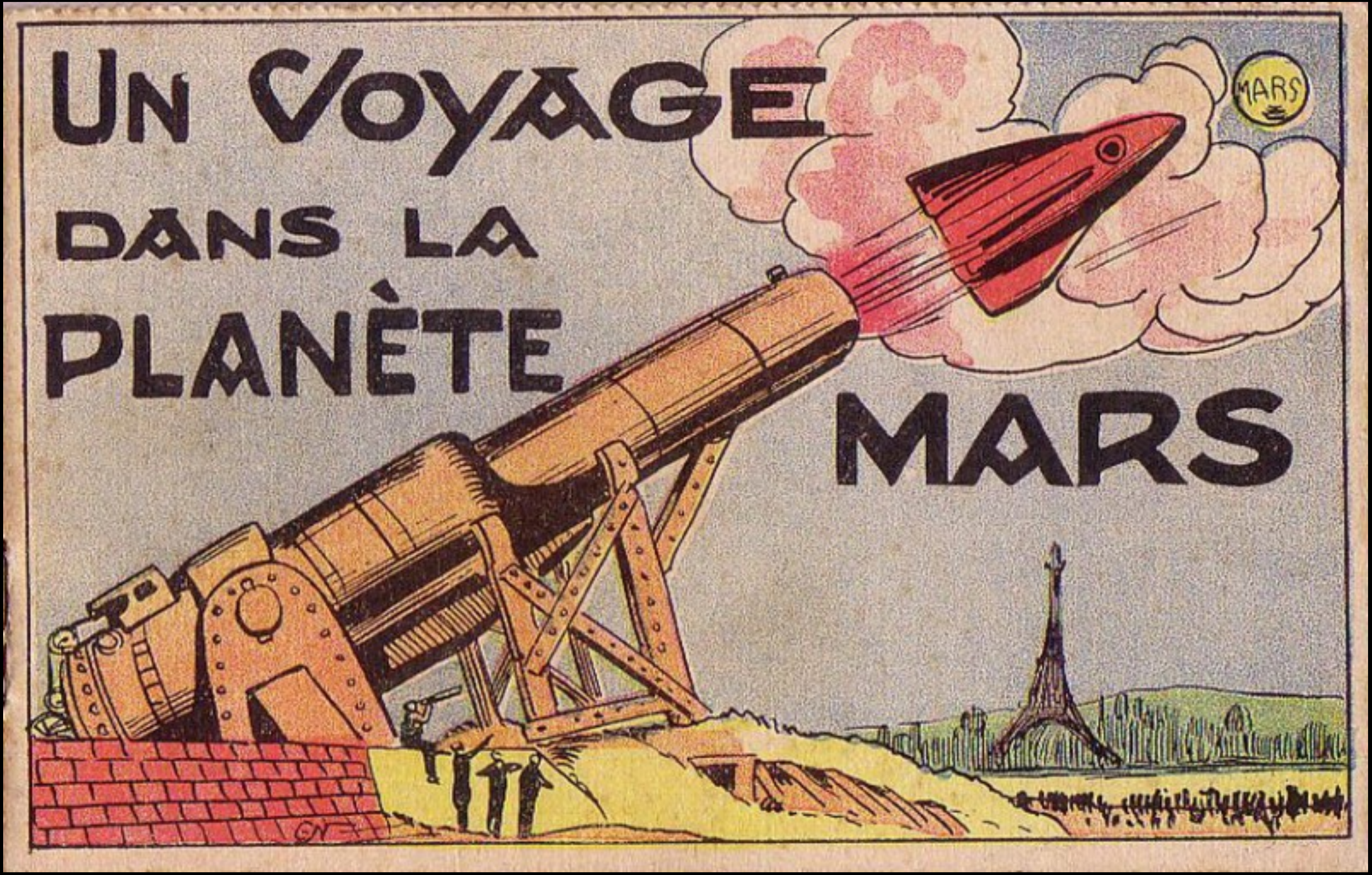
InMARS: a comprehensive program for the development of key-technologies for miniature Martian probes.

15TH ANNUAL INTERNATIONAL PLANETARY PROBE WORKSHOP



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CONTENTS

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1.- The need for miniaturization: synergy between Planetary Exploration and Small Satellites

Planetary Exploration missions impose some special conditions to any Space H/W to be put on-board:

- Low power available
- Low mass and volume
- High performance desired

Technology Development programs with a Non-Specific-Mission approach have existed for long, both in NASA and ESA, to boost Planetary Exploration capabilities.

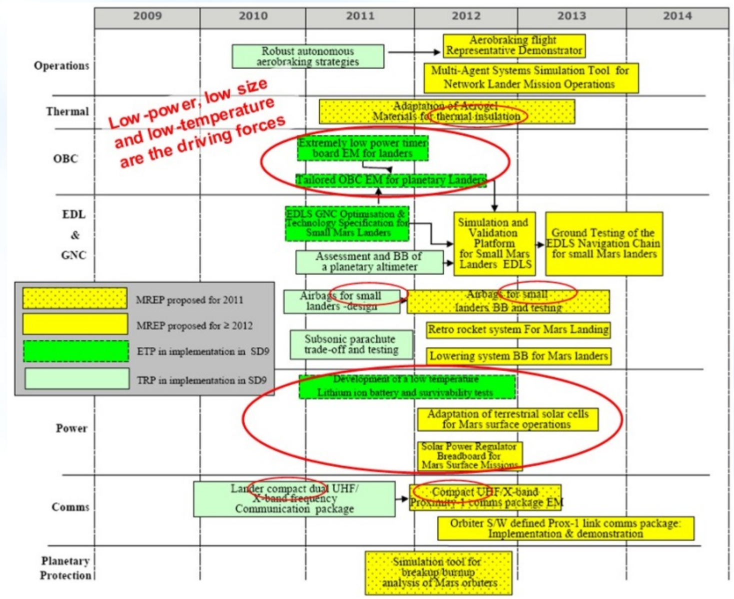
At a reduced scale, we started a similar program working on:

1. A bottom-up approach, from components to systems
2. Technology developments that we test within our Small Satellites Program, which also demand low-power, low-mass, high-performance.

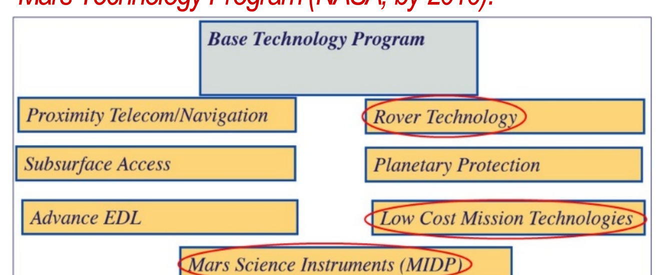
Sci. Instr., Observatories & Sensors Roadmap (NASA, by 2010):

Mission	Technology	Metric	State of Art	Need	Start	TRL6
Discovery 13/14, New Frontiers 4, EJSM	Large arrays: Vis & IR	Pixel count	1 k x 1k format	>2k x 2k format	2011	2015
	Spectral-tunable IR	Narrow-band/ range	1 µm/ few µm	0.1 µm / 1-15 µm	2015	2018
	Spectral-tune Sub-mm	Tunability @ x GHz	60 @600 GHz	>150 GHz @1200	2015	2018
	γ-ray, neutron detectors	Energy resolution, Directionality	1%, 10 deg	0.1%, 1 deg	2015	2018
	Polarization	s/p, switching speed	50%, ~1 Hz	>90%, >50 Hz	2013	2018
	Photon Counting	Λ, array size	Some λ's:	UV/vis InGaAs	2010	2018
	Rad hard Detector	TID, no SEU/SEL	Heavy shielding	<100 mils shield	2010	2020
Dis 13/14, NF 4, EJSM	Rad Hard Electronics	TID tolerance	0.1-1 Mrad	3 Mrad	2010	2020
	Low Noise Electronics	Noise level (%)	<1%	<0.01%	2011	2020
	Extreme Environment Electronics	Operating temperature	-55C to 125C	-180C to125C	2011	2020

Robotic Exploration Technology Plan (ESA, by 2010):



Mars Technology Program (NASA, by 2010):



