PoCat Operations

In this book information about the Lektron Operations is provided.

Mission Phases

The mission is segmented into five distinct phases: 1) Prelaunch, 2) LEOP, 3) In-orbit Commissioning, 4) Operations, and 5) Post-mission. Throughout each phase, various procedures are carried out, either commanded from the ground or autonomously performed by the satellite. This section delineates the expected duration of each phase and specifies the actions performed and how they are executed.

1) Prelaunch Phase: This preliminary stage will take place between one and six months prior to the launch and is estimated to span approximately two days. It involves performing tests and validation processes to guarantee the proper functionality of all subsystems, right up until the satellite is integrated into the deployer. Moreover, meticulous visual examinations will be performed on the satellite's outer components to confirm they are in good condition and have not suffered any damage. Upon completion of these final checks, the final software configuration parameters are uploaded, and all counters are reset to initialize the satellite in its initial flight conditions.

2) Launch and Early Operations Phase: This phase, which lasts about 10 hours, is autonomously handled by the spacecraft, starting after the launch, with the satellite being dispatched into space. Following deployment, the satellite's kill switches are deactivated, and it powers on automatically. Initially, the satellite remains in standby mode for the first 30 minutes to prevent collisions with other satellites or debris. Subsequently, the satellite may initiate AOCS activities to stabilize itself, concurrently attempting to deploy the communication antenna. However, it will delay initiating periodic beacon transmissions until 15 minutes later (45 minutes post-deployment), adhering to requirements prohibiting radio emissions beyond this time. These periodic beacons facilitate ground tracking of the satellite.

3) In-orbit Commissioning Phase: This phase begins after the ground station receives the first beacon from the satellite, which means that commanding from the ground can start. It is estimated to last less than a week. The telemetry data contained in the beacon allows operators to verify the satellite's and all subsystems' correct operation and the successful execution of LEOP autonomously by the satellite. Assuming no issues arise, operators can start sending specific commands such as "PING" to acknowledge signal reception and initiate communication, "UPDATETIME" to synchronize the satellite's clock, and "UPLOAD_TLE" for orbital data purposes. Additional configurations and checks are performed, including payload antenna deployment. Once stabilized and operational, the satellite, commanded by the ground, will undergo experimental testing and calibration, transitioning to the operational phase. Detailed procedure explanations are available in Section 3.

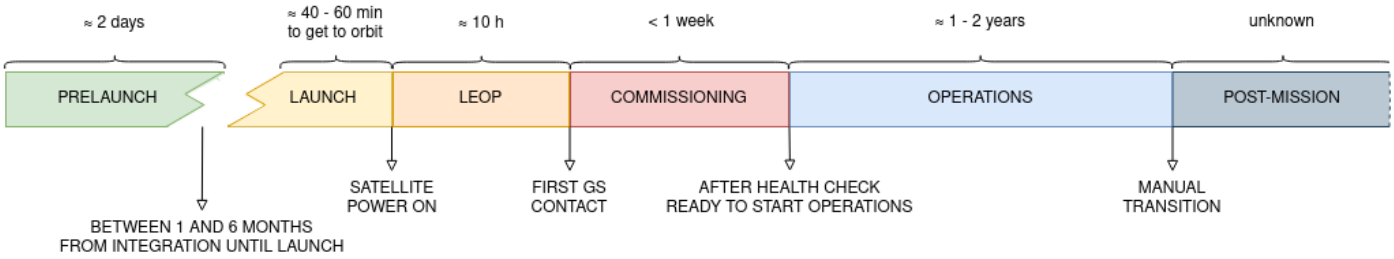
4) Operational Phase: The fourth mission phase, Operations, is where the satellite is expected to spend most of its orbital lifetime, approximately one to two years. During this phase, the satellite's health is monitored, payload operations are scheduled and executed, and housekeeping tasks are

performed to maintain the satellite's functionality.

5) End of Life and Post-mission Phase: The final phase begins once the team decides to conclude operations, either because the payload is no longer functioning correctly or the satellite can no longer operate. Expected to commence after about two years of operations, the satellite enters a passivation state, gradually depleting its energy until battery exhaustion or atmospheric re-entry. During this phase, the FSS may remain operational, providing services to nearby satellites through federation agreements.

