Inspire-Sat, un nouveau satellite du LATMOS en orbite depuis avril 2023
INSPIRE
From Teaching Tools to Sun and Earth Observation Satellites

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The International Satellite Program in Research and Education (INSPIRE) is a global consortium of space universities formed to advance space science and engineering, spearheaded by the Laboratory for Atmospheric and Space Physics of the University of Colorado at Boulder (CU Boulder-LASP) and its international academic partners. Each INSPIRE small satellite (Figure 1) typically proceeds from concept to flight in three years, providing the opportunity for undergraduate and graduate student involvement in small satellite design, implementation, testing, and operations. INSPIRE brings science, engineering, and management to campuses across the globe. The INSPIRE program aims to provide a constellation of Earth and space weather observing satellites. To date, eight satellites are part of this program.

INSPIRE universities involved in this program are:

- The University of Colorado at Boulder (CU Boulder), USA
- The University of Versailles (UVSQ), France
- The National Central University (NCU), China: Academy of Sciences Located in Taipei
- Nanyang Technological University (NTU), Singapore
- The Indian Institute of Space Science and Technology (IIST), India
- The University of Iowa, USA
- The University of Alberta (UoA), Canada
- Sultan Qaboos University at Muscat (SQU), Oman
- Kyushu Institute of Technology (Kyutech), Japan
- Research Centre Jülich, Wuppertal University, Germany

The INSPIRE programme aims to provide a constellation of Earth and space weather observing satellites.
INSPIRE-Sat ...

Inspire-Sat 1  
*Launched on Feb. 2022*

Inspire-Sat 2  
*Launched on Jan. 2021*

Inspire-Sat 3  

Inspire-Sat 4  
*Launched on Jul. 2023*

Inspire-Sat 5  
*Launched on Jan. 2021*

Inspire-Sat 6  

Inspire-Sat 7  
*Launched on Apr. 2023*

Inspire-Sat X
Timeline

**UVSQ-SAT (Inspire-Sat 5)**

- **Studies** + **Manufacture**
  - 2018
  - Tests
  - 13/03/2021

- **Exploitation**
  - 24/01/2021

- **End of Life**
  - 24/01/2024 ?

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**Inspire-Sat 7**

- **Studies** + **Manufacture**
  - 2020
  - Tests
  - 15/04/2023

- **Exploitation**
  - 15/04/2023

- **End of Life**
  - 15/04/2026 ?

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**UVSQ-SAT NG (Inspire-Sat X)**

- **Studies** + **Manufacture**
  - 2021
  - Tests
  - 13/03/2025

**Phases 0/A, B, C, D**

**Phase E**

**Phase F**

**Tests**

**End of Life**
General objectives of Inspire-Sat 7

- **(1) Science**: Earth observation, Climate physics, ERB, Solar physics, …

- **(2) Education & outreach**: Satellite, Payload development, Software development, Training material.
  - Enable students to move towards Nanosat via start-ups in creation
  - Foster the emergence and development of start-ups in the Nanosat field
  - Make the space field more accessible to technicians
  - Create new vocations
  - Thinking about tomorrow's jobs
  - Promote the ‘Space Academy of Île-de-France’

- **(3) Technology demonstration**: Satellite, Payload, Spectrometer, Telescope
  - Instruments miniaturization for Earth observations and solar physics
  - Instruments validation & satellites constellation validation for Earth observations
  - Validation of new low mass, low power and compact design instruments that incorporate artificial intelligence on future space flights
  - Facilitate collaboration with industrial partners
  - Amateur radio payload (SPINO)
Inspire-Sat 7

1. Etudes + Réalisations
2. Exploitation
3. Fin de vie

Tests
15/04/2023
30/04/2023
01/04/2027

Utilisation des données
Inspire-Sat

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**PAYLOAD**
- IMU
- TOTEM
- Oledcomm
- Radio-amateur
- Main board

**PLATFORM**
- DB
- OBC
- EPS
- TRXVU
- Battery
- MTQ

LATMOS
Inspire-Sat

- (1) Space segment
Inspire-Sat

**SPINO**

- **Uplink**: 145.830MHz
- **Downlink**: 435.200MHz

<table>
<thead>
<tr>
<th>Mode 1</th>
<th>Mode 2</th>
<th>Mode 3</th>
<th>Mode 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TX / RX</strong></td>
<td><strong>TX Only</strong></td>
<td><strong>TX Only</strong></td>
<td><strong>TX Only</strong></td>
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<tr>
<td>Modulation</td>
<td>2FSK (no deviation filter)</td>
<td>2GFSK (gaussian deviation filter, BT=0.5)</td>
<td>4GFSK (gaussian deviation filter, BT=0.5)</td>
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<tr>
<td>Datarate</td>
<td>2400bits/s</td>
<td>9600bits/s</td>
<td>10800bits/s</td>
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<td>Deviation</td>
<td>1200Hz</td>
<td>4800Hz (+/-4800Hz, meaning modulation index is 1)</td>
<td>4212Hz (+/-4212Hz, meaning modulation index is 0.76)</td>
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<tr>
<td>Preamble</td>
<td>16x &quot;0xAA&quot;</td>
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<td>Sync Word</td>
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<tr>
<td>(32bits)</td>
<td>0x2EFC9827</td>
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<td></td>
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<tr>
<td>Payload length</td>
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</table>
Inspire-Sat
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Inspire-Sat

