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</table>
Overview

Introduction

Mission Objectives

Scientific Specifications

Mission Analysis

System Dimensioning

Mass Budget

Conclusion
SIRONA Objectives

• Educational Objectives
  Learning by doing Experience
  Knowledge Acquisition

• Science Objectives
  Impact of cosmic radiation on living organisms
  Observation of lunar mares

• Technical Objectives
  Engineering developments
  Demonstration/Flight of innovative technologies
Mission objectives

Cislunar Orbit < 6 months

Polar Orbit from PSLV to reduce van Allen belt exposure

Science Orbit > 6 months
Overview

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Conclusion
What is a lunar sea?

Time dependence of the Lunar cratering rate (Neukum 1983)

- Test the cataclysm hypothesis by providing high resolution images

- Crater counting allows to constrain the age of the lunar seas
ASTERICS: Deployable Telescope

First Stage Deployment

Final Deployed Configuration

Panels deployment by springs

Stops

Release Mechanism
ASTERICS: Deployable Telescope

From left to right:

1) Small Cubesats (simulated)
2) SIRONA (simulated)
3) Lunar Reconnaissance Orbiter (best data available, four times closer to the Moon than SIRONA)
OBELICS: Biological Experiment

Artistic view of a cislunar station

OBELICS’ deployment

Wells’ design

- Phase change material
- Photodiode
- LED
- Growth medium
- Thermal spreader
- Polycarbonate + PCB
- Dosimeter
- Coil heater
- Filter for entering/exiting growth medium

Ø 3 mm

10 mm
Mission Concept

Cislunar Orbit < 6 months

Polar Orbit from PSLV to reduce van Allen belt exposure

Science Orbit > 6 months
System Design - Structure

SIRONA
Undeployed configuration

SIRONA
Deployed configuration
System Design – Bloc Diagram

System description

Electrical Power System
- Battery
- Power Regulation and Conversion

Command and Data Handling
- Flight Computer
- Auxiliary boards
- Data Interface
- Radiation Protection

Communication
- Uplink Sband
- Downlink Xband
- Transceiver
- UHF VHF Transceiver
- UHF VHF antenna

Propulsion System
- Propellant tank
- Main thrusters
- PPT
- Prop Power Unit

Thermal System
- Heaters
- Thermal Sensors

Cubesat Parameters
- Payload
- Petri Dish
- Science Card
- Telescope
- Dosimeter
- CMOS
- Magnetometer

ADCS
- IMU
- Reaction wheels
- Star Tracker
- Magnetotorquers
- Sun Sensors
- GPS Receiver

Information Flow
Energy Flow
System Design - SubSystems

- Command & Data Handling
- Electric Propulsion Engine
- On Board Computer
- Ergol Tank & Propulsion Management Unit

SIRONA subsystems (front view)
- Electric Power System (EPS)
- Transceiver
  - Tx: X-band
  - Rx: S-band
- Attitude Determination and Control Unit (ADCS)
- Pulsed Plasma Thrusters (Momentum Wheels desaturation)

SIRONA subsystems (back view)

Batteries

7 units available for payloads and system margins
STR - Structure

Cells arrangement

Strain simulation
PPT - Pulsed Plasma Thrusters

Proof Of Concept

Anode | Spark plug | Copper capacitance rail

Cathode | Carrier | PTFE

Final Design Concept

Final assembly of the PPT system.
EPS - Electrical Power System

- Large deployable solar panels. Direct them always towards the sun.
- Development of the PADA

12U CubeSat with large deployed solar panels
PADA – Panel Array Drive Assembly

CAD model of the PADA position in SIRONA

The interface between the PADA (blue) and an array deployable mechanism (purple & light grey)

Zoom on PADA mechanical assembly
## Summary of SIRONA’s parameters in the lunar phase

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Signal/General</strong></td>
<td></td>
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<tr>
<td>Downlink Frequency Band</td>
<td>X-Band</td>
</tr>
<tr>
<td>Uplink Frequency Band</td>
<td>S-Band</td>
</tr>
<tr>
<td>Signal Polarization</td>
<td>Circular polarisation</td>
</tr>
<tr>
<td>Modulation Scheme</td>
<td>QPSK</td>
</tr>
<tr>
<td>Minimum elevation angle</td>
<td>15°</td>
</tr>
<tr>
<td><strong>SIRONA Tx</strong></td>
<td></td>
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<tr>
<td>Power</td>
<td>5.0W</td>
</tr>
<tr>
<td>Antenna Gain</td>
<td>25.0dBi</td>
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<tr>
<td>Antenna type</td>
<td>Micropatch-array</td>
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<tr>
<td><strong>SIRONA Rx</strong></td>
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<tr>
<td>Antenna Gain</td>
<td>1.0dBi</td>
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</table>
Overview