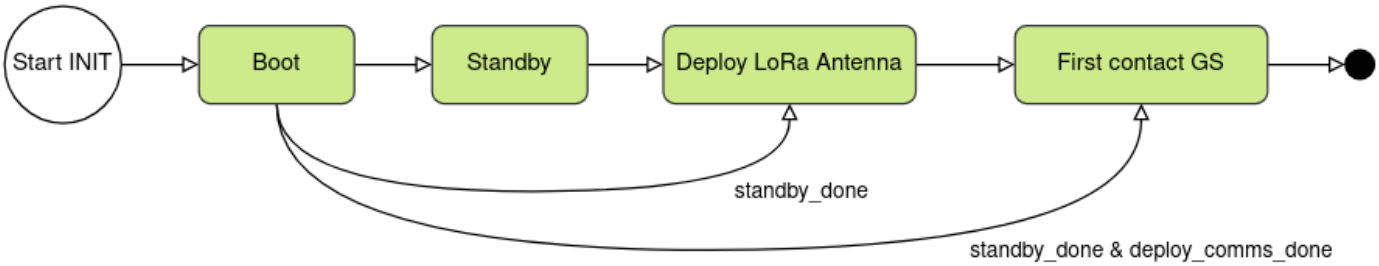
Mission Timelines

Mission phases are divided into Prelaunch, LEOP, In-orbit Commissioning, Operations, and Post-mission. The mission phases and the expected duration of each of them can be observed in the following picture.



1. Activation sequence

The activation sequence encompasses the first two flight mission phases, which correspond to the LEOP and In-Orbit Commissioning phases. The LEOP phase is entirely performed automatically and is executed solely by the Init mode.



After the satellite is released into space by the deployer, the kill switches are depressed, and the satellite is powered on, causing it to enter the Init state. According to the requirements, the satellite remains in standby for 45 minutes before commencing operations. Once this time period is completed, the deployment of the COMMS antenna begins. After the deployment process is finished, the satellite starts sending periodic beacons and awaits the reception of a telecommand from the ground segment to exit the Init state and start operations.

Two different flags can be activated to skip certain steps. The *standby_done* flag is activated once the standby period is complete, while the *deploy_comms_done* flag is activated through a telecommand sent by the ground segment, confirming that the deployment has been successfully completed and that communications are feasible. Both flags must be deactivated during the activation sequences; however, in the event of a system reboot, they can be used to facilitate a faster recovery of the system.

When the first contact with the ground segment is achieved, the operators can check the state of the satellite through the HK information provided by the beacons. Those parameters, such as the battery level, the satellite temperatures, and the stabilization of the satellite, among other parameters, are checked. If everything is as expected, the operator will send a "PING" telecommand to the satellite, triggering it to exit the Init mode and transition to the Nominal Mode.

In the Nominal Mode, two actions from the operator's side are essential to guarantee the proper functionality of the satellite. These are the upload of the current timestamp to ensure the correct synchronization of the satellite with the ground segment and the upload of the TLE information to allow the satellite to correctly perform AOCS tasks and achieve proper pointing.

At the same time, the task in charge of the payload gets activated. This allows for the deployment of the payload antenna and the scheduling of some test experiments to perform calibrations and upload the proper configurations of the payload for its correct functioning. Once everything is ready, it will be possible to transition to the Operations phase, which will consist of scheduling new experiments at the desired times to start the collection of data at the desired locations.

