Israel Space Agency
Ministry of Science, Technology & Space

C³IEL MISSION

CLUSTER FOR CLIMATE AND CLOUD IMAGING OF EVOLUTION AND LIGHTNING

PAYLOAD-TO-PLATFORM INTERFACE CONTROL DOCUMENT

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APPENDIX: INTERFACE CONTROL DOCUMENT

Cluster **C**limate and **C**loud **I**maging of **E**volution and **L**ightning - C^3IEL is a bi-national France-Israel satellite mission, led by CNES and ISA. The mission is supported by both France and Israeli governmental funds.

The main goals of the mission are to realize the synergy between the unique capabilities of measuring cloud updrafts (Clouds), detecting the distribution of Water Vapor (WV), and tracking the electrification of clouds (Zeus).

SCOPE OF THIS DOCUMENT

This document defines the (i) interfaces between the payload and the satellite, and (ii) lists the main components (i.e. instruments) of the payload.

Additionally, this document describes the technical high-level design of the proposed project discussing the satellite bus and the payload.

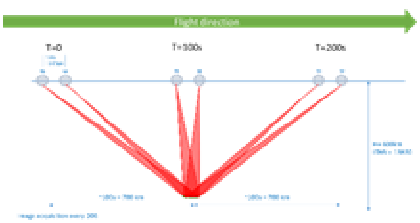
1 C³IEL MISSION OVERVIEW

A "*cycle*" in this document refers to a sectional angular arc along the orbit which can last up to 300sec (end to end flight time of the satellite).

Cycle is sub-divided into three measurement stages:
(i) *Search and Acquire* – lasts up to 20s,
(ii) *Track and Measure* – lasts up to 200s during which measurements (i.e. images) are taken each 5-20s and
(iii) *Fly-back stage* – lasts up to 100s.

The following mission requirements have been determined to be driving the design.

Table 1 Mission overview

Parameter	**Unit**	**Value**	**Comment**
Number of satellites	[-]	2 or 3[1]	Train of 2 (or 3) nanosatellites
Satellite Orbit	[km]	~600	A Sun Synchronous Orbit (SSO)
Local Hour	[h]	13h30	
In orbit separation	[s]	10 to 30	Indicates the time separation that is equivalent to distance separation of 75km to 225km between the satellites
Time of Measurement		• Daylight • Night	• Daylight – clouds, water-vapor, lightnings • Night – lightnings
Measurement scenario 			• Each nanosatellite shall capture simultaneously the same scene during data acquisition and mission's accumulation time. • All nanosatellites point to and measure in the same observation area during 200 s • Configurable image acquisition between 5 and 20s
Satellite Orbital Life	[-]	2 Years	• Option to extend operation for an additional year

[1] The number of satellites is yet to be confirmed (3 or 2). Likewise, the presence of the water vapor cameras and lightning imagers and photometers on the satellites has to be confirmed, according to their impact on the scientific value and cost of the mission.

Parameter	Unit	Value	Comment
Launch		2024	

2 PAYLOAD'S INTERNAL ICD

The payload consists from three scientific instruments (Clouds imager, Water Vapor imager and Lightning imager). In what follows, a several general requirements are described:

a. All the required scientific instruments and their sub-systems will be capsulated and should be interfaced with the satellite as a single instrument, i.e. the payload will implement one interface for each one of the following: (i) data transfer, (ii) command and control, (iii) power line and (iv) time synchronization signal (1pps).
b. All the instruments should be located within the defined volume (as shown further in the document).

2.1 PAYLOAD VOLUME ALLOCATION

Shape and volume of the payload requires an "L" shaped 3U (1U = 10x10x10cm) structure of the payload, in which two of the units (2U) have to be exposed towards the earth and one unit (1U) located above one of the two, as depicted in Figure 1 below.

