


Electric Propulsion Diagnostic Package Instruments

- Heritage and Prospects-

 **FINMECCANICA**
AIRBORNE & SPACE SYSTEMS DIVISION



EPDP – Instrument Overview and motivations

[#1 of 2]

Since the time of the Artemis mission, the EP team based on Florence former PROEL/LABEN/ALENIA ALCATEL/THALES and, nowadays, within the FINMECCANICA Airborne & Space Systems division, was involved in the development of Electric Propulsion Diagnostic Package instruments. The aim of these instruments is the monitoring of the interaction between the S/C and the onboard Electric Propulsion system.

Indeed it is known that various phenomena might, in principle, appear in presence of active plasma generators on board a S/C during a mission:

- S/C charging on depending specific thruster plumes parameters, satellite geometry and grounding philosophy;
- S/C discharging in case of external induced charging events;
- Interaction with Payload or S/C surfaces and their parameters modification caused either by the thruster plume or by the generated local plasma;
- EMC phenomena.



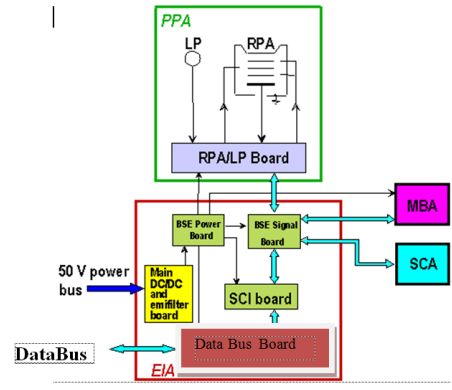
EPDP – Instrument Overview and motivations

[#2 of 2]

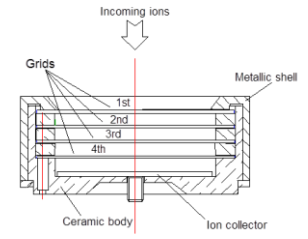
The architecture of the EPDP instrument might in principle adapted from missions to mission; in general the instrument is composed by a main Electronic Unit (EIA) and separate secondary units carrying sensors with front ends e-boards.

Sensors since now implemented in the instrument are: Langmuir probes, Retarding potential Analyser, Quartz Micro balance and Solar patches.

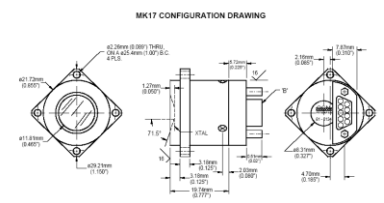
Study for the implementation of other sensor types have been preliminary performed in the past: such as double or triple LP probes, and charging sensors (ACCS unit and M-PDP study)



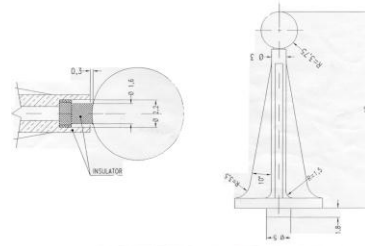
EPDP Instrument typical architecture



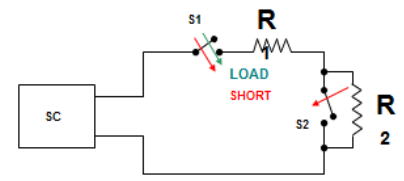
RPA Sensor in PPA



QCM Sensor (MBA)



LP Sensor in PPA



SCA Patch Sensor

EPDP Instruments Heritage

- Ion Propulsion Diagnostic Package (**IPDS**) for ARTEMIS: *Flight Model*
- Plasma Diagnostic Package (**PDP**) for the HET on STENTOR: *Flight Model*
- Electric Propulsion Diagnostic Package (**EPDP**) for the HET on SMART-1; *Flight Model*
- Electric Propulsion Diagnostic Package (**EPDP**) for FEEP on LISA PF: *Flight Model*
- Modular Multi Application El. Propulsion Diagnostic Package (**MM-EPDP**): *BB model (Development program)*



