IV SPANISH-RUSSIAN
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Mars Exploration within the Programme MetNet / MarsNet

Luis VÁZQUEZ
Facultad de Informática
Universidad Complutense de Madrid (UCM)
lvazquez@fdi.ucm.es
www.meiga-metnet.org

Coordinates of a Joint Project for Mars Exploration: Russia, Finland and Spain

MetNet/ MarsNet Programme

- It could become the first Scientific Network on Mars surface.
- The need for Miniaturization:
  - Lower power and mass
  - High realiability. High performance
  - Extended environmental survavility
  - Optical wireless tecnology developments

UCM: MARS EXPLORATION

- The University UCM has been recognized by the Ministry of Education as an International Campus of Excellence. The UCM covers most fields of knowledge and has 14 research assistance centres for experimental research.

- Collaboration with INTA (Instituto Nacional de Técnica Aeroespacial) Space Exploration Programs.

- **Luis Vázquez** (UCM)
  - Calibration Coordinator of the *Beagle 2* UV sensors.
  - Principal Investigator of *REMS-Mars Science Laboratory-NASA (2004-2007).*
  - *Science Leader of Spanish Science Team for Mars MetNet Precursor Mission.*
  - *Co-I of the DREAMS project associated to the Landing Demonstrator Module (EDM) of ExoMars 2016. Mission to Mars of ESA-NASA.*

KEY EXPERIENCE

- ***Scientific Experience*: Nonlinear Dynamics; Nonlinear Wave Equations; Random Processes; Fractional Calculus; Long-Memory Processes; Numerical Algorithms; Data Mining; Retrieval Algorithms; Applications of Cloud Computing.**

- ***Scientific-Technological Experience:***
  - ***Related to Missions to Mars*: Martian Electromagnetic Radiation, Martian Atmospheric Issues, Planetary Boundary Layer and Martian Dust.**
  - ***Generation and properties of electromagnetic shock waves.***

- ***Innovation Experience*:**
  - **Foro de Empresas Innovadoras (FEI): www.encuentroinnovacion.es**
  - **Parque Científico y Tecnológico del Bierzo (PCTB, 2011).**

UCM: MARS EXPLORATION

- The relevant research areas at UCM related to the exploration of Mars at different levels are the following:
  - Dynamics of regional clime and paleoclimatic modelling.
  - Geodesic studies of Mars, geostationary satellites control, celestial mechanics and astrodynamics as well as applications of the relativity theory in fundamental astronomy and space geodesy.
  - Radiative transfer theory and scattering phenomena applied to seismic coda waves. Ionosphere models and electron density anomalies.
  - Hiperformance Computing: Large and massive computations, cloud computing.
  - Data Mining.

THE MARTIAN ATMOSPHERIC BOUNDARY LAYER

A. Petrosyan,[1] B. Galperin,[2] S. E. Larsen,[3] S. R. Lewis,[4] A. Määttänen,[5] P. L. Read,[6] N. Renno,[7] L. P. H. T. Rogberg,[6] H. Savijärvi,[8] T. Siili,[9] A. Spiga,[4,12] A. Toigo,[10] L. Vázquez,[11]

The planetary boundary layer (PBL) represents the part of the atmosphere that is strongly influenced by the presence of the underlying surface and mediates the key interactions between the atmosphere and the surface. On Mars, this represents the lowest 10 km of the atmosphere, with turbulent convective plumes and vortices rising to altitudes of 5-10 km during the daytime. This portion of the atmosphere is extremely important, both scientifically and operationally, being the region within which surface lander spacecraft must operate, as well as determining the short- and long-term exchanges of heat, momentum, dust, water and other tracers between surface/sub-surface reservoirs and the free atmosphere. To date, this region of the atmosphere has been studied both directly, by instrumented lander spacecraft, and to some extent from orbital remote sensing, though not so far to the extent that is necessary to fully constrain its character and behavior. Current data strongly suggest that, as for the Earth's PBL, classical Monin-Obukhov similarity theory applies reasonably well to the Martian PBL under most conditions, though with some intriguing differences relating to the lower atmospheric density at the Martian surface and the likely greater role of direct radiative heating of the atmosphere within the PBL itself. Most of the modeling techniques used for the PBL on Earth are also being applied to the Martian PBL, including novel uses of very high resolution Large Eddy Simulation methods that allow direct simulation of microscale phenomena such as cellular convection and dust devil formation with significant success. In the final section, we review those aspects of the PBL that will require further investigation and new measurements in order to constrain models, and discuss the extent to which anticipated missions to Mars in the near future will fulfill these requirements.

surface and atmospheric reservoirs. It is also the region of the atmosphere through which landed and (at least

...ne spacecraft need to pass through to ...s of operations. A clear and quantita- ... of this part of the atmosphere, and ... it interacts with the surface and free ...ld therefore be a vital part of any pro- ...nd understand the Martian environ- ...nt or future. Such an understanding ...eliable predictions to be made of en- ...itions encountered during spacecraft ...ions, which are essential for mission ...t design.

