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Pages: 45
### DOCUMENT CHANGE RECORD

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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 WP3 of the deliverable D2.17 OG5-D2_User Manual [RD23].

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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2.2 Reference Documents

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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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<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>
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<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>
<tr>
<td>SpW</td>
<td>SpaceWire</td>
</tr>
<tr>
<td>SRR</td>
<td>System Requirements Review</td>
</tr>
<tr>
<td>TBC</td>
<td>To Be Confirmed</td>
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<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>
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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.

![Figure 4-1 Two SIROMs coupled](image)

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.

![SIROM Main parts](image)

Figure 4-2 SIROM Main parts

### 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.

![Diagram of mating connection sequence between SIROM A and B]

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.

![Diagram of coupling and decoupling sequence]

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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>SENSOR Status</th>
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<tr>
<td>A</td>
<td>Check Latched sensor is 'ON'</td>
<td>Latched</td>
<td>RTC Latched Connected</td>
</tr>
<tr>
<td>B</td>
<td>Unlatch TC: Go to Capture sensor</td>
<td>Moving from Latched to Captured</td>
<td>OFF ON OFF ON</td>
</tr>
<tr>
<td>B to C</td>
<td>Actuator moving CCW</td>
<td>Captured</td>
<td>OFF OFF OFF OFF</td>
</tr>
<tr>
<td>C</td>
<td>Movement stopped by Capture sensor</td>
<td>Moving from Captured to Ready To Capture</td>
<td>OFF OFF OFF OFF</td>
</tr>
<tr>
<td>D</td>
<td>Release TC: Go to Ready To Capture sensor</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>E</td>
<td>Command manipulator to change to impedance mode</td>
<td>Ready To Capture</td>
<td>ON</td>
</tr>
<tr>
<td>G</td>
<td>Command go to Captured sensor</td>
<td>Moving from RTC to Captured</td>
<td>OFF OFF OFF OFF</td>
</tr>
<tr>
<td>H</td>
<td>Movement stopped by Captured sensor</td>
<td>Captured</td>
<td>OFF ON OFF OFF</td>
</tr>
<tr>
<td>I</td>
<td>Actuator moving CW</td>
<td>Moving from Captured to Latched</td>
<td>OFF ON ON</td>
</tr>
<tr>
<td>J</td>
<td>Command manipulator to place the EE in capture position wrt APM &amp; Confirm when positioned</td>
<td>Latched</td>
<td>OFF</td>
</tr>
<tr>
<td>K</td>
<td>Command manipulator to separate from APM</td>
<td>Connected</td>
<td>OFF ON ON</td>
</tr>
<tr>
<td>L</td>
<td>Disconnect TC: Go to Latched sensor</td>
<td>Moving from Connected to Latched</td>
<td>OFF OFF OFF OFF</td>
</tr>
<tr>
<td>M</td>
<td>Actuator moving CCW</td>
<td>Latched</td>
<td>OFF OFF OFF OFF</td>
</tr>
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<td>N</td>
<td>Movement stopped by Latched sensor</td>
<td>Moving from Latched to Captured</td>
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<tr>
<td>O</td>
<td>Release TC: Go to Ready To Capture sensor</td>
<td>Ready To Capture</td>
<td>ON OFF OFF OFF</td>
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<tr>
<td>P</td>
<td>Movement stopped by Ready To Capture sensor</td>
<td>Moving from Captured to Connected</td>
<td>OFF OFF OFF OFF</td>
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<td>Q</td>
<td>Command manipulator to go to Ready To Capture sensor</td>
<td>Connected</td>
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<tr>
<td>T</td>
<td>Movement stopped by Latched sensor</td>
<td>Latched</td>
<td>OFF ON ON</td>
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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:

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

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 APM will consist on:
- 4 Data IF connectors (CAN: 1N+1R; SpW: 1N+1R)
- 2 threaded holes for the tubing of the Thermal IF
- 2 power harnesses that are directly removed from the lower case and connected to the controller
- 6 sensors directly connected to the SIROM controller
- Motor harness directly connected to the SIROM controller

Following figure shows the lower part of SIROM and the interface with APM. Each output (IF or harness) is labelled with an M or an F. These letters stand for the male or female connectors of the Connectors plate to which these lines are coupled.