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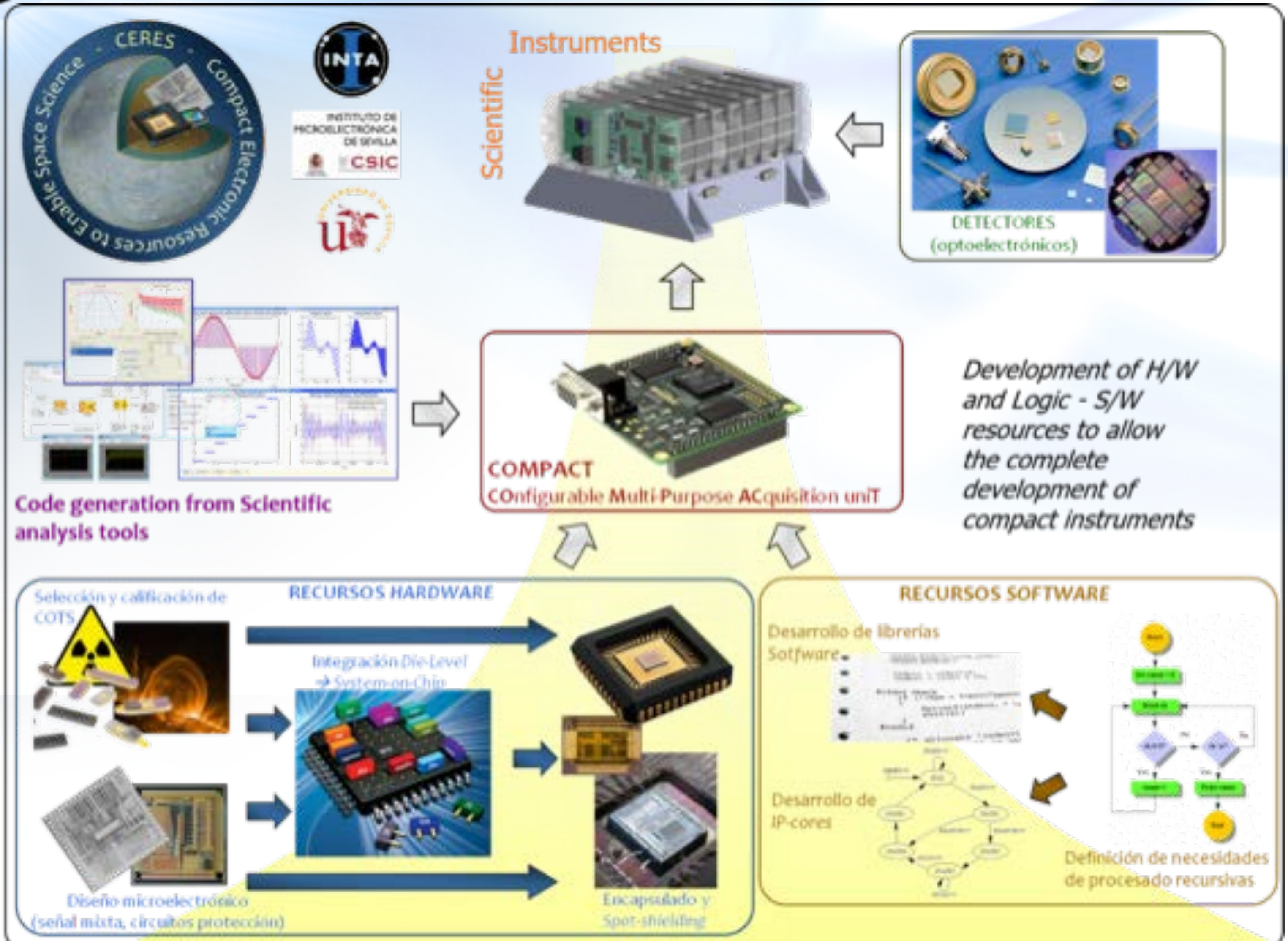
2.- Starting from the basic building blocks: EEE parts, OE, MEMS



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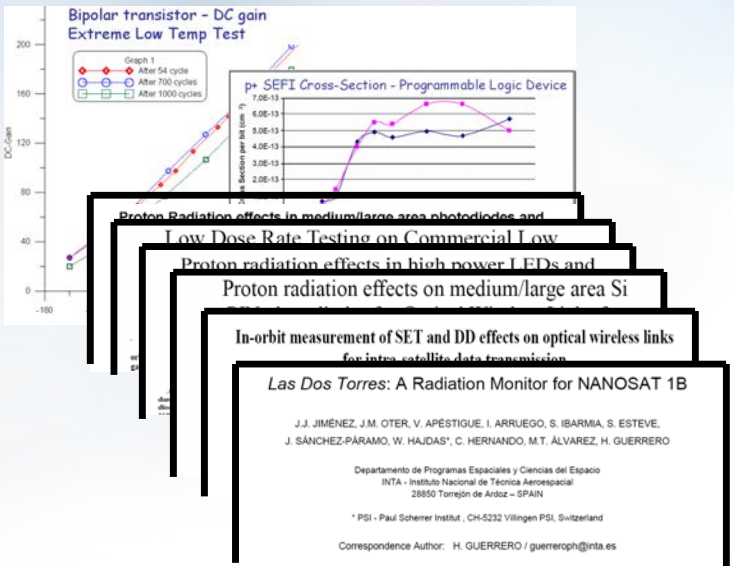
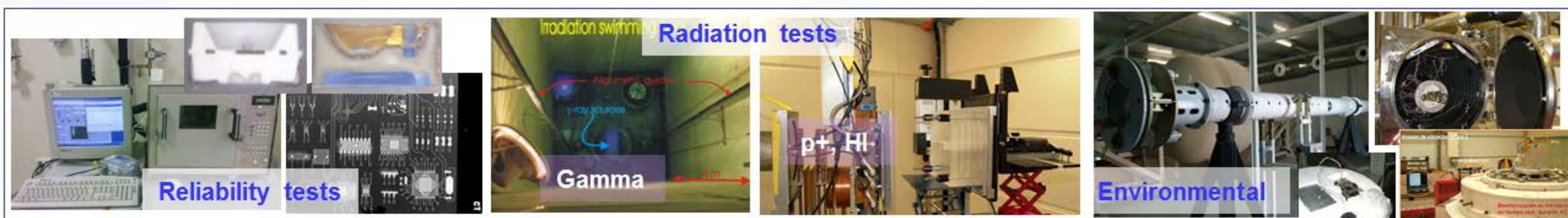
2.- Starting from the basic building blocks: EEE parts, OE, MEMS

- Analysis & selection
- Intensive testing
- Qualification and Screening for COTS
- Low temperature + Resistance to termal cycling, also for Space Grade parts



	Kind of Part	Number of different P/Ns	TID	SEE	Extreme Temp.	In-Orbit
Space grade	A/D Converter	1	N/A	N/A	X	X
	D/A Converter	1	N/A	N/A	X	X
	Analog MUX/Switch	3	N/A	N/A	X	X
	FPGA	1	N/A	N/A	X	X
	Voltage Reg./Ref.	3	N/A	N/A	X	X
	Comparator	1	N/A	N/A	X	X
	SRAM	1	N/A	N/A	X	X
COTS	A/D Converter	1	X		X	
	D/A Converter	1	X		X	
	Instrum. Amplif.	4	X		X	X
	FPAA	1	X	X		
	CPLD	2	X	X		X
	Microcontroller	2	X	X	X	X
	Operational Amp.	8	X	X (2)	X	X (3)
	Voltage Reg./Ref.	3	X		X	X (2)
Sensors	Temperature	6	X		X	
	Magnetic	5	X			
	Accelerometer	1	X		X	
	TID	4	X			
Optoelectr.	Emitters (UV/VIS/NIR)	28	X	X	X (3)	X (4)
	Photodetectors	23	X	X	X (3)	X (3)
	Microspectrometer	1	X		X	
	CMOS, linear array	1	X		X	
	CMOS, image	1	X	X		X

TOTAL: 103



E.g. PQV for Radiation and Dust Sensor (RDS) on Mars 2020 Rover

20 UUT BOARDS

2 RDS SUBASSEMBLIES

18 EGSE BOARDS

MORE THAN 170 DOCUMENTS

7 PEOPLE HAVE WORKED INTENSIVELY

300k€ ESTIMATED COST

ALMOST 4 YEARS OF UNINTERRUPTED THERMAL CYCLING!!!

Tested Technology	NUMBER OF ITEMS
Paint	2 Types
Glue	3 Types
Silicones	2 Types
PCB material	2 Types
Coating	1 Type

EEE Parts Tested	NUMBER OF ITEMS
Photodiodes (stand alone)	6 Large size 6 Small size
Opto-mechanical sets	6 Large size 9 Small size
Cristal Oscillator	3 FMI 3 QTech
Operational Amplifier	3 National 3 Analog Dev.
ADC	3 Maxwell 3 Texas Instr.
SERIAL DRIVERS	6 Intersil 3 Texas Instr.
FPGA	3 Actel
RAM MEMORY	3 Atmel
DAC	3 Texas Instr.
PASIVES	TONS
MULTIPLEXER	3 Intersil 3 Maxwell

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2 – Starting from the basic building blocks: EEE parts, OE, MEMS

Access to Space through Small Platforms

3.- Gaining in-orbit Experience

Space Programs and Flight Segment

Minisatellites   Microsatellites   Nanosatellites

INTASAT (1974) . 25 Kg. 1974

Payload: Ionospheric Beacon
Subsystems: Developed by INTA and national Industries
Launch: Delta Rocket (Vanderberg, USA). Sep. 74 with ITOS-G
AIT: Assembled, qualified and tested at INTA facilities

MINISAT-01 (1997) - 190 Kg.