...time, our understanding of the Mar- ...lity to model it are strongly guided ... studies of its terrestrial counterpart. ... a valid initial approach, the Martian ...rs from that of the Earth in a num- ...spects. The much lower atmospheric ...artian surface may be significant, es- ...e thin surface layer, affecting the de- ...entum and mass fluxes. The range of ...ntered in the Martian PBL may also ...nore extreme than found typically on ...l contrasts from intensely convective ...ustained super-adiabatic thermal gradients, to very strongly stably stratified conditions during the night. Such widespread and extreme variability

Reviews of Geophysics, ???, /
pages 1–48

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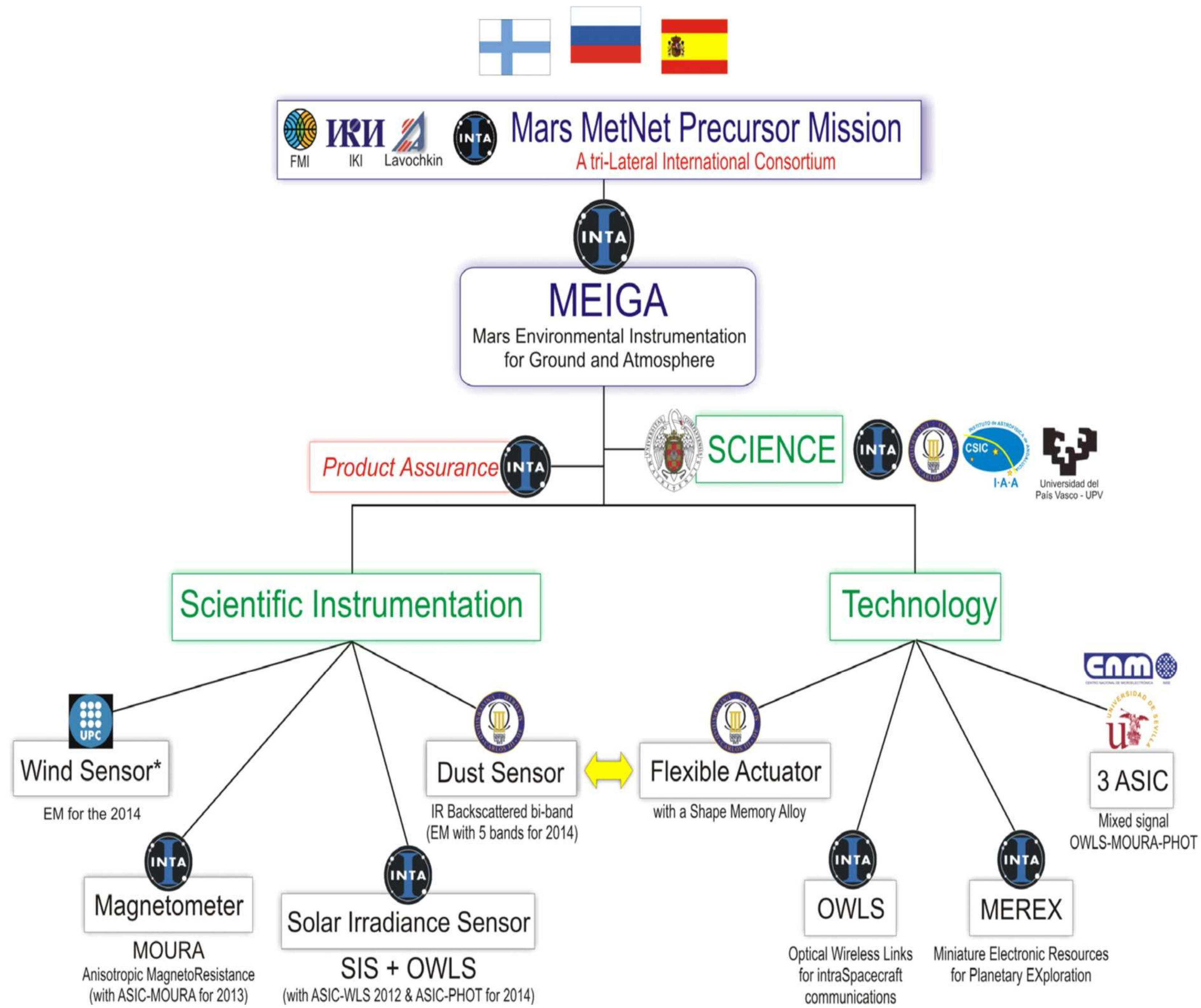
Paper number

“Mars as a Service: Cloud Computing for the Red Planet Exploration Era”.