Introduction

Mission Objectives

Scientific Specifications

Mission Analysis

System Dimensioning

Mass Budget

Conclusion
## Mass Budget

<table>
<thead>
<tr>
<th>SUB-SYSTEM</th>
<th>Sirona 12U (Full Mission)</th>
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<tbody>
<tr>
<td>Structure</td>
<td>1800</td>
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<tr>
<td>Thermal Components</td>
<td>150</td>
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<td>Radiation Shield</td>
<td>150</td>
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<tr>
<td>Solar Panels</td>
<td>1000</td>
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<tr>
<td>Power Board (EPS)</td>
<td>110</td>
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<tr>
<td>Solar Panel Motor</td>
<td>20</td>
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<tr>
<td>Battery</td>
<td>1000</td>
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<tr>
<td>Command and Data Handling</td>
<td>300</td>
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<td>Antenna 1 (DOWNLINK)</td>
<td>64</td>
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<tr>
<td>Antenna 2 (UPLINK)</td>
<td>65</td>
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<tr>
<td>Transmitter</td>
<td>50</td>
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<td>Receiver</td>
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<td>IMU</td>
<td>80</td>
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<tr>
<td>Star Trackers</td>
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<tr>
<td>Sun Trackers</td>
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<tr>
<td>GPS Receiver</td>
<td>45</td>
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<tr>
<td>Reaction wheels</td>
<td>1200</td>
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<td>PPT</td>
<td>200</td>
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<tr>
<td>Deployable Telescope</td>
<td>500</td>
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<td>Main Propulsion</td>
<td>5000</td>
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<td>Dosimeter</td>
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<td>Beacon UHF/VHF*</td>
<td>85</td>
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<td><strong>TOTAL</strong></td>
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Thank you for your attention
Appendix n°1

Project Management
Appendix n°2

Budgets
## Mission Budgets

### Power Budget (W)

We consider representative modes of the mission

<table>
<thead>
<tr>
<th>SUB-SYSTEM</th>
<th>Sleep Mode</th>
<th>Detumbling Mode</th>
<th>Propulsion Mode</th>
<th>Telecom Mode</th>
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</thead>
<tbody>
<tr>
<td>Power Board (EPS)</td>
<td>ON</td>
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<td>ON</td>
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<tr>
<td>Solar Panel Motor</td>
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<tr>
<td>Battery</td>
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<td>Command and Data Handling</td>
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<td>Antenna 1 (DOWNLINK)</td>
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<tr>
<td>Antenna 2 (UPLINK)</td>
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<td>Receiver</td>
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<td>IMU</td>
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<td>Star Trackers</td>
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<tr>
<td>Sun Trackers</td>
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<td>GPS Receiver</td>
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<tr>
<td>Reaction wheels</td>
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<tr>
<td>Power needed</td>
<td>7,25 W</td>
<td>8,5 W</td>
<td>90 W</td>
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## Mission Modes

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<th>Detumbling Mode</th>
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<th>Attitude Correction Mode</th>
<th>Determination Mode</th>
<th>End of Mission Mode</th>
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<tr>
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<td><strong>Total power need (W)</strong></td>
<td>0</td>
<td>7,25</td>
<td>9,55</td>
<td>209,35</td>
<td>8,25</td>
<td>11,75</td>
<td>8,25</td>
<td>12,25</td>
<td>12,75</td>
<td>12,25</td>
<td>14,05</td>
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Appendix n°3

Risk Mitigation
## Risk Mitigation

<table>
<thead>
<tr>
<th>Risk number</th>
<th>Risk situation</th>
<th>Mitigation strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Ground Station is not ready yet</td>
<td>Cooperation Strategy with international ground station network</td>
</tr>
<tr>
<td>7</td>
<td>The spacecraft does not follow the expected trajectory</td>
<td>Trajectory checked on the ground, If necessary, commands will be uploaded to correct the trajectory.</td>
</tr>
<tr>
<td>20</td>
<td>Battery non-function due to extreme temperatures</td>
<td>Thermal Sensor in the System and Integrated Thermal Regulator in the battery area (backup Heaters integrated). Insulated from the spacecraft frame.</td>
</tr>
<tr>
<td>23</td>
<td>Solar Panel Orientation Motor fails (SADA)</td>
<td>The satellite attitude can be changed to get the panels exposed to the sun radiation, using the ADCS</td>
</tr>
</tbody>
</table>
## Risk Mitigation