1997

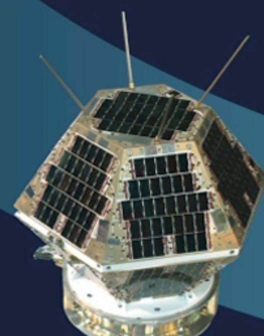
Platform: developed by INTA and national industries

Payload : Three Instruments:
LEGRI (INTA-UV-RAL) Gamma ray instrument
EURD (INTA-UCB) UV Spectrograph
CPLM (INTA-UPM) Microgravity experiment

Assembly of Rocket/Satellite at INTA facilities.

MINISAT 01 re-entered atmosphere after 5 year of successful operation

NANOSAT 01 (2004) - 18 Kg.



2004

Mission: Store and Forward Communications
Experiments: Micro-nanotechnologies magnetic and solar sensors
Platform: developed at INTA. Electronics modular design
Batteries: Ion-Li From AEA technologies (UK)
Solar Panels: GaAs/Ge form Galileo Avionica (Italy)
Launch: Ariane 5/ASAP, 18 sep. 04
Life time: 3 years nominal. 5 years feasible.
Developed, integrated and tested at INTA facilities

NANOSAT 1B
2009

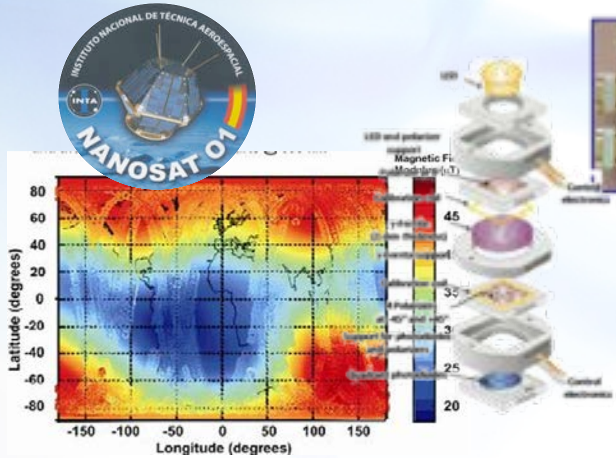
Technical support to National Space Programs (HISPASAT, HISDESAT, SEOSAT, etc)

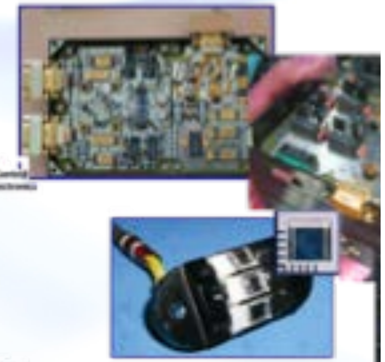
3.- Gaining in-orbit Experience

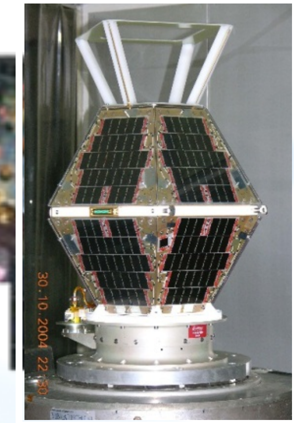
NANOSAT-01 (2004 – 2016)

In-orbit test-bed for:

- AMR magnetic sensor. Later used for Mars
- Faraday Effect Magnetometer (on nano-structured material)
- Porous Silicon Sun Sensors
- Diffuse Optical Wireless Comms. With OE parts later used for Mars

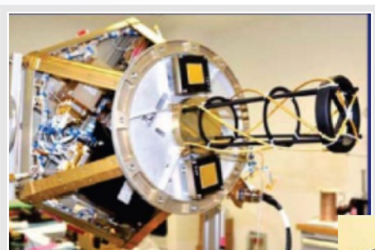


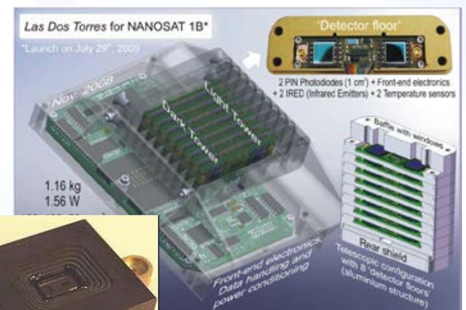


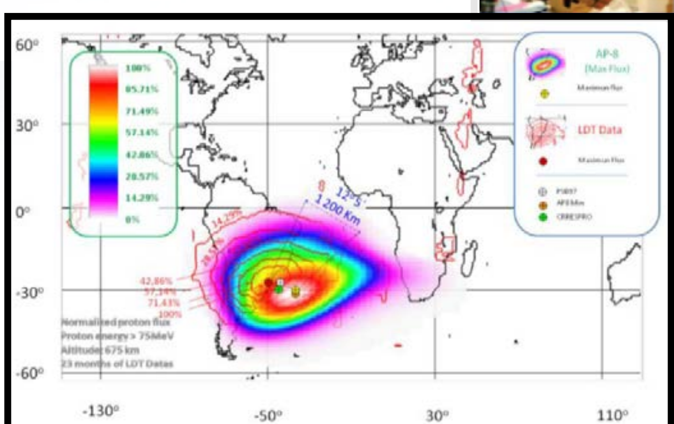


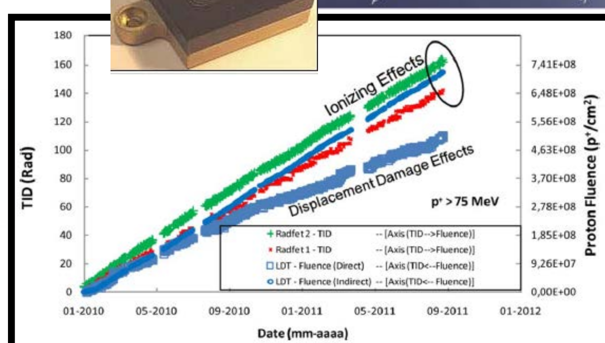
NANOSAT-1B (2009 – 2016)

- Improved communications S/S
- Radiation Monitor (particle flux, fluence, TID)
- Magneto-impedance sensor
- Micro Sun Sensor









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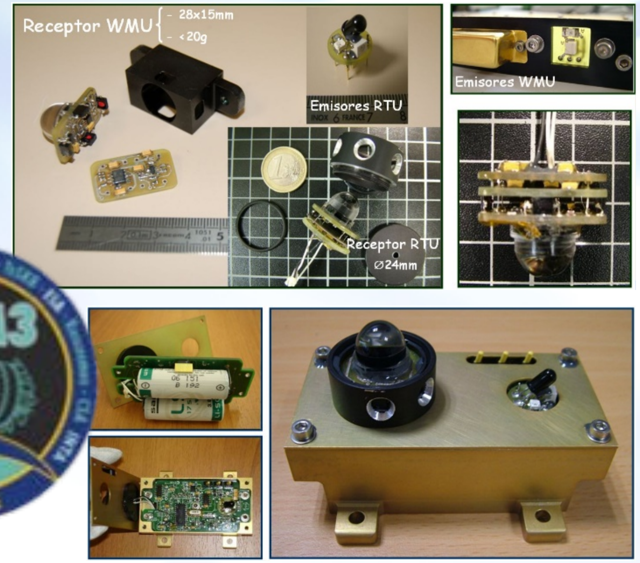
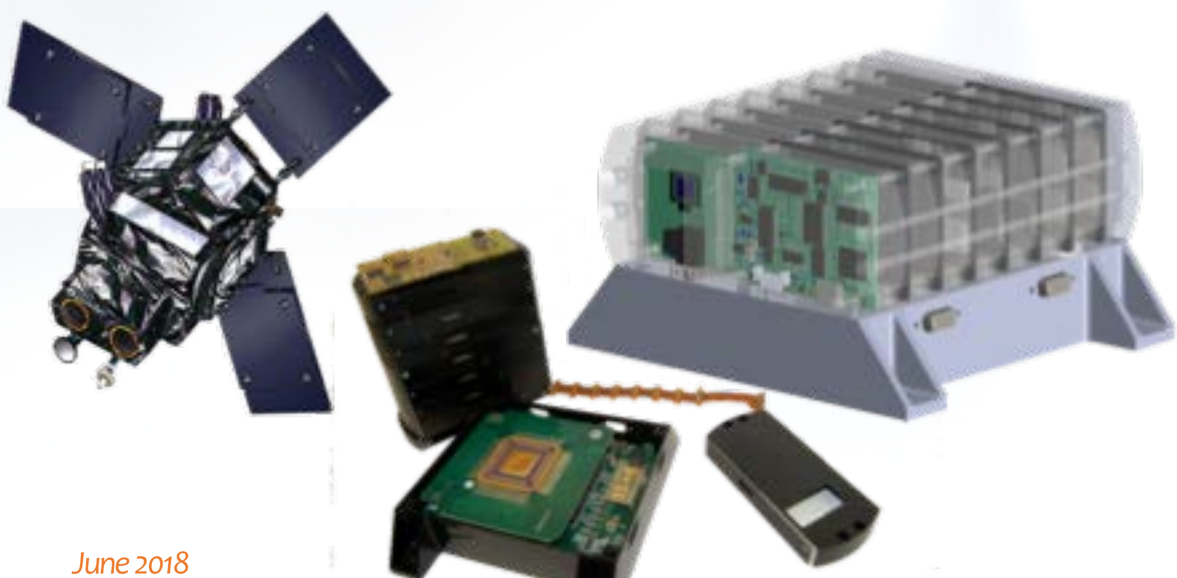
3.- Gaining in-orbit Experience

