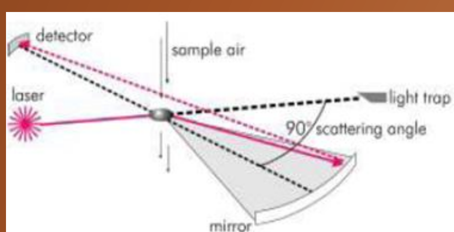
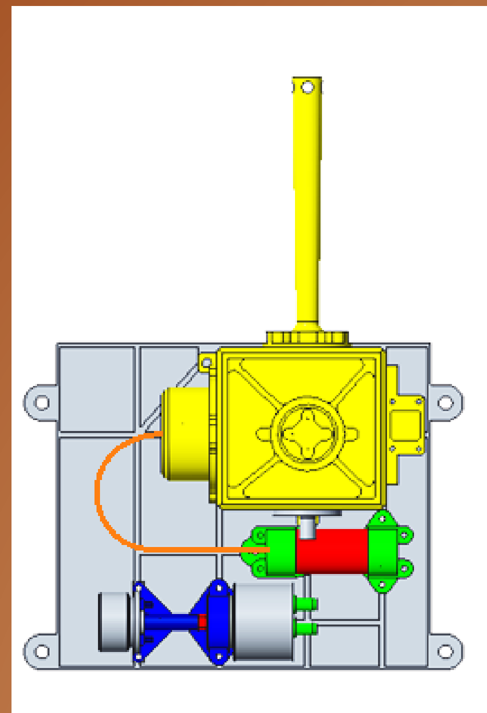
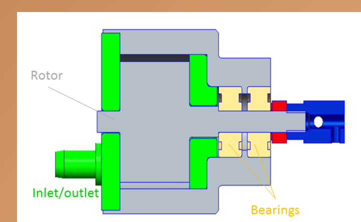
MicroMED: the Dust Particle Analyser of the ExoMars 2020 Dust Suite







Exomars Atmospheric Science and Missions Workshop

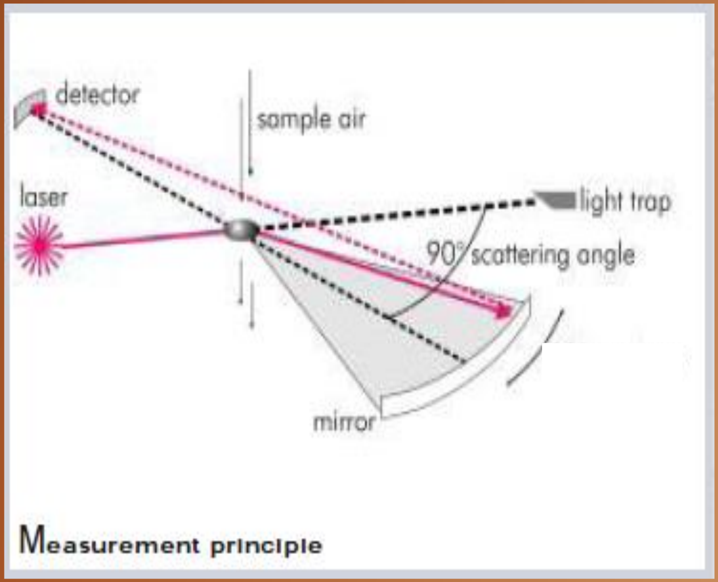
Saariselka, Finland, 26-30 March 2017

C.Molfese(1), F.Esposito(1), F.Cozzolino(1), F.Cortecchia(2), B.Saggin(3), D.Scaccabarozzi(3), I.Arruego Rodríguez(4), A. Martín Ortega Rico(4), V. Apestigue(4), P.Schipani(1), S.Silvestro(1), C.I.Popa(1), A.Zakharov(5), G.Dolnikov(5), A.Lyash(5), I.Kuznetsov(5)