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Number</th>
<th>Risk Situation</th>
<th>Mitigation Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mission Preparation</td>
<td>1</td>
<td>Component/Sub-System is not developed on time</td>
<td>Handling Procedures. Different Options. Different Providers</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Mission Launch postponed</td>
<td>No impact on the mission per se. Calculations done for different configurations and launch windows</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Deviation from CubeSat standards (volume, mass)</td>
<td>Very Accurate PDR and CDR. In depth Analysis and Studies. List of Critical Elements</td>
</tr>
<tr>
<td>Mission Operation</td>
<td>4</td>
<td>Ground Station is not ready yet</td>
<td>Cooperation Strategy with international ground station network</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Other partners in command centers are unwilling to cooperate</td>
<td>Robust Communication Strategy and mutual beneficial partnerships establishment. Centrale Mission Control as backup</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>The spacecraft is hit by space debris or hits a debris.</td>
<td>Orbits and Trajectory computed to avoid space debris. ACDS able to prevent the near-presence of debris and avoid them (possibly using Main Propulsion)</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>The spacecraft does not follow the expected trajectory</td>
<td>Trajectory checked on the ground, if necessary, commands will be uploaded to correct the trajectory.</td>
</tr>
<tr>
<td>Orbit/Trajectory</td>
<td>8</td>
<td>Solar Eruption</td>
<td>Radiation Shielding. Trajectories computed to take the parameter into account. Shut down of the system</td>
</tr>
<tr>
<td>Structure</td>
<td>9</td>
<td>Structure fails while Launching</td>
<td>Extensive Simulation and tests on Structure.</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Star Tracker fails</td>
<td>Redondance of Star Trackers and Robust ADCS. Test Procedures</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Sun Sensor fails</td>
<td>Redondance of Sun Sensor and Robust ADCS. Test Procedures</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>IMU fails</td>
<td>Complete and Redondant ADCSystem.</td>
</tr>
<tr>
<td>Attitude Determination</td>
<td>13</td>
<td>Reaction Wheels fail</td>
<td>PPT can make up for the loss of the wheels</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>PPT fails</td>
<td>Use the main engine equipped with gimbals</td>
</tr>
<tr>
<td>Attitude Control</td>
<td>15</td>
<td>Antenna deployement failure</td>
<td>Redondant hot wire. Antenna can be used undeployed but need for ADCS action in this case</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>UHF Beacon System fails</td>
<td>Critical and Basic Information can be sent using the X-band Antenna (Redondance)</td>
</tr>
<tr>
<td>Communication</td>
<td>17</td>
<td>OBC fails</td>
<td>Robust Testing of electronic systems (Test Plateform)</td>
</tr>
<tr>
<td>Command - Data Handling</td>
<td>18</td>
<td>Failure in the software functions</td>
<td>Extensive Testing and Simulating. Possibility to update the satellite’s on board code by sending ground commands</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>OBC fails because of Radiation/Cosmic rays</td>
<td>Latch up protection by detecting and isolating latchup currents integrated in boards</td>
</tr>
<tr>
<td>Thermal control</td>
<td>20</td>
<td>Battery non-function due to extreme temperatures</td>
<td>Thermal Sensor in the System and Integrated Thermal Regulator in the battery area (backup Heaters integrated). Insulated from the spacecraft frame.</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>Components/Systems affected by extreme temperatures</td>
<td>Thermal Simulation, thermal vacuum cycling Robust Testing</td>
</tr>
<tr>
<td>Electrical Power System</td>
<td>22</td>
<td>Solar Panel deployment failure</td>
<td>Some cells exposed to the outer surface: Battery Charging not so effective but possible. Low Power Mode activated. One third of the surface available</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>Solar Panel Orientation Motor fails (SADA)</td>
<td>The satellite attitude can be changed to get the panels exposed to the sun radiation, using the ADCS</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>Overdegradation of Solar Cells</td>
<td>Update of the duty cycle thanks to an upload command</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>EPS Board fails</td>
<td>Update of the duty cycle until EOL</td>
</tr>
<tr>
<td>Propulsion</td>
<td>26</td>
<td>Main Propulsion failure</td>
<td>Robust Testing. Redondance of the Main Propulsion (two distinct but similar orientable parts). PPT can help</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>Thrusters Overheat</td>
<td>Shutdown and Update of the duty cycle. Robust Testing. Sensors</td>
</tr>
<tr>
<td>Science</td>
<td>28</td>
<td>Biological Experience fails</td>
<td>Different Payloads with different objectives on board.</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>Data cannot be transmitted</td>
<td>Different Sensors and Parameters measured. Some Elements available.</td>
</tr>
</tbody>
</table>
Appendix n°4