FOTON-M3 (2007)

IOD of Optical Wireless CAN in a big S/C

- 1 OBC, 2 RTUs
- COTS microcontrollers, later used for Mars





"The Two Towers"
SEOSAT/INGENIO (2015)

- Space Weather Monitor
- Autonomous Instrument
- Payload Computer
- 5 Radiation Sensing Technologies
- Microcontroller, OE Detectors, later used for Mars

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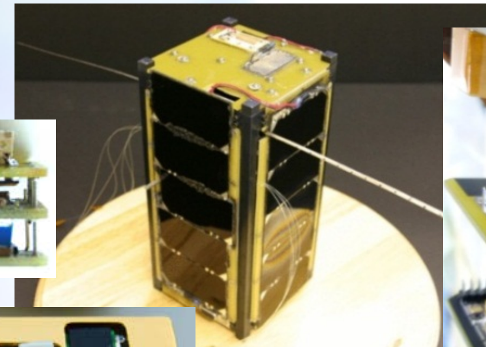
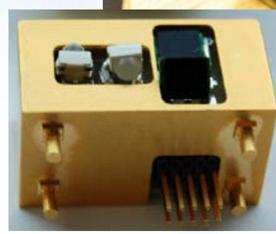
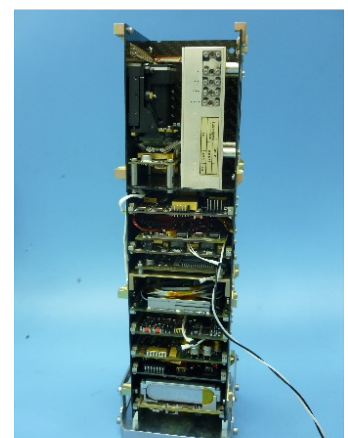
3.- Gaining in-orbit Experience





OPTOS (2013 - 2016)

- Hi-Rel, Low-Cost Distributed Computer arquitecture
- Diffuse Optical Wireless OBDH bus: first ever 100% wireless satellite
- Deployable solar pannels for 2x power
- Different experiments: GMR sensor, Radiation monitor, APS camera, Bragg grating thermal sensor.
- OE parts and Magnetic Sensor, later used for Mars

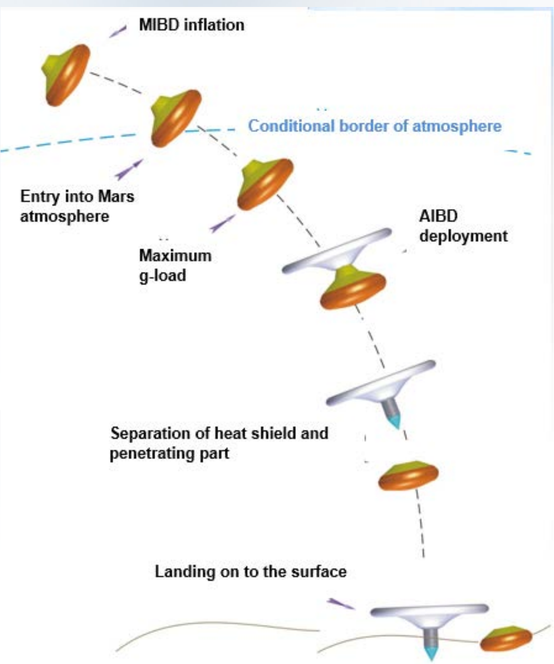


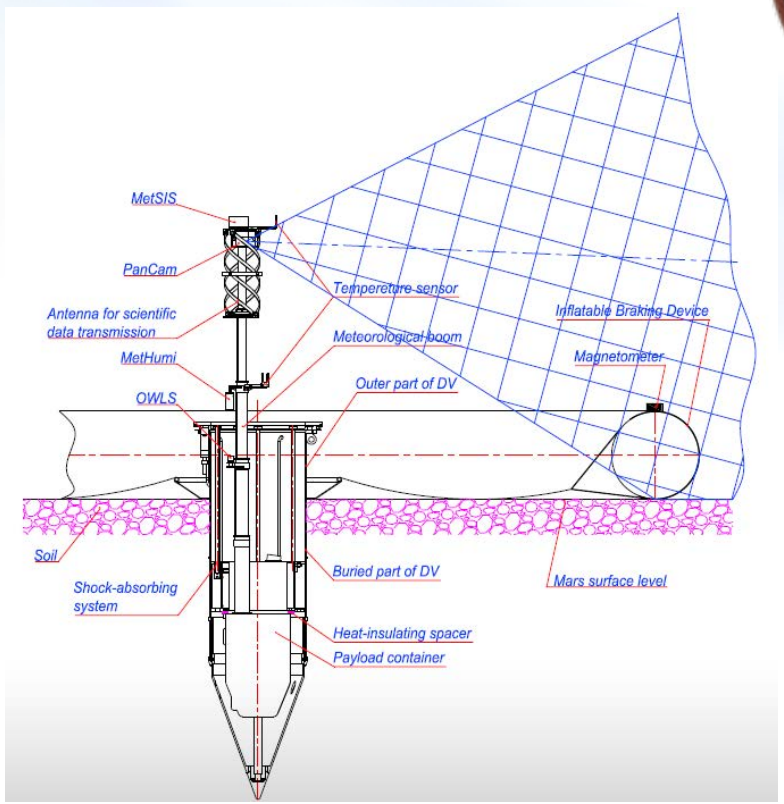
Xatcobeo (2012), Humesat (2013)
(Not INTA's)

- On board processor

MetNet - Meteorological Network

EDL system	12 kg
Penetrator	9.2 kg
Sci. Payload	4 kg
TOTAL	25.2 kg





- Air temperature sensors
- Pressure
- Humidity
- PanCam
- DesCam
- Tri-axial accelerometer
- Megnetometer
- Photometer
- Dust sensor

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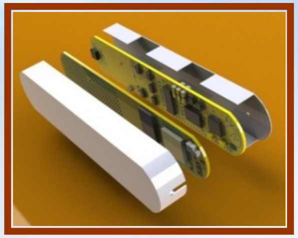
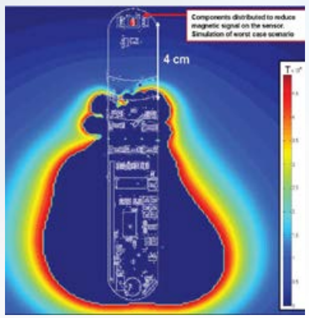
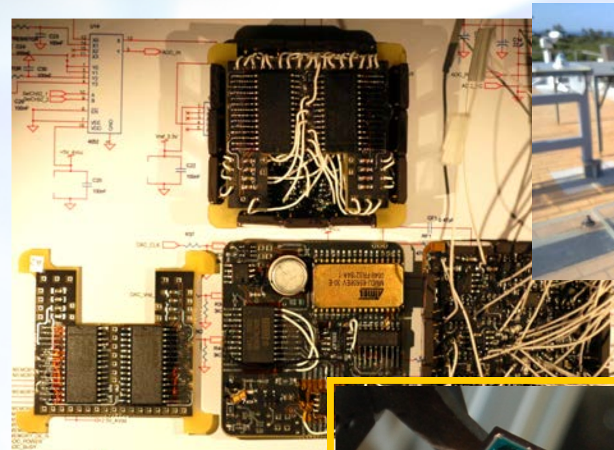
4.- Going to Mars – Scientific instruments

