# SIROM

## D5.3: OG5-D2_User Manual WP5

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<thead>
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<th>Name</th>
<th>Company</th>
<th>Date</th>
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1. INTRODUCTION AND SCOPE

The objective of the user manual (UM) is to provide information on design, operations and data of the product that is required by the user to handle, install, operate, maintain and dispose the product during its life time.


This document is the updated version for WP4 of the deliverable D4.6 OG5-D2_User Manual WP4.

This document is provided with an annex containing the product specifications (data sheet) of SIROM mechanism.
2. REFERENCES

2.1 Applicable Documents

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Table 2-1 Applicable Documents

2.2 Reference Documents

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Table 2-2 Reference Documents

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730035.
### 3. ACRONYMS LIST

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<thead>
<tr>
<th>Acronyms</th>
<th>Meaning</th>
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<tr>
<td>AIT</td>
<td>Assembly Integration and Test</td>
</tr>
<tr>
<td>APM</td>
<td>Active Payload Module</td>
</tr>
<tr>
<td>CAN</td>
<td>Controller Area Network</td>
</tr>
<tr>
<td>DDF</td>
<td>Design Definition File</td>
</tr>
<tr>
<td>EE</td>
<td>End Effector</td>
</tr>
<tr>
<td>EGSE</td>
<td>Electrical Ground Support Equipment</td>
</tr>
<tr>
<td>IF</td>
<td>Interface</td>
</tr>
<tr>
<td>KO</td>
<td>Kick-Off</td>
</tr>
<tr>
<td>MoM</td>
<td>Minutes of Meeting</td>
</tr>
<tr>
<td>NCR</td>
<td>Non Conformance Report</td>
</tr>
<tr>
<td>OBC</td>
<td>On Board Computer</td>
</tr>
<tr>
<td>OG</td>
<td>Operational Grant</td>
</tr>
<tr>
<td>PM</td>
<td>Progress Meeting</td>
</tr>
<tr>
<td>RfD</td>
<td>Request for Deviation</td>
</tr>
<tr>
<td>RfW</td>
<td>Request for Waiver</td>
</tr>
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<td>SIROM</td>
<td>Standard Interface for Robotic Manipulation</td>
</tr>
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<td>SpW</td>
<td>SpaceWire</td>
</tr>
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<td>SRR</td>
<td>System Requirements Review</td>
</tr>
<tr>
<td>TBC</td>
<td>To Be Confirmed</td>
</tr>
<tr>
<td>TBD</td>
<td>To Be Defined</td>
</tr>
<tr>
<td>TC</td>
<td>Telecommand</td>
</tr>
<tr>
<td>TM</td>
<td>Telemetry</td>
</tr>
</tbody>
</table>

Table 3-1 Acronyms list
4. SIROM DESIGN DESCRIPTION

4.1 General configuration

SIROM is a device provided by four IFs with capabilities to transfer loads, data, power and heat. The generic design is divided in blocks that envelope each IF achieving a compact design. Data, Power and Thermal IFs are located in a plate called Connectors Plate, while Mechanical IF is on its own. SIROM must match another SIROM in one flange (SIROM standard IF is androgynous and coupling is done between two functional units), whereas an Active Payload Module (APM) will be fixed in the other. The idea is being capable of constructing a modular and scalable structure that will connect the APM to any spacecraft platform mechanically and provide data, power and thermal coupling.

Furthermore, the connection between SIROM and the robotic arm is made by an End Effector, which must ensure the functionality of SIROM IFs.

![Two SIROMs coupled](image)

Figure 4-1 Two SIROMs coupled

4.2 Physical description

SIROM general envelope dimensions above APM interface are:
- Base: 120 mm diameter
- Height: 30 mm

Envelope dimension underneath APM interface are:
- Base: 120 mm square taking into account the actuator
- Height: 30 mm from APM outer surface

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SIROM Controller and EIS are located inside APM envelope.

4.3 Functional description

The functional description is divided in two main aspects:
- Mating stages
- Connection sequence and TM/TC timing

4.3.1 Mating stages

OG5 operations consist of two different aspects:
- Mating one SIROM against another to provide Mechanical, Power, Data and Thermal coupling between the robotic arm and the APM (or between two APMs).
- Once connection is made, receiving and complying commands from the OBC / EGSE (or from another APM) and transmitting data from the APM to the OBC / EGSE (or to another APM).

All SIROMS used for OG6 demonstration are mechanically identical. However the following terminology is used to define SIROMs depending on their role on the coupling process:
- Active SIROM. This is the SIROM which motor is actuated by the controller during the coupling process. It actuates its latches in order to capture and preload both SIROMs. It is also in charge of opening its dust covers and its Connectors plate as well as the ones of the passive SIROM.
- Passive SIROM. During the coupling process this SIROM is completely un-energized (passive). It is the one captured by the latches of the active SIROM and its dust covers and connector plate are mechanically actuated by actuator of the active SIROM. Therefore, this SIROM does not need to be energized at all to complete the latching and connecting process.

The mating stage is performed by an active SIROM A docking a passive SIROM B. This redundancy concept allows to connect 2 SIROMs even if one of them is damaged or inactive.
4.3.2 Mating Connection sequence and related TM/TC timing

In this paragraph, mating sequence between SIROM A and SIROM B will be described in detail. Every command is delivered via CAN Bus from the EGSE / OBC to the controller. Both SIROMS are in “latched” (launch) position at the start of the sequence.

For a better understanding, following figure summarizes the steps of the coupling (blue lines) and decoupling (red lines) sequences between SIROM A and B. The upper axis shows the position of SIROM A four sensors considering the “latched” sensor as reference. In the scheme, black dots indicate communication between EGSE and SIROM controller (detecting sensor status, commanding movement of the motor etc.) and orange dots indicate communication with the robotic arm (manipulator). CW stands for clockwise rotation of the motor, while CCW stands for counter clockwise rotation.
Each of the steps is labelled with a letter from A to T. Following table summarizes the status of the sensors and SIROM in each of these steps.

<table>
<thead>
<tr>
<th>STEP</th>
<th>Command</th>
<th>SIROM Status</th>
<th>RTC</th>
<th>Captured</th>
<th>Latched</th>
<th>Connected</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Check Latched sensor is 'ON'</td>
<td>Latched</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>B</td>
<td>Unlatch TC: Go to Capture sensor</td>
<td>Moving from Latched to Captured</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>C</td>
<td>Movement stopped by Capture sensor</td>
<td>Captured</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>D</td>
<td>Release TC: Go to Ready To Capture sensor</td>
<td>Moving from Captured to Ready To Capture</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>E</td>
<td>Command manipulator to place the EE in capture position wrt APM &amp; Confirm when positioned</td>
<td>Ready To Capture</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>F</td>
<td>Command manipulator to change to impedance mode</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>Command go to Captured sensor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>Movement stopped by Captured sensor</td>
<td>Moving from RTC to Captured</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>I</td>
<td>Actuator moving CW</td>
<td>Captured</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>Connect TC: Go to Connected sensor</td>
<td>Latched</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>ON</td>
</tr>
<tr>
<td>K</td>
<td>Movement stopped by Connected sensor</td>
<td>Moving from Captured to Connected</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
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<tr>
<td>L</td>
<td>Command manipulator to separate from APM</td>
<td>Ready To Capture</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
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<tr>
<td>M</td>
<td>Disconnect TC: Go to latched sensor</td>
<td></td>
<td></td>
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<td>N</td>
<td>Actuator moving CW</td>
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<td>OFF</td>
<td>OFF</td>
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<td>OFF</td>
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<tr>
<td>O</td>
<td>Movement stopped by Latched sensor</td>
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<td>ON</td>
<td>OFF</td>
<td>OFF</td>
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<tr>
<td>P</td>
<td>Actuator moving CW</td>
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<tr>
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<td>Ready To Capture</td>
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<td>OFF</td>
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<tr>
<td>R</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>Move to Latched TC</td>
<td>Captured</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
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<td>Connect TC: Go to Connected sensor</td>
<td>Latched</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
</tr>
</tbody>
</table>