José Luis Vázquez-Poletti. HPC in the Cloud, February 7th, 2011.

METNET

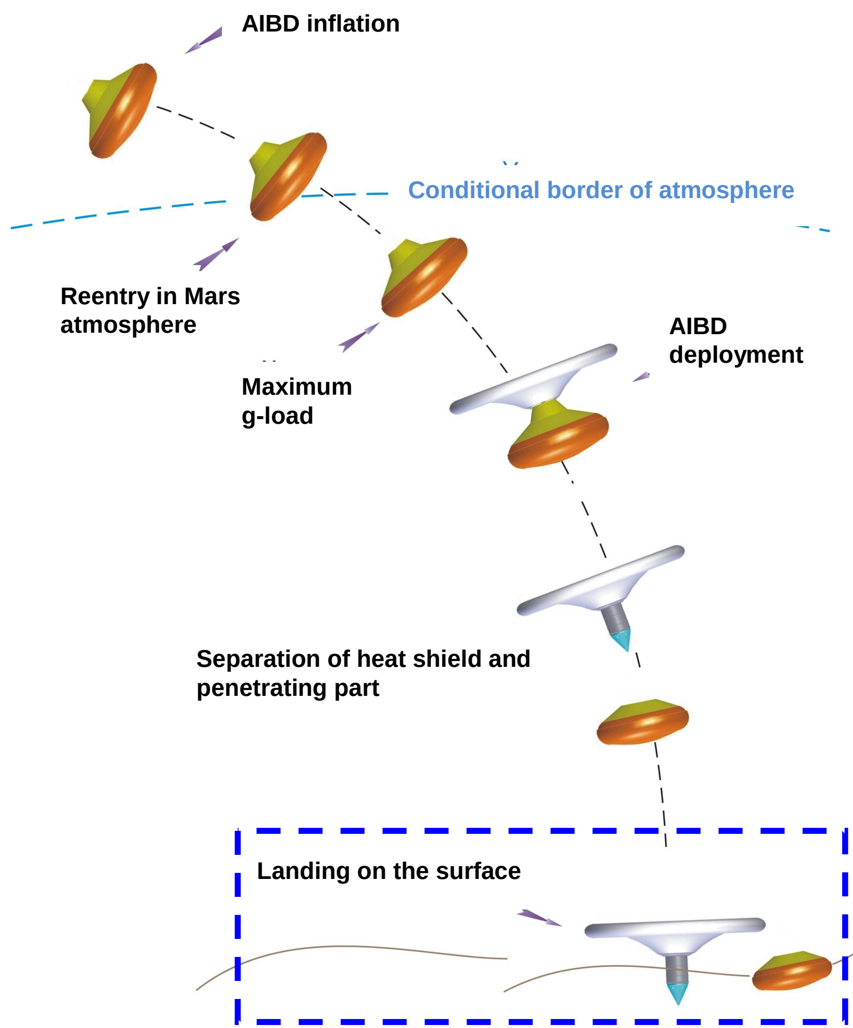

Finnish Meteorological Institute
Russian Space Research Institute
Lavochkin Association, Russia
INTA, Spain
MetNet
The Next Generation Lander Mission
For Martian Atmospheric Science



FMI
IKI
Lavochkin
INTA
Mars MetNet Precursor Mission
A tri-Lateral International Consortium
INTA
MEIGA
Mars Environmental Instrumentation for Ground and Atmosphere
Product Assurance
INTA
SCIENCE
INTA
CSIC
I·A·A
Universidad del País Vasco - UPV
Scientific Instrumentation
Technology
UPC
Wind Sensor*
EM for the 2014
Dust Sensor
IR Backscattered bi-band (EM with 5 bands for 2014)
Flexible Actuator
with a Shape Memory Alloy
3 ASIC
Mixed signal OWLS-MOURA-PHOT
INTA
Magnetometer
MOURA
Anisotropic MagnetoResistance (with ASIC-MOURA for 2013)
INTA
Solar Irradiance Sensor
SIS + OWLS
(with ASIC-WLS 2012 & ASIC-PHOT for 2014)
INTA
OWLS
Optical Wireless Links for intraSpacecraft communications
INTA
MEREX
Miniature Electronic Resources for Planetary EXploration

Entry, Descent and Landing Scenario of MetNet

Scheme of MML descent in atmosphere (Option 1)