- (2) Ground segment – MOC
Inspire-Sat
**Inspire-Sat**

**Configuration:**
- **Frequency** = 437.410 MHz
- **Demodulation** = BPSK
- **De-scrambling** = G3RUH
- **Baud rate** = 4200, 9600

**Multi-Software chain**
- BPSK G3RUH 9600 bps
  - VB-Cable, SDR#, SoundModem, AMSAT-F KissTool

**Multi-Software chain**
- BPSB G3RUH 1200 bps
  - VB-Cable, SDR#, SoundModem, AMSAT-F KissTool

**Load 1W (or other decoding chain)**
Inspire-Sat

Configuration of the coding:
- Frequency = 145.970 MHz
- Modulation = FSK
- Scrambling = G3RUH
- Baud rate = 9600
Inspire-Sat
(3) Ground segment – SOC

1) SOC
   - Database InfluxDB
   - Treatments (L0, L1, L2…)
   - Grafana
   - Automation

2) External access (≠ official website):
   - sFTP (json files)
   - Web (SIDS+ Quickview + NEW: Pictures)
   - Database MySQL

3) Developpements and tests
Inspire-Sat

- Launch with Transporter 7 – 15 April 2023
Inspire-Sat
Inspire-Sat

Welcome to Inspire-Sat 5/7 RX Dashboard

Note that all data in this dashboard are receipt data, not acquisition ones.

To switch to SAT 7 Dashboards:
1. HOUSSEIDING
2. SCIENCE

To switch to SAT 5 Dashboards:
1. HOUSSEIDING
2. SCIENCE

Number of TCs received by SAT 7:
- 14115 Validated TCs
- 6236 Rejected TCs
- 103 Ping TCs

Number of TCs received by SAT 5:
- 1847 Validated TCs
- 2056 Rejected TCs
- 81 Ping TCs

Last information on board satellites (regardless of Grafana timestamps):
- TM since first: 15901708
- TM in SO: 49

Sources SAT 7:

UTC Time
2024/03/15
21:52:26
Inspire-Sat
Inspire-Sat
Inspire-Sat
Inspire-Sat

Sun direction

Nadir direction

Nov 24, 2023

09:00 09:30 10:00 10:30 11:00 11:30 12:00

09:00 09:30 10:00 10:30 11:00 11:30 12:00

X-axis
Y-axis
Z-axis
Inspire-Sat
Inspire-Sat

- ISR [W.m$^{-2}$]
- OSR [W.m$^{-2}$]
- OLR [W.m$^{-2}$]

Mar 06, 2024
Inspire-Sat
Rayonnement solaire réfléchi au sommet de l'atmosphère de la Terre

Données : Uvsq-Sat
Aout 2023
Crédits : LATMOS
Données : Inspire-Sat
Aout 2023
Crédits : LATMOS
Inspire-Sat

Observations depuis l'espace : 15 au 16 août 2023

- Red: Uvsq-Sat
- Blue: Inspire-Sat
Inspire-Sat
Inspire-Sat

SPINO Ecosystem

- Spino Board
- Spino Simulator
- ApplicationSpinoController
- Kisstool
- Amsat-f DataBase

https://amsat.electrolab.fr
Conclusions

Our main scientific goal is:
- To observe essential climate variables with a constellation of small satellites.

The INSPIRE goals are:
- To initiate a Space Program, and to teach courses related to Space.
- To have Laboratory facilities for hardware development and specialized personnel for teaching.
- To have facilities for building and testing CubeSat/small Instruments.
- To have ground stations for satellite operations.

Our positions are:
- To Design for simplicity and robustness:
  – Assume designs will fail and then prove they will work.
  – Design the satellite for easy assembly and disassembly.
  – Have respectable margins, robust safe modes, few deployables, graceful performance degradation, and frequent preventative satellite resets.
- To Build an experienced team—it matters:
  – A successful team has veteran member(s) and frequent informal peer reviews (discussions) with proven subject matter experts.
- To have an excellent cooperation with radio amateurs.