### Table 4.3.1 Coupling and decoupling sequence

The sequence is described in detail:

A. & B. The EGSE receives “latched” state and commands SIROM A controller to execute Unlatch TC. SIROM goes from “latched” to “captured”. Actuator moves CCW in this step.

C. The EGSE receives “captured” state and commands SIROM A controller to execute Release TC. SIROM goes from “captured” to “ready to capture” (CCW).

D. The EGSE receives “ready to capture” state.

E. EGSE / operator commands the robotic arm to go to ready to capture and positions both SIROMs one in front of the other.

F. The EGSE / operator commands the robotic arm to be change to impedance mode.

G. The EGSE commands SIROM A controller to execute Capture TC. SIROM goes from “Ready-to-capture” to “captured” state (CW).

H. The EGSE receives “Captured” state. At this point, SIROM A latches still have not made contact with SIROM B capture tabs. SIROM A latches are inside SIROM B pockets.

- The EGSE commands SIROM A to execute Latch TC. SIROM goes from “captured position” to “latched position” (CW). During this movement:

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a) The latches will start preloading SIROM A against SIROM B. When a force or a torque superior to 10 N or 0.5 Nm is sensed by the robotic arm sensors, it starts moving (or rotating) toward SIROM B until the force and torque values are under the mentioned ones (10 N or 0.5 Nm). Meanwhile, latches continue retracting.

b) While approximating SIROM A and SIROM B, the guiding petals correct possible misalignments by contacting the guide counterpart of the opposite SIROM.

c) Both SIROM faces make contact and, after latches preloading, “Latched” position is achieved (“latched” sensor activated)

I. The EGSE receives “Latched” state and commands SIROM A controller to execute “Connect” TC. SIROM goes from “latched” to “connected” (CW). During this process:
   a) The dust covers of both SIROMs are opened and the connector plates starts its movements approaching each other.
   b) Connectors get connected and the “connected” sensors are activated

J. SIROM A Controller sends “Connected” state to EGSE.

Mating sequence is finished.

SIROM controller also is capable of performing the sequence in a more autonomous manner. For instance, it can go from A to C (“latched” to “ready to capture”) with Release TC. It can also go from G to J (“ready to capture” to “connected”) with Connect TC. This is shown with purple lines in Figure 4-4 Coupling and decoupling sequence. A more detailed description of the SIROM controller, its telecommands and its capabilities is depicted in the DJF.

The de-coupling process is similar to the coupling process described above. As depicted in Figure 4-4.

4.4 Interfaces description

In the following paragraphs each IF will be described.

![Figure 4-5 SIROM Interfaces](image-url)
4.4.1 Mechanical IF

The Mechanical IF is responsible of providing SIROM berthing capability against another SIROM and proving compliant to loads arising during operations once attachment is made.

It is formed by hooks (latches), sensors, an actuator (motor + planetary gearhead) and a guiding system to correct misalignments.

The robotic arm places the SIROM A close to SIROM B (the positioning error being the misalignment to be corrected by the guiding system) and SIROM A latches SIROM B continuing the sequence described above commanded by the OBC / EGSE.

4.4.2 Power IF

Electrical IF (i.e. Power IF) is responsible of providing power to SIROM Controller and APM Controller and it is placed in the Connectors Plate. A power source shall be mounted in the Platform (satellite or rover) or APM, and cables will reach SIROM IF.

The connectors selected are Dsubminiature ESA/ESCC 3401/002 DEMA with 9 contacts, Shell size E (Standard density).

The Connectors Plate is populated with one male and one female connector achieving an androgynous Electrical IF and redundancy at the same time.

4.4.3 Data IF

Data IF is responsible of providing communication between SIROMs and OBC / EGSE. This is understood in two communication types. One the one hand it holds commands (CAN) for monitoring and controlling the SIROM and the APM, and on the other hand it ensures transmission of the data (SpW) obtained (e.g. images taken) by the APM. It is located on the Connectors Plate and, as for the Electrical IF, a pair of connectors is provided for each communication type achieving androgyny and redundancy. The connectors selected are Micro-miniature D-type ESA/ESCC 3401/029 MDM with 9 contacts.

The Connectors Plate is populated with:

- For CAN bus: one male and one female connector achieving an androgynous Electrical IF and redundancy at the same time
- For SpW: one male and one female connector achieving an androgynous Electrical IF and redundancy at the same time

The CAN bus shall be terminated at both its ends using 120ohm resistors to improve the signal quality and to pull the lines to the same voltage in the recessive state (see D3.7). On end being at the EGSE, the other end will be opened/closed (depending on the APMs and SIROM connections) using mechanical switches (inside SIROM mechanism) triggered when two SIROM interfaces connect/disconnect.

4.4.4 Thermal IF

Thermal IF is responsible of transferring heat flux from APM to APM via SIROM-SIROM Thermal IF.

The Connectors plate is comprised of one male and one female STAUBLI connector model CGO 03/C.
### 4.4.5 IF to APM

The SIROM is bolted (6xM3) in a 128mm diameter circumference on its lower side to the EE or to the APM. The functional IF between SIROM and its electronics (mounted on APM) will consist of:

- 2 CAN bus lines (Main & Redundant)
- 2 SpaceWire lines (Main & Redundant)
- 2 power lines (electrical lines)
- 2 threaded holes for the tubing of the Thermal IF
- Sensor harness (of 4x Hall sensors and 2x Thermistors)
- CAN switches harness (2x Switches for Main & Redundant CAN bus lines)
- Motor harness

Following figures show the lower part of SIROM, and a diagram of the harness.

![Figure 4-6 SIROM IF with APM and SIROM electronics (harness coming out from SIROM holes)](image-url)
Figure 4-7 – SIROM Harness diagram (letter “M” indicates male connector; “F”: female connector)
5. ORBITAL APM

The mission of the orbital test is to demonstrate the successful transfer of Mechanical Loads/Data/Power/Heat Flux while moving an APM from an initial to a final operational location by means of a robot manipulator using SIROMs. The functioning of the interface of the APM with its payload and with the robot end-effector, as well as that of the end-effector with the robot manipulator will be validated.

Two Orbital APMs are designed and built to support the test and demonstration of the functionalities and performance of the SIROM IF.