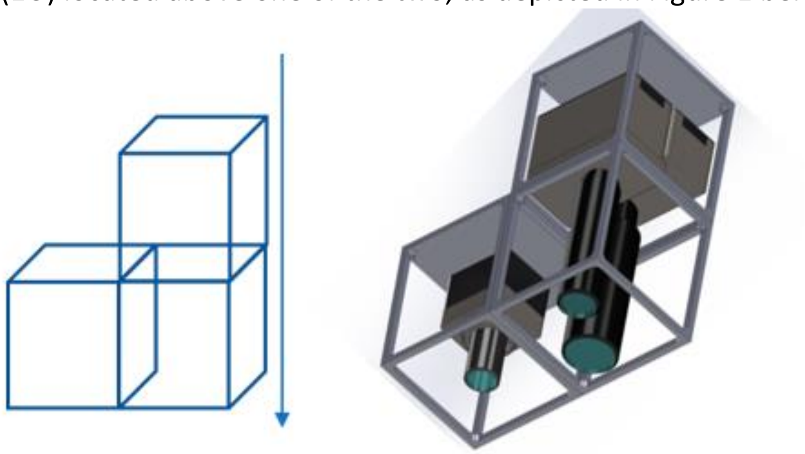


Figure 2.1 – Conceptual design of the payload. Left: A sketch of available volume for the payload, where narrow plate points down to earth. Right: A possible arrangement of the optical equipment and its related electronics.

3 SATELLITE PLATFORM

3.1 PLATFORM BUS TECHNICAL SOLUTION

Three solutions are considered at this stage of the project:

- Nanosatellite 6U
- Nanosatellite 8U
- Nanosatellite 12U

3.1.1 ELECTRICITY POWER SYSTEM

The satellite platform will support the payload with a total power supply of up to 35W. (for a 6U Nanosatellite)

3.1.2 COMMAND/CONTROL

3.1.2.1 Datation

The requirement for relative datation between the payload of the satellite is 1 ms

3.1.3 LOCALIZATION

The satellite embeds an integrated GNSS receiver that supports localization of 10 m. A 1PPS signal received from the GNSS and its matching message (via command and control interface) will be used for synchronization.

3.1.4 TM/TC COMMUNICATIONS

The requirement for the TM/TC communications are:

- Housekeeping TM/TC is in S-band.
- Payload telemetry is in X band with expected bit rate of up to 30 Mbits/s.

3.2 PAYLOAD INTERFACES

- **Primary and secondary Voltages** - payload should be able to derive all the necessary secondary voltages from the provided primary voltages as described below.
- **Power Switching Support** - payload should take care the “power switching” of the components in order to:
  - Protect the sensitive electronic components from single-events
  - To operate by command, in different operational modes (e.g. when only selected imagers are active).

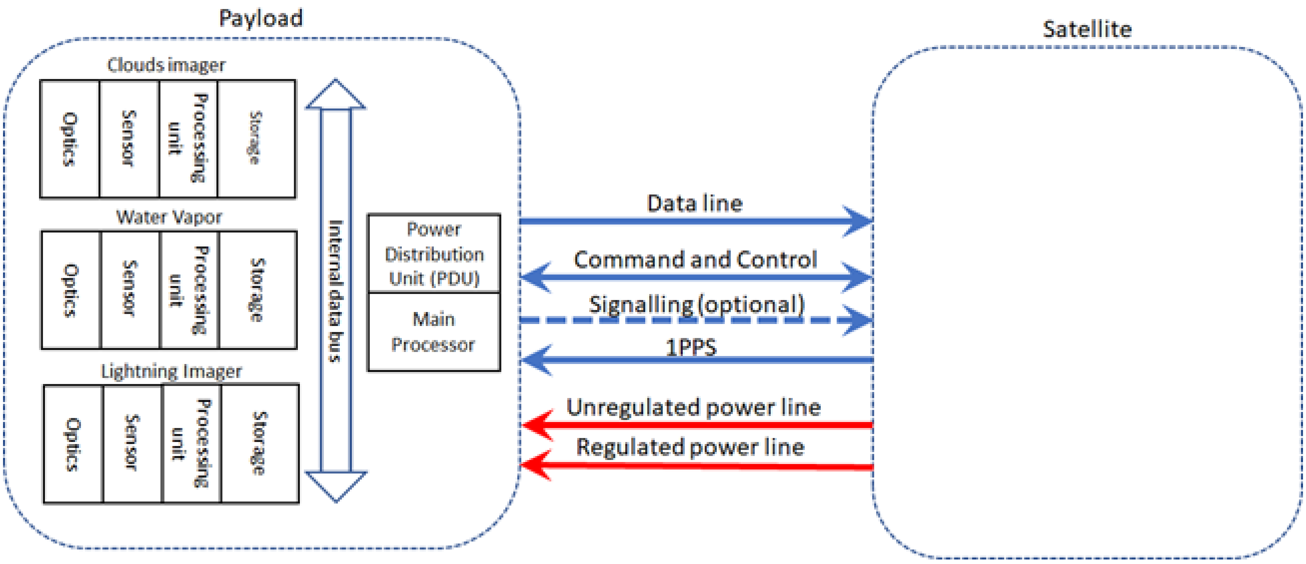


Figure 3.1 – Description of main interfaces: (i) between the satellite and the payload and (ii) within payload. Blue lines indicate communication lines and red lines indicate power line.