![SIROM IF to APM](image)

**Figure 4-6 SIROM IF to APM**
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 passively 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 pictures highlight the main components of the P-APM and its internal accommodation.

![Figure 6-1: Primary APM components](image-url)
This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730035.

Figure 6-2: Primary APM accommodation
There are two physical configurations of the P-APM:

- Stowed – Configuration for transport by the rover or standby. In this configuration 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.
- Deployed – Operational configuration. In this configuration P-APM sits safely on flat and horizontal surface, with deployed solar panel and rotating mast, pointing the panels to the sun.

Figure 6-3: Primary APM in deployed and stowed configurations
6.1.3 Functional Description

The P-APM provides three principal functionalities:

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

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

- Passive cooling to dissipate its own heat but also the one coming from connected SIROM I/F (e.g. auxiliary APM).

The payload is equipped with several battery protections that can be monitored.

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

- The CAN interface is used for control and monitoring purpose. It is interfaced with the active SIROMs controllers, other APMs controllers and EGSE if connected.
- 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 SIROM interface.

The P-APM offers a mechanical interface to be connected on the bottom of the Sherpa rover in the stowed configuration, for transportation purpose.

Finally, the P-APM is equipped with visual aids to support the approach of the robotic manipulator and the A-APM during the planetary demonstration scenario.

![Figure 6-4: Primary APM Architecture](image)
6.1.4 Operations

6.1.4.1 Operational Modes

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

- **Stowed, Power-OFF**: The P-APM is switched OFF by the main switch that isolates the internal battery power.
- **Stowed, Power-ON under rover**: The P-APM is transported by the Sherpa rover and can be dropped to the operation location.
- **Stowed, Power-ON on ground**: The P-APM is switched ON and can provide most functionalities, except battery charging from solar panel.
- **Deployed, Power-ON on ground**: 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, transfer or dissipation of power.
- **Powering mode**: provides power on the power buses of the SIROM I/F (100V and 24V), from the internal battery.
- **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).
- **Dissipating mode**: dissipates power in an internal load, coming from the P-APM internal battery or the SIROM I/F (e.g. A-APM connected internal battery).

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 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.

6.1.4.3 Telecommands and Telemetry

See section 8.2.
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 rover or other APMs. The mode of operation (idle, charge or discharge) is controllable by the platform master (Rover, ground station or a 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 of the P-APM and its internal accommodation.

![Figure 6-5: A-APM components and accommodation](image)

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

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

- The CAN interface is used for control and monitoring purpose. It is interfaced with the active SIROMs controllers, other APMs controllers and EGSE if connected.
- 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.

![A-APM architecture](image)

Figure 6-6: A-APM architecture

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 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).
- **Powering mode**: provides power on the high voltage 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.
6.3.3 Telecommand and Telemetry

See section 8.2.
7. UNPACKING AND INTEGRATION

7.1 ORBITAL APM

7.1.1 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):

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730035.
- Any other comment / recommendations necessary for the protection of the unit.

7.1.2 Integration

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

7.2 PLANETARY APM

7.2.1 Planetary APM (P-APM)

The Planetary APM is packed as illustrated in Figure 7-1 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 7-1: P-APM in packed configuration](image)

7.2.1.1 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

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730035.
The solar panel can be rotated around the central structure to align with the light source.

![Solar Panel](image)

**Figure 7-2: Different solar panel deployment configuration**

### 7.2.1.2 Power Switch

The green power switch (Figure 7-3, 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.

![Power Switch](image)

**Figure 7-3: [Left] External USB, power switch and external charging plug, [RIGHT] External CAN interface connection**

### 7.2.1.3 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 7-3, 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 ¡Error! No se encuentra el origen de la referencia¡). The current expected on the power supply is between 1.5 and 1.7 Amperes.