The two Orbital APMs developed for testing the SIROM IF in OG6 facilities in OG6 will be different:

- APM-1 will have two SIROMs and a Payload (camera).
- APM-2 will have one SIROM and no payload. It will be directly mated to the OG6 S/C dummy by means of 3 M6 bolts at 120°.

5.1 APM-1

APM-1 of Orbital Test is the active APM of the demonstration. It will be equipped with the optical sensor that is the payload of the APM.

APM-1 consists of:

- 2 SIROMs
- 2 SIROM Controllers (1 per SIROM): RPi-zero + CAN 2 DUO interface board and Teensy 2.0 controller + connector/interface board
- Housing: Responsible of enveloping every part
- APM-1 Payload: RPi Camera Module V2
- APM Controller: RPi-3 + CAN 2 DUO interface board. It implements control of the APM activity
- Power, Data & Thermal lines: Coming from upper SIROM towards lower SIROM, shall be inside the APM-1
- SpaceWire-USB brick: SIROM Data transfer will be performed via SpW connection. As SpW protocol is not native on RPi-zero, STAR-Dundee USB Brick will provide a bridge between the USB of APM controller and SpW bus
- 2 EIS boards (1 per SIROM)

The following figure shows APM-1 design, not including the complete routing of all the cables.
5.2 APM-2

APM-2 of Orbital Test is the non-active APM of the demonstration. It is not be equipped with any payload as it will not be used for any specific aspect.

APM-2 is similar to APM-1, though instead of having a SIROM IF at its lower surface, it has 3xM6 holes evenly distributed (at 120°) over a 200mm diameter circumference to get attached to the target S/C dummy.

The components of APM-2 are:

- Housing: Responsible of enveloping and supporting every component
- 1 SIROM
- 1 SIROM Controllers (1 per SIROM): RPi-zero + CAN 2 DUO interface board and Teensy 2.0 controller + connector/interface board
- Power, Data & Thermal lines: Coming from SIROM towards the EGSE / OBC.
- EIS board
- Interface with 3xM6 screws

The following figure shows APM-2 design, not including the complete routing of all the cables.
Figure 5-2 APM-2 main components
6. PLANETARY APM

6.1 Primary APM

6.1.1 General Description

The main mission of the P-APM is to provide support to the robotic exploration, by providing charging capabilities to battery modules to be used by the rover, or other APMs. Battery modules are to be charged by harvesting the available solar energy. For maximum efficiency of the charging process, the solar panel is going to be mounted on a rotating deployable mast, so it can be positioned in optimal position relative to the sun, throughout the day.

P-APM is also going to be equipped with optical sensor which can provide situational awareness to the mission control on Earth. The data from the optical sensor can be streamed real-time or stored on-board for later retrieval, through SIROM IF. P-APM can also actively dissipate heat into environment, providing limited cooling capability to itself and other APMs (or rover) connected on it.

6.1.2 Physical Description

The following picture highlights the main components and interfaces of the P-APM.

![Primary APM components](image)

Figure 6-1: Primary APM components

P-APM Dimensions: 600x630x193 mm

P-APM Weight: 11.8kg
There are three physical configurations of the P-APM:

- **Fully Stowed** – Configuration for transport by the rover or standby. In this configuration, the P-APM takes least volume, and is most resistant to the environment. However, it cannot perform all functions, and it is envisaged that in this configuration it should be either in off, or standby mode (some part of the foil cannot be fully inserted in the foil roller).

- **Partially Deployed** – Initial operational configuration, with the solar foil extended on the Mast for the section that cannot be stowed in the foil roller. This is a functional configuration but with reduced active foil surface.

- **Deployed** – Operational configuration. In this configuration, the P-APM sits safely on flat and horizontal surface, with fully deployed solar panel and rotating mast, pointing the panels to the sun.

![Figure 6-2: Different configurations of the solar panel deployment](image-url)
6.1.3 Functional Description

The P-APM provides three principal functionalities:

- Power management for the producing, storage, transfer and dissipation of electrical energy. It can be configured in different modes of operation:
  - Idle
  - Charging (from solar panel, SIROM I/F or external interface)
  - Discharging (to SIROM I/F power 100V and 24V bus)

- Visualization of the surroundings of the P-APM location by video acquisition from an optical sensor. The images can be been either accessed by direct streaming or recorded in the P-APM memory for further access.

- Active cooling through side fans, to dissipate its generated heat.

The payload is equipped with several battery protections that can be monitored with automatic switching off-of the charging or discharging process.

The P-APM provides three data communications channels, with specific purpose for each:

- The CAN interface is used for control and monitoring purpose. It can be either interfaced through the SIROM connector or by an external CAN harness.

- The Space Wire interface is used for data transfer, which is here the video stream recorded by the optical system.

- The Wi-Fi interface, for debugging purpose, to perform the same operations than the CAN interface when the APM is not connected by the CAN interface.

A mechanical interface can be attached to the P-APM for connection on the bottom of the Sherpa rover in the stowed configuration, for transportation purpose.
6.1.4 Operations

6.1.4.1 Operational Modes

The P-APM can be configured in different operational modes:

- **Power-OFF**: The P-APM is switched OFF by the main switch that isolates the internal battery power.
- **Stowed, Power-ON**: The P-APM is switched on and can provide most functionalities, except battery charging from solar panel.
- **Deployed, Power-ON**: The P-APM is switched ON and can provide theoretically all functionalities (at the condition that solar power inputs is sufficient for charging operations).

6.1.4.2 Functional Modes

A. **Solar Panel Deployment and Orientation**

The solar panel can be deployed and oriented to be aligned with the sun, to optimize the charging power. These operations are performed manually by an operator.

B. **Power management**

From CAN commands (SIROM control I/F or external I/F) sent to the P-APM controller, the system can be configured in different powering modes:

- **Idle mode**: only keep energy in the internal battery. There is no production or transfer of power.
- **Discharging mode**: provides power on the power buses of the SIROM I/F (100V and 24V), from the internal battery.

---

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730035.
• Charging mode: charge the internal battery of the P-APM, either from the solar panel, the SIROM I/F (optional to be able to charge the P-APM from the A-APM) or an external power interface (in case solar power is not available).

C. Visual Data Management

From CAN commands (SIROM control I/F or external I/F) sent to the P-APM controller, the system can control the embedded camera for different functions:
• Recording video from optical sensor (internal memory)
• Streaming video from optical sensor to SIROM SpW data I/F

D. Status Request

From CAN commands (SIROM control I/F or external I/F) sent to the P-APM controller, an external system (e.g. EGSE) can request the status of the P-APM, including the values of all data monitored and protections.

E. External Command Interfaces

For debugging purpose or in absence of SIROM interfaces attached, all above commands can be triggered through the WIFI connection of the P-APM controller.
6.2 Auxiliary APM

6.2.1 General configuration

The Auxiliary APM (A-APM) is a portable battery pack, with two SIROM interfaces, allowing to supply or be able to charge itself through SIROM interfaces with other APMs. The mode of operation (idle, charge or discharge) is controllable by the platform master (EGSE or Primary APM) through SIROM command control port. A-APM features telemetry information to support operations.

6.2.2 Physical description

The following pictures highlight the main components and interfaces of the A-APM.