3.2.1 PF/PL ELECTRICAL INTERFACE

The total power of the payload should not exceed 35W.
Nanosatellite 6U:

- 2 Power lines
  - A 5Vdc (up to 10W) regulated supply voltage power line
  - A 12Vdc to 14Vdc unregulated supply voltage power line

Nanosatellite 12U:

- Unregulated battery bus between [14.5-16.2] V

3.2.2 COMMAND/CONTROL INTERFACE

Nanosatellite 6U:

- I²C or SpaceWire
  - For I²C signaling (dotted line in figure 3.1) from payload to satellite platform to be discussed
- 1PPS signal from the GNSS and 1PPS matching message (via command and control interface)

Nanosatellite 12U:

- RS422/485 @ 115 200 kbps
- 1PPS signal from the GNSS and 1PPS matching message (via command and control interface)

3.2.3 PAYLOAD DATA INTERFACE

Nanosatellite 6U:

- **SpaceWire data communication (through the OBC) is preferred**
  Additional options are:
- I^2C (through the OBC)
- LVDS + clock (direct communication to the communication board)

Nanosatellite 12U:

- High data rates up to 200 Mbps: SpaceWire or LVDS
- Lower data rates: SPI, I2C or RS422/485

3.2.4 PAYLOAD MODES OF OPERATION

The payload is planned to support the following modes of operation:

(i) "*Operational*" mode; during which, the entire payload is fully operational (i.e. all or a subset of imagers, all the processors and memory, PDU)

(ii) "*Data transfer*" and "*Parameters setup*" modes; during which the main processor, memory and PDU are active.

(iii) "*Safe Mode*"; during which the main processor, memory and PDU are active. Additional devices can be activated only by command.

(iv) "*Self Test*"; during which the main processor, memory and PDU are active, and other modules are activated by command.

If time to reach Operational mode, after cold start, exceeds several seconds, a "Standby" mode shall be added.

3.2.4.1 Operational mode

The mission scheduling based on these scenes is elaborated on ground and sent to the satellite, say, every week.

The following sequence diagram demonstrates the use of the payload in operational mode.

Prior to the acquisition (preferably several seconds) the payload is turned on, then system self-test should be run and when the payload reports "operational" the acquisition starts. During this step, three imagers are active and operate in parallel in a synchronized way as shown in the figure below (Figure 2). More specifically, each one of the instruments should have its own acquisition loop synchronized with 1pps coming from the satellite platform. The data from each of the instruments should be accumulated at the main memory of the device located within the payload.