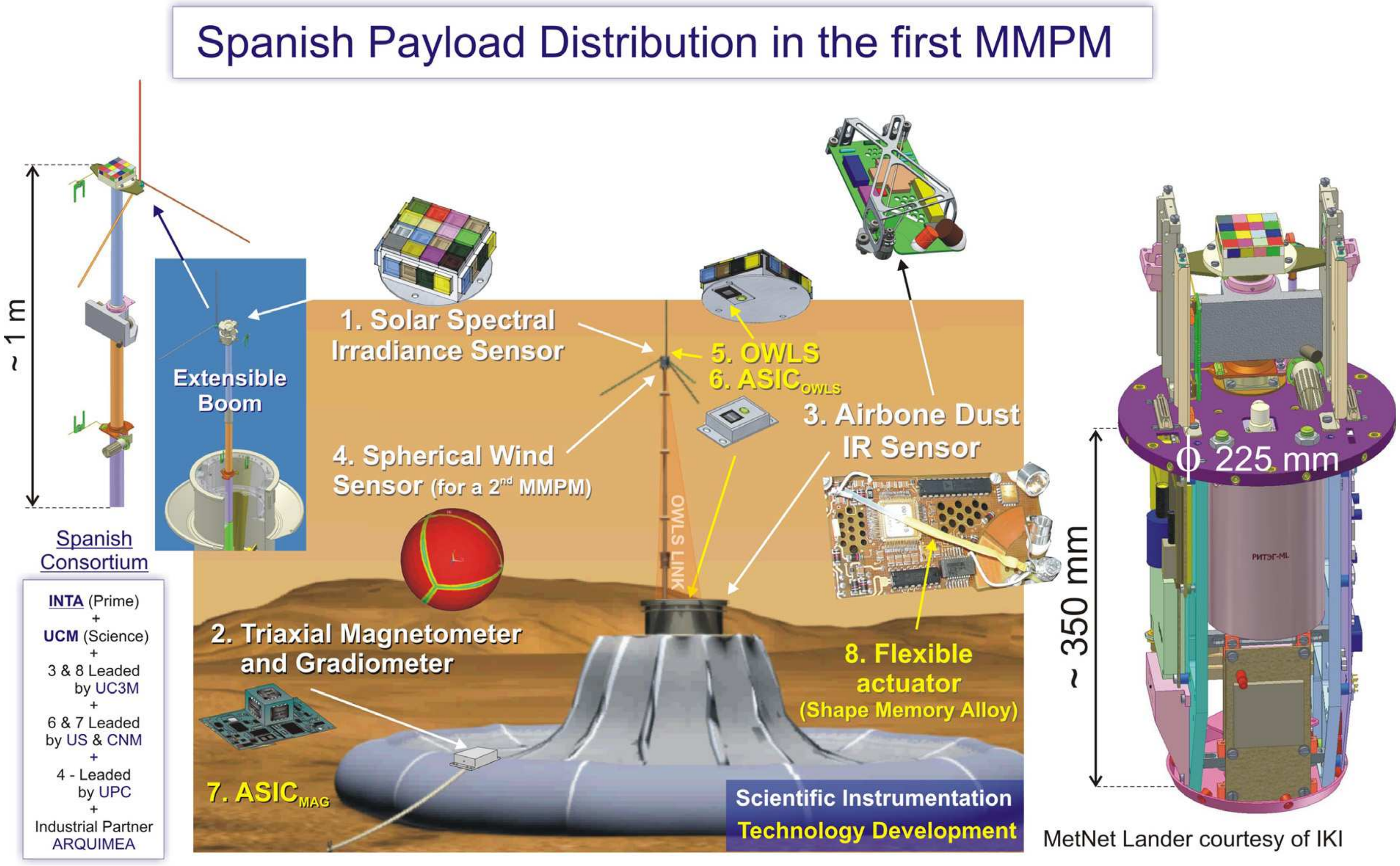


Main phases of MML descent

	Flight phases		Time from the moment of reentry T_0	Phase description
1	MIBD inflation		T_0 - 30 min.	
2	Oriented reentry in Mars atmosphere		T_0 = 0	H = 120 km Vabs ≈ 4.83 km/sec θabs = -14±3 degr.
3	Maximum g-load		T_0+ 67s…118s	H = 30…39 km θ = -7.6…-15.7 degr. Q_{max} = 2880 Pa Nx_{max} = -14.7
4	AIBD deployment (command for deployment is defined on-board depending on change of g-load Nx)		T_0 +170s…282s	H = 4.3…10.4 km Q_{max} = 126 Pa M = 0.7…0.8
5	Separation of aerodynamic shield and penetrating part		T_0+180s…292s	H = 3.1…9.1 km θ = -67.1…-75.7degr. Q_{max} = 55 Pa M = 0.45…0.51
6	Landing on the surface:	level 2 km	T_0+215s…386s	V = 51.1…65.8 m/sec Q = 16.5…24.1 Pa
		level 0 km	T_0+249s…427s	V = 47.1…55.5 m/sec Q = 16.7…20.6 Pa

Velocity at Mars ground arrival: between 47 and 56 m/s

Spanish Payload



MEIGA-MARS-METNET-PRECURSOR

The Modelling and Simulation of the Planetary Boundary Layer on Mars.