![A-APM components and accommodation](image)

A-APM Dimensions: 430x159x156 mm
A-APM Weight: 4.9kg

6.2.3 Functional description

The principal function of the A-APM is to store energy and provide power to other connected APMs, through the SIROM I/F. The A-APM is also capable to power itself from the internal battery. It provides the same functionalities as the P-APM.

The payload is equipped with several battery protections that can be monitored with automatic switching off-of the charging or discharging process.

The A-APM provides two data communications channels, with specific purpose for each:

- The CAN interface is used for control and monitoring purpose. It can be interfaced through the SIROM connector or by an external CAN harness (not physically implemented in the current version).
- The Wi-Fi interface, for debugging purpose, to perform the same operations than the CAN interface when the APM is not connected by the SIROM interface.

The A-APM is a pass-through for the Space Wire interface of the SIROMs. The mechanical structure offers passive cooling to the system.

---

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730035.
6.3 Operations

6.3.1 Operational modes

The A-APM can be configured in different operational modes:

- **Power-OFF**: The A-APM is switched OFF by the main switch that isolates the internal battery power.
- **Power-ON stand-by**: The A-APM is switched on but not power exchange is possible (e.g. during transportation with the rover)
- **Power-ON, active**: The A-APM is switched ON and can provide/receive power from the SIROM I/Fs or external power interface.
6.3.2 Functional modes

A. Power management

From CAN commands (SIROM control I/F or external I/F) sent to the A-APM controller, the system can be configured in different powering modes:

- **Idle mode**: only keep energy in the internal battery. There is no transfer of energy.
- **Charging mode**: charge the internal battery of the A-APM, from the SIROM I/F or an external power interface (as a backup for the demonstration).
- **Discharging mode**: provides power on the high voltage 100V power or 24V buses of the SIROM I/F from the internal battery.

B. Visual Data Servoing

The camera of the A-APM is used to implement the visual servoing process during the approach and alignment between the A-APM and P-APM SIROM I/Fs. The A-APM provides data information (pose estimation) to the manipulator controller through TCP/IP connection (Wifi or Ethernet connection).

C. Status Request

From CAN commands (SIROM control I/F or external I/F) sent to the A-APM controller, an external system (e.g. EGSE) can request the status of the A-APM, including the values of all data monitored and protections.

D. External Command Interfaces

For debugging purpose or in absence of SIROM interfaces attached, all above commands can be triggered through the WIFI connection of the A-APM controller.
7. UNPACKING AND INTEGRATION

7.1 SIROM

7.1.1 Unpacking SIROM

When unpacking SIROM:

- Keep the container to send SIROM back to SENER
- WARNING #1: Do not pull/grab any harness
- WARNING #2: Do not touch the latches
- WARNING #3: Do not touch the capture tabs
- Always grab SIROM by its interface plate, by the supporting rods or by the supporting plate (see figure below)

![SIROM interface plate](image)

Figure 7-1 SIROM interface plate
- Unscrew the 6x screw+nut of the supporting plate (white plastic part) from the container (see figure below).

7.1.2 Installing SIROM

When installing SIROMs:

- WARNING #4: Make sure the internal harness (SIR-CAN-H1, SIR-CAN-H2, SIR-SPW-H1, SIR-SPW-H2, SIR-PWR-H1, SIR-PWR-H2) is loose when connected to another
harness. This harness must not be tight because the Connectors Plate translates vertically 9mm.

![SpW harness](image)

Figure 7-2 SpW harness

- **WARNING #5**: Verify the cables do not touch the rotor of the motor (it could damage the cables)

- It is not allowed to unscrew/open/… any part of the whole mechanism

- **WARNING #6**: There is ONLY 1 angular position to mate both SIROMs.
Please bear in mind that passive SIROM is at “Latched” position and therefore, there is contact between its latches and the capture tabs of active SIROM. This results in a small force that may prevent both SIROMs contact perfectly at the contact plates before the latching of the active SIROM is completed.

### 7.1.3 Operating SIROMs

When operating SIROMs:

- **WARNING #7**: Do not actuate the motor of the passive SIROM.

- **WARNING #8**: Before moving the actuator of ACTIVE SIROM, it is mandatory to check the 4 hall sensors work properly approximating a magnet from the outside of SIROM. It is not allowed to operate SIROM if any of the hall sensors does not activate.
7.1.4 Packing SIROMs

When packing SIROMs:

- Write down and send to SENER the number of cycles performed.
- Pack SIROMs in the same container sent by SENER and return them back in the same conditions as sent.

7.1.5 SIROM List of warnings

<table>
<thead>
<tr>
<th>WARNING #1</th>
<th>Do not pull/ grab any harness</th>
</tr>
</thead>
<tbody>
<tr>
<td>WARNING #2</td>
<td>Do not touch the latches</td>
</tr>
<tr>
<td>WARNING #3</td>
<td>Do not touch the capture tabs</td>
</tr>
<tr>
<td>WARNING #4</td>
<td>Make sure the internal harness (SIR-CAN-H1, SIR-CAN-H2, SIR-SPW-H1, SIR-SPW-H2, SIR-PWR-H1, SIR-PWR-H2) is loose when connected to another harness. This harness must not be tight because the Connectors Plate translates vertically 9mm.</td>
</tr>
<tr>
<td>WARNING #5</td>
<td>Verify the cables do not touch the rotor of the motor (it could damage the cables)</td>
</tr>
<tr>
<td>WARNING #6</td>
<td>There is ONLY 1 angular position to mate both SIROMs.</td>
</tr>
<tr>
<td>WARNING #7</td>
<td>Do not actuate the motor of the passive SIROM.</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>WARNING #8</td>
<td>Before moving the actuator of ACTIVE SIROM, it is mandatory to check the 4 hall sensors work properly approximating a magnet from the outside of SIROM. It is not allowed to operate SIROM if any of the hall sensors does not activate.</td>
</tr>
</tbody>
</table>

7.2 ORBITAL APM

7.2.1 Unpacking

The packing / unpacking activities are not required to be performed in a controlled clean area.

The hardware shall be packed and unpacked carefully. In order to proceed with the packing, the equipment shall be in clean conditions (cleaned with isopropyl alcohol), and covered with foam pieces to protect the inner hardware.

When unpacking, an overall visual inspection of flight hardware before any handling shall be performed to check that there is no anomaly in it.

It is recommended to manipulate carefully the SIROM interface to avoid get cut with the guiding petals’ sharp corners.

Each hardware transportation container shall be labelled, tagged or marked to show at least the following:

- Responsible of Integration:
- Project Name: SIROM
- Unit Name:
- Part Number (if applicable):
- Contact Number (where applicable):
- Quantity or weight (kg):
- Any other comment / recommendations necessary for the protection of the unit.

### 7.2.2 Integration

The integration of orbital APMs will be performed according to D4.7 OG5-D3_Test Specification & Test Procedure WP4.