12 U Mission
We consider three Mission Options depending on exogeneous parameters:

- **Full Mission**: 12U – 20 kg
- **Light Mission**: 12U – 12 kg
- **Low Volume Mission**: 6U – 10 kg
Advantages 12U

- Easy integration of the Ablative Pulsed Plasma Thrusters in a pair of dedicated thuna cans.

- Better Performance of the main propulsion module (ionic propulsion would contain two exhaust blocks).

- Larger available mass for payloads (at least for the first two scientific objectives). This could allow a larger mass dedicated to the biological experiments, allowing us to integrate a larger number of wells (and consequently of material tests) and increase the scientific relevance of the mission and data collected.

- Easier design and integration of the scientific payloads (especially deployable ones: biological experience and telescope).

- Benefiting from the expertise of Nexaya in the 12U CubeSat Standard (ELISE Project).

- Being pioneers by using one of the first 12U CubeSat Plateform.

- Larger available volume for payloads enabling the welcoming of a potentially larger number of other payloads, reinforcing the scientific weight of the mission and the international cooperation on SIRONA.
Appendix n°5

Structure
Structure

Assembly - Unit cells insertion

Unit Cell

Unit cells arrangements
1. Radiation shielding conception

• The high doses of radiation force the development of a protection strategy.

• Thus the need to engage in the study of different materials that can be used in order to provide this protection for the electronic devices on board.
2. Structure validation and optimization

- The mission requirements impose that the structure must withstand 10 g acceleration in each direction.
- A safety factor of 2 was homogenized among the structure in order to minimized the mass.
Appendix n°6

ADCS
Attitude Control System

WHY?

→ For the purposes of the mission, the attitude of the satellite will need to be controlled and modified several times:

- Detumbling phase (A)
- Power production Phase (B)
- Communication phase – Pointing the Earth (C)
- Scientific Phase (telescope, living organisms) (D)

→ We will use Reaction wheels to modify the attitude
Reasonable desaturation time: ~ 1 hour

Thrust required: ~ 1 µN
PPT – Main Characteristics

WHY ?

- Zero warmup time
- Scaleable
- Discreet impulses
- Variable thrust level
- Versatility
- Solid Propellant

F. Chen and al (2000) Design and testing of a micro PPT for CubeSat applications, Scuola di Ingegneria Aerospaziale
Figure 5.1: A one dimensional circuit schematic overlaid on the components of a PPT.
PPT – Design

- Cathode
- Carrier
- PTFE
- Anode
- Spark plug
- Copper capacitance rail
- Copper Rail
- Spark plug
PPT – Results
Appendix n°7

Electrical Power System
### EPS – Electrical Power System

**EPS – intro**

**Objective:**

Provide necessary power to all subsystems aboard SIRONA.

**EPS breakdown:**

- Power generation
- Power storage
- Power distribution
- Power regulation and control

<table>
<thead>
<tr>
<th>Common values:</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 W (solar electricity)</td>
</tr>
<tr>
<td>40 Wh (batteries)</td>
</tr>
<tr>
<td>3,3 V-12 V (I²C bus, PC/104...)</td>
</tr>
</tbody>
</table>

- Without a functional EPS the mission fails.

- **Budget:** 1 kg, max. 1 Unit

  Battery stack (Clydespace, GomSpace)
Power generation depends on:

a) the CubeSats relative position to the sun.
   - Attitude of the CubeSat
   - Albedo of the moon
   - Albedo of the earth
   - Solar flux at different distances

b) the solar cell’s characteristics.
   - Efficiency, BOL/EOL

→ Analyse the CubeSats position in Matlab simulations to predict power generation
Irradiation analysis based on SwissCube’s report

Simulation - Progress of light source around satellite

φ azimuth
Θ elevation
Large deployable solar panels. Direct them always towards the sun.
Development of the PADA

12U CubeSat with large deployed solar panels
Appendix n°8

Communications
COM – Why?