Martian Surface Radiation

- **The objective is the measurement of the Local Radiation Martian Environment in the range 190-1100 nm:**

  - **Intensity of the ultraviolet (UV) radiation in the Martian surface.**
  - **The atmospheric opacity due to the Martian dust.**
  - **Measure of the seasonal asymmetries in the ground Martian radiation.**
  - **Concentration of Ozone and Water Vapour in the Martian atmosphere.**
  - **Correlations between the radiation with the temperature, pressure and water on the Martian surface.**

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MEIGA-MARS-METNET-PRECURSOR

Magnetic Studies

- **The magnetic field on the Martian surface has the static components, related to the crustal magnetic field, and the dynamic components associated to the interaction with the solar wind, atmospheric dynamics and induced planetary magnetic effects.**
- **For the *first time,* we will have the opportunity to measure the Martian magnetic field at surface. These data will shed light on the internal structure and composition of the Martian magnetic field.**

Geodesic Studies

- **Characterization of the eclipses of Phobos and Deimos.**
    - **They will be detected through the variations of the flux radiation on the Martian surface. This will provide information about the rotation and orbit of Mars.**

Data Mining

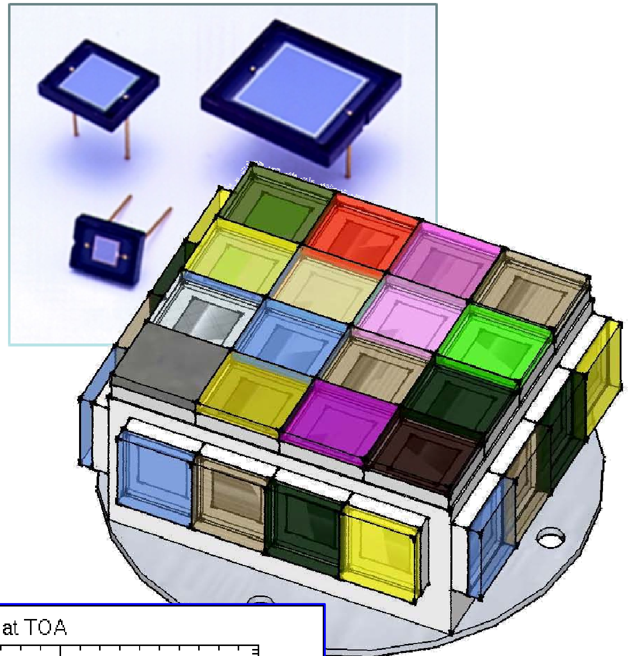
Ph.D. Programme and Outreach Activities

1 – SIS - Solar Irradiance Sensor

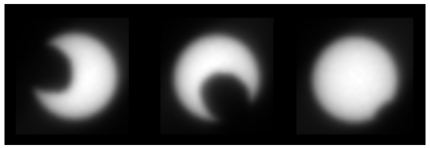
Bands detection

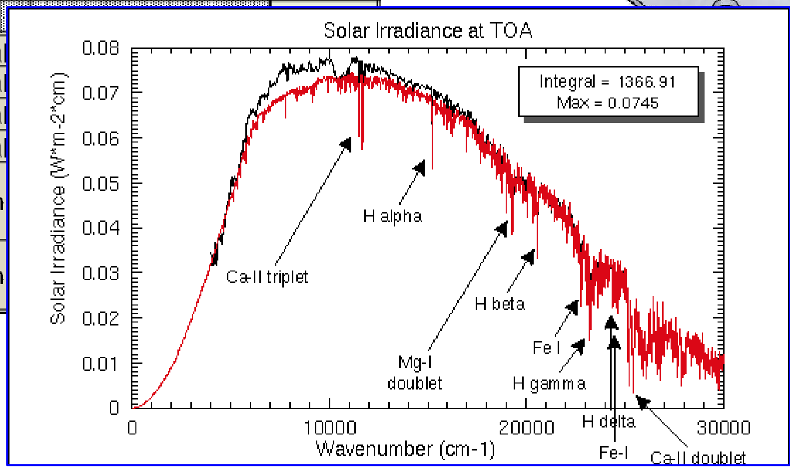
SOLAR IRRADIANCE SENSOR ACQUISITION CHANNELS							
Channel	Wavelength	Use	Position		Wavelength	Use	Channel
1	----	Background reference	Top Surface	Side 2	440 / 660 nm	Dust Optical Depth	21
2	190 - 1100 nm	Total luminosity reference			700 - 1100 nm	IR	22
3	710 - 730 nm	H_2O			400 - 700 nm	VIS	23
4	810 - 830 nm	H_2O					24
5	930 - 950 nm	H_2O		Side 3	440 / 660 nm	Dust Optical Depth	25
6	759 - 771 nm	A Band - O_2			700 - 1100 nm	IR	26
7	315 - 400 nm	UVA			400 - 700 nm	VIS	27
8	280 - 315 nm	UVB					28
9	200 - 280 nm	UVC		Side 4	440 / 660 nm	Dust Optical Depth	29
10	200 - 310 nm	Hartley Band - O_3			700 - 1100 nm	IR	30
11	300 - 345 nm	Huggins Band - O_3			400 - 700 nm	VIS	31
12	440 nm	Dust Optical Depth		Additional features			
13	600 nm	Dust Optical Depth			non optical		
14	700 - 1100 nm	IR			non optical		
15	400 - 700 nm	VIS			non optical		
16	245 - 290 nm	UV Redundancy			non optical		
17	440 / 660 nm	Dust Optical Depth	Side 1		760 - 1100 n		
18	700 - 1100 nm	IR					
19	400 - 700 nm	VIS			760 - 1100 n		
20							

