CSES-Limadou Program

P. Diego [a], *on behalf of CSES-Limadou collaboration* [a, b, c]

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b) *INFN Sezione di Roma Tor Vergata, Via della Ricerca Scientifica 1, I-00133 Rome, Italy*
c) *University of "Rome Tor Vergata", Rome, ITALY*

CSES Missions

CSES **(China Seismo-Electromagnetic Satellite)** scientific space missions are dedicated to:

- monitoring electromagnetic field and waves,
- plasma and particle perturbations of the atmosphere, ionosphere and magnetosphere

CSES-01 satellite is in orbit since February 2nd, 2018.
CSES-02 satellite launch is foreseen for December 2022.

High Energy Particle Detector (HEPD)

Search-Coil Magnetometer (SCM)

High Precision Magnetometer (HPM)

Electric Field Detector (EFD)

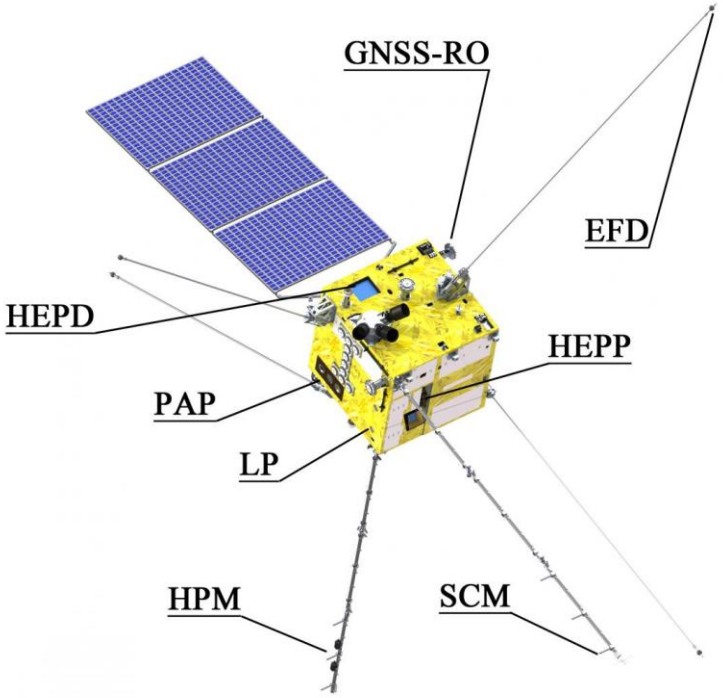
Plasma analyzer (RPA, IDM, ICM)

2 Langmuir probe

GNSS Occultation Receiver

Tri-Band Beacon

Ionospheric Photometer



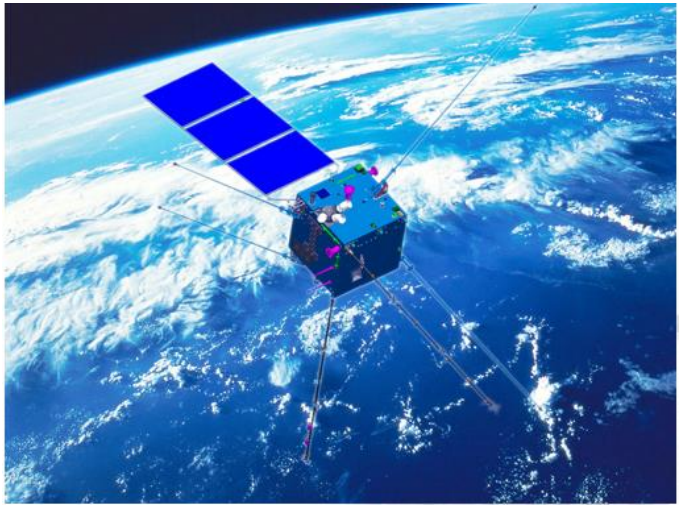
Sun-synchronous orbit (14-02 LT)
Altitude about 500 km

CSES – Limadou

Limadou is the Italian ASI program in the framework of CSES missions

Limadou-1 (2013-2019) Activities:

- HEPD-01 QM and FM development
- Italian EFD-01 EM development
- Chinese EFD-01 test and calibration
- Langmuir probes test and calibration
- Plasma Analyser test and calibration
- Science program (data analysis and validation)



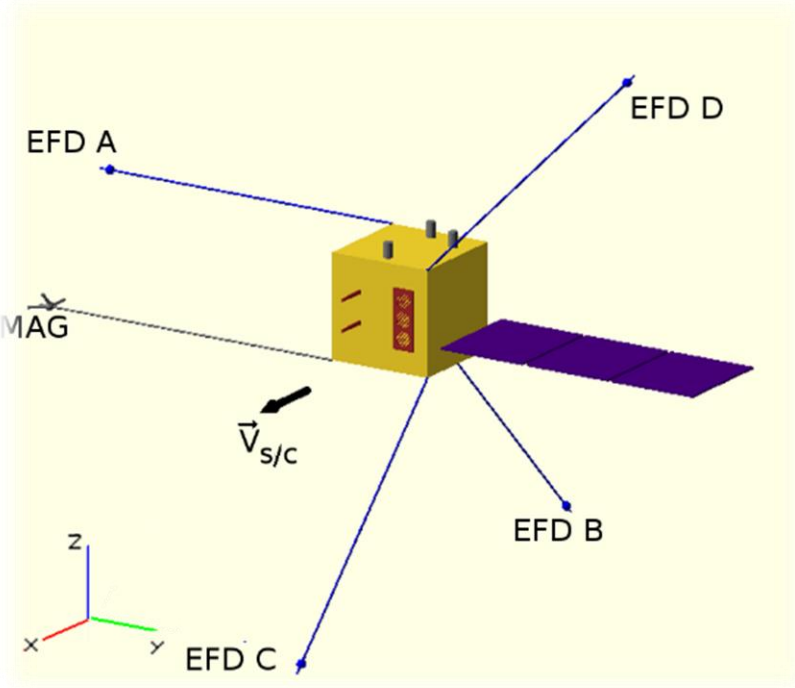
Limadou-2 (since 2020) Activities:

- HEPD-02 QM and FM development
- **Italian EFD-02 EM QM and FM development**
- **Langmuir probes test and calibration**
- **Plasma Analyser test and calibration**

} Leadership INAF

Budget INAF (ASI)
- About **110 k€** for Limadou-1
- About **2.5 M€** for Limadou-2

EFD-02

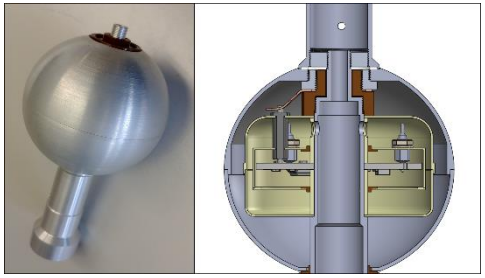


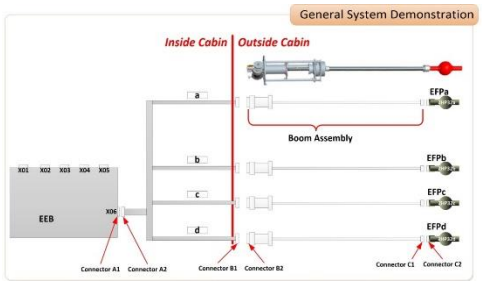
- Four identical probes are located at the tip of four booms deployed from a 3-axes stabilized spacecraft.
- In CSES-01 the booms are 4.5 m long, with a minimum distance between probe pairs of about 6.7 m.