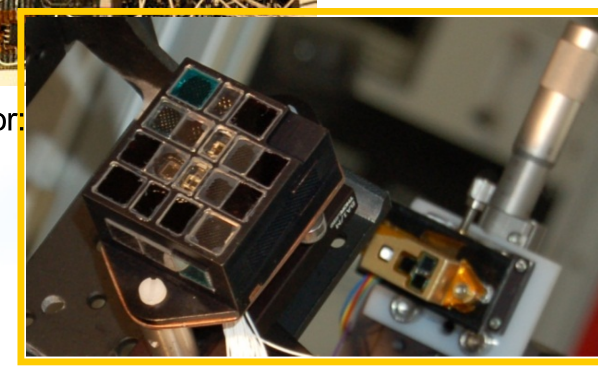




AMR-based magnetometer:

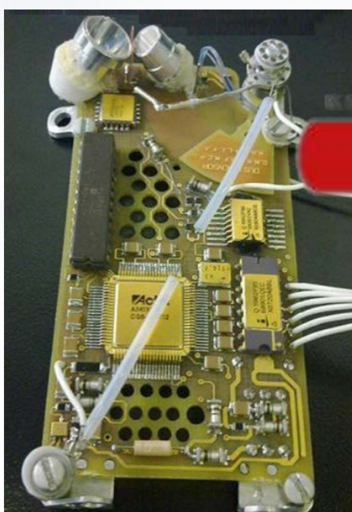
70 g
400 mW
2000g, 20ms

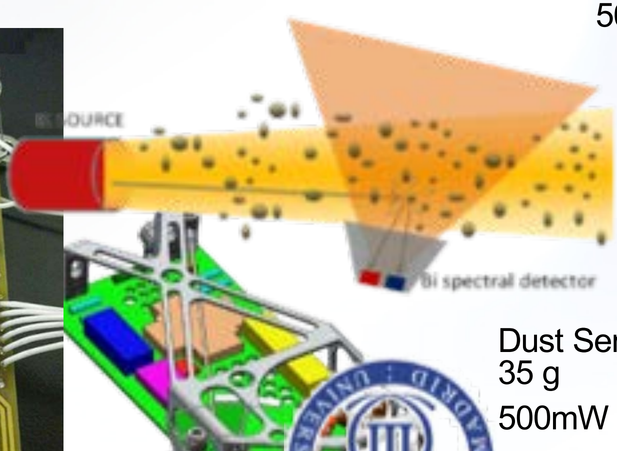




Sun Irradiance Sensor:
11 spectral bands

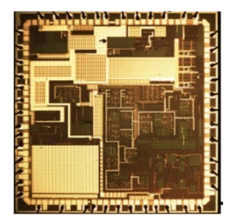
28 detectors
114 g
500 mW





Dust Sensor:
35 g

500mW



+ 2 ASICs

CENTRO NACIONAL DE MICROELECTRÓNICA IMSE

UNIVERSIDAD DE SEVILLA

UNIVERSIDAD CARLOS III DE MADRID

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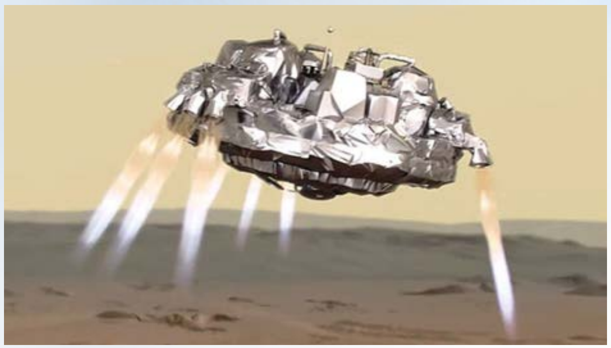
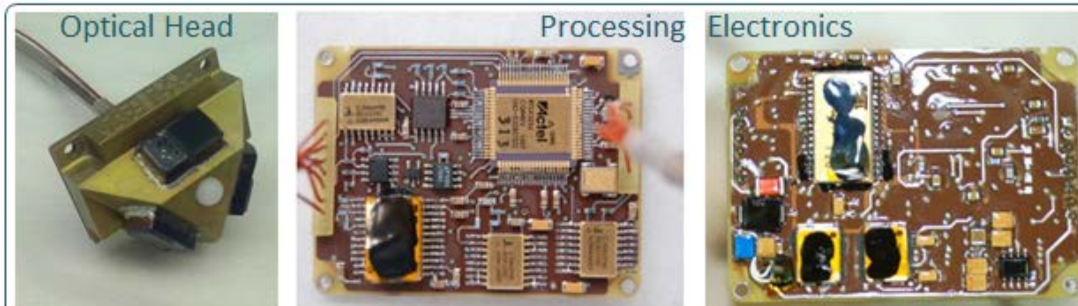
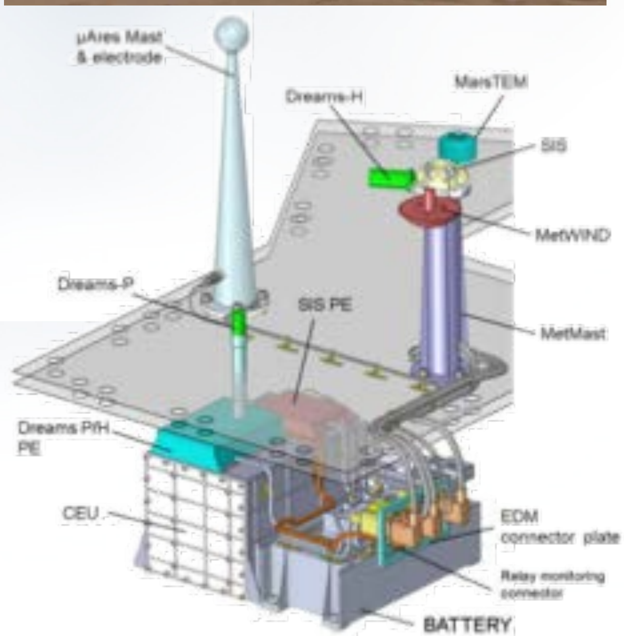
EXOMARS

DREAMS:
Dust characterization, Risk assessment and Environment Analyzer on the Martian Surface







DREAMS (ExoMars 2016 EDM) Solar Irradiance Sensor – DREAMS SIS	
Sensing elements	Si-photodiodes + interference filters + density filters + FoV shaping elements
Power supply	5 V
Current consumption	<58 mA
Data I/F	Serial, RS-422
Mass	25 g Optical Head (OH) + 52 g Processing Electronics (PE)
Dimensions	OH: 42x33.7x22.5 mm; PE: 80x50x13.5 mm
Operating Temperature	-120 to +125 °C
Optical Bands (nm)	Total:[220-1200], UV:[315-400], NIR:[700-1100]
Range / Resolution (W/m^2)	Total: 1050 / 10^{-3}, UV: 110 / 10^{-4}, NIR: 390 / $3.7x10^{-4}$
Additional Sensors	Temperature (PT-1000, x2: OH and PE), Dark-current for Dispacement Damage estimation.
Operation and others	Fully digital. RadHard FPGA used. Allows autonomous operation under configurable parameters: channels to acquire, sampling period, etc. 128 kB internal RadTol memory.