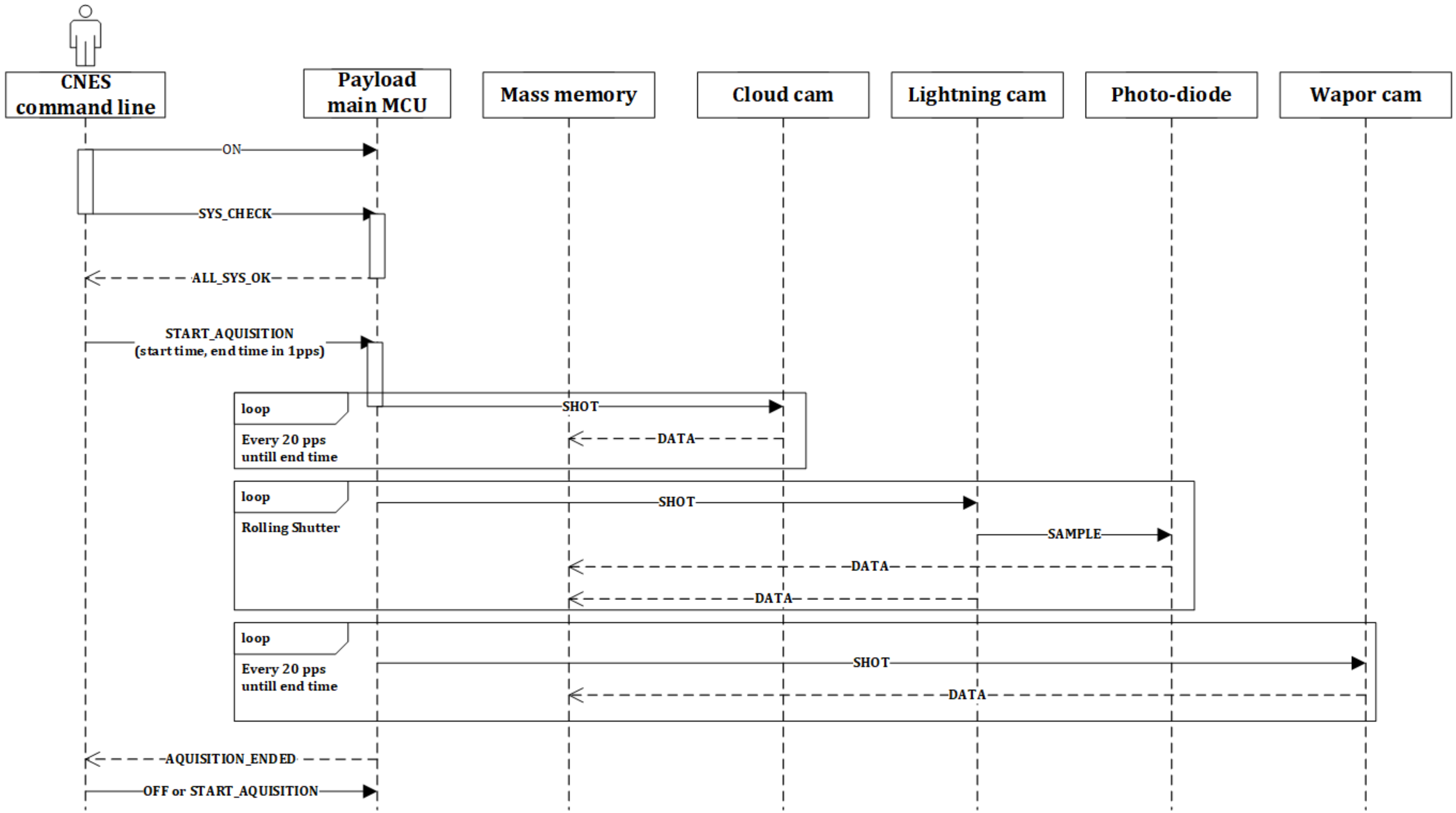


Figure 3.2 – A sequence diagram that demonstrates the use of the payload in operational mode.

3.2.4.2 Data transfer

This mode responsible for transferring the data from the payload's main memory storage to the ground.