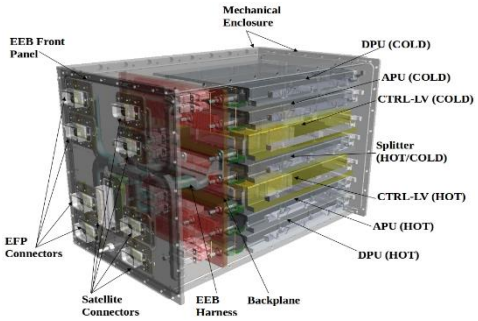
- The difference of the probe's floating potential (V_f) between a given pair of probes, divided by their mutual distance, provides the electric field component along the direction defined by their positions.

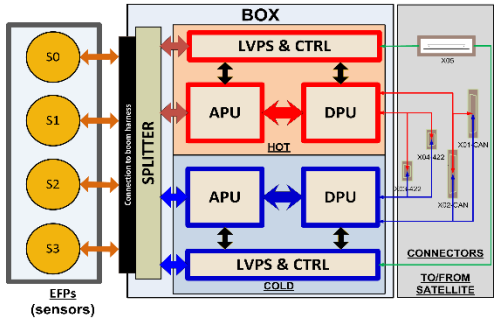
- The electric field is measured for an extended band of frequencies from quasi-DC up to about 3.5 MHz.
- The Sensitivity is of the order of 1μV/m in the ULF band with a dynamic range of 120 dB.

$$E_{ij} = \frac{V_{f_i} - V_{f_i}}{d_{ij}}$$









EFD-02 Subsystems under development are:

-Spherical sensors (EFP)
-Harness
-Electronic box (EEB)
-Back plane (BP)
-Analog unit (APU)
-Digital unit (DPU)
-Low Voltage Power Supply (LVPS)
-Splitter

EFD-02 development schedule

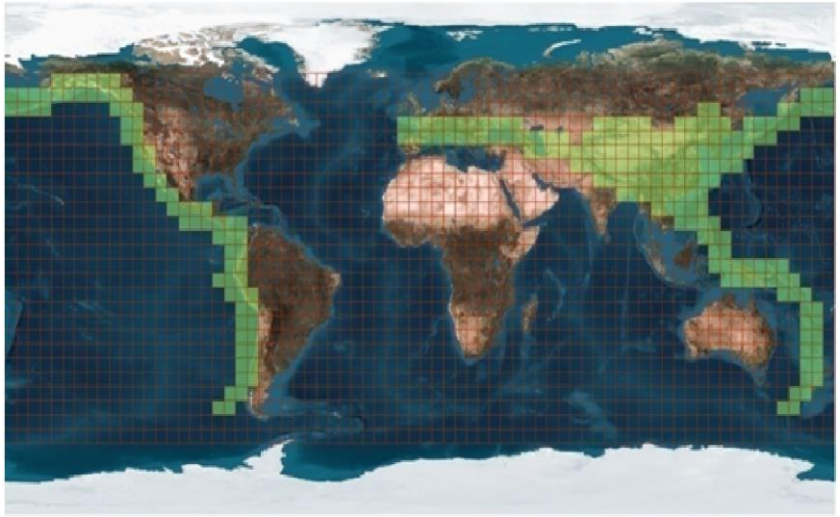
EM; already realized – June 2020
QM; under development – November 2021
FM; under development – March 2023

EFD-02 data output

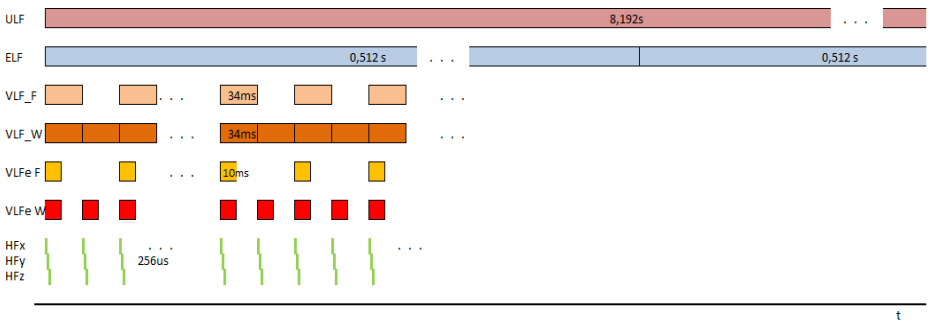
Band	ULF	ELF	VLF FFT	VLF extended FFT	HF FFT	Total
Frequency	DC-100 Hz	15Hz-2kHz	1kHz-30kHz	21kHz-100kHz	21kHz-4MHz	
Sampling (sps)	2.50E+02	4.00E+03	6.00E+04	2.00E+05	8.00E+06	
Bit depth	24	20	16	16	12	
Channels	4	3	3	3	3	
Weight per second (bits)	2.40E+04	2.40E+05	4.32E+06	1.44E+07	4.32E+08	
Weight per day (bits)	2.07E+09	2.07E+10	3.73E+11	1.24E+12	3.73E+13	
%age	100	100	1	0.5	0.032	
Survey weight	2.07E+09	2.07E+10	3.73E+09	6.22E+09	1.19E+10	**4.47E+10**