### 7.3 PLANETARY APM

#### 7.3.1 Planetary APM (P-APM)

The Planetary APM is packed as illustrated in Figure 7-5 during transportation. It is fully assembled with:

- The mechanical structure
- One SIROM interface (passive in the current configuration)
- One dummy interface or empty hole (allowing access to the RPi 3 controller)
- The internal battery and its management system
- The RPi camera and the SpW data interface (SpW Brick)
- The retractable mast in retracted configuration
- The solar foil in folded configuration. Due to mechanical interaction with the solar foil cables, it is not possible to unfold completely the solar panel. It can be rounded as illustrated below for transportation

When unpacked, the P-APM shall be placed on an even and stable surface. The P-APM can be handled by the 4 black handles connected on the ground plate.

![Figure 7-5: P-APM in packed configuration](image)

#### 7.3.1.1 Solar Panel Deployment

To deploy the solar panel, follow this procedure:
1. Unfold the retractable mast to the target size (max 2m)
2. Unfold the solar array foil
3. Connect the top grey solar fail structure to the mast with the small M3 screw
4. Connect the solar harness from the foil to the P-APM box

The solar panel can be rotated around the central structure to align with the light source.

Figure 7-6: Different solar panel deployment configuration

7.3.1.2 Power Switch

The green power switch (Figure 7-7, left) allows to switch on/off the P-APM controller from the internal battery to enable communication through WIFI or CAN (SIROM or external) communication.

The switch shall be closed after operation to avoid that the battery fully discharge (risk of damage). It should also be protected during transportation to avoid mis-operation.

When switching on the P-APM, the fans should be enabled.

Figure 7-7: [Left] External USB, power switch and external charging plug, [RIGHT] External CAN interface connection

7.3.1.3 External Charging

The P-APM can be charged from an external power interface by connecting the charge power plug to an external stabilized power supply with 15V output (Figure 7-7, left). The tele-
command to start the charging process can be triggered by the CAN interface or by Wi-Fi with the python debugging interface (see section 9.6). The current expected on the power supply is between 1.5 and 1.7 Amperes.

7.3.1.4 External CAN Connection

If not connected to the CAN bus through SIROM interface, the P-APM can be connected through its external CAN harness (Figure 7-7, right), directly to the EGSE with the CAN-EGSE harness. Once the P-APM is powered on, CAN communication with the EGSE should be detected on the GUI interface.

7.3.1.5 External USB Connection

The external USB connection can be used to interface and power (on 5V) directly the APM controller (RPI3 and APM Teensy). This should allow to connect with the Wi-Fi interface to the Raspberry, such that the python debugging scripts can be used. This can be useful to revive the APM if the battery remaining power is not sufficient to power it on.

7.3.1.6 DFKI Interface

The DFKI mechanical interface to the Sherpa Rover can be connected to the 3D printed plate in the middle of the P-APM.

7.3.2 Orbital APM (A-APM)

The Auxiliary APM is packed as illustrated in Figure 7-8 during transportation. It is fully assembled with:

- The mechanical structure
- Two SIROM interfaces (in the current configuration, one passive and one active)
- The internal battery and its management system
7.3.2.1 Power Switch

The green power switch (Figure 7-8, bottom) allows to switch on/off the A-APM controller from the internal battery to enable communication through WIFI or CAN (SIROM or external) communication.

The switch shall be closed after operation to avoid that the battery fully discharge (risk of damage). It should also be protected during transportation to avoid mis-operation.

7.3.2.2 External Charging

The A-APM can be charged from an external power interface by connecting the charge power plug to an external stabilized power supply with 15V output (Figure 7-8, left). The telecommand to start the charging process can be triggered by the CAN interface or by Wi-Fi with the python debugging interface (see section 9.6). The current expected on the power supply is between 1.5 and 1.7 Amperes.

7.3.2.3 External CAN Connection

If not connected to the CAN bus through SIROM interface, the A-APM can be connected through its external CAN harness (not implemented in the current assembly), directly to the EGSE with the CAN-EGSE harness. Once the A-APM is powered on, CAN communication with the EGSE should be detected on the GUI interface.

7.3.2.4 External USB Connection

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730035.
The external USB connection can be used to interface and power (on 5V) directly the APM controller (RPI3 and APM Teensy). This should allow to connect with the Wi-Fi interface to the Raspberry, such that the python debugging scripts can be used. This can be useful to revive the APM if the battery remaining power is not sufficient to power it on.
8. SIROM SYSTEM SETUP

This section describes the generic setup of the SIROM system between the EGSE and one SIROM interface. This is a common setup for the orbital and planetary scenario, with the first SIROM being embedded on the End-effector.

As illustrated in Figure 8-1, it includes the following components:

- The EGSE, that provides the power interface (100V and 24V), the CAN and the SpW interface to the SIROMs. Please refer to [RD23] for details about the device and its operation.
- The remote Laptop that is used to remotely access the EGSE and display the GUI to operate the SIROM and later the APM controllers.
- The local router that enables local Ethernet network between the Remote Laptop and the EGSE, as well as the Wi-Fi in interface for APMs

![Figure 8-1: SIROM system setup](image)

8.1 General Setup Connections

By referring to [RD23], here is the list of required connections before starting the system (see Figure 8-2 and Figure 8-3 for support):

1. Remote Laptop power connected to main supply through laptop DC convertor
2. Local router connected to main supply through DC convertor
3. EGSE power rack (top rack) and EGSE PC (bottom rack) connected to main supply
4. Remote Laptop connected by Ethernet to local router
5. EGSE PCI Ethernet interface connected to EGSE power rack Ethernet (for controlling the power rack from the EGSE PC)
6. EGSE PC Ethernet port connected to the local router
7. EGSE-SpW-H1 harness (10m cable) connected to the SpaceWire Port 0 and the SIROM SpW input
8. EGSE-CAN-H1 and EGSE-CAN-H2 connected to the EGSE CAN port interface, through the CAN adapter cable (H1 on Channel 0 and H2 on channel 1) through the bus termination resistors
9. EGSE-CAN-H1 connected to the Channel B of the PICAN2DUO board of the first SIROM controller (left in Figure 8-3), using the adaptor DUO-A-CAN-H1
10. EGSE-CAN-H2 connected to the Channel A of the PICAN2DUO board of the first SIROM controller (right in Figure 8-3), using the adaptor DUO-A-CAN-H2.

11. EGSE-PWR-H1 power harness connected to the EGSE power rack PSU connectors 100V and 24V (see cable labels) and to the first SIROM EIS board through the EIS-A-PWR-H1 (3 wires cable/connector, black/yellow/red).

The EGSE-PWR-H1 harness has the following color code: black:gnd, red:24V, yellow:100V. **The voltage of these lines should be checked before connecting to the first EIS.** Use the remote EGSE interface to switch one the power (see below).

---

**Figure 8-2: EGSE back connections**

**Figure 8-3: PICAN2 DUO and RPi board**
8.2 SIROM Internal Harnessing

The following picture provides the full internal harnessing from EGSE to the first SIROM, including the connections with the mechatronics system. The diagram refers to the harness labelling.

![SIROM Internal Harnessing Diagram]

Figure 8-4: Detailed internal harnessing from EGSE to the first SIROM

Here are some hints to support the integration between the different components of SIROM:

- The EIS USB output should be connected to the Power USB plug of the RPi zero (see Figure 8-3)
- The Teensy USB should be connected to the Data USB plug of the RPi zero (see Figure 8-3)
- On an active SIROM, the DUO-X-SWTCH-H1 cable should be connected to the Jumper A and B of the PICAN2 DUO board. On a passive SIROM, a mechanical jumper can be placed to enable the CAN termination. It should be placed on the last passive SIROM of the chain
- CAN channels (A and B) should not be mixed between successive SIROM
- CAN and power connectors between SIROM and Controller and EIS boards have different sizes and gender to avoid mixing redundant buses.