Engineering Importance
• Send commands to SIRONA
• Receive data about state of health

Scientific Importance
• Transmit to earth all the data we collect

Some useful definitions
Uplink – From the ground to SIRONA
Downlink – From SIRONA to the ground
COTS – Commercial off-the-shelf [equipment]
COM - Overview

Two phases of operation

Lunar orbit

Near-earth orbit

Key Requirements
- Highly directional → pointing mechanism
- High power + gain

Key Requirements
- Isotropic operation
- Low power consumption

DOWNLINK LUNAR ORBIT
### Summary of SIRONA’s parameters in the lunar phase

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Signal/General</strong></td>
<td></td>
</tr>
<tr>
<td>Downlink Frequency Band</td>
<td>X-Band</td>
</tr>
<tr>
<td>Uplink Frequency Band</td>
<td>S-Band</td>
</tr>
<tr>
<td>Signal Polarization</td>
<td>Circular polarisation</td>
</tr>
<tr>
<td>Modulation Scheme</td>
<td>QPSK</td>
</tr>
<tr>
<td>Minimum elevation angle</td>
<td>15°</td>
</tr>
<tr>
<td><strong>SIRONA Tx</strong></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>5.0W</td>
</tr>
<tr>
<td>Antenna Gain</td>
<td>25.0dBi</td>
</tr>
<tr>
<td>Antenna type</td>
<td>Micropatch-array</td>
</tr>
<tr>
<td><strong>SIRONA Rx</strong></td>
<td></td>
</tr>
<tr>
<td>Antenna Gain</td>
<td>1.0dBi</td>
</tr>
</tbody>
</table>
COM – Future Work

• **Survey existing COTS equipment**
  - French supply chain
  - Possible adjustment to Preliminary Design (PD)

• **Bring other COM phases to the same design stage.**
  - Lunar uplink
  - Near-earth Up/Downlink

• **Pointing Budget**
  - Integrate work done by ADCS, PADA and COM
Appendix n°9

PADA

(Panel Array Drive Mechanism)
What is a PADA?
A mechanism that rotates deployed panels.

A mechanism?

- Motor-gearbox design
- 3-axis adjustable
- Panel pointing accuracy

Increasing importance with increasing distance from the sun

Solar irradiation:
- Earth’s surface: 1370 W/m²
- Mars’ surface: 590 W/m²
PADA – Panel Array Drive Assembly

PADA – Sketch

CAD model of the PADA position in SIRONA
Appendix n°10

Thermal Modelling
Sub-Systems – Thermal control

Thermal Simulation - ESATAN

Result radiative simulation – Radiative Case

Heat Flux (W/m²): Polar.SAF

F (W/m²)

1036.21
971.44
906.68
841.92
777.15
712.39
647.63
582.87
518.10
453.34
388.58
323.81
259.05
194.29
129.53
64.76
0.00
Sub-Systems – Thermal control

Thermal Simulation - ESATAN

Single result simulation in Earth Orbit

Heat Power (W): Polar A/C & PAP + Polar IR_PAP + PAPSIS

P (W)

59.247
55.544
51.841
48.138
44.435
40.732
37.029
33.326
29.623
25.920
22.217
18.515
14.812
11.109
7.406
3.703
0.000
Sub-Systems – Thermal control

System Modelling - ESATAN

SIRONA Modelling with antennae


P(W)

54.715
51.296
47.876
44.456
41.036
37.617
34.197
30.777
27.358
23.938
20.518
17.099
13.679
10.259
6.839
3.420
0.000
Deployable
Deployable Telescope Payload - Concept

- Deployable telescope
  - Allow for higher magnifications
  - 1 unit in SIRONA (retracted)
  - 25cm length (deployed)

- Ritchey-Chrétien architecture
  - Minimum optical aberrations
  - Maximum magnification/volume ratio
  - Proven technology - Hubble

- Preliminary dimensioning:
  - Primary mirror aperture: 86 mm
  - 1.5m resolution at 200km altitude
  - 7200 Mbyte/hr to accurately image the moon

Monochromatic CCD sensor
Major points to consider in the design:

- Accuracy
- Reliability
- Thermal behaviour
- Mass
- Volume before deployment
- Deployment triggerer
Deployable telescope design

Objectives

- Minimisation of mass
- Deployment mechanism
- Release mechanism
- Radiation
- Thermal behavior & Statics