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# C<sup>3</sup>IEL MISSION

CLUSTER FOR CLIMATE AND CLOUD IMAGING OF  
EVOLUTION AND LIGHTNING

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## PAYLOAD STATEMENT OF WORK

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19 AUGUST 2019  
VERSION 0.53

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## APPENDIX: PAYLOAD STATEMENT OF WORK (SOW)

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Cluster **C**limate and **C**loud **I**maging of **E**volution and **L**ightning - C<sup>3</sup>IEL 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

This appendix defines the Statement of Work (SOW) requirements for PayLoad (PL) of C3IEL system. Its design, implementation, including development, analysis, test, integration, documentation, verification and operation.

# 1 SOW REQUIREMENTS FOR C3IEL PAYLOAD

## 1.1 TOP LEVEL SOW REQUIREMENTS

### **The contractor shall:**

- [SOW-1] Design the HW of the Payload (PL) subsystem
- [SOW-2] Design and implement the SW of the PL.
  - [SOW-2.1] Including: develop, analyze, code, test, integrate, document, verify performance of the SW of the PL
- [SOW-3] Design and implement the FW of the PL.
  - [SOW-3.1] Including: develop, analyze, code, test, integrate, document, verify performance of the FW of the PL
- [SOW-4] Design, on the PL side, the interfaces between the PL and the Platform (PF)
  - [SOW-4.1] Mechanical interfaces
  - [SOW-4.2] Electrical interfaces
  - [SOW-4.3] Electronic interfaces
- [SOW-5] Design, the mechanical packaging of the PL to be fitted in the nanosatellite.
  - [SOW-5.1] To be fitted in an L shape 3U volume of each PF nanosatellite
- [SOW-6] Run and perform the structural analysis of the PL in the context of the PF
- [SOW-7] Run and perform the thermal analysis of the PL in the context of the PF
- [SOW-8] Run and perform the failure analysis and management of the PL in the context of the PF
  - [SOW-8.1] Propose failure mitigations
- [SOW-9] Run and perform the risk analysis and management of the PL in the context of the PF

## 1.2 PROTOTYPE FOR FEASIBILITY

### **The contractor shall:**

- [SOW-10] Design and build a prototype of a clouds imager
  - [SOW-10.1] Evaluate the features and performance of the clouds imager
- [SOW-11] Design and build a prototype of a Water Vapor (WV) camera
  - [SOW-11.1] Evaluate the features and performance of the Water Vapor camera
- [SOW-12] Design and build a prototype of a lightning camera
  - [SOW-12.1] Design and build a prototype of PMT photometer

- [SOW-12.2] Design and build a prototype of Photodiode photometer
- [SOW-12.3] Evaluate the features and performance of the Lightning camera with each photometer
- [SOW-13] Evaluate the features and performance of cameras combinations Including:
  - [SOW-13.1] Clouds imager + WV camera
  - [SOW-13.2] Clouds imager + Lightning camera
  - [SOW-13.3] WV camera + Lightning camera
  - [SOW-13.4] Clouds imager + WV camera + Lightning camera

### 1.3 BREADBOARDS AND ENGINEERING UNITS FOR FEASIBILITY

**The contractor shall design, build and deliver (on completion of Phase A):**

- [SOW-14] On completion of Phase A: Concept and Technology Development
  - [SOW-14.1] Concept and system concept definition
  - [SOW-14.2] Simulation analysis
- [SOW-15] Participate in system's reviews (internal and external reviews, in France or in Israel). Including:
  - [SOW-15.1] System Requirements Review (SRR)
  - [SOW-15.2] Mission Definition Review (MDR) and/or
  - [SOW-15.3] System Definition Review (SDR)

**The contractor shall design, build and deliver (on completion of Phase A +):**

- [SOW-16] On completion of Phase A+: Breadboards and engineering units
  - [SOW-16.1] Deliver working breadboards
  - [SOW-16.2] Deliver engineering units for feasibility studies
  - [SOW-16.3] Engineering models and Mock-ups

### 1.4 PROGRAMATIC ISSUES

**The contractor shall design, build and deliver (HW, SW, and FW deliverables):**

- [SOW-17] Two (2) Engineering Model (EM) payloads
- [SOW-18] Two (2) Qualification Flight Model (QFM) payloads
- [SOW-19] Two (2) Flight Model (FM) payloads
- [SOW-20] Upon request: An optional extra Flight Model (FM) payload
- [SOW-21] Breadboard models for feasibility studies at the end of phase A and A+