### 7.2.1.4 External CAN Connection

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730035.
If not connected to the CAN bus through SIROM interface, the P-APM can be connected through its external CAN harness (Figure 7-3, 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.

### 7.2.1.5 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.

### 7.2.1.6 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.

### 7.2.2 Orbital APM (A-APM)

The Auxiliary APM is packed as illustrated in Figure 7-4 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

![Figure 7-4: [Centre] Assembled auxiliary APM, [Left] External charger plug, [Right] External USB, [BOTTOM] Power switch](image)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730035.
7.2.2.1 Power Switch

The green power switch (Figure 7-4, 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.

7.2.2.2 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 7-4, 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 ¡Error! No se encuentra el origen de la referencia.). The current expected on the power supply is between 1.5 and 1.7 Amperes.

7.2.2.3 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.

7.2.2.4 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.
8. CONTROLLERS SW

Both the SIROM and the APM controller software respond to CAN commands. In addition to the CAN interface the PAPM controller uses SpaceWire interface to transfer camera data as shown in the figure below.

![Diagram of APM and SIROM connections](figure8-1.png)

Figure 8-1 APM and SIROM connections

The EGSE is used to control both interfaces to send commands, receive telemetry and data. The received telemetry and data is displayed on the EGSE in a user friendly format.

8.1 SIROM Controller

The main purpose of the SIROM I/F controller is to control mating/unmating mechanism of the SIROMs by monitoring sensors and controlling the actuators and control power switches. The SIROM I/F controller has a control interface to receive telecommands, send responses and telemetries via CAN bus.

The architecture of the SIROM I/F controller depicts the main components and relationship of the major components identified. SIROM I/F Controller software consists of four main components as shown in the figure below;

Device Manager: manages the device, receives commands from the CAN manager and takes necessary actions and handles telemetry requests. The Device Manager is central in the architecture.

CAN Manager: handles the CAN bus communication, receives commands from the bus and dispatches to the Device Manager and sends received packages over the CAN bus, implements extra services such as redundancy and flying masters. CANopen protocol is used in CAN communication and the CANopen implementation is based on a SW stack from port GmbH.

Control Algorithm: runs the control algorithm and interfaces to Teensy 2.0 to control the motor and monitor the sensors. Motor is controlled by 2 PWM signals and Teensy board is able to
generate these signals. The same board will read the sensor data as it has also Analog Digital Converters (ADC).

*I/O Controller:* manages input and outputs of device to control the motor and power switches and monitor the sensors. That is a thin API layer allows access to motor, sensors and switches.

![Diagram](image)

Figure 8-2 Application Software Static Architecture

The SIROM I/F controller responds to following TM/TCs:

<table>
<thead>
<tr>
<th>Telecommands</th>
<th>Nominal response</th>
<th>Off-nominal response</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ready-to-capture</td>
<td>Readied-to-capture</td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>capture</td>
<td>captured</td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>latch</td>
<td>Latched</td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>connect</td>
<td>Connected</td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>disconnect</td>
<td>Disconnected</td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>unlatch</td>
<td>Unlatched</td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>release</td>
<td>released</td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>Unready-to-capture</td>
<td>Unreadied-to-capture</td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>Turn-on-24V</td>
<td>Turned-on-24V</td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>Turn-on-100V</td>
<td>Turned-on-100V</td>
<td>Error(type of error)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Telemetries</th>
<th>Nominal response</th>
<th>Off-nominal response</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC</td>
<td></td>
<td></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.
These high level TCs and TMs are transmitted on the CAN bus using CANopen PDOs.

### 8.2 Primary APM Controller

The Primary APM software is similar to the SIROM application software. Basically the SIROM application software is used as a baseline for the APM software as there are many commonalities in between. For instance redundancy, flying masters are examples of the functionalities shared between the APMs and the SIROM I/F controller.

