RAPPORT

Cahier des charges pour l'intégration du logiciel de vol du projet NanoMagSat	
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HISTORY

Subject of the modifications	Date	Version
Creation	25/07/2024	0.0
Review of work packages and tasks definitions.	16/09/2024	0.1
Integration of figures from the CNES:	20/09/2024	0.2
Add the Deliveries summary section	25/09/2024	0.3
Remove Task 6 and add On-request services Clarify licencing	02/10/2024	0.4
Precise L1-2 and L2-2 deadlines	15/10/2024	0.5

SUMMARY

The CEA participates to the mission NanoMagSat that is part of the SCOUT program from ESA. The objective is to embed two Helium-4 magnetometers in a satellite dedicated to earth observation.

The present specification describes the scope of the expected service for the integration of the flight software embedded on the DPU. It encompasses libraries from the CNES and applicative software from CEA.

In addition to the technical realization, the contractor shall provide support for the validation and the qualification of the instrument in the spatial domain.

KEY WORDS

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TABLES

1 Documentation

1.1 Applicable Documents

N°	Reference	Title	Source
DA 1	ASC-DTU-ICD-3004 October 11, 2023; Issue 4.4	µASC TM/TC Interface Control Document"	DTU
DA 2		(SRS) APPDK - Software Requirement Specification	CNES
DA 3	FSW-APPDK-ICD-0001	(ICD) APPDK - Interface Control Document	CNES
DA 4	ECSS-E-ST-40C	Space Engineering Software	ESA
DA 5	ECSS-Q-ST-80C	Software Product Assurance	ESA

Tableau 1 : documents applicables

1.2 Reference Documents

Référence	Titre
DR1 : LVCUGEN-MU-BSW_CORE-0273-CNES	LVCUGEN User Manual LVCUGEN-MU-BSW_CORE-0273-CNES
DR2 : -	LVCUGEN Coding Standard
DR3 : -	LVCUGEN Coding Standard Verification

Tableau 2: Reference documents

2 Terms, Definitions and Abbreviated Terms

AIT	Assembly Integration and Test
AIV	Assembly Integration and Validation
ASW	Application Software
BSW	Basic Software
CC	Command / control
CCSW	Command/Control Software
DPU	Data Processing Unit
DRL	Document Requirement List
HFM	High Frequency Magnetometer
HSEM	HW & SW Events Manager engine
ICD	Swoftware Interface Control document
MAM	Miniature Absolute Magnetometer
MMDL	Modes Management & DL engine
MSW	Mission Software: LVCUGEN partition for the Mission in interface with the partition CC.
NMS	NanoMagSat
SRS	Software requirement Specification
SSIS	A standardized API (SSIS) allows to initialize the I/O drivers and perform open/read/write/control/close operations to the memory. It is used by the HSEM partition.

Tableau 3: Abbreviated terms

3 Introduction

Following on from the current Swarm Earth Explorer mission, which was launched back in 2013, NanoMagSat aims to maintain Europe's leadership in monitoring the Earth magnetic field. In addition, NanoMagSat will measure the ionosphere environment. The NanoMagSat project has been elaborated in response to the SCOUT program defined by ESA

As part of the NanoMagSat proposal, the CEA must develop an instrument incorporating two quantum magnetometers based on Helium-4 cells. The "MAM" delivers very high accuracy scalar measurements and calibrated vector data while the "HFM" delivers high bandwidth vector data.

This specification document describes the scope of work expected for the development and the qualification of the flight software embedded in the DPU of the NMS instrument.

4 Overview of the « NanoMagSat » project

NanoMagSat is a project involving a constellation of three nanosatellites for a 3. 5 years mission to study the Earth's magnetic and ionospheric fields.

This project aligns with a « new space » low-cost philosophy aimed at offering an observation solution of the Earth magnetic fields in the long term from space to complement the Intermagnet network of ground-based observatories.

The NanoMagSat satellites are primarily composed of several hardware platforms:

- The main On-Board-Computer (OBC).
- A start Tracker from DTU (µASC: Micro Advanced Stellar Compass).
- The NMS magnetometers, developed by CEA. It encompasses a Data Processing Unit embedding an AP70030 programmable FPGA from AMD plus analog and digital interfaces with two quantum probes: the "MAM" delivers very high accuracy scalar measurements and calibrated vector data while the "HFM" delivers high bandwidth vector data. The hardware DPU is solely dedicated to controlling the magnetometer probes and performing housekeeping operations.
- A Langmuir probe developed by UIO (University of Oslo).

5 Purpose of the subcontracted service

The objective of the service is to develop and qualify the « flight software » (LV) embedded in the Programmable System (PS) of the DPU FPGA based on:

- the LVCUGEN (plus XNG from FentISS) runtime provided by CNES,
- the PUS communication protocol implementation (LibPUS) from CNES,
- The SW to drive the NMS instrument delivered by the CEA, referenced as the NMS partition.

Using the LVCUGEN + XNG offers a strict temporal and spatial partitioning, which allows:

- Focusing on the scientific development using existing internal development framework
- Taking benefit from the CNES expertise on the LVCUGEN development framework to facilitate the integration
- Delaying the full integration to the last part of the project with a reasonable risk assessment

During the project, the CEA will develop the science partition (NMS partition) with the framework provided by CNES and will delegate the integration and qualification of the full LV to the contractor.

5.1 LVCUGEN

CNES provides the generic LVCUGEN framework and an implementation of the PUS protocol stack. This framework ensures strict temporal and spatial separation between multiple partitions and relies on the Xtratum hypervisor provided by FentISS.