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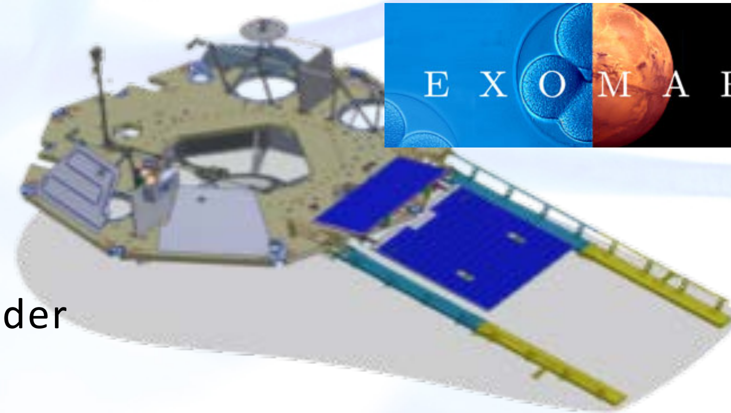
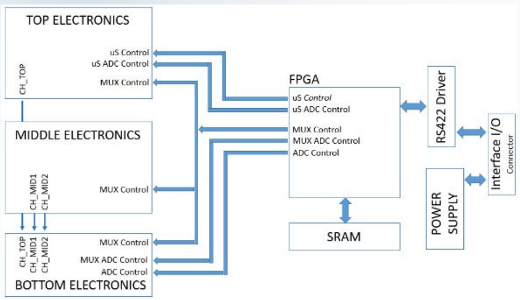
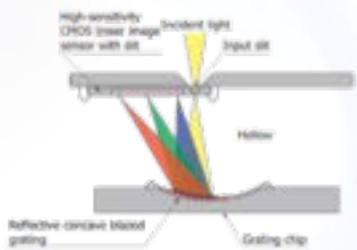
4.– Going to Mars – Scientific instruments

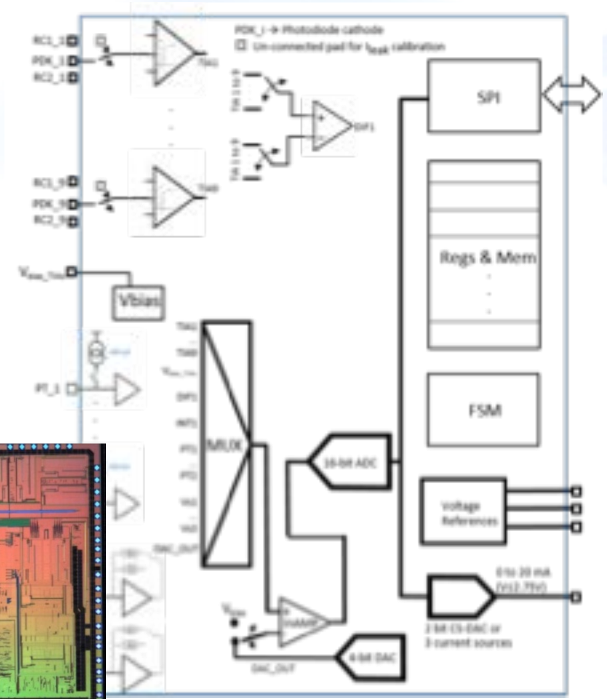
SIS'20
ExoMars 2020 Lander

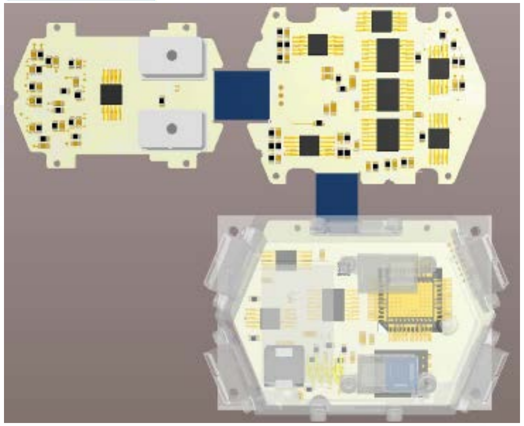


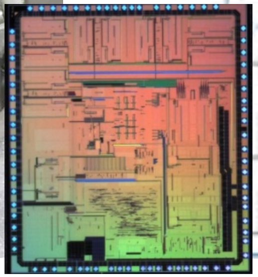
EXOMARS











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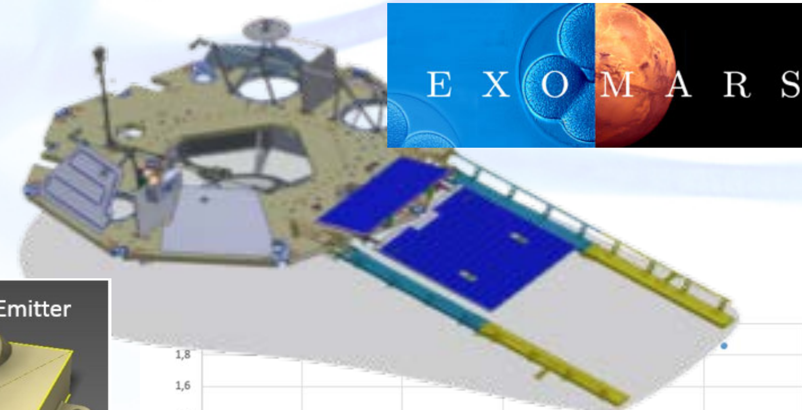
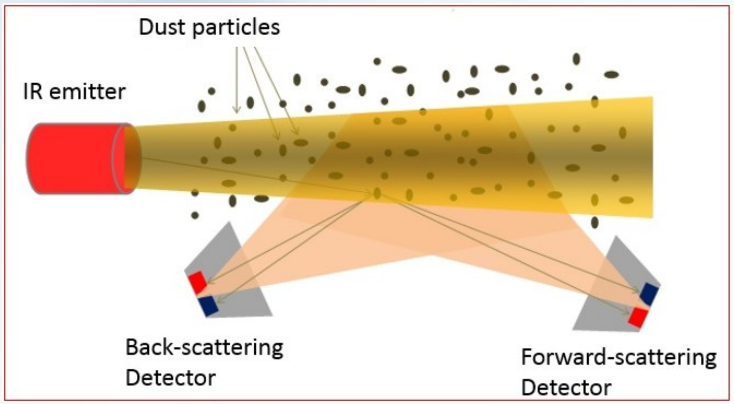
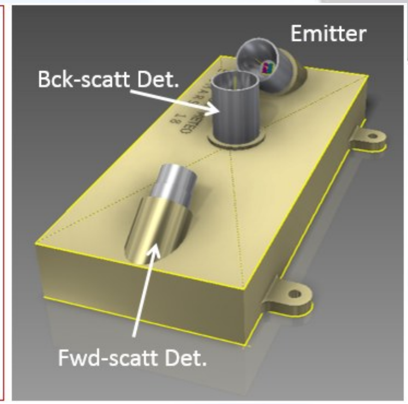
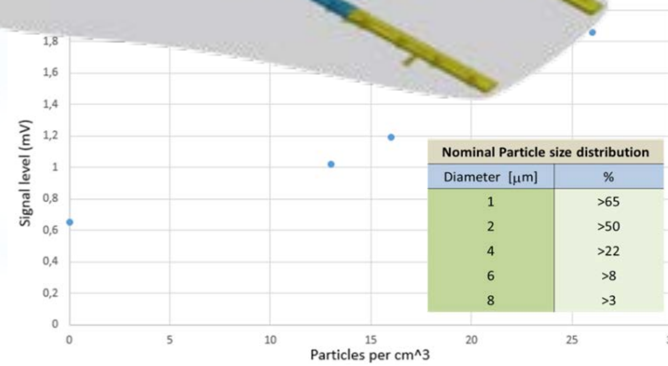
EXOMARS