Si photodiodes



Eclipses: Phobos and Deimos





Solar Irradiance

Martian Surface Solar Radiation: 190-1100 nm

- The objective is the measurement of the Local Solar Radiation Martian Environment in the range 190-1100 nm:
    - Intensity of the ultraviolet (UV) radiation in the Martian surface.
    - The atmospheric opacity due to the Martian dust.
    - Measure of the seasonal asymmetries in the ground Martian radiation.
    - Concentration of Ozone and Water Vapour in the Martian atmosphere.
    - Correlations between the radiation with the temperature, pressure and water at the Martian surface

Geodesic Studies

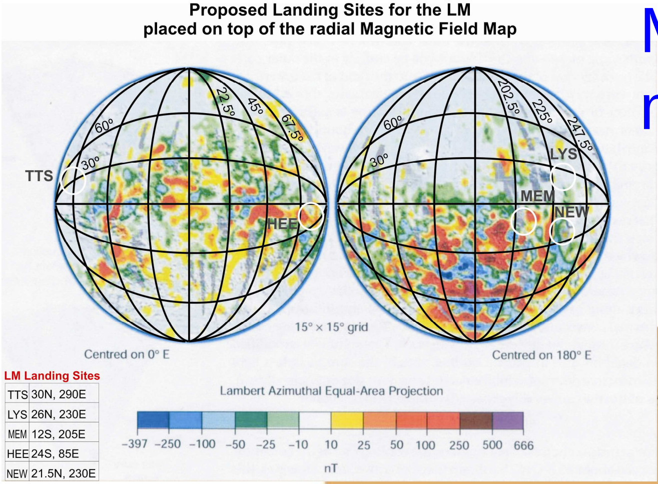
- **Characterization of the eclipses of Phobos and Deimos.**
    - They will be detected through the variations of the flux radiation on the Martian surface. This will provide information about the rotation and orbit of Mars.

The Objectives

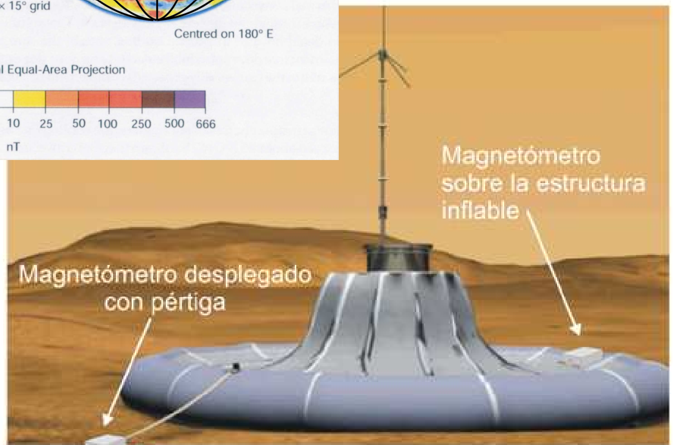
- **Development** of a chronogram of eclipses of Phobos and Deimos in the band of latitude ± 5º, and its geometric parametrization in order to determine the position of the landing site. Study of the accuracy by analizing the influence of Phobos's irregular shape, the precision of the light curves, and Mars and Phobos orbits.