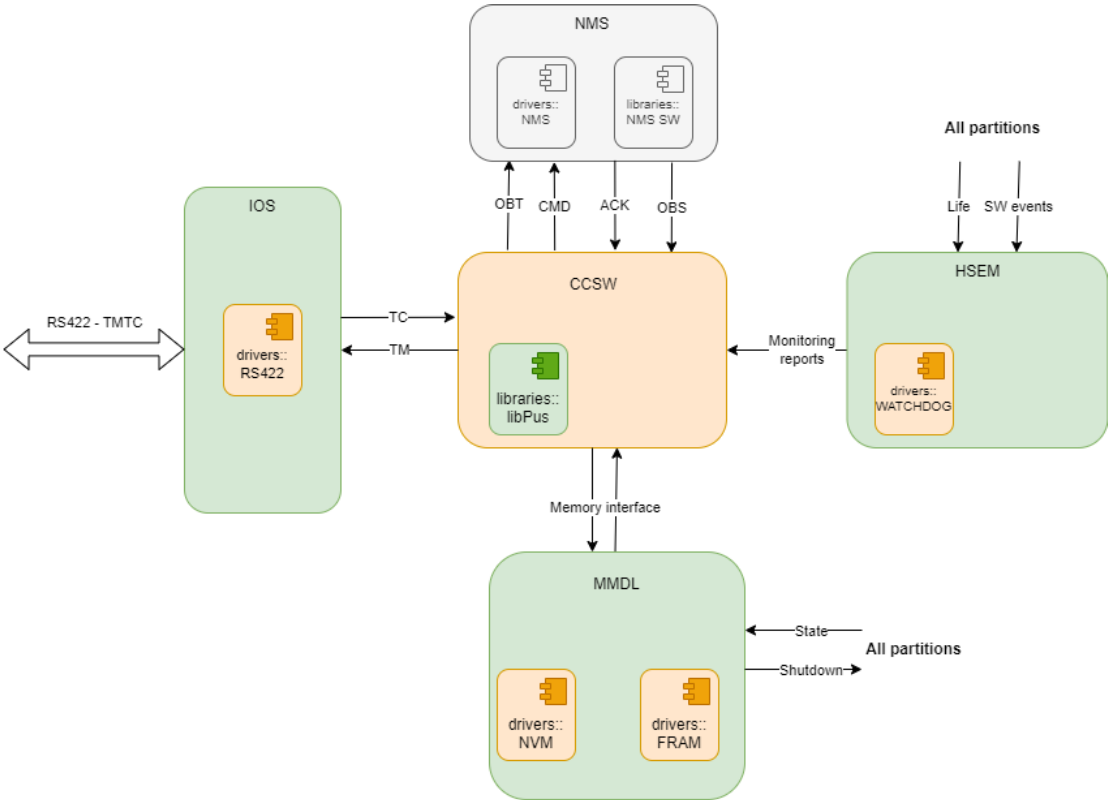

Figure 1: LVCUGEN partitions.

In addition to providing common services illustrated in blue in Figure 1, LVCUGEN facilitates the integration of partitions from different suppliers illustrated in grey. Each supplier can focus on developing their own software modules within one or several partitions, which will share the same hardware resources with other partitions of varying levels of criticality.

For CEA, the advantage of using LVCUGEN in this context is the ability to focus on developing scientific services independently at the beginning of the project, with the expectation of smoothly integrating these services into a partition of the complete flight software, alongside already qualified components.

At that time, CNES supports the LVCUGEN port on the Zynq Zybo Z7-10 and Z7-20 platforms (Cortex-A9). Port and validation on the DPU hardware platform is part of the subcontracted service and subject of this document.

5.2 LibPUS

Both the star tracker instrument and the magnetometers communicate using the PUS protocol. The OBC is in charge of forwarding messages between the ground segment and the instruments. It is not supposed to eavesdrop the information with two exceptions: a message from the NMS instrument which reports the temperature from a Peltier sensor to allow the platform to control the MAM Peltier driver, and in addition to a PPS signal, the OBC shall transmit the absolute date to the NMS instruments

There are different official versions of the PUS standard: the first ECSS-E-ST-70-41A (or PUS-A) and ECSS-E-ST-70-41C, typically referred as PUS-C. The star tracker is compliant with PUS-A according to the document referenced in AD1. LibPUS from the CNES complies with PUS ISIS v8.0. It is an intermediate standard in between PUS-A and PUS-C.

The implementation of LibPUS shall be centralized in a CCSW partition. The CEA partition and the other LVCUGEN partitions share communication channels with the CCSW which is in charge of the PUS message decoding, TM serialization, OBT management, mode management, FDIR management.

PUS messages are carried over RS422 to the OBC. The required bandwidth is below 320kbps. To secure the integrity of the packets and be resilient to data loss, there is a need to implement a data link layer in agreement with OpenCosmos. This protocol is used:

- To detect start of frames
- To check that a full frame is received
- To validate a checksum/CRC (Optional)

The CCSW partition embeds the LibPUS but delegates reception and transmission of TC and TM messages to the IOS engine. A specific driver shall be specified, implemented and validated to communicate with the OBC through RS422.

5.3 NMS Instrument Partition

CEA will develop the scientific partition of the flight software. It consists in driving the probes and the HW interfaces according to the commands received by telemetry. The communication, the housekeeping,… are delegated to generic LVCUGEN partitions such as HSEM, MMDL and CCSW.

In order to simplify the scheduling of the flight software, the hard real time constraints are managed by functionalities implemented in the Programmable logic (PL) of the FPGA. Consequently, the buffers size shall be configured accordingly.

The NMS partition controls the HW interfaces with the FPGA. Drivers will be included in the partition, as they are not directly accessed by other partitions.

The development of the NMS instrument software is in progress at CEA and will proceed during the project. CEA has developed a flow to test and validate the NMS instrument software. The criticality qualification of the partition may be lower than the rest of the LVCUGEN since it's acceptable to re-load and re-start if a default is detected.

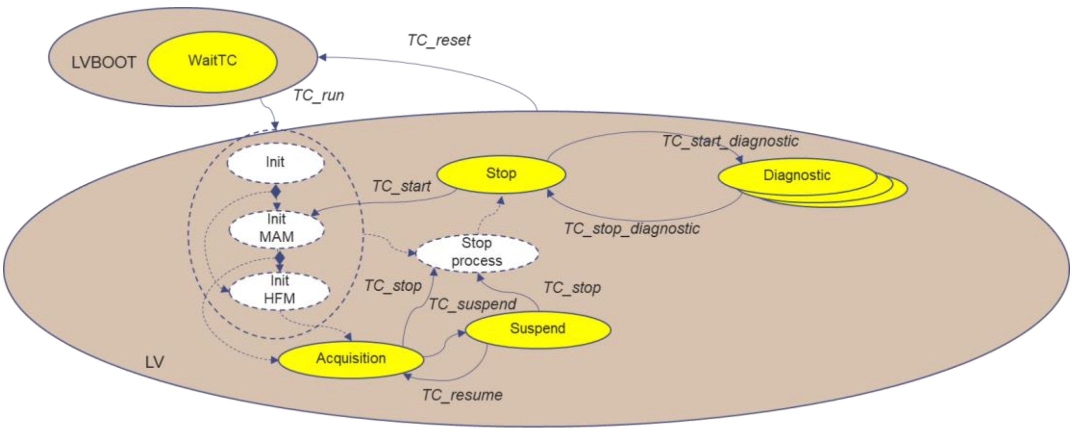

Figure 2: NMS instrument main states.