The main commanding interface of the software is the CAN bus. The P-APM software is responsible to control and monitor all the electronics:

- MPPT (Maximum Power Point Tracking) to control power of the solar panels
- BCDR (Battery Charge Discharge Regulator) to control the direction of the battery power
- Electronic Load to control the load
- Camera to turn on or off the camera to transfer images via SpaceWire

The following TM/TCs are used to control and monitor the P-APM:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ready-to-capture-sensor</td>
<td>0,1</td>
<td>Any other value</td>
</tr>
<tr>
<td>Capture-sensor</td>
<td>0,1</td>
<td>Any other value</td>
</tr>
<tr>
<td>Latch-sensor</td>
<td>0,1</td>
<td>Any other value</td>
</tr>
<tr>
<td>Connect-sensor</td>
<td>0,1</td>
<td>Any other value</td>
</tr>
<tr>
<td>Motor Position</td>
<td>[0; 360°]</td>
<td>Any other value</td>
</tr>
<tr>
<td>24V-relay state</td>
<td>0,1</td>
<td>Any other value</td>
</tr>
<tr>
<td>100V-relay state</td>
<td>0,1</td>
<td>Any other value</td>
</tr>
<tr>
<td>Temperature1</td>
<td>[0, +85°]</td>
<td>Any other value</td>
</tr>
<tr>
<td>Temperature2</td>
<td>[0, +85°]</td>
<td>Any other value</td>
</tr>
<tr>
<td>Status</td>
<td>Idle=0,</td>
<td>Idle=0,</td>
</tr>
<tr>
<td></td>
<td>Readied-to-capture=1,</td>
<td>Readied-to-capture=1,</td>
</tr>
<tr>
<td></td>
<td>Captured=2,</td>
<td>Captured=2,</td>
</tr>
<tr>
<td></td>
<td>Latched=3,</td>
<td>Latched=3,</td>
</tr>
<tr>
<td></td>
<td>Connected=4</td>
<td>Connected=4</td>
</tr>
</tbody>
</table>
### Telecommands

<table>
<thead>
<tr>
<th>TC</th>
<th>Nominal response</th>
<th>Off-nominal response</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPPT_connect</td>
<td>MPPT_connect_ok</td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>MPPT_idle</td>
<td>MPPT_idle_ok</td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>BCDR_charge</td>
<td>BCDR_charge_ok</td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>BCDR_discharge</td>
<td>BCDR_discharge_ok</td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>BCDR_idle</td>
<td>BCDR_idle_ok</td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>Load_on</td>
<td>Load_on_ok</td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>Load_off</td>
<td>Load_off_ok</td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>Start_Camera_Recording_on</td>
<td>Start_Camera_Recording_ok</td>
<td>Recording_on_ok</td>
</tr>
<tr>
<td>[Time]</td>
<td></td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>Stop_Camera_Recording_Recordin g_off</td>
<td>Stop_Camera_Recording_ok</td>
<td>Recording_off_ok</td>
</tr>
<tr>
<td>Start_Camera_Streaming_on</td>
<td>Start_Camera_Streaming_ok</td>
<td>Streaming_on_ok</td>
</tr>
<tr>
<td>[Source]</td>
<td></td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>Stop_Camera_Streaming_off</td>
<td>Stop_Camera_Streaming_ok</td>
<td>Streaming_off_ok</td>
</tr>
<tr>
<td>Start_Camera_Playback</td>
<td>Stop_Camera_Playback_ok</td>
<td></td>
</tr>
<tr>
<td>Stop_Camera_Playback</td>
<td>Stop_Camera_Playback_ok</td>
<td></td>
</tr>
<tr>
<td>Delete_all_records</td>
<td>Delete_all_records_ok</td>
<td>Error(type of error)</td>
</tr>
</tbody>
</table>