DS’20
ExoMars 2020 Lander

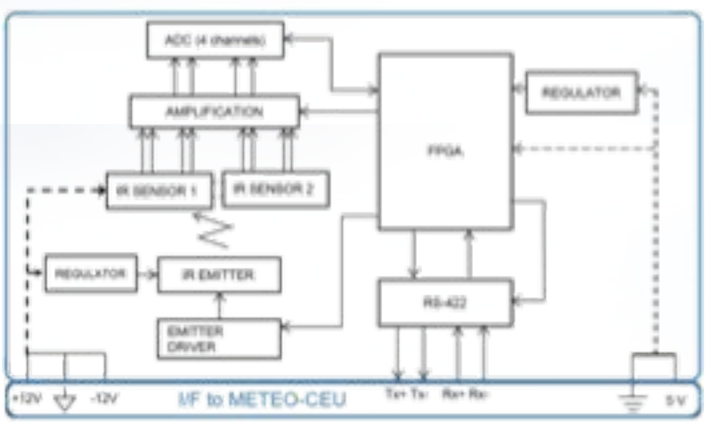


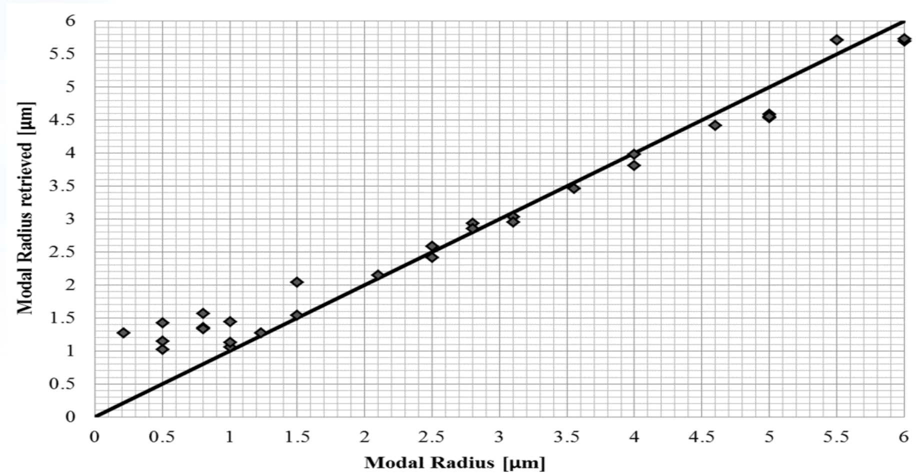






Nominal Particle size distribution	
Diameter [μm]	%
1	>65
2	>50
4	>22
6	>8
8	>3

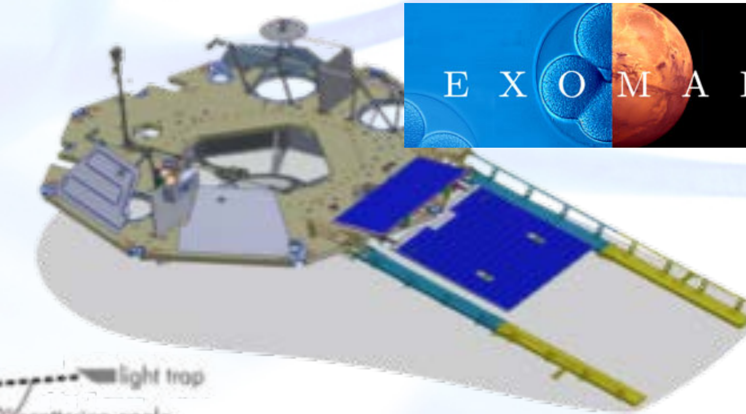


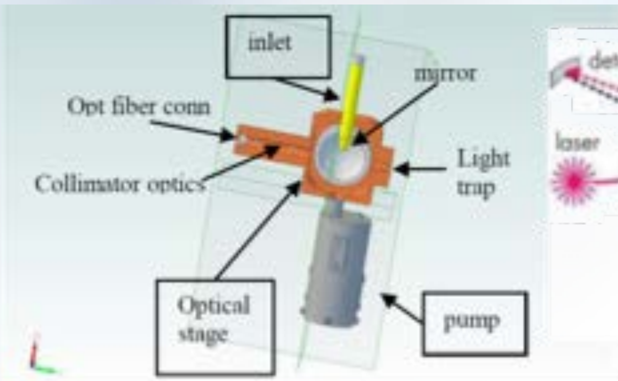


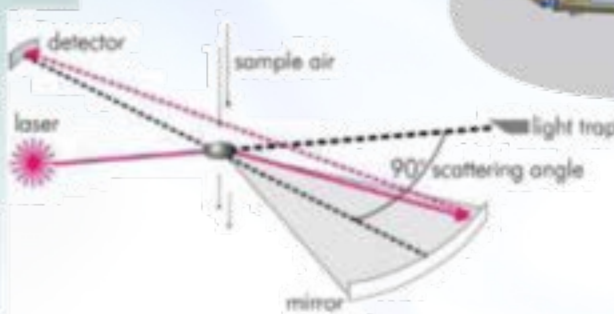
4.– Going to Mars – Scientific instruments

MicroMED nephelometer
ExoMars 2020 Lander

EXOMARS

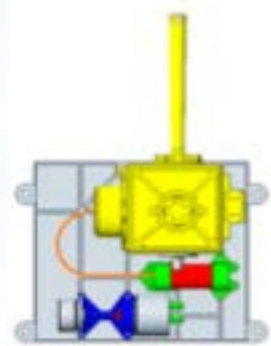




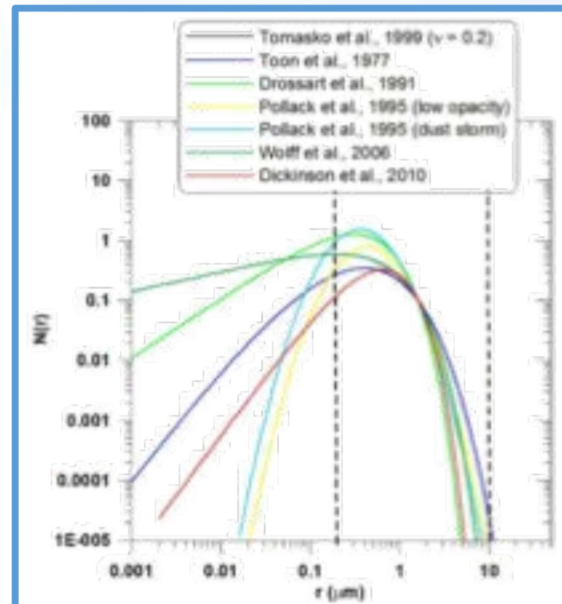


MEDUSA
(TRL=5.3 at PDR 2009)

MICROMED
Laboratory B/B 4<TRL<5



MICROMED
ExoMars 2020



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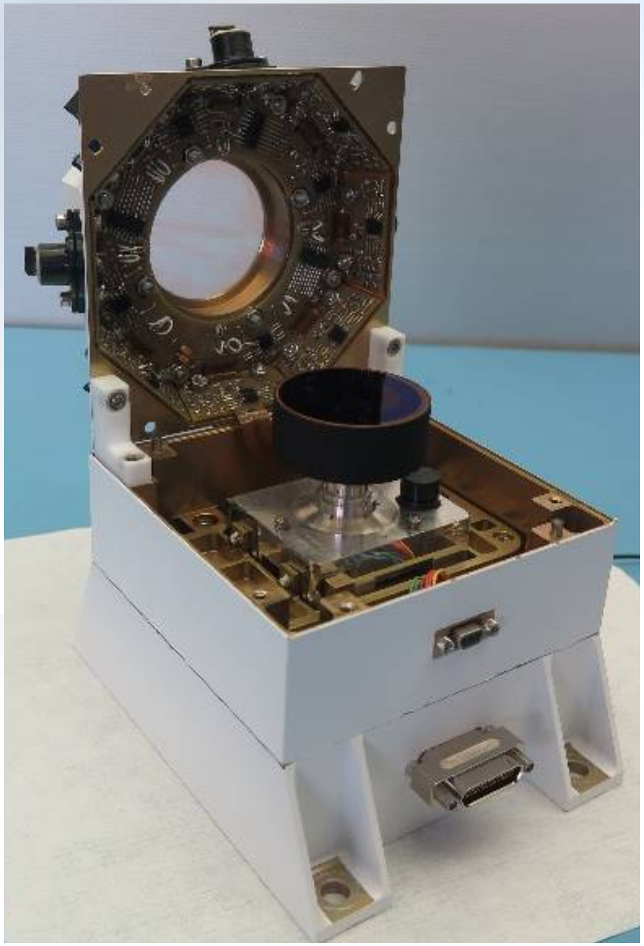
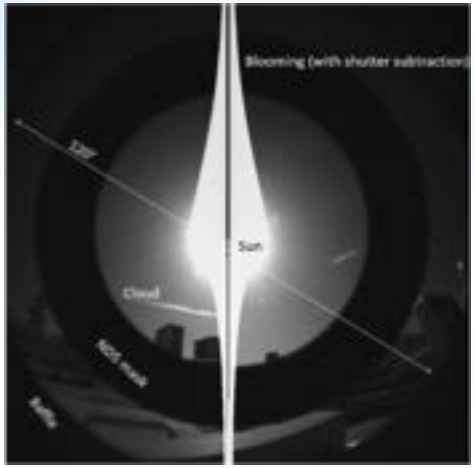
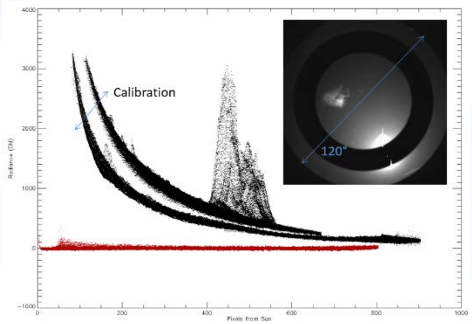
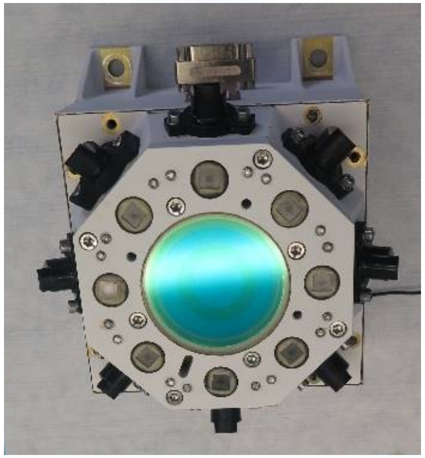
15TH ANNUAL INTERNATIONAL PLANETARY PROBE WORKSHOP IPPW-2018