5.4 Flight Software

Integration and qualification of the flight software is the purpose of the service. This include two types of activities: software development and management of the development cycle including the production of the requested documentation required by CEA.

The technical activities concern:

- Porting LVCUGEN on the DPU and establish basic communication with the OBC developed by OpenCosmos.
- Providing an application development kit to CEA to develop the scientific partition.
- Building the final flight software based on the generic LVCUGEN environment.

6 Plan of SW development

As illustrated below, CEA plans to divide the development of the flight software into three stages. This split is justified by the fact that CEA wants to focus its resources on the development of the scientific instrument independently of the constraints of a complex runtime and wants to rely on the expertise of partners to secure the final integration of the flight software at the end of the project.

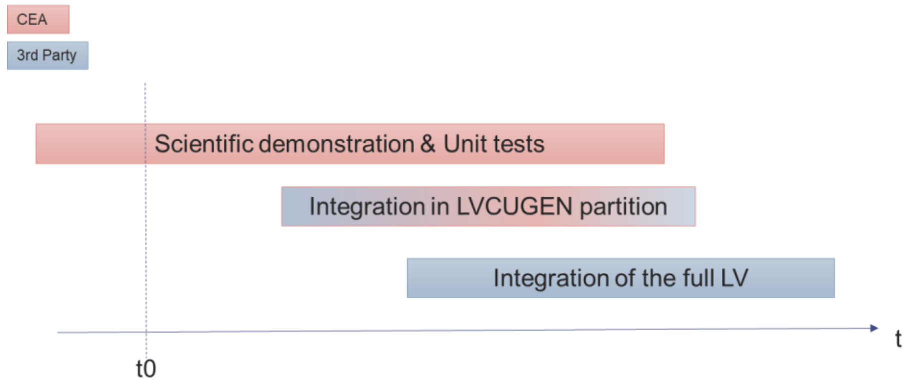

Figure 3: Plan of SW development

CEA will handle the first stage autonomously. This stage involves creating interfaces for the instrument's hardware, implementing operations to control sensors through these interfaces, and collecting data, including scientific measurements, which will be retrieved via telemetry. CEA employs its own development methodology, which is a bottom-up approach. It includes continuous integration and non-regression testing with hardware-in-the-loop. During this first stage, CEA will also progressively define the Interface Control Document (ICD) and the Software Requirements Specification (SRS) for the scientific instrument. By the end of this stage, the CEA will be able to demonstrate the instrument behavior controlled from a connected PC sending commands.

The second stage consists in embedding CEA software into a LVCUGEN partition. CNES recommends testing this partition in a sandbox before the final integration. The contractor shall provide a test framework to validate the partition interface. The objective is for CEA to test the partition and its interfaces without the requirement of a full integration and with a lighter development platform to increase the efficiency.

The third stage consists in the integration of the flight software with all the different components. This first delivery consists in the porting of LVCUGEN on the EDU at the beginning of the project and the implementation of some of the TC/TMs and the datalink layer to validate the communication with the OBC. During the integration, the contractor shall use the APPDK provided by CNES and interface the partition elaborated during the second stage with the HSEM, MMDL and CCSW partitions

6.1 Roles and responsibilities

CNES provides - key components of the flight software integrated in the BSW (LVCUGEN plus Xtratum and the LibPUS) plus a datapack (documentation, coverage matrix, performance assessment…).

CEA will focus in the development of the scientific partition, the specification of the instrument control (scientific partition) and the TC/TM plan of the ICD. CEA is in charge of the relations with the other partners of the project in particular OpenCosmos (leading OBC development).

The **Contractor** is in charge of the integration of the flight software. It does also the project management of the verification and qualification activities of the flight software.

6.2 Quality level requirements

The following table describes the Quality Levels for each software components.

LV Component	Owner	Criticality Level	Comment
Boot SW	CNES	B	Drivers shall be adapted by the contractor
Boot SW drivers	Contractor	B	
Hypervisor	FortISS	B	Qualified
LVCUGEN (BSW)	CNES	B	Qualified
LibPUS	CNES	B	Qualified
CCSW partition	Contractor	B	
RS422 driver	Contractor	B	It shall include a data link layer implementation
Watchdog driver	Contractor	B	
Memory drivers	Contractor	B	QSPI, NAND, FRAM
Scientific partition	CEA	C	It is acceptable to reboot it, and to reload it.

Table 1: Criticality levels for qualification.

The Scientific partition is not critical since it can be updated during the mission (Criticality Level C). However, all Non-Scientific Software involved in the update of the ASW or part of the ASW (scientific partition) is considered as critical for the mission (Criticality Level B).

7 Work Packages and deliveries

A flat sat demonstrator shall be demonstrated as early as possible after the beginning of the project (**Task 3**). At this early stage, it is acceptable to use an existing Dev Kit based on a Zynq AP7000. Some developments are required to adapt communication drivers.

CEA is in charge of the applicative LVCUGEN partition development. CEA is expecting support from the contractor (**Task 4**):

- to port an APPDK on the targeted DPU,
- To provide support with the sandbox partition used to stress the applicative partition without the constraint of the full BSW during the validation stage.

The contractor is in charge of the Flight Software integration (**Task 5**). CEA will provide access to the EM hardware platform. This task involves tailoring the HSEM and MMDL partitions, as well as developing a CCSW partition, in accordance with the ICD specification.

The contractor shall provide on-request services negotiated after the completion of Task5. It includes post-warranty support and maintenance for all of its supplies for AIT/AIV activities and in-flight acceptance testing until the end of the project. A portion of the budget is reserved for these additional support and maintenance activities.

In addition to the previous technical activities, the contractor shall organize period reviews with CEA to assess progress, milestones, risks… The contractor shall prepare the different reviews (**Task 1**). At least, the contractor is in charge of the FS documentation required for the different reviews as defined in ECSS-E-ST-40C document (**Task 2**).