FFT will be provided as Average values of 50 FFT, with SD and Kurtosys

Run time to fill a 2048 package in ULF (8.192 s)



EFD-02 data scheduler



Burst Mode (Survey + VLF WF for 2h/d)

Total weight is 80 Gbit/day

Scientific targets of EFD-02 measurements

- **ULF band** has been extended up to 100 Hz to improve its reliability in both Space Weather and Ionosphere-Litosphere coupling studies. **Probe potentials** provide useful information to plasma conditions and complete Lp measurements.

- **ELF band** is useful for the detection of secondary emission due to gravito-acoustic waves (order of hundreds Hz).

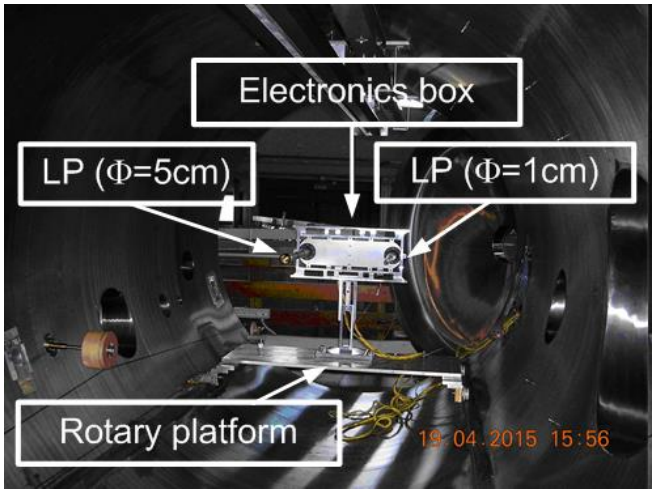
- **VLF** has been splitted in two bands to improve the detection of **Whistler** waves

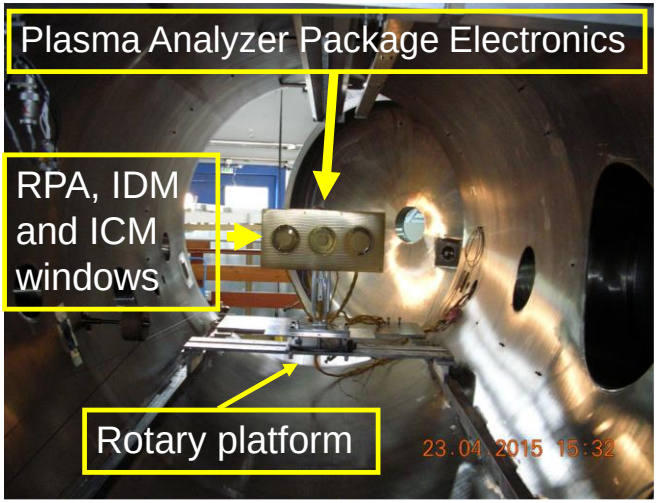
- **VLF extended** – FFT averages together with SD and Kurtosys provide information in higher VLF frequencies without significant loss of information (FFT are computed every 40ms – spatial resolution about 300 m)