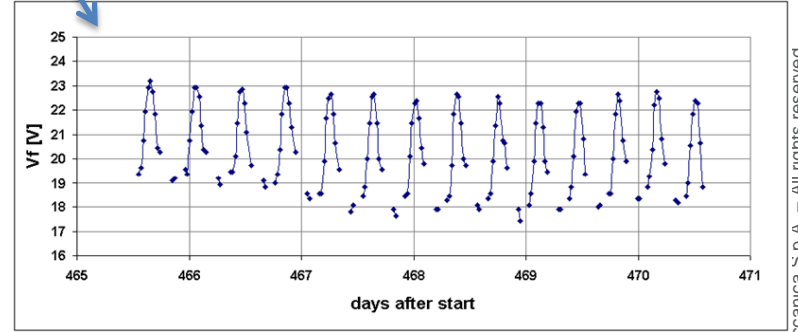
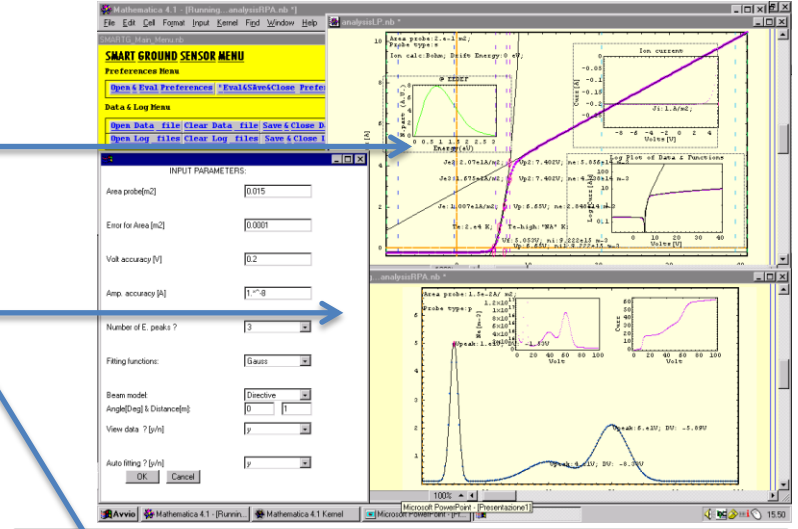
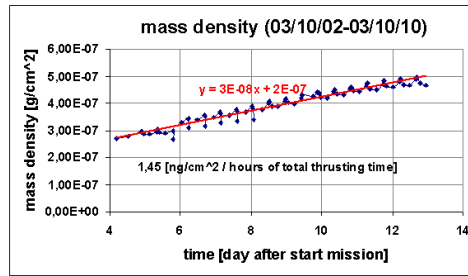
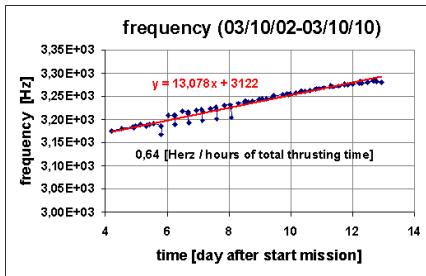
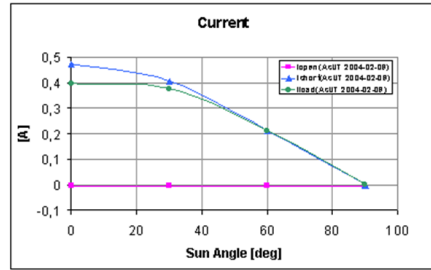
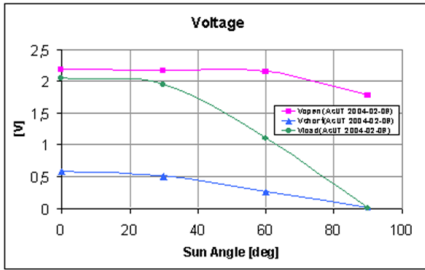


EPDP Instruments – Typical Data Products

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Examples of data products that can be obtained from EPDP instruments can be retrieved from the experience of SMART-1 mission:

1. Plasma parameters from LP (V_p, T_e, n_e, n_i) including S/C gnd potential and their trend during mission phases;
2. Ion Energy Spectrum (peak energies and relative current estimates) from RPA sensors and their temporal trends;