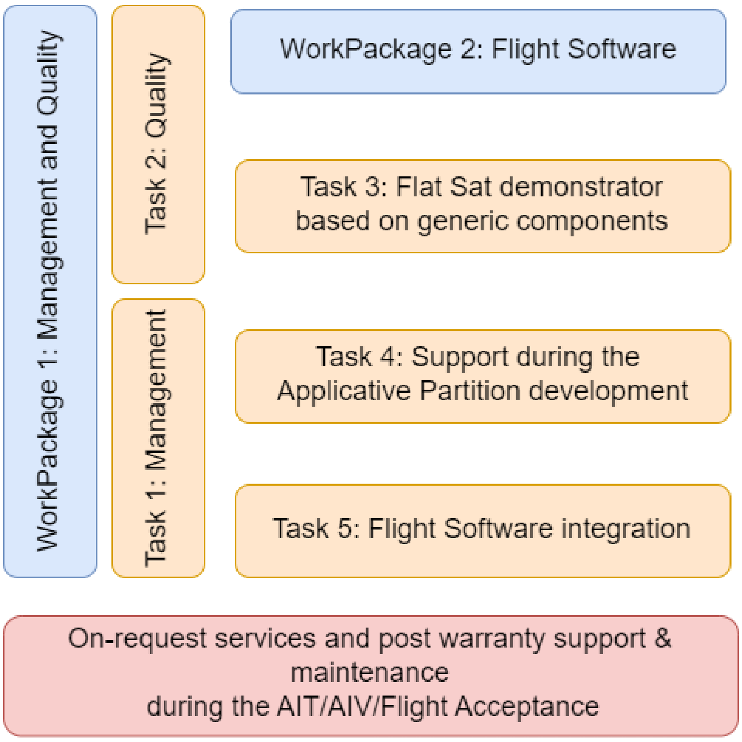

Figure 4: Presentation of Work Packages and tasks.

7.1 Work Package 1 : Management and quality

7.1.1 Task 1: Management

7.1.1.1 Objective

The contractor shall organize and implement:

- Internal project management to monitor the activities entrusted to the contractor,
- Interface management with CEA.

7.1.1.2 Requirements

R1-1	Establish and maintain a management plan and a development plan applicable to the project, with the aim of demonstrating control and coherence of the development, presenting the major elements of the development, and highlighting the key milestones of the project in accordance with the specifications and constraints of NMS project.
R1-2	Establish and maintain a validation and testing plan
R1-3	Coordinate the project activities internally
R1-4	Ensure the creation of all technical documentation,
R1-5	Act as the interface between the internal project teams and the client,
R1-6	Prepare meetings, key milestones, and reviews as requested by the client.

7.1.1.3 Expected deliveries

L1-1	Regularly report to the client (monthly) on the progress of the project (schedule, critical points),
L1-2	Control the software life cycle process and prepare the SRR, PDR, DDR, QR and AR reviews in accordance to the ECSS-E-ST-40C document.

7.1.2 Task 2: Quality

7.1.2.1 Objective

With the support of the client, the contractor shall establish the quality organization to carry out the development planned in the second Work Package in accordance to the ECSS-E-ST-40C specification.

The CEA will provide the Software Interface Control document (ICD) which consists in the tailorisation of the PUS protocol for the mission.

The CEA will provide part of the Software Requirement Specification (SRS) that concerns specifically the behavior of the MSW LVCUGEN partition. The contractor shall complete this document in accordance to the tailorization of the BSW partitions.

7.1.2.2 Requirements

R3-1	The contractor shall put in place the necessary tools for tracking technical issues.
R3-2	The contractor shall put in place the necessary tools for software configuration management.
R3-3	The contractor shall put in place the necessary tools for validation and quality metrics.
R3-4	The contractor shall put in place the definition of coding rules to be followed for the development in accordance with the CEA.
R3-5	The contractor shall put in place the traceability matrices to verify that all requirements are covered from design to testing phases.
R3-6	The contractor shall implement activities related to configuration and documentation management.
R3-7	All the documents shall be written in English.

7.1.2.3 Expected deliveries

L2-1	Support on the Software Requirement Specification redaction.
L2-2	Documentation specified in the Table 2: Document Requirement List. This set of documentation shall be ready for the sw life cycle reviews (SWRR, DDR, QR, AR).

	Documents		Flight Sw	Review			
	Acronym	Name	Owner	SWRR	DDR	TRR	TRB
	SRS	Software Requirement Specification	CEA	x			
	ICD	Software Interface Control document	CEA	x	x		
	SDD	Software Design Document	Contractor		x	x	
	SCF	Software Configuration File	Contractor		x	x	
DDF	DDD	Software Detailed Design Document	Contractor				
	SUM	Software User Manual	Contractor/CEA		x		
		Software Source Code	Contractor		x		
		Software Product	Contractor			x	
			Contractor			x	
	SRF	Software Reuse File	Contractor	x			
		Sw Validation Specification	Contractor			x	
DJF	SVerP	Sw Validation&Verification Plan	Contractor			x	
	SVR	Sw Validation Report	Contractor				x
	SPAP	Sw Product Assurance Plan	Contractor			x	
	SUITP	Sw Unit & Integration tests Plan	NA			x	
		Budget Report	Contractor				
		SRS/SVS Traceability Matrix	Contractor		x		
		SRB/SVS Traceability Matrix	Contractor		x		
		SRS/SDD Traceability Matrix	Contractor		x		
		Sw Product Assurance Report	Contractor/CEA				X

Table 2: Document Requirement List.

7.2 Work Package 2: Flight Software

7.2.1 Task 3: Development of a minimal NMS demonstrator usable in the context of the FlatSat demonstrator.

7.2.1.1 Objective

A FlatSat platform shall be demonstrated early in the project. The DPU is not supposed to deliver any functional operations. The hardware consists in a standard a Zinq AP7030 development kit with a RS232 interface capable to reach 921k bps. At the beginning of the project, CEA and contractor shall agree on the platform. The objective is to demonstrate some basic communications based on the PUS protocol on a reliable communication link. In terms of software, generic components: LVCUGEN, XtraTum and LibPUS shall be used. The applicative partition will maintain fake observables for Service 3 and generate random data for Service 20 telemetry in order to maintain a certain baud rate.