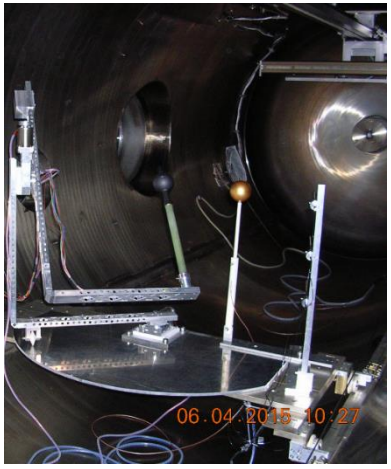
- **HF** – monitoring of fast plasma oscillations (FFT are computed every 16ms – spatial resolution about 120 m)

PLASMA CHAMBER TEST AND CALIBRATION

Chinese payload (Langmuir and Plasma Analyser) are checked and calibrated in the IAPS plasma chamber according to MoU ASI-CNSA







The Plasma Chamber of IAPS (SWIPS) is a facility able to reproduce ionospheric environment relevant to plasma and geomagnetic field conditions encountered along LEO.

A solar simulator to check the sensor's functionality variation under the e.m. solar flux is under development.

The facility will be able to evaluate the effect of IR band (electronics heating) and UV band (induced photoemission)

Team CSES-Limadou-2

Critical issue

The staff-team is mainly composed by technician/technologists

The acquisition of a researcher in plasma physics is needed to continue the CSES program and to the rebirth of experimental plasma research group for next programs

Name	Role	Position	FTE
Diego P.	Responsabile	Ric. Tec III	0.5, 0.5, 0.5
Bertello I.	Ground Segment	TD CTER	0.7, 0.7, 0.7
Cicone A.	Scient. Consultant	Associated	0, 0, 0
D'Angelo G.	Commissioning	AdR	0.5, 0.5, 0.5
Di Giorgio A.	Scient. Consultant	Ric. II	0.2 extra
Fiorenza E.	Sensor Develop.	CTER	0.3, 0.2, 0.1
Galli E.	DPU	Ric. Tec III	0.1, 0.1, 0
Noschese R.	Ground Segment	Ric. Tec III	0.1 extra
Nuccilli F.	MAIT	CTER	0.3, 0.3, 0.3
Piersanti M.	Commissioning	TD Ric.	0.4, 0.4, 0.4
Russi A.	DPU	TD Tec.	0.2 extra
Santoli	PM	Ric. Tec. II	0.1 extra
Tofani S.	DPU	AdR	0.5, 0.5, 0
Ubertini P.	Scient. Consultant	Associated	0.3 extra
Vertolli N.	Test	CTER	0.3, 0.3, 0.3

FTE tot 10.6 (+2 TD not yet acquired)

CSES-Limadou Science+

***P. Diego**, on behalf of Limadou Science INAF team*

Previous program CSES Science (2016-2020)

Budget INAF about 200 k€

Tasks:

- Algorithms for electric and magnetic field CSES data analysis
- Algorithms for the evaluation of geomagnetic field effect in the CSES electric field data
- Analysis and computation of spurious effects in electric fied data
- Solar forcing data base development for CSES data analysis
- Web-site for data and analysis tools sharing

Results:
More than 30 congress contribution and 15 refereed papers

CSES Science+ (2021 – 2024)

Budget INAF 300k€

The main topics of the new **CSES Science+** program are:

1. - Study of correlation among atmospheric, ionospheric, magnetospheric and seismic phenomena with CSES data

2. - Analysis and characterization of Earth's magnetosphere and ionosphere (INAF Leadership)

3. - Solar physics and space weather

INAF-IAPS scientific tasks

1. **LAP Data validation**
2. **EFD-01 data validation**
3. Electromagnetic field properties of auroral oval
4. Algorithms development for time-frequency domain analysis of electric and magnetic data
5. Environmental and instrumental background level detection with multi-scale tecniques
6. Characterization of plasma acceleration processes with EFD and HEPD joint usage
7. Modellization of ionosphere-litosphere coupling processes
8. Ionospheric plasma depletion; modelization and climatology
9. Turbolence in electric and magnetic fields and plasma drift features

Team Limadou Science+

Critical issue

The staff-team is mainly composed by research contract.