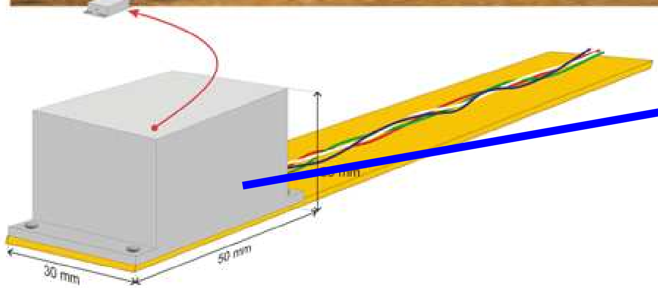
- **Characterization**, by using a rotation model, of the core inertia moments and nucleous size from the proper frequencies obtained from the derived polar motion data.

2 – MOURA: The first magnetometer on Mars surface?



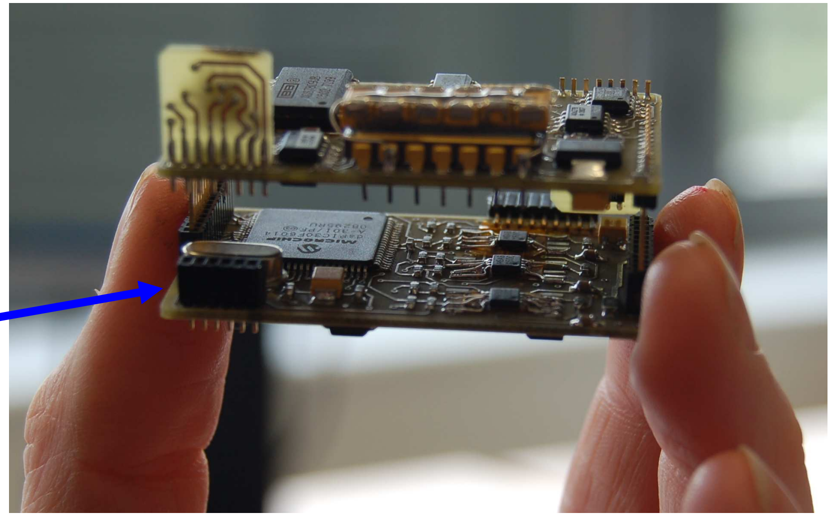
Mars: A magnetic world!





Based on the AMR technology (AnisotropicMagnetoResistance)

- Previous heritage
- Resolution less than 3 nT
- Mass of order 45 g
- Deployement system (tbd)



MARTIAN MAGNETIC FIELD

- Useful data about the magnetic field and about the plasma environment near Mars: ***Missions Phobos 2 and Mars Global Surveyor.***

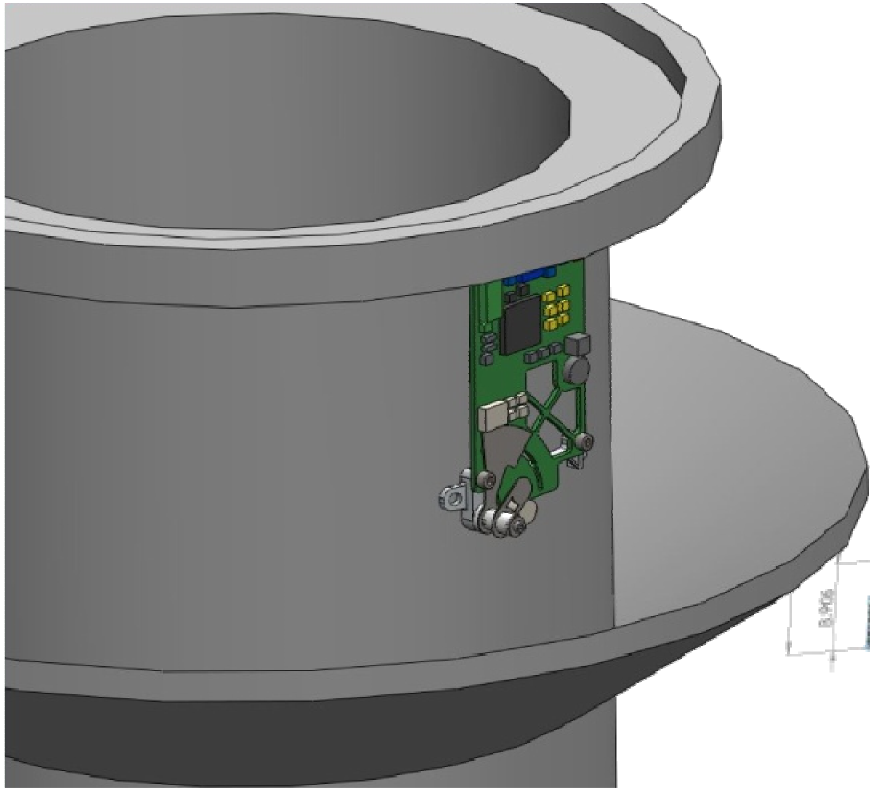
- The magnetic field on the Martian surface has the **static components**, related to the crustal magnetic field, and the **dynamic components** associated to the interaction with the solar wind, atmospheric dynamics and induced planetary magnetic effects.