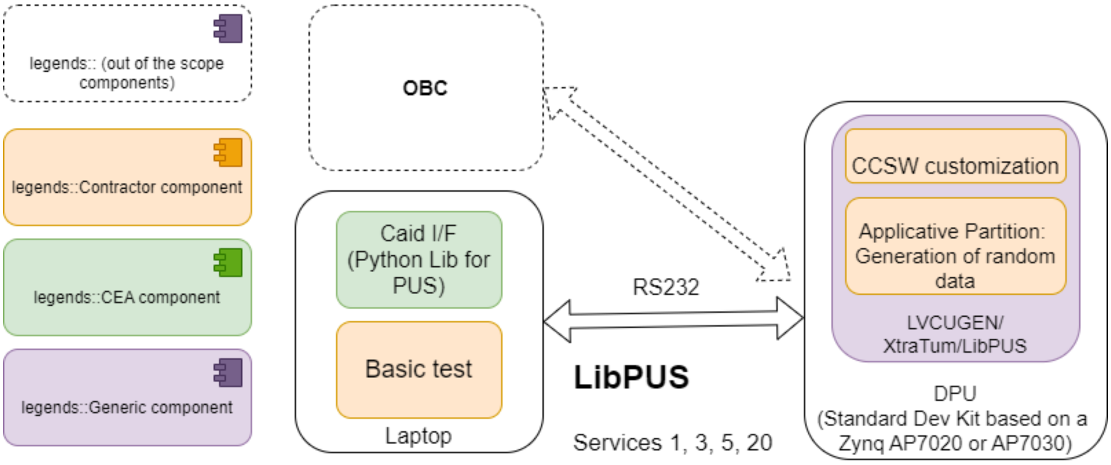

Figure 5: Minimal NMS demonstrator

Some basic scripts shall be developed by the contractor to test the communication from a PC connected with the embedded platform through RS232. CEA will provide a Python library to pack PUS TC/TM frames.

7.2.1.2 Requirements

R3-1 The platform shall be based on the LVCUGEN and XtraTum versions provided by CNES.
R3-2 The communication interface shall be based on LibPUS provided by CNES
A centralized implementation of LibPUS in a CCSW partition is preferred.
R3-3 A robustified data link layer protocol shall be implemented to robustifiy the communication over RS232
Without an additional protocol layer, any byte loss would disrupt communication, as no recovery mechanism is currently in place. A lightweight data link layer (such as KISS protocol) needs to be implemented to detect errors and enable recovery.
R3-4 The demo platform shall support a minimal set of TC/TM: Cf TC/TM plan for the minimal NMS demonstrator.

A minimal TC/TM command set consists in the default commands supported by LibPUS and LVCUGEN plus scientific TM filled with randomly generated payloads.	
R3-5	Provides an additional PUS service for Science Data
The plan is to stress the communication interface with large TM filled with scientific data (random data). LibPUS shall be extended with support for Service 20 or any User PUS Services.	
R3-6	If not part of the A RS422 driver shall be implemented driven by the IO Server partition
PUS messages are transmitted over RS422 serial lines at 900 kbps between the OBC and the NMS DPU. A driver, interfaced with the IOServer partition, needs to be developed.	

7.2.1.3 List of dependencies (provided by CEA)

D3-1.	TC/TM plan for the minimal NMS demonstrator	CEA
A minimal set of TC/TM commands (Services 1, 3, 17 and 20) shall be implemented. The objective is to test the communication interface between the OBC and the NMS DPU. Scientific payloads generated from random data are transferred through the Service 20 or any User PUS Services to stress the communication interface.		
D3-2.	Data Link layer specification	CEA
The partner responsible for the OBC must also implement this protocol.		
D3-1.	CAID Interface	CEA

7.2.1.4 Expected deliveries

L3-1	Detailed Specification
L3-2	Unit tests to validate and qualify the implementation of the KISS protocol in the RS232 driver
L3-3	Binary and source code of the minimal NMS demonstrator.
L3-4	Detailed description including the user manual

7.2.2 Task 4: Support to develop the applicative LVCUGEN partition interfaced with the APPDK sandbox.

7.2.2.1 Objective

Using a complete LVCUGEN solution to develop and test a partition would slow down the process. CNES has developed an Application Development Kit (APPDK) to facilitate the maturing of a partition and the final integration of the system.

The objective of CEA is to embed the code used for unit test into a partition and to test it using another sandbox partition to emulate the communication. CEA is expecting from the contractor expertize from the development flow and guidelines to put in place the test bench.