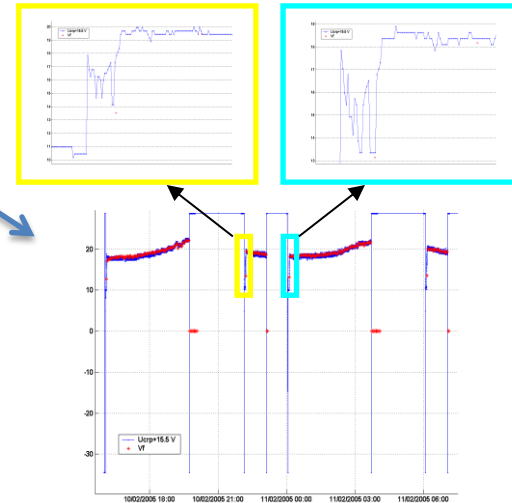
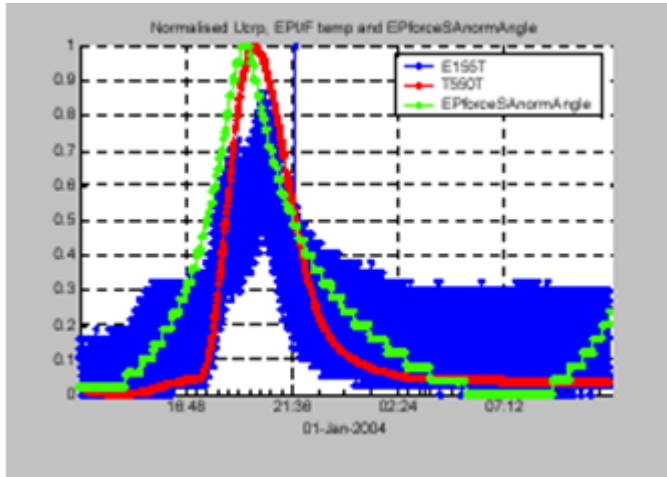
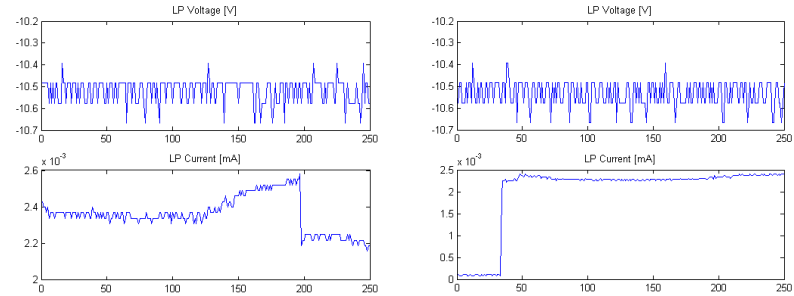
3. Solar Cell patches degradation monitoring;
4. Mass deposition on S/C surfaces monitoring.



EPDP Instruments – Typical Data Products

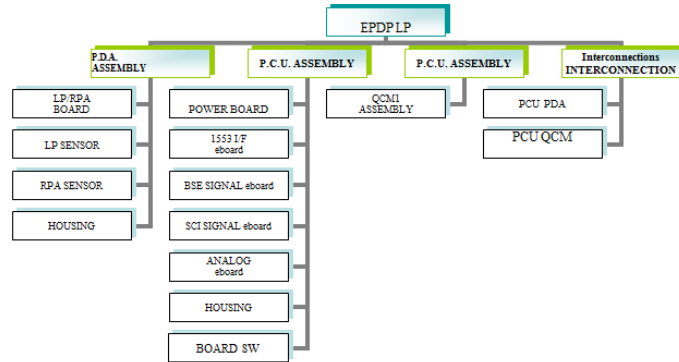
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5. Thruster Transients on local plasma env. Monitoring (Switch On / OFF/ Power changes);
6. Cross interactions between Thrusters and other S/C subsystems (on SMART-1 a correlation between thruster and SolarArray Panel orientation was identified)





Re-use of EPDP for LISA PF

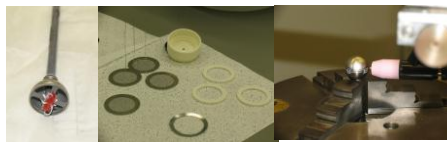


The EPDP for LISA PF instrument was not boarded on the LISA PF satellite due to a change of the S/C Propulsion system from FEEP to Cold GAS thrusters (no plasma).

The HW is presently available at ESA and could be re-addressed for a future mission (using electric propulsion systems); furthermore due to the relative high sensitiveness of the probes, (dimensioned for the thin plasma produced by FEEP thrusters), even earth low orbit local plasma parameters might be successfully monitored



EPDP instrument Units



EPDP probe technology (assembling phase)

EPDP Main Performance Specifications for LISA PF mission

Parameter	Min	Max	Unit
Ion Energy	0	450	eV
Electron Energy	0	5	eV
Plasma density	10	10 ³	mm ⁻³
Plasma potential	-200	200	V

EPDP Main Probe parameters Specifications for LISA PF mission

Parameter	Range	Max. Accuracy
V_{lp}	-210 V ÷ 210 V	±0.1V
I_{lp}	-1 μ A ÷ 1.0 mA	±0.05nA (goal)
V_{rpa}	0 ÷ 450 V	±0.1V
I_{rpa}	0 ÷ 2 μ A	±0.05nA (goal)
Input Current (Bus)	0 ÷ 0.6 A	±20mA
$T_{qcm1&2}$	-50°C ÷ 150 °C	±3% reading
T_{pda}	-50°C ÷ 150 °C	±3% reading
T_{pcu}	-50°C ÷ 150 °C	±3% reading
$F_{qcm}(1 \text{ and } 2)$	1k ÷ 135 kHz	±0.1Hz



THANK YOU FOR YOUR ATTENTION