### Telemetries

<table>
<thead>
<tr>
<th>TM</th>
<th>Nominal response</th>
<th>Off-nominal response</th>
</tr>
</thead>
<tbody>
<tr>
<td>BatteryCurrent</td>
<td>[0, 15A]</td>
<td>Any other value</td>
</tr>
<tr>
<td>BatteryVoltage</td>
<td>[8V, 13V]</td>
<td>Any other value</td>
</tr>
<tr>
<td>BatteryStateOfCharge</td>
<td>[20%, 100%]</td>
<td>Any other value</td>
</tr>
<tr>
<td>Battery in charge</td>
<td>[yes/no]</td>
<td>n.a.</td>
</tr>
<tr>
<td>Battery in discharge</td>
<td>[yes/no]</td>
<td>n.a.</td>
</tr>
<tr>
<td>Battery Temperature</td>
<td>[0, +85°C]</td>
<td>Any other value</td>
</tr>
<tr>
<td>Solar Bus Voltage</td>
<td>[10V, 70V]</td>
<td>Any other value</td>
</tr>
<tr>
<td>Solar Bus Current</td>
<td>[0A, 1A]</td>
<td>Any other value</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.
<table>
<thead>
<tr>
<th></th>
<th>feedback</th>
<th>[Error]</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>BCDR Status</td>
<td>[Overcurrent]</td>
<td>[Undervoltage]</td>
<td>Overvoltage</td>
</tr>
<tr>
<td>MPPT Status</td>
<td>[Overcurrent]</td>
<td>[Undervoltage]</td>
<td>Overvoltage</td>
</tr>
</tbody>
</table>

These high level TCs and TMs are transmitted on the CAN bus using CANopen PDOs.
8.3 Auxiliary APM Controller

The Auxiliary APM is basically an external battery charger. It allows control and monitor of the battery like the P-APM and interface with the camera for visual servoing.

The following TM/TCs are used to control and monitor the A-APM:

<table>
<thead>
<tr>
<th>Telecommands</th>
<th>Nominal response</th>
<th>Off-nominal response</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCDR_charge</td>
<td>BCDR_charge_ok</td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>BCDR_discharge</td>
<td>BCDR_discharge_ok</td>
<td>Error(type of error)</td>
</tr>
<tr>
<td>BCDR_idle</td>
<td>BCDR_idle_ok</td>
<td>Error(type of error)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Telemetries</th>
<th>Nominal response</th>
<th>Off-nominal response</th>
</tr>
</thead>
<tbody>
<tr>
<td>BatteryCurrent</td>
<td>[0,15A]</td>
<td>Any other value</td>
</tr>
<tr>
<td>BatteryVoltage</td>
<td>[8V,13V]</td>
<td>Any other value</td>
</tr>
<tr>
<td>BatteryStateOfCharge</td>
<td>[20%,100%]</td>
<td>Any other value</td>
</tr>
<tr>
<td>BatteryTemperature</td>
<td>[0, +85°C]</td>
<td>Any other value</td>
</tr>
<tr>
<td>A-APM Status</td>
<td>[Operation Mode feedback] [Error]</td>
<td>Any other value</td>
</tr>
<tr>
<td>BCDR Status</td>
<td>[Overcurrent] [Undervoltage] [Overvoltage]</td>
<td>Any other value</td>
</tr>
</tbody>
</table>

These high level TCs and TMs are transmitted on the CAN bus using CANopen PDOs.
9. **EEGSE GUI INTERFACE**

The GUI is used to control and monitor the SIROM I/F controllers and the APMs. Two main interfaces for controlling and monitoring are SpaceWire and CAN. Both buses can be used for controlling and monitoring. Since SpaceWire node is only available in the P-APM, commanding and monitoring over SpaceWire is possible only for the P-APM. On the other hand, all the SIROMs and the APMs include CAN nodes as a common channel for communication.

The GUI implements commanding and monitoring of all the components via CAN and SpaceWire in a user friendly way.