8.3 SIROM System Startup

This section describes the standard procedure to startup the SIROM system as described in section 8:

1. Switch on the remote laptop and connect to the share windows session
2. Switch on the EGSE power rack from the front panel button 1 (see [RD23], section 4.2.1.1)
3. Switch on the EGSE PC. After around one minute, the front panel of the EGSE power rack should be locked by the EGSE PC (It is taking full control).
4. From the remote computer, use “Remote Desktop Connection” program from windows to connect to the EGSE with the following parameters:
   a. IP: 192.168.1.100
b. Login: iSAFT-User

c. Password: isaft

5. The EGSE iSaft console should be displayed as in [RD23]-Figure 10

6. Click on top-left iSaft button and select “Power Front End”. This should open the front panel for the control of the Power rack. If this is not working and you see some line like “… localhost….”, the EGSE PC should be restarted.

7. Enable the control by right-click on the gear of the “PSUnit” in the right pane, and click on "Enable all"

8. Each power supply (100V and 24V) can now be enabled by clicking on the switch in the middle pane. The middle pane displays the voltage, current and power delivered by each power supply.

9. When switching on the 24V, if the SIROM controller is visible, the LED of the RPi zero and the Teensy should toggled. Active SIROM have a quick toggle rate, while passive SIROM have a slow toggle rate.

10. Start the SIROM Controller GUI interface by starting the “egse_gui.py” application script located in the folder on the Windows desktop. This will automatically enable the SpW and CAN interfaces, that can be confirmed with the green LED in the left pane of the EGSE remote desktop.

11. After around 30 seconds, the telemetry from the connected SIROM should be displayed in the GUI interface.

8.4 SIROM System Configuration

The SIROM EGSE config file contains configuration information. It can be found in : “C:/opt/sirom/etc/sirom_egse.conf” (Figure 8-5 as example).

It is used to:

- Configure the IP address, port and node ID of the EGSE computer
- Configure the nominal CAN channel and CAN bus baud rate
- Configure the nominal SpW bus, baud rate and configuration file
- Configure the SpW sink for transmitted images (see P-APM)
- Configure the IP address of each SIROM interface in the setup

![Configuration](Figure 8-5: SIROM EGSE configuration)

8.5 SIROM System Operation

This section describes the operations of the SIROM setup as described in section 8 with the EGSE GUI interface (running on the EGSE laptop), as illustrated in Figure 8-6:
Figure 8-6: SIROM interface pane of the EGSE GUI

A. Menu Tab

The menu Tab allows selecting the specific pane of operation between SIROM I/Fs, A-APM and P-APM.

B. SIROM Interface Telemetry

For each SIROM interface (up to 5), the Telemetry area displays the telemetry data of the corresponding SIROM.

Table 2: SIROM telemetry

<table>
<thead>
<tr>
<th>Telemetry</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curr.Status</td>
<td>Position of the SIROM interface based on the last known status of the Hall sensors and the motor pulses detection:</td>
</tr>
<tr>
<td></td>
<td>• UNKNOWN (e.g. at startup if no hall sensor is detected)</td>
</tr>
<tr>
<td></td>
<td>• READY TO CAPTURE</td>
</tr>
<tr>
<td></td>
<td>• CAPTURED</td>
</tr>
<tr>
<td></td>
<td>• LATCHED</td>
</tr>
<tr>
<td></td>
<td>• CONNECTED</td>
</tr>
<tr>
<td></td>
<td>• RDC-CAP (intermediate state)</td>
</tr>
<tr>
<td></td>
<td>• CAP-LAT (intermediate state)</td>
</tr>
<tr>
<td></td>
<td>• LAT-CON (intermediate state)</td>
</tr>
<tr>
<td>Req. Status</td>
<td>Request status by the operator, based on the sent tele-commands:</td>
</tr>
<tr>
<td></td>
<td>• UNKNOWN</td>
</tr>
<tr>
<td></td>
<td>• READY TO CAPTURE</td>
</tr>
<tr>
<td></td>
<td>• CAPTURED</td>
</tr>
</tbody>
</table>

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730035.
The telemetry area also includes two tele-commands:
- **Motor PWM**: to define the motor speed, based on the PWM equivalent voltage output (1V, 2V or 3V)
- **STOP!**: to stop the motor rotation instantaneously during operation

### C. CAN Connectivity

The LED blinks when CAN communication is detected on the CAN bus
D. Tele-command Selection

The selection list allows to select the tele-command to be sent to the SIROM I/F

<table>
<thead>
<tr>
<th>Tele-command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GO_TO_01_RTC</td>
<td>Update request status to go to the READY TO CAPTURE position. The tele-command will be accepted only if the current status is CAPTURED, RTC-CAP or UNKNOWN (in which case the SIROM will rotate CCW)</td>
</tr>
<tr>
<td>GO_TO_02_CAP</td>
<td>Update request status to go to the CAPTURED position. The tele-command will be accepted only if the current status is READY TO CAPTURE, LATCHED, RTC-CAP or CAP-LAT.</td>
</tr>
<tr>
<td>GO_TO_03_LAT</td>
<td>Update request status to go to the LATCHED position. The tele-command will be accepted only if the current status is CAPTURED, CONNECTED, CAP-LAT or LAT-CON.</td>
</tr>
<tr>
<td>GO_TO_04_CON</td>
<td>Update request status to go to the CONNECTED position. The tele-command will be accepted only if the current status is LATCHED or LAT-CON or UNKNOWN (in which case the SIROM will rotate CW)</td>
</tr>
<tr>
<td>TURN_024V_ON</td>
<td>Switch ON the EIS 24V output line (only possible in CONNECTED position)</td>
</tr>
<tr>
<td>TURN_024V_OFF</td>
<td>Switch OFF the EIS 24V output line</td>
</tr>
<tr>
<td>TURN_100V_ON</td>
<td>Switch ON the EIS 100V output line (only possible in CONNECTED position)</td>
</tr>
<tr>
<td>TURN_100V_OFF</td>
<td>Switch OFF the EIS 100V output line</td>
</tr>
<tr>
<td>TURN_LEDS_ON</td>
<td>Switch ON the LED</td>
</tr>
<tr>
<td>TURN_LEDS_OFF</td>
<td>Switch OFF the LED</td>
</tr>
</tbody>
</table>

E. SIROM Selection

The selection list allows to select the SIROM to which the tele-command will be sent

F. Send

The button triggers the send of the tele-command based on the selected command and the selected SIROM interface

F. Redundancy selection

The radio buttons allow selecting which CAN bus is used for CAN communication

F. Command Feedback

The box displays the commands sent through the CAN interface

I. Acknowledgement

The two boxes display acknowledgement and verification of the CAN commands

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730035.
J. Error
The box displays error messages going on the CAN bus

8.6 Multiple SIROM Connections
As an illustration, this section describes the full sequence of operation to connect two SIROM interfaces. This can be repeated if other SIROM are after in the chain. For the example, SIROM 1 is the active one that will connect to SIROM 2.