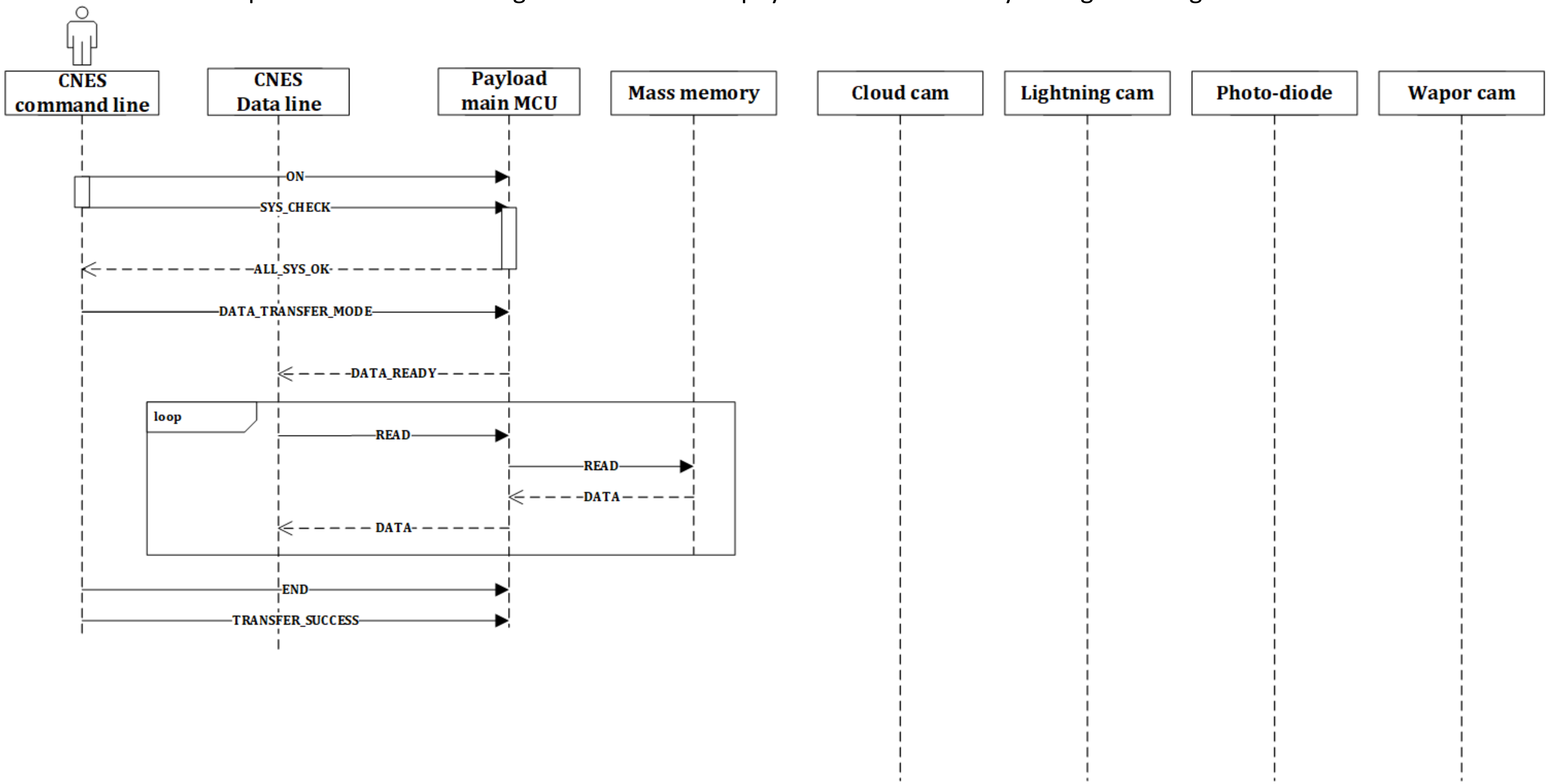


Figure 3.3 – A sequence diagram that demonstrates the use of the system in Data Transfer mode

3.2.4.3 Parameters set

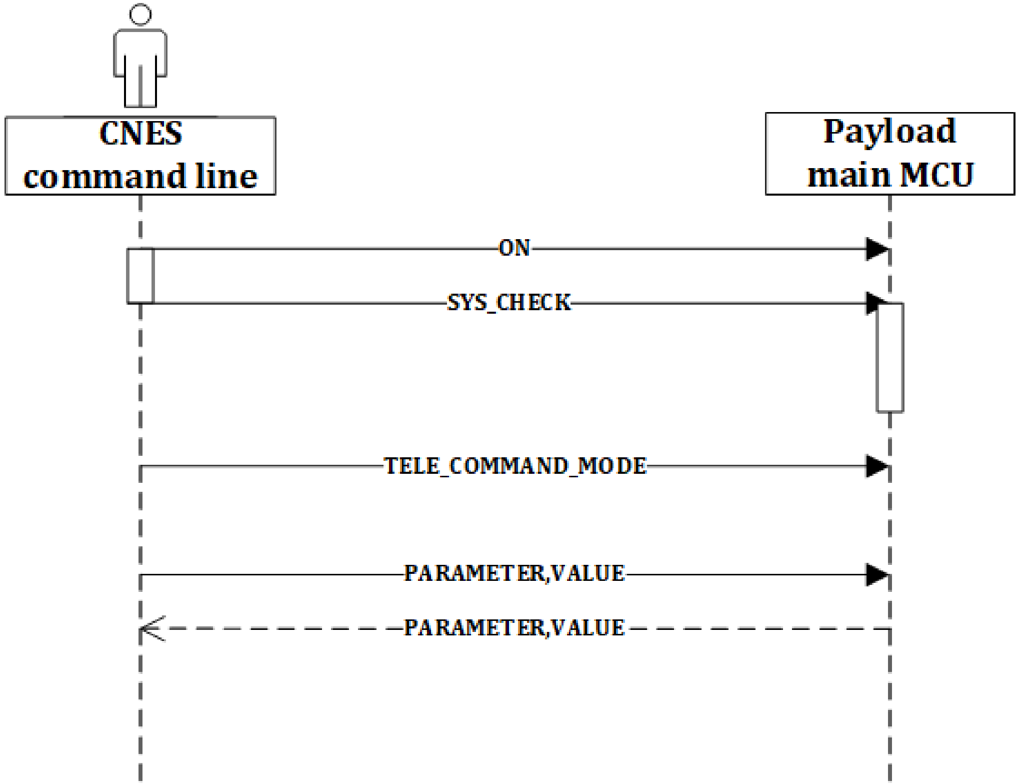


Figure 3.4 – Sequence diagram that demonstrates the use of the system in Parameters Set mode