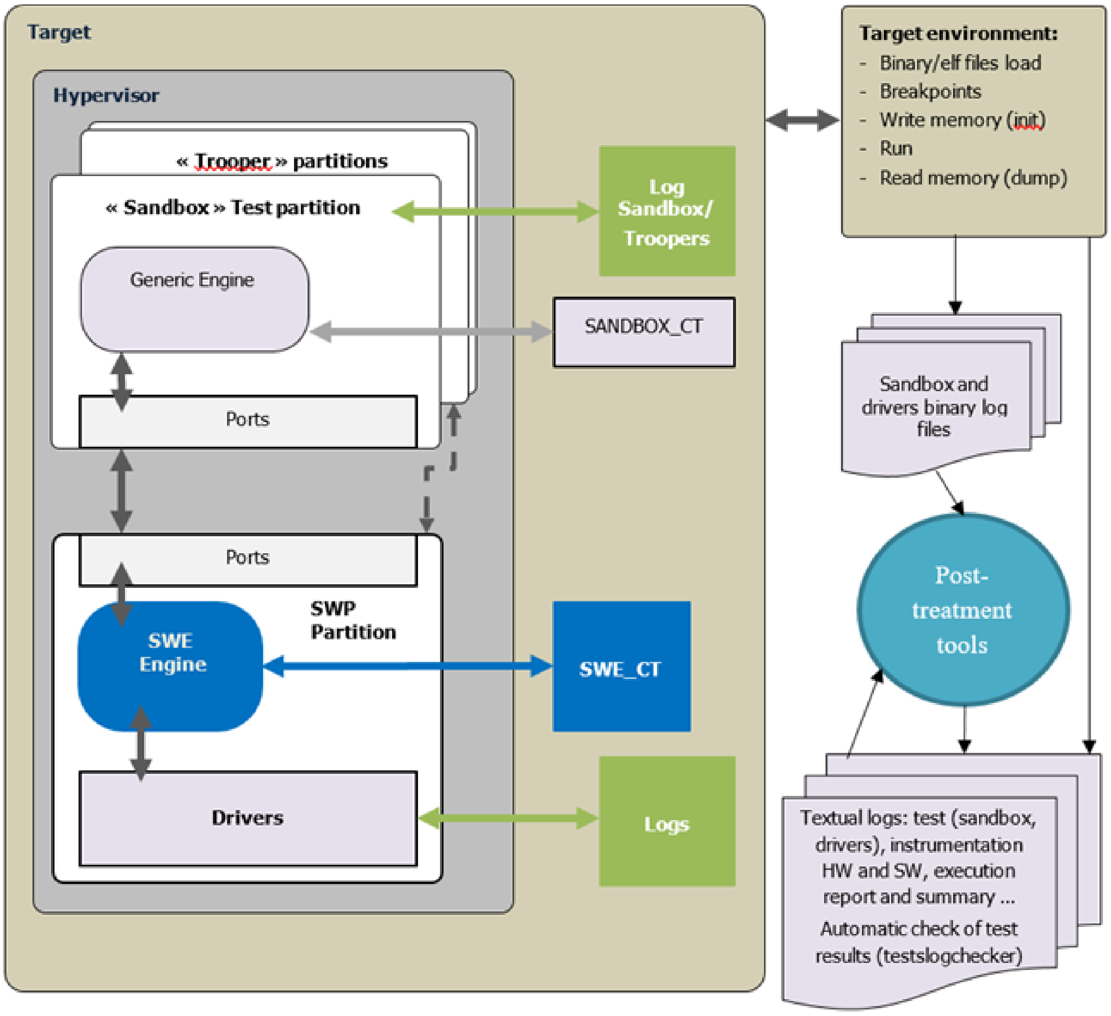

Figure 6: Sandbox test environment.

The platform used for this task will be the Engineering Model of the DPU.

The partition developed in this task will be integrated in the full LV during the Task 5.

7.2.2.2 Requirements

R4-1 The contractor shall provide a development kit ported on the Engineering Model (EM) of the DPU.
R4-2 The sample partition shall include with a real-time scheduler with synchronization primitives. The RTOS reference has to be confirmed.

R4-3	The development kit shall be based on APPDK provided by the CNES.
R4-4	The contractor shall support CEA to embed the source code developed for unit tests into the partition.
R4-5	The contractor shall support CEA to write some integration tests within the sandbox partition.

7.2.2.3 List of dependencies provided by CEA

D4-1.	Access to the EM DPU HW platform
NMS DPU platform is based on a Zynq AP7030. There are few DPUs manufactured. CEA will grant access to the Contractor to the platform.	
D4-2.	DPU Hardware Platform description
A full description of the platform will not be available at this stage of the project. Nevertheless, CEA will provide a basic description including the memories attributes and the description of the serial interface.	

7.2.2.4 Expected deliveries

L4-1	A basic exemple of a partition testbench based on the Application Development Kit
L4-2	A two days training on how to use the APPDK and develop test scripts to stress a partition. Training materials (slides, …) are part of the delivery.

7.2.3 Task 5: Integration and Qualification of the Flight Software.

7.2.3.1 Objective

The contractor is in charge of the integration qualification of the flight software including the activities illustrated in Figure 7: LV components providers..

- The contractor is in charge of the qualification of the CCSW partition from the CC-DK provided by CNES including LibPUS and a Qualification package.
- The contractor is in charge of the development and qualification of NVM drivers used by the MMDL partition,
- The contractor is in charge of the adaption and qualification of the watchdog driver used in the HSEM partition
- The contractor is in charge of the development and qualification of the RS422 driver
- The contractor is in charge of the integration of the Applicative software with the Boot software provided as a generic component.

CEA will provide a validated MSW partition (using the APPDK delivered in Task 2).

The contractor is in charge of the Boot SW. CNES provides the source code of the Boot Sw developed for a Zynq AP7030 on a Ninano platform. This one has to be adapted to the NMS hardware platforms. This BootSW does not embed any upload functionalities. The upload of a new ASW or a partition is possible using PUS 6 services.

At this stage of the project, the plan if to store the BootSW in a QSPI memory, ASW, parameter and event tables in NAND and contextual data in FRAM (OBT, modes, boot context…).

Mechanisms to upload and boot an ASW are critical to the mission (Criticality Level B). For the rest the criticality constraints can be relaxed.