1. Initial Condition:
   a. SIROM A is connected, configured and started as described from section 8.1 to 8.4. The TM is received and displayed on the EGSE GUI interface (on SIROM 1 area).

2. Sequence:
   a. Send TC to SIROM 1 “GO_TO_01_RTC” (or other intermediate status to reach the CAPTURED status before). Wait that the READY TO CAPTURE position is reached (green LED, open latches)
   b. Align the two SIROMS (manually or with a manipulator)
   c. Send TC to SIROM 1 “GO_TO_02_CAP”. Wait that the “CAPTURED” position is reached (green LED).
   d. Send TC to SIROM 1 “GO_TO_03_LAT”. Wait that the “LATCHED” position is reached (green LED).
   e. Send TC to SIROM 1 “GO_TO_04_CON”. Wait that the “CONNECTED” position is reached (green LED).
   f. Send TC to SIROM 1 “TURN_024V_ON”. The 24V feedback LED should go green. This will provide 24V to the SIROM 2 power line and starts the controller. After around 30 seconds, the TM from SIROM 2 should be received and display on the EGSE GUI interface, on SIROM 2 area.
   g. From now, SIROM 2 position can be control as done for SIROM 1

8.7 SIROM Controller Wi-Fi Access
For SIROM controller configuration, low-level TC/TM or debugging purpose, a SIROM controller (RPi zero) can be accessed through SSH by Wi-Fi connection:

1. Connect by SSH to the SIROM controller RPi zero (the IP address can be found on the router configuration (192.168.1.1)).
   a. Login: pi
   b. Password: raspberry

For low-level TC/TN, once connected, a python script allows to directly interface the Teensy controller (connected by USB to the RPi zero) to send commands and receive telemetry:

1. In the open terminal, start the python script in the start-up folder: “python3 pysend_0.py”
2. Send commands to initiate communication with the Teensy (press “H” to get the help on the available commands)

For configuration of the SIROM controller (once connected):
1. In the open terminal, edit the SIROM configuration file “SIROM-SW.conf”, located in “/opt/sirom/etc/”
2. This allows to edit different configuration parameters related to the logging, CAN bus (Baudrate, nodeID, redundancy, Flying master), SpW, Camera (if connected) and Teensy interface (Figure 8-7).

It has to be noted that this configuration file is similar with the A-APM and P-APM controllers.

Once modified, the system has to be rebooted or the sirom service restarted:
   1. sudo systemctl stop sirom.service
   2. sudo systemctl start sirom.service

The terminal command “sudo systemctl status sirom.service” allows to check the status of the sirom service.

```
; * ---------------------------------------------------------
[logging]
LogFile=/opt/sirom/log/SIROM-SW.log
THA=x=10,y=10
DebugMode=yes
LogToLogFileMode=yes

; * ---------------------------------------------------------
[server]
TmPort=28000

; * ---------------------------------------------------------
[CANbus]
BaudrateMbps=100
NodeID=3
MasterCapable=no
FlyingMasterPriority=3
StartAs=slave
DefaultCanBus=can0
MasterID=1
MasterSelectionProcessEnabled=no
MuxRedundancyEnabled=no
DedRedundancyToggle=4
DedRedundancyToggle=10
MuxRedundancyUpdateConfFile=no

; * ---------------------------------------------------------
[SpW]
SpWPort=1
SpWLinkRateMbps=100

; * ---------------------------------------------------------
[camera]
ImageWidthPixels=800
ImageHeightPixels=600
ImageFramePerSec=5
ImageDirectoryPath=/opt/sirom/images
ImageDirectoryMaxSizeMB=500

; * ---------------------------------------------------------
[Teensy]
SerialPort=/dev/ttyACM0
BaudRateEnum=115200
BufferSize=255
```

Figure 8-7: SIROM controller configuration file

The sirom.service itself can be configured by editing the file:

“/etc/systemd/system/sirom.service”

This allows to determine which components are started. This should however not be updated by standard users.
9. PLANETARY APM SETUP

This section describes the implementation of the planetary APMs that are the A-APM and P-APM, focusing on the operation of the battery sub-system. Control of the SIROM interfaces connected to the planetary APMs are covered in section 8.

9.1 Planetary APM Connection

To have connection between the EGSE and the APMs there is two possible configurations (Figure 9-1 as example):

1. EE SIROM connected to A-APM/P-APM SIROM 1 (only APM)
2. EE SIROM connected to A-APM SIROM 1, and A-APM SIROM 2 connected to P-APM SIROM (both A-APM and P-APM).

The CAN bus of the EGSE can also be connected directly to the external CAN interface of the A-APM/P-APM, by using the harness DUO-EXT-CAN-H1/H2.

Figure 9-1: [Left] EE connected to A-APM, [Right] EE connected to A-APM connected to P-APM

As illustrated in Figure 6-5, the A-APM is:

- A pass-through for the CAN bus between the two connected SIROM, with connection to the A-APM controller
- A pass-through for the power bus (100V and 24V) between the two connected SIROM, with connection to the A-APM battery sub-system (Figure 9-2)
- A pass-through for the SpW bus between the two connected SIROM

As illustrated in Figure 6-3, the P-APM is:
- A termination for the CAN bus, with the connection to the P-APM controller
- A termination for the power bus (100V and 24V), with a connection to the P-APM controller
- A termination for the SpW bus with a connection to the SpW brick

The following picture illustrates the battery sub-system of both A-APM and P-APM, highlighting power interfaces with the 24V (yellow) and 100V (red) line connected with/between the SIROM. The left part is related to the charging operation (from 100V line, external 15V or solar charger for the P-APM). The right part is related to the discharge to the 100V and 24V lines.

The internal battery can provide the 24V power to the connected SIROM. However, in the current version of the board, the 24V line of the SIROM (from the EGSE) cannot power the battery sub-system.

Figure 9-2: Architecture of the planetary APM battery sub-system

9.2 APM Internal Harnessing

The following pictures provide the full internal harnessing of the A-APM and P-APM, including The diagrams refer to the harness labelling.
Figure 9-3: Detailed internal harnessing of the A-APM
This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730035.
9.3 APM System Startup

This section describes the standard procedure to startup the APM (both A-APM and P-APM), considering the case of a connection through the EE. The first sequence focuses on the APM, that uses its internal battery for powering. The same sequence can be applied with a connection through the external CAN interface.

1. Switch on the remote laptop and connect to the share windows session
2. Switch on the EGSE PC to enable CAN communication
3. Start the SIROM Controller GUI interface by starting the “egse_gui.py” application script located in the folder on the Windows desktop. This will automatically enable the SpW and CAN interfaces, that can be confirmed with the green LED in the left pane of the EGSE remote desktop.
4. Switch on the external power switch of the APM that will provide the battery power to the internal components of the battery sub-system and starts the APM controller. (When powering on the P-APM, that will also start the fans located on the side of the casing)

After around 30 seconds, the telemetry from APM should be displayed in the GUI interface.