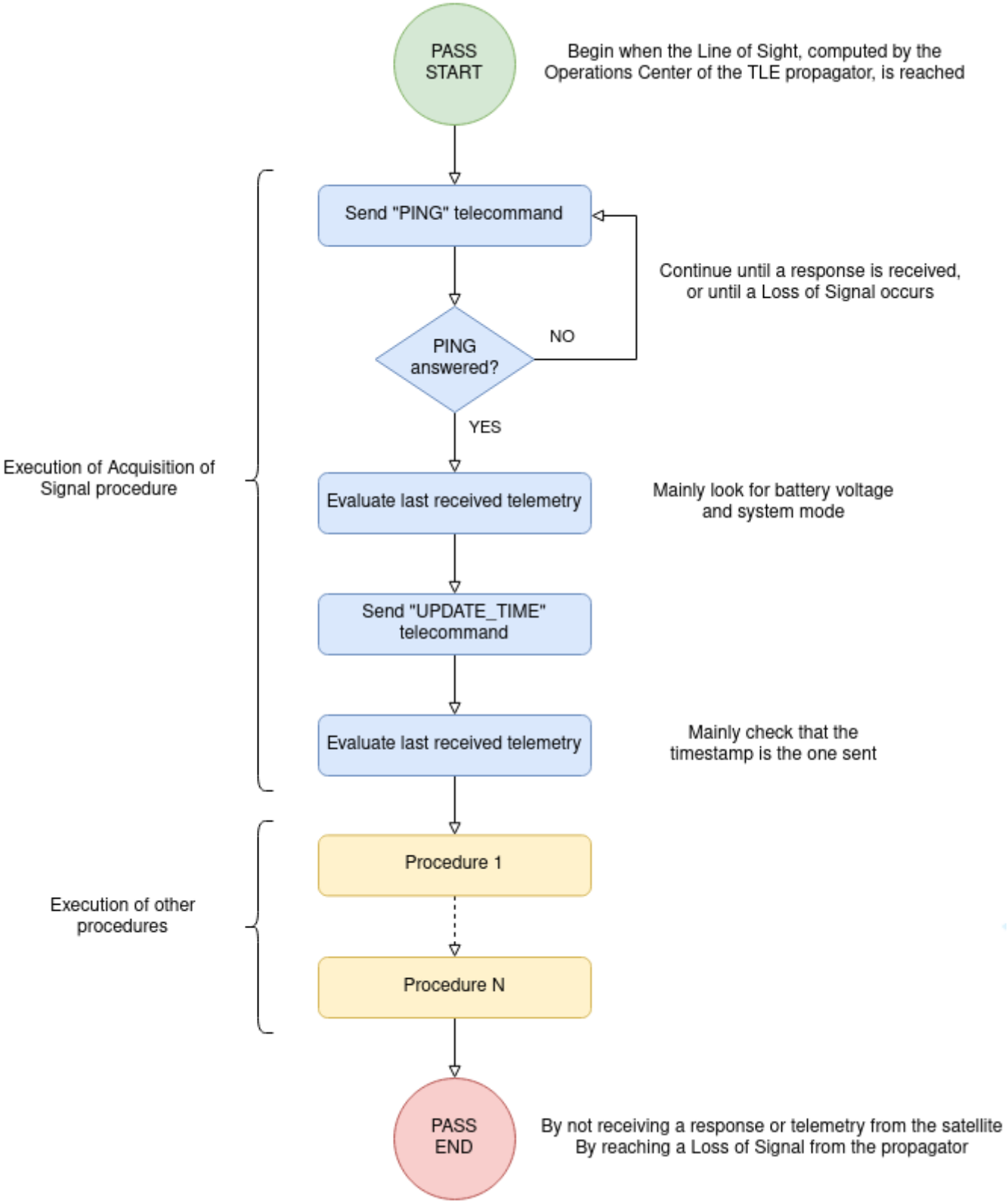
However, in the case of low battery, the satellite will transit to the Nominal mode upon exiting the Init mode and, immediately, transit to the Contingency mode or another mode of lower power consumption. In this case, the upload of the timestamp and the TLE is also needed, as it will allow the satellite to correctly position itself with respect to the Sun to optimize the charging of the batteries.

Once the battery level is adequate, the operator will send a telecommand to transition the satellite to Nominal mode and perform the deployment of the payload and the calibrations as mentioned before.

2. Nominal pass timeline

In nominal conditions, each pass is structured around the execution of different procedures from the procedures list. Each procedure should be executable within one pass, achieving granularity for the system. However, in specific cases, it may extend further if needed. Each pass will begin with the Line of Sight predicted by the TLE orbital propagation.

At the same time, each pass must start with the Acquisition of Signal procedure, which ensures valid communication between the ground segment and the space segment. The operator will then execute the procedure or procedures assigned to that pass. This is briefly depicted in the following figure.