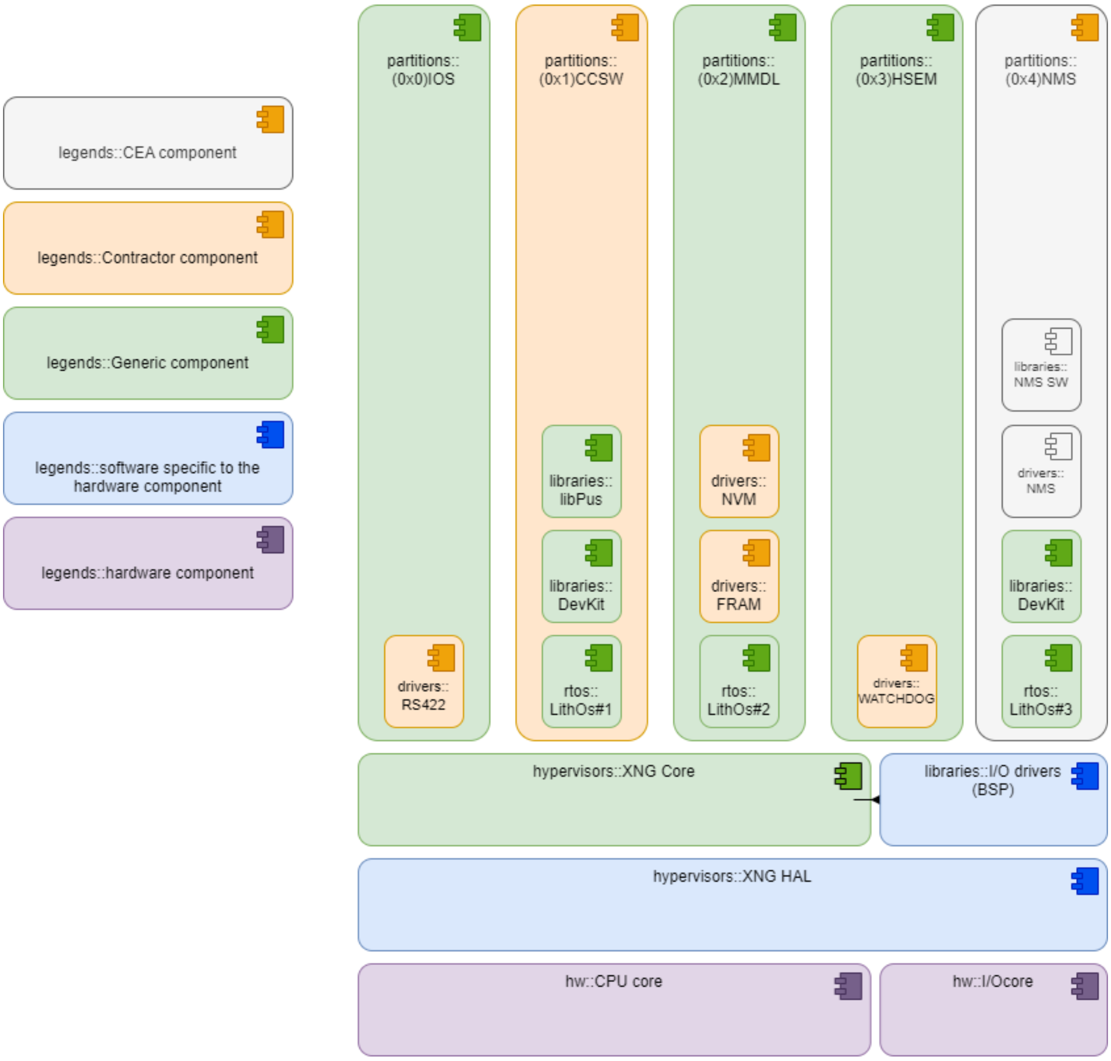

Figure 7: LV components providers.

As illustrated au-dessous, the test platform will consists in an EGSE connected directly to the EDU or to the EQM through RS422. CEA will develop a software library in Python to send and receive TC from a laptop through the EGSE. The EGSE will implement the same datalink layer as the DPU.

It will be possible to write scripts in python to send and receive TC/TM to validate functional scenarios.

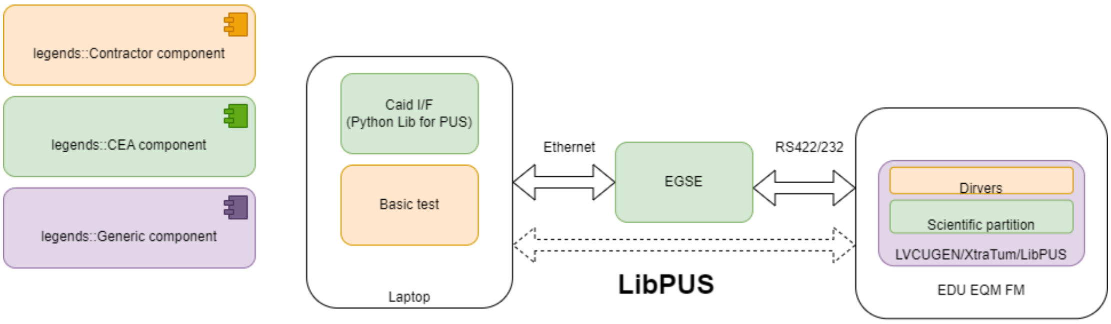

Figure 8: Test platform

7.2.3.2 Requirements

R5-1 Activities will be conducted as specified by the rules defined in Management and Quality Work Package.
R5-2 Nonscientific partitions shall be executed executed on Core 0. The scientific NMS partition shall be executed in parallel on core 1.
The Zynq AP7030 is equipped with a dual-core Arm Cortex-A9 processor. The objective is to simplify the temporal partitioning and to secure the integration process. CEA will develop and validate the NMS partition using a single code.
R5-3 The contractor shall rely on the components provided by the client.
• LV_ROOT • XNG • LithOS (To be confirmed) • IOServer • MMDL • HSEM • CCDK • APPDK
R5-4 The contractor shall develop a CCSW partition including LibPUS to support the following services: 1, 3, 5, 6, 8, 9, 17 and 20. (Criticality level B)
R5-5 The contractor shall configure IO server partition to meet the needs of the LV.
R5-6 The contractor shall robustify the serial driver (datalink layer) and adapt it to a new RS422 HW IP.
R5-7 The contractor shall develop the memory drivers and integrate them in the MMDL partition.
The memories concerned are: QSPI, NAND and FRAM. (Criticality level B)
R5-8 The contractor shall configure MMDL partition to meet the needs of the LV.

R5-9 The contractor shall develop a watchdog driver compatible to the HSEM partition (criticality level B).	
R5-10 The contractor shall configure HSEM partition to meet the needs of the LV.	
R5-11 The contractor shall adapt the generic ZBSW to the platform DPU.	
R5-12 The contractor shall apply the quality process described in DA 4 and DA 5 for a qualification of level B for nonscientific partitions.	

7.2.3.3 List of dependencies provided by CEA

D5-1. Access to the FM HW platform	
NMS DPU platform is based on a Zynq AP7030. There are few DPUs manufactured. CEA will grant access to the Contractor to the platform.	
D5-2. CEA will grant access to LVCUGEN and Hypervisor licences.	
D5-3. LVCUGEN Applicative partition	
This partition will be developed by CEAbased on the development framework developed in Task 3.	
D5-4. HSEM configuration: • Partition monitored • Events configuration • Scheduling plan of the HSEM activities • Memory areas to scrub	Contractor + CEA
There is only one MSW partition to monitor.	