The acquisition of a researcher in plasma physics is needed to continue the CSES Science program

Name	Role	Position	FTE
Diego P.	Responsabile	Ric. Tec III	0.3, 0.3, 0.3
Bertello I.	Ground Segment	TD CTER	0.3, 0.3, 0.3
Cicone A.	Scient. Consultant	Associated	0, 0, 0
Consolini G.	WP Leader	Ric II	0.15, 0.15, 0.15
D'Angelo G.	Scientific Ed.	AdR	0.5, 0.5, 0.5
Laurenza M.	Scient. Consultant	Ric III	0.1, 0.1, 0.1
Marcucci F.	Scient. Consultant	Ric III	0.1, 0.1, 0.1
Piersanti M.	WP Leader	TD Ric.	0.6, 0.6, 0.6
Quattrociochi V.	Scientific Ed.	AdR	1, 1, 0
Ubertini P.	Scient. Consultant	Associated	0.2 extra
TBD	Team member	TD Ric	1, 1, 1
TBD	Student	PhD	1, 1, 1

FTE tot 14.35

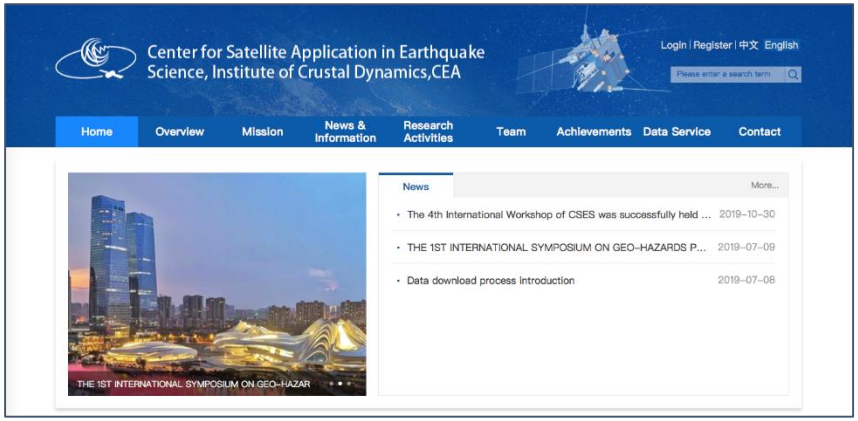
Useful Links

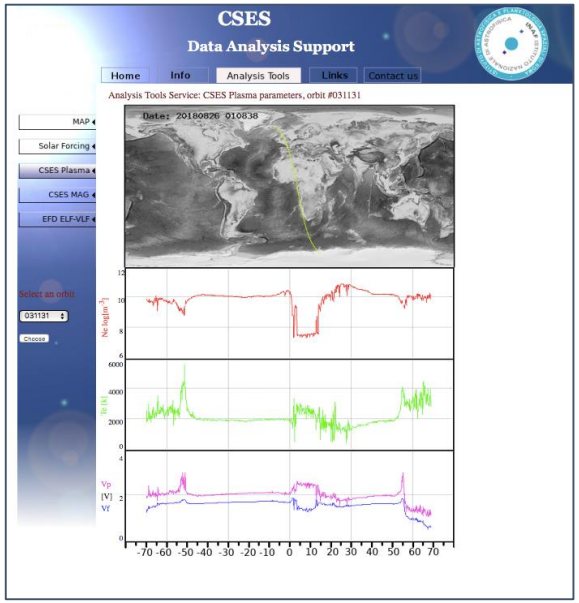
for general information

http://cses.roma2.infn.it

http://www.iaps.inaf.it/2020/09/30/cses-limadou-2/

http://www.leos.ac.cn/#/home
data download service





http://cses.iaps.inaf.it/

IAPS web site provides tools for supporting the CSES data analysis