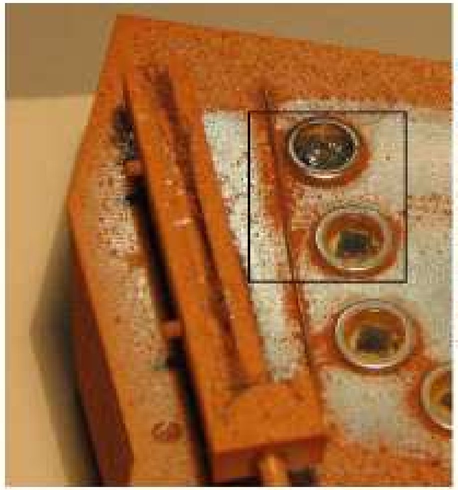
- In situ measurements for the *first time* of the Martian magnetic field at surface. These data will shed light on the internal structure and composition of Mars. Local and global models of the Martian magnetic field.

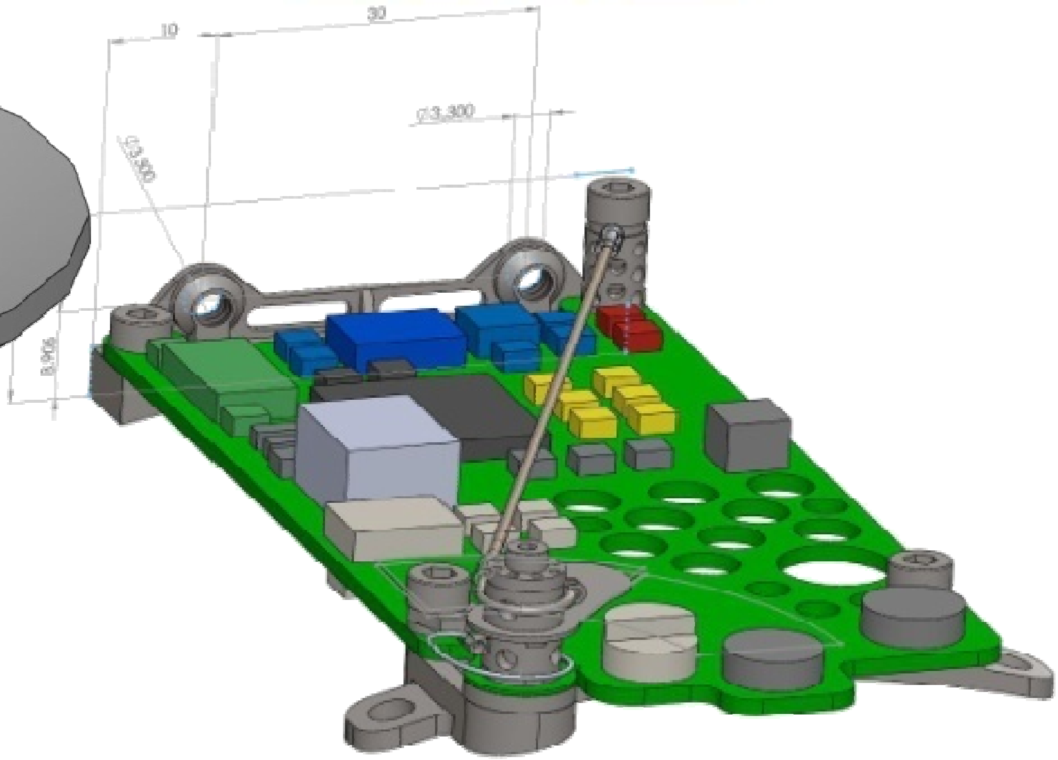
Surface magnetic measurements will provide information for the following science objectives

- Solar wind-atmosphere interactions.
- Mars magnetosphere properties. Ionosphere.
- Solar explosive events and Martian environment.
- Geophysical properties of the landing site.
- Correlation of the induction effects and Mars interior.

3. Dust Deposited and Dust Airbone Sensor







Environment of Martian Studies:Outreach

Environment of Martian Studies:Outreach

www.rusiahoy.com/blogs/limites-cientificos

POSSIBLE FUTURE COLABORATION

- **The Spanish-Russia collaboration within MetNet / MarsNet programme should be boosted.**
- **To develop jointly technologies and scientific instrumentation for space (ASICs,..).**
- **Integration and tests of scientific payloads.**
- **Organization of a serie of Joint Summer Space Schools.**
- **Interchange of students in the framework of a Space Programme.**


Спасибо!
¡Muchas gracias!
Thank you!...