9.4 APM System Operation

This section describes the operations of the APM (A-APM or P-APM) with the EGSE GUI interface (running on the EGSE laptop), as illustrated in Figure 9-5. Both A-APM and P-APM have the same interface, except the video rendering only accessible on the P-APM.

A. Menu Tab

The menu Tab allows selecting the specific pane of operation between SIROM I/Fs, A-APM and P-APM.
B. Status Information

This area provides status information of the APM with the CAN node ID and the current charging mode.

C. APM Telemetry

The Telemetry area displays the telemetry data of the APM.

Table 4: APM telemetry

<table>
<thead>
<tr>
<th>Telemetry</th>
<th>Description</th>
</tr>
</thead>
</table>
| SIROM 100V | Voltage measurement applied on the 100V line bus (red tabs in Figure 9-2, either from external source as SIROM interface or from internal battery conversion), range [90V-110V]  
Current measurement on the 100V discharge line, range [0A, 0.4A] |
| SIROM 24V | Voltage measurement applied on the 24 line bus (yellow tabs in Figure 9-2, either from external source as SIROM interface or from internal battery conversion), range [22V, 26V]  
Current measurement on the 24V discharge line, range [0A, 0.4A] |
| Battery | Voltage measurement on the battery, range [9V, 12.7V]  
Current measurement out of the battery, range [0A, 20A]  
Temperature of the thermistor connected on the battery sub-system board, in degree Celsius, range [-5, 50] degrees |
| Solar | Charging current from the solar panel, range [0A, 2A] |
| EGSE 15V | Voltage measurement on the external charging input interface (also connected to the 100V charging convertor), range [12V, 17V] |

**Warning:** if the battery is over-discharged, this could cause permanent damage. It is then asked to not let the system powered-on when not used and to check the battery voltage to initiate charging if necessary (preferably before the battery voltage goes below 10V).

The batteries capacity of both APM is 10Ah.
D. APM Charging Tele-commands

The selection list allows to select the tele-command to be sent to control charging process of the APM battery sub-system.

Table 5: SIROM tele-commands

<table>
<thead>
<tr>
<th>Tele-command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>idle</td>
<td>The APM is reset to idle mode, meaning that any charging process is switched off. This is obtained by triggering the internal switches of the battery sub-system (see Figure 9-2). The idle mode will be automatically triggers if any problem is detected or between two charging transitions</td>
</tr>
<tr>
<td>Solar Charging</td>
<td>Enables the switch on the Solar charging line (see Figure 9-2) to start the charging process from the Solar Array.</td>
</tr>
<tr>
<td>EGSE Charging</td>
<td>Enables the switch on the output of the battery charger component (see Figure 9-2) to start the charging process from an external source. 15V should be applied on the external connector to allow the transition to the charging process. If no voltage is detected, the system will remain in idle mode.</td>
</tr>
<tr>
<td>SIROM Charging</td>
<td>Enables the switch on the 100V charging line (connected to the SIROM interfaces) and the convertor (see Figure 9-2) to start the charging process from SIROM. This mode can not be triggered with the 100V discharge mode to avoid power loop inside the system.</td>
</tr>
</tbody>
</table>

E. APM Discharging Tele-commands

The two checkboxes allow to select the discharge mode of the APM battery sub-system. They will trigger the switches of the respective discharge line as well as enable the convertors (see Figure 9-2). They can be simultaneously enabled. As mentioned above, the 100V discharge can not be triggered at the same time as the 100V charge.

F. Graphics Output

The selection list allows to chose which voltage/current signals are displayed on the GUI interface between the battery, 24V line, 100V line and 15V input.

G. Video Stream

This area allows to control the video stream (start/stop, save on disk) received from the P-APM through the SpW bus. The configuration file "C:/opt/sirom/etc/sirom_egse.conf" allows to select where the video images for the streaming are saved.

9.5 APM Charging/Discharging control

As an illustration, this section describes the full sequence of operation to connect start the charging process of the A-APM from the P-APM, through connected SIROM interfaces. The start sequence to connect the SIROM interfaces with the EGSE are described in section 8.

1. Initial Condition:
   a. EE SIROM is connected to EGSE
   b. EE SIROM is connected with A-APM SIROM 1
   c. A-APM SIROM 2 is connected with P-APM SIROM 1
   d. Both APM external switches are enabled

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730035.
2. **Sequence:**
   a. Send TC to P-APM to enable discharge on the 24V line. This will power on the internal battery sub-system as well as the connected SIROM interface. After around 30s, the telemetry of the P-APM and the SIROM is received and displayed on the EGSE GUI interface.
   b. Send TC to A-APM to enable discharge on the 24V line. This will power on the internal battery sub-system as well as the two connected SIROM interfaces. After around 30s, the telemetry of the A-APM and the two SIROM is received and displayed on the EGSE GUI interface.
   c. Send TC to P-APM to enable discharge on the 100V line.
   d. Send TC to P-APM SIROM 1 to TURN_100V_ON. That will be confirmed by the green LED on the 100V status of P-APM SIROM 1.
   e. Send TC to A-APM SIROM 2 to TURN_100V_ON. That will be confirmed by the green LED on the 100V status of A-APM SIROM 2. This can also be confirmed by the availability of 100V on the A-APM line.
   f. Send TC to A-APM to enable SIROM Charging. That should start the charging process of the A-APM from the P-APM. This can be directly observed by the availability of the 15V on the A-APM telemetry as well as an output current on the 100V line of the P-APM of around 0.3A.

9.6 **APM Controller Wi-Fi Access**

For APM controller configuration, low-level TC/TM or debugging purpose, a APM controller (RPi-3) can be accessed through SSH by Wi-Fi connection:

2. Connect by SSH to the APM controller RPi-3 (the IP address can be found on the router configuration (192.168.1.1)).
   a. Login: pi
   b. Password: raspberry

For low-level TC/TN, once connected, a python script allows to directly interface the Teensy controller (connected by USB to the RPi-3) to send commands and receive telemetry:

3. In the open terminal, start the python script in the start-up folder: “python3 pysend_BAT_0.py”
4. Send commands to initiate communication with the Teensy (press “H” to get the help on the available commands)

For configuration of the APM controller (once connected):

3. In the open terminal, edit the SIROM configuration file “SIROM-SW.conf”, located in “/opt/sirom/etc/”
4. This allows to edit different configuration parameters related to the logging, CAN bus (Baudrate, nodeID, redundancy, Flying master), SpW, Camera (if connected) and Teensy interface (Figure 8-7).

It has to be noted that this configuration file is similar with the A-APM and P-APM controllers.

Once modified, the system has to be rebooted or the sirom service restarted:

1. sudo systemctl stop sirom.service
2. sudo systemctl start sirom.service

The terminal command “sudo systemctl status sirom.service” allows to check the status of the sirom service.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730035.
The sirom.service itself can be configured by editing the file:

```
/etc/systemd/system/sirom.service
```

This allows to determine which components are started. This should however not be updated by standard users.

### 9.7 APM Battery Recovery

In the case that the internal battery is not anymore capable to switch on the internal components, there is still the possibility to connect an external 5V supply to the mini-usb connector. That will enable the starting of the RPi-3 with then the possibility to connect through Wi-Fi to control the battery management system from with the SSH access.