7.2.3.4 Expected deliveries

L5-1 Metrics and budget of the flight software (Nonscientific partitions) and the boot software complying with the corresponding criticality Level:

- **D1-1** Lines of code
- **D1-2** Lines of comment
- **D1-3** Number of VT/Analysis
- **D1-4** Number of UT
- **D1-5** Coverage
- **D1-6** NVM size
- **D1-7** RAM size

Metrics	Target
CPU margin	30%
Memory margin	30%
Code Coverage	30%

Cyclomatic complexity	10
Imbrication de branches	5
Lines of Code per function	60
Frequency of comments	30%

L5-2	Boot-SW source and binaries
L5-3	Watchdog driver compatible with the HSEM requirements
L5-4	NVM drivers compatible with the SSIS API used by the MMDL partition
L5-5	Flight Software source and binaries

7.3 On-request Services during AIT/AIV in flight acceptance and Post-warranty Support&Maintenance.

7.3.1 Objective

Once Task 5 has been completed, for the following 24 months, CEA may request out-of-scope services, such as software modifications or bug fixes. The warranty covers bug fixes for a period of 12 months, after which any further bug corrections will be treated as non-included services.

A portion of the budget is reserved for these additional support and maintenance activities. If required, CEA will submit a request to the contractor via letter or email.

It is difficult to anticipate the details of these activities, which is why they are not defined as specific tasks within the project but are instead considered as « out-of-scope services".

7.3.2 Requirements

R6-1	The contractor shall quote the service requested by CEA in term of effort for Junior/Confirmed/Senior engineers.
R6-2	LV The contractor must be able to make corrections, implement updates to its supplies by validating these updates, and perform non-regression testing campaigns.

7.3.3 Expected deliveries

L6-1	The updated documentation as specified in Task2.
L6-2	The updated flight software and collaterals as specified in Task5.

8 Scheduling

Temporal constraints on the project are very strong. The satellite has to be ready for launch 36 month after the project kickoff. Integration will take place late in the scheduling, it has to be anticipated as much as possible. The number of iterations during AIT/AIV phases will be also limited.

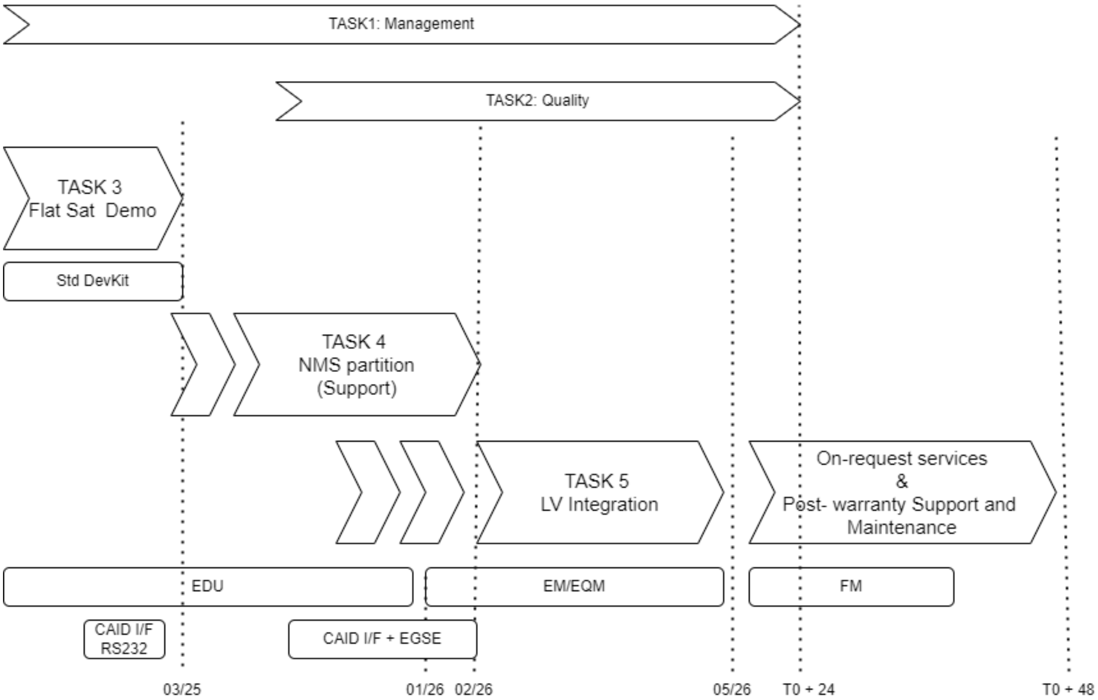

Figure 9: Scheduling and deadlines.

Access to the EM/EQM platforms will be very limited. However, changes between the EDU and EM/EQM do not concern nonscientific partitions. Task 5 can be anticipated in 2025 using EDU platforms. CEA tries to open the access to the platform through a connected PC tele operable. This solution has to be confirmed. Visiting CEA offices for tests and validation for short periods is also possible.

9 Deliveries summary

CEA will open a private source forge shared with the contractor (based on Tuleap). Source code delivered shall be delivered through this infrastructure. It should be possible to list sub tasks and issues through the web portal.

T0 : Project Kickoff

Ref	Delivery	Estimated Deadline
L1-1	Regularly report to the client (monthly) on the progress of the project (schedule, critical points)	Every Half-year
L1-2	Control the software life cycle process and prepare the SRR, PDR, DDR, QR and AR reviews in accordance to the ECSS-E-ST-40C document.	T0 + 18 SRR, PDR, DDR T0 + 24 QR, AR
L2-1	Support on the Software Requirement Specification redaction.	T0 + 12
L2-2	DRL	T0 + 12 documents due for DDR T0 + 24 rest of the documentation
L3-1	Detailed Specification	T0 + 3
L3-2	Unit tests to validate and qualify the implementation of the KISS protocol in the RS232 driver	T0 + 3
L3-3	Binary and source code of the minimal NMS demonstrator.	T0 + 3
L3-4	Detailed description including the user manual	T0 + 3
L4-1	Application Development Kit	T0 + 6
L4-2	Training materials	T0 + 6
L5-1	Metrics and budget of the flight software (Nonscientific partitions) and the boot software	T0 + 18
L5-2	Boot-SW source and binaries	T0 + 18
L5-3	Watchdog driver compatible with the HSEM requirements	T0 + 18
L5-4	NVM drivers compatible with the SSIS API used by the MMDL partition	T0 + 18
L5-5	Flight Software source and binaries	T0 + 18
L6-1	The updated documentation (as specified in Task2)	On request services.
L6-2	The updated flight software and collaterals.	On request services.

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