### 1.5 MILESTONES, STATUS, MEETINGS, AND REPORTS

**The contractor shall prepare, submit and participate:**

[SOW-22] Project's periodic monthly status meetings (on top of design reviews)

[SOW-23] Report on delivery of milestones including:

[SOW-23.1] HW and its sub-systems milestones

[SOW-23.2] SW milestones

[SOW-23.3] FW milestones

[SOW-24] Cost estimates including:

[SOW-24.1] HW and sub-system estimated cost

[SOW-24.2] SW and Coding estimated cost

[SOW-24.3] FW sub-system and Coding estimated cost

[SOW-24.4] Mechanical estimated cost

[SOW-25] Payment major milestones:

## 1.6 SW + FW DELIVERABLES

**The contractor shall deliver:**

[SOW-26] All SW source code with comments

[SOW-26.1] SW documentation

- i. SW user manual
- ii. SW programmers manual
- iii. SW test environment

[SOW-27] All FPGA source code with comments

[SOW-27.1] FW documentation

- i. FW user manual
- ii. FW programmers manual
- iii. FW testing environment

## 1.7 CONTRACTOR'S PARTICIPATION

**The contractor shall:**

[SOW-28] Participate in the integration process for planned periods of time in:

[SOW-28.1] System HW integration

[SOW-28.2] System SW integration

[SOW-28.3] System FW integration

[SOW-29] Participate in the Acceptance Test (ATP) process for planned periods of time in:

[SOW-29.1] Modules and sub-systems ATP

[SOW-29.2] System ATP

[SOW-30] Participate in the verification process for planned periods of time in:

[SOW-30.1] Modules and sub-systems verification

[SOW-30.2] System verification

[SOW-31] Participate in the SW Test process for planned periods of time in:

- [SOW-31.1] Modules and sub-SW tests
- [SOW-31.2] System SW tests
- [SOW-31.3] Mechanical, electrical and electronic interfaces documentation
- [SOW-31.4] Documentation of analysis results and budgets calculations
- [SOW-32] Write, process, and deliver Monthly Status Reports

## 1.8 QUAL TESTS

### **The contractor shall:**

- [SOW-33] Design, develop, prepare, components and sub-systems to be ready for partial Qual tests. Including:
  - [SOW-33.1] Sensors
  - [SOW-33.2] FPGA's
  - [SOW-33.3] Electronics
  - [SOW-33.4] Support power supplies
- [SOW-34] Perform the required Qual tests

## 1.9 SYSTEM REVIEWS

### **The contractor shall:**

- [SOW-35] Develop, process, prepare, document and make the design data available for the system's reviews (both internal and external reviews).
- [SOW-36] Participate in the system's reviews (both internal and external reviews, in either France or in Israel). Including:
  - [SOW-36.1] Mission Concept Review (MCR)
  - [SOW-36.2] System Requirements Review (SRR)
  - [SOW-36.3] Mission Definition Review (MDR) and/or
  - [SOW-36.4] System Definition Review (SDR)
  - [SOW-36.5] Preliminary Design Review (PDR)
  - [SOW-36.6] Critical Design Review (CDR)
  - [SOW-36.7] System Integration Review (SIR)
  - [SOW-36.8] Mission Readiness Review (MRR)
  - [SOW-36.9] Operational Readiness Review (ORR)
  - [SOW-36.10] Launch Readiness Review (LRR)
  - [SOW-36.11] Disposal Readiness Review (DRR)

## 1.10 DOCUMENTATION

### The contractor shall:

[SOW-37] Write, process, and deliver the system documentation. Including:

[SOW-37.1] HW, SW, and FW documentation

[SOW-37.2] Mechanical, electrical and electronic interfaces documentation

[SOW-37.3] Documentation of analysis results and budgets calculations

- i. Feasibility studies
- ii. Structural analysis
- iii. Thermal analysis
- iv. Failure analysis
- v. Risk analysis
- vi. Mass budget calculations
- vii. Electricity budget calculations
- viii. Communication budget calculations
- ix. Mass storage budget calculations

[SOW-38] Write, process, and deliver Monthly Status Reports

## 1.11 ENVIRONMENTAL TESTS

### The contractor shall:

[SOW-39] Design develop define, run tests, process results of the Environmental Tests. Including:

[SOW-39.1] Vibration tests

[SOW-39.2] Thermal tests

[SOW-39.3] Thermal vacuum tests

[SOW-39.4] Physical characteristics tests

[SOW-39.5] Structural and Mechanical Verification

[SOW-39.6] Electromagnetic Compatibility Verification

[SOW-40] Participate in the integration process for planned periods of time in