9.1 **Design**

The GUI consists of four main pages:

- SIROM; controlling and monitoring of all the SIROM I/F controllers
- P-APM; controlling and monitoring of the P-APM
- A-APM; controlling and monitoring of the A-APM
- Synoptic Panel; overview of the whole system
- WiFi; controlling and monitoring of all the components by using WiFi debug interface

The GUI should be design in accordance with the following criteria;

- Green indicates expected behaviour
- Grey indicates inactive component, unit, parameter, etc.
- Red indicates a problem
- All the transactions are logged in a single text file per bus; CAN and SpaceWire to follow the sequence of events in a human readable format. Only SpaceWire camera data transfer is not recorded in the log file. However, the data could be stored in a local file by using “Save Stream” button defined in the P-APM tab as needed.
9.2 SIROM

The main parameters of the command to be sent via the CAN bus is set by using text and combo boxes.

- **Delay**: Time delay of the command to be sent. If 0, the command is dispatched immediately. This parameter is used to add several commands to the command queue.
- **TC**: Telecommand to be sent. All the telecommands are listed in Interface Control Document. The basic telecommands are; ready-to-capture, capture, latch, connect, etc. The ICD should be used in the implementation.
- **Param**: Command parameters such as resolution setting
- **Destination**: Destination node. These could be EE(End Effector), A, B, C, D.
- **Nominal/Redundant**: CAN bus selection using radio buttons.
- **CAN Traffic**: Shows the activity of the selected bus by Nominal/Redundant radio buttons. Blinks when a CAN package is sent or received by the EGSE including heart beat signals. In case of a bus error, the indicator turns red.
- **Send**: To dispatch the command

**CMD QUEUE**

Add: The command defined in the CMD is added to the command queue

Clear: Clear all the commands in the list

Save: Save all the commands in the list to a local file. The local file could be edited afterwards by using a text editor. When the script is loaded again to the test application, basic sanity checked will be applied to avoid typos. In case of an error, the command will be displayed in red and not executed.

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Load: Load a script file

Step: Step-by-step execution of the command queue. It should be noted that the commands are separated by time delay and step-by-step execution overrides the delay parameter. This could be used for debug purposes.

Run: Runs the command queue.

**RESP**

Response of the command is presented in four columns. Usually the remote node acknowledges the commands as soon as it is received. After the completion of the command another message to confirm the completion is sent.

- **Command:** Time tag of the command issued, delay defined in the command and command itself.
- **Acknowledgement:** Time tagged acknowledgement of the command from the remote and acknowledgement message
- **Confirmation:** Time tagged confirmation of completion of the command. This could be a positive or negative response.
- **Error:** Time tagged error message of the EGSE. If the EGSE doesn't receive an acknowledgement or a confirmation within a specified time interval, it re-sends the package and increments the retry counter by one according to the protocol defined in the DJF. All the timeout errors and any other errors are presented in the error column.

**SIROM Status Boxes:** Summary of all the SIROM I/F controllers.

- **Sensors:** Sensor data of the SIROMs
  - Ready-to-capture: Green is 1, grey is 0
  - Capture: Green is 1, grey is 0
  - Latch: Green is 1, grey is 0
  - Connect: Green is 1, grey is 0
  - Temp. 1: Green is [TBD, TBD] °C, otherwise grey
  - Temp. 2: Green is [TBD, TBD] °C, otherwise grey
- **Power:** Status of power switches
  - 24V: Green is on, grey is off
  - 100V: Green is on, grey is off
- **Motor:** Position of the motor.
- **Status:** Internal state of the SIROM I/F controller
- **Error:** The last error
9.3 P-APM

The page is similar to the SIROM page. Therefore only the main differences are explained in this section. The main difference is additional SpaceWire interfacing, the PAPM information and the camera stream.

**CMD**

- **CAN/SpW Radio Buttons:** To identify the channel to be used for commanding. If CAN is selected, Nominal/Redundant radio buttons are also allow user to select the channel.

- **SpW Traffic:** Shows the activity of SpaceWire. Blinks when a SpaceWire package is sent or received by the EGSE. In case of a bus error, the indicator turns red.