3. Mission critical periods

Under non-nominal mission conditions, the OBSW is designed to operate in a safer mode and to recover from failures. This includes scenarios such as low battery capacity, software errors, and failed attempts to deploy antennas.

In the event of low battery capacity, the satellite automatically transitions to a low-power operational state. During this transition, the microcontroller reduces the CPU frequency to decrease energy consumption. Concurrently, high-energy tasks, such as nadir pointing and payload experiments, are halted. The satellite will then orient itself aligning its solar panels toward the sun to maximize battery charging. It will remain in this state until new instructions are received from ground operators.

Additionally, in the case of software errors or incorrect parameter readings, the OBSW is equipped to handle these issues and recover automatically. If the errors are significant, the satellite will switch to a safer mode and notify operators through information incorporated

Operational Database

The operational database contains all relevant telemetry and telecommand information.

For detailed insights, please refer to the attached file PoCat TM_TC DATABASE.xlsx. This Excel document contains a list of all the telemetry data and telecommands that allow the control of the satellite and the successful execution of the mission.

Operational Procedures

4. Operational procedures list

This section provides a set of routine and recommended procedures to be followed during the operations of the satellite, which can take one or several consecutive passes. These procedures are designed to ensure an efficient management of the satellite's vital functions, enabling operators to detect, respond and correct any issues that may arise during the mission.

Procedure ID	Title
1	Acquisition Of Signal
2	Upload Configuration File
3	Payload Scheduling
4	Deploy Payload
5	Manually Deploy COMMS
6	Resume RF Communications
7	Stop RF Communications
8	Change Operational Mode
9	Request On-Demand HT Packet
10	Download and Clear Payload Execution
11	Force Payload Executions
12	Hard Reboot Execution
13	Soft Reboot Execution
14	Operational Health Check
15	Update TLE Data
16	Clear All Experiments Memory
17	Clear All HT Memory

For a detailed explanation of the steps to be followed in each of the procedures, please refer to the attached file titled OPS-SAT PoCat.xlsx. This document outlines the specific cases in which each procedure is applicable, the commands to be exchanged, the checks to be performed, and the estimated time required for each procedure.

5. Procedure format/rules and example

Each procedure follows this structure:

Procedure ID	1
Title	Acquisition Of Signal
Objective	Manage the 1st contact with the satellite for each pass
Introduction	Manage the contact with the satellite once receiving the 1st TM beacon by sending a ping command to validate communications. Update onboard time. Validation of telemetry to know satellite state.
Expected duration	2 minuts
Procedure Description	1.1 Upon AOS, send a "ping" TC. 1.2 Wait for 20 seconds for the answer. If not successful, send again. 1.3 Wait for next TM beacon and check satellite system mode and battery voltage. If not in nominals/expected conditions, analyse and try to solve the problem. 1.4 Send the telecommand "update time" to send an updated timestamp to the satellite.
Expected outcome	Satellite processes ping TC correctly and is in the expected system mode. Battery voltage is over threshold.
Contingency scenario	If satellite does not answer to the hello but keeps sending TM, analyse system mode and perform soft reboot (ID: 12)
Cautions	None

To provide a log and historical record of the procedures and events that have been handled during a satellite pass, it is recommended to complete a summary table.

Additionally, this will facilitate an easy handover between operators and serve as a resource for investigating potential issues. An example of a template is provided below:

HANDOVER PROCEDURE		
	Outcome	**Notes**
Last Operator's name		
Date of last pass		
Hour of the last pass		
Satellite mode		
Battery voltage (V)		
Errors raised during operation (Yes/No)		
Payload scheduled (Yes/No)		
Pending procedures (Yes/No)		
Nominal track (Yes/No)		
Configuration Changes (Subsystem Name/No)		
Remarks		
Next Operator's name		
Date of first pass		
Hour of the first pass		
Satellite mode		
Battery voltage (V)		
Errors raised during no-operation (Yes/No)		
Payload packets ready to download (Yes/No)		
Pending procedures to execute (Yes/No)		
Nominal track (Yes/No)		
Configuration Changes (Subsystem Name/No)		
Remarks		