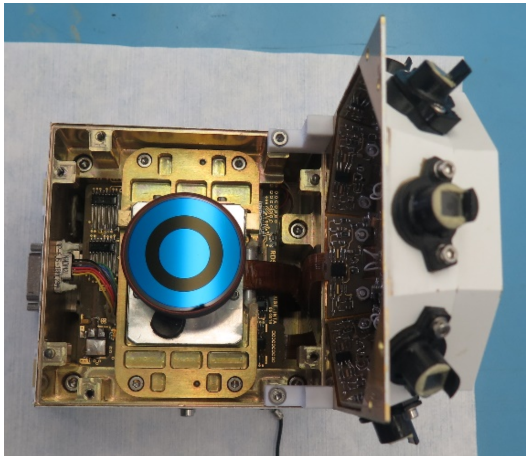
Radiation and Dust Sensor on Mars 2020 Rover (part of the MEDA meteo station)











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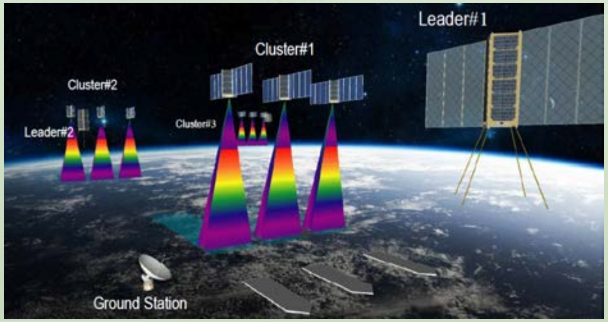
5.– Future? – Synergies between our 3 present lines of work

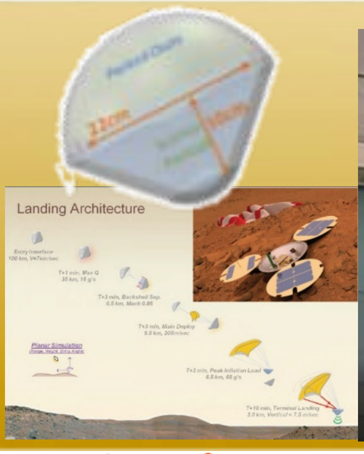
Advanced intra-OWL and O-ISL:

- High BW optical RX
- (Pointing/tracking)



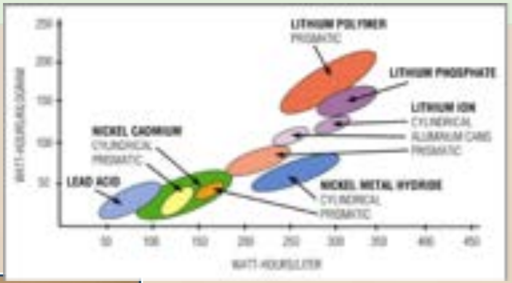
Small Sats' clusters:

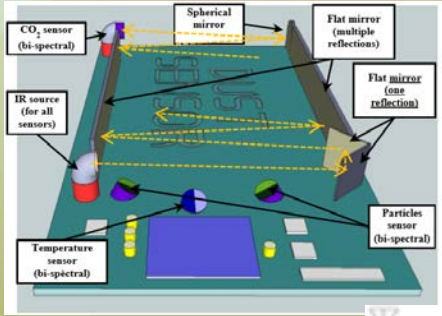
- O-ISL
- Ranging → High BW opt.RX
- High-Eff Power Sys.
- CO2 monitoring
- (Pointing/tracking)
- Proximity comms.

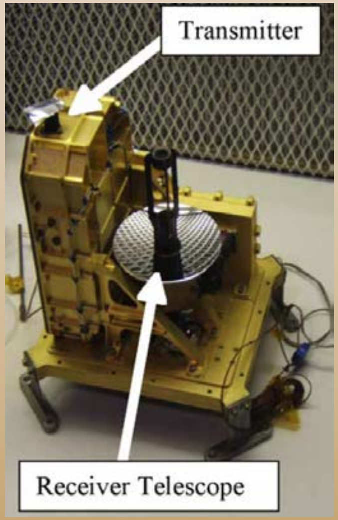


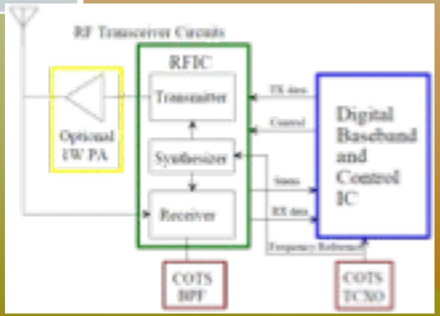
Small Martian Probes & Instruments:

- LIDAR → High BW opt.RX
- CO2
- Proximity Comms.
- High-Eff Power Sys.









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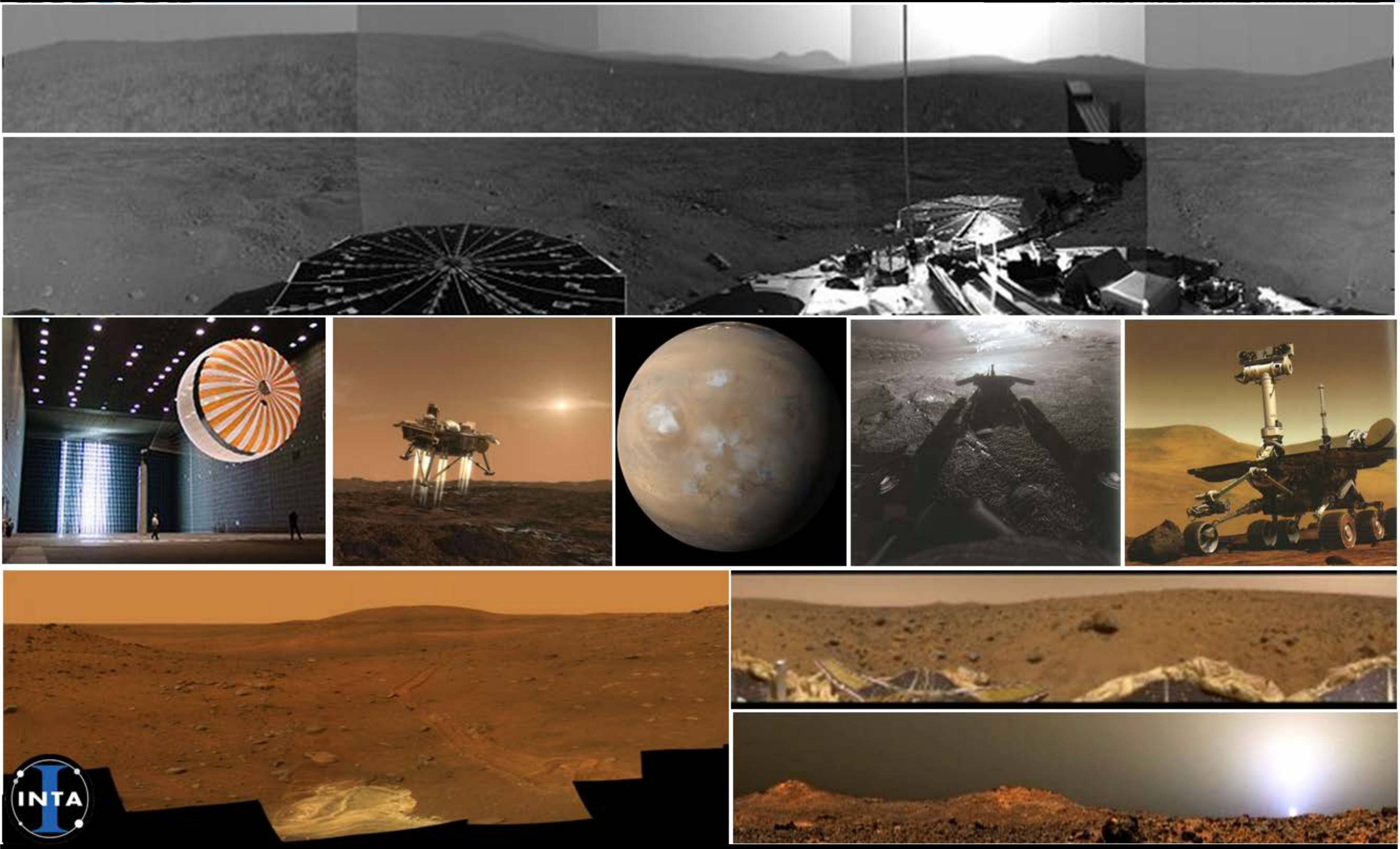

Thank you!!