**PAPM STATUS**

- **Battery:** Status information of the battery
  - Voltage: Battery voltage
  - Current: Battery current
  - State of Charge: State of charge of the battery
  - Temperature: Temperature of the battery

- **Solar Bus:** Status information of the solar bus
  - Voltage: Solar bus voltage
  - Current: Solar bus current

- **APM Status:** Internal state of the PAPM
- **BCDR Status:** Internal state of the BCDR
- **MPPT Status:** Internal state of the MPPT
- **Error:** The last error
- **Voltage Graph:** Voltage vs. time graph. When the graph is clicked, it should be enlarged for better visibility on top of the camera stream area.

---

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• Current Graph: Current vs. time graph. When the graph is clicked, it should be enlarged for better visibility on top of the camera stream area.
• State of Charge Graph: State of charge vs. time graph. When the graph is clicked, it should be enlarged for better visibility on top of the camera stream area.
• Link: SpaceWire link speed vs. time graph. When the graph is clicked, it should be enlarged for better visibility on top of the camera stream area.

**CAMERA STREAM**

• Stream: Received camera data stream via SpaceWire
• Resolution: Resolution of the camera
• Mode: Mode of the camera: live data stream or replay of stored data
• Link: Measured speed of SpaceWire link
• Package Drop: Packaged dropped during data transfer based on segment counter.
• Num. Ack. Retrial: If the package is not acknowledged, the counter is increased by one.
• Num. Conf. Retrial: If the execution is not confirmed, the counter is increased by one.
• Num. Timeout: If a timeout occurs, the counter is increased by one.
• Save Stream: Save the data stream in a local file
• Display Stream: Display the data stream on the test application

9.4 A-APM

![A-APM Interface Tab](image)

Figure 9-3: A-APM Interface Tab

The A-APM page is simplified version of the P-APM (See section 9.3).
9.5 Synoptic Panel

The overview represents an overview of the whole system including the EGSE, rover, SIROMs and APMs as shown in the figure above in a more graphical for a better visualization.

- SIROM State Diagram is a static state diagram representing state transition of the SIROM I/F controller. The last state diagram should be taken from the DJF.
- The CAN bus connections are represented with green circles. The full circle means the node is connected, grey means the node is disconnected, and red means a malfunction.
- SIROM Internal status is represented with 5 different icons; readied for capture, captured, latched, connected and idle and state diagrams for each active SIROMs.
- The power switch status icons are closed (or green) when the switch is on and open (or grey) when the switch is off.
- A-APM statuses are shown with two icons.
  - Internal state of the A-APM controller which is active in the figure
  - BCDR status. Depending on the charge or discharge operation, corresponding arrow will be green. The icon is black, when it is idle.
- P-APM statuses are shown with five icons.
  - Internal state of the P-APM controller which is active in the figure
  - Camera status: Green is on, grey is off.
  - MPPT status: Green is connected, grey is idle.
  - BCDR status. Depending on the charge or discharge operation, corresponding arrow will be green. The icon is black, when it is idle.
- Load status: Green is on, grey is off.
- SpaceWire connections are represented with purple circles. The full circle means the node is connected, empty means the node is disconnected.
- Dashed lines represent disconnected links.
- Arrows represent the current flow directions.

Orange SIROMs are active, grey SIROMs are passive or dummy in the figure.
9.6 Wi-Fi

<table>
<thead>
<tr>
<th>IP Controller</th>
<th>A.TTN</th>
<th>ETH-ARTS</th>
<th>ETH-ARTS</th>
<th>ETH-ARTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.168.0.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>192.168.0.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>192.168.0.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 9-5: Wi-Fi Interface Tab

This page provides debug information to the user.

Active Wi-Fi connections: List of all the nodes with Wi-Fi connection and their IP addresses.

Servoing: Data provided by servoing algorithm by Ethernet broadcast messages. The servoing algorithm broadcasts the data periodically and all the nodes in the Wi-Fi network will be able to receive the data.