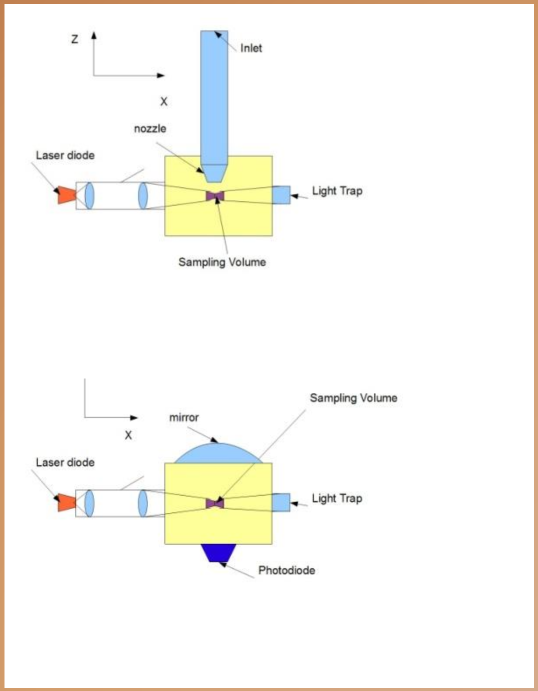
(1) INAF - Osservatorio Astronomico di Capodimonte, Napoli, Italy (molfese@na.astro.it), (2) INAF – Osservatorio Astronomico di Bologna, Bologna, Italy, (3) Politecnico di Milano, Milano, Italy, (4) INTA, Madrid, Spain, (5) IKI, Moscow, Russia

MicroMED Working Principle and Objectives

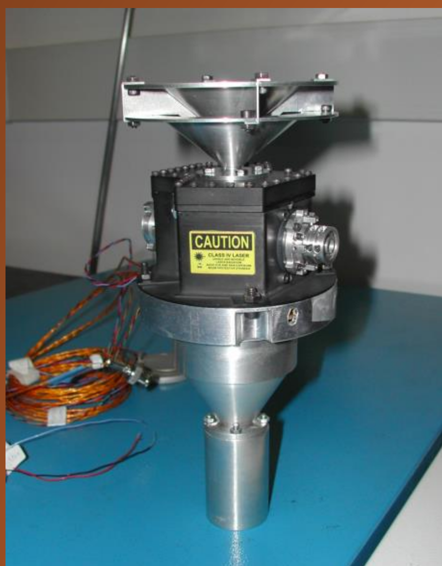
- It measures particle size and abundance near the Martian surface
- A proper fluid-dynamic system (pump and a sampling head), allows the sampling of Martian atmosphere
- Dust grains are detected by an Optical System, based on light scattering, and then ejected into the atmosphere



Measurement principle

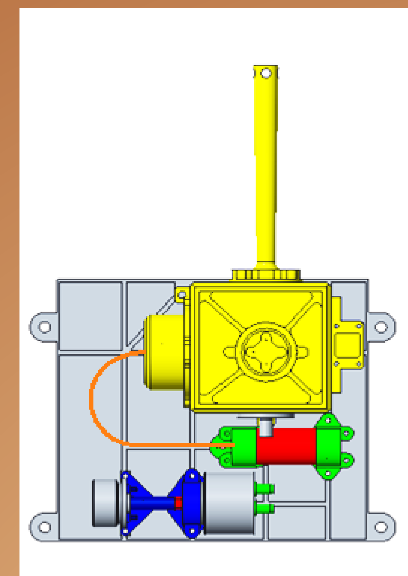


MicroMED Development



MEDUSA
(TRL=5.3 at PDR 2009)

MICROMED
Laboratory B/B 4<TRL<5



MICROMED
ExoMars 2020

Optical Design - Guidelines

The optical design was carried out taking into account:

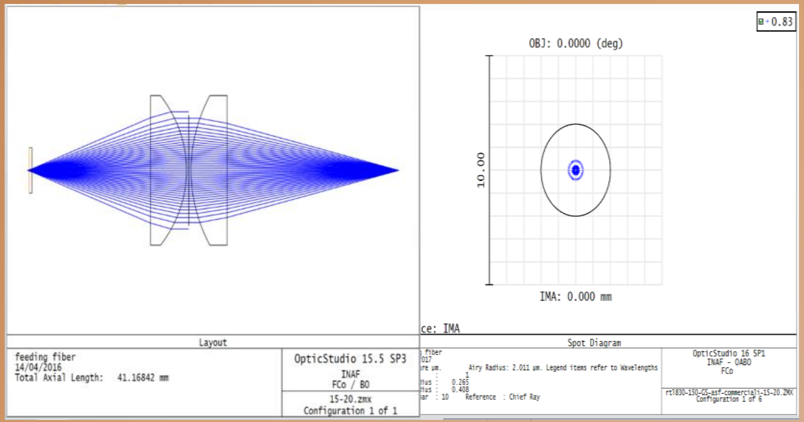
- Effective laser beam divergence and energy output
- Focusing optical system to feed an optical fiber to make the light coming from the laser uniform
- Min. optical density 0.4 W/mm^2 (equivalent to min. particles size to be detected = 0.4 µm)
- Optimized distances between system objects (lenses, mirror, detector)

Optical Design – Laser and Fiber

Laser: 830 nm, 150 mW
Fibre core: 50 µm
Fibre Input NA: 0.22
Conceptual mechanical mounting: laser and fibre alignment versus lenses
Laser characteristics: x-divergence 40° and y-divergence 25°

Environmental analyses ranges are:
- Temperature from -100°C to +60°
- Pressure from 0.006 ATM to 1 ATM

Material with low TCE

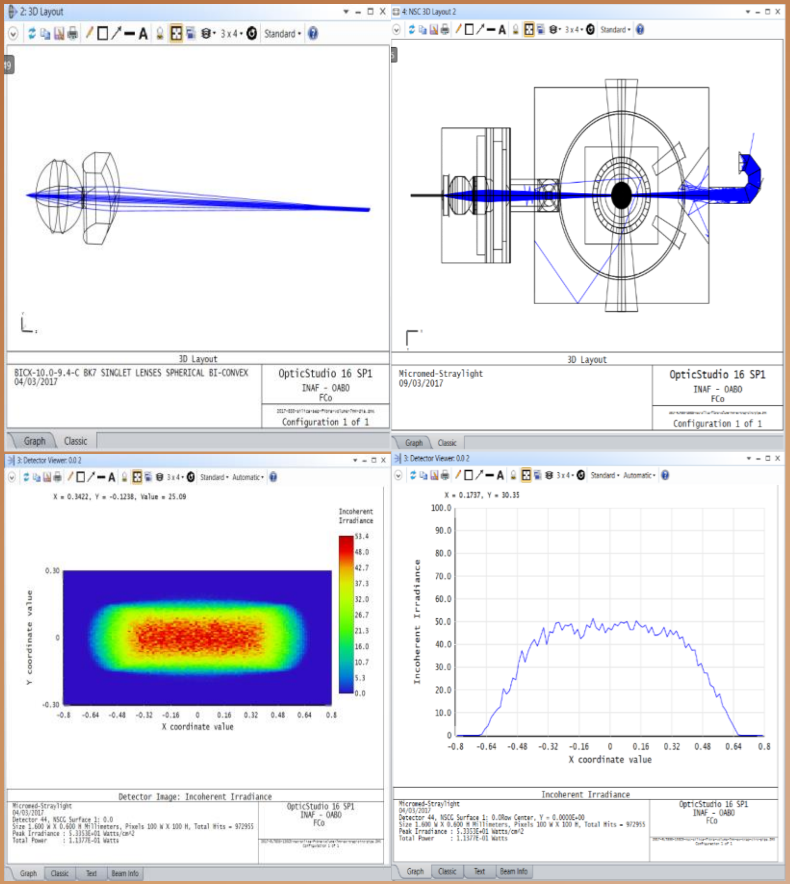


Optical Design – Sampling volume

Sampling volume: 1.3 x 1 x 0.360 mm^3
Uniformity FWHM: 0.8 x 1 x 0.240 mm^3
Fibre Exit NA: 0.22
Lenses material: fused silica
Wavelength: 830 nm
Optical density: 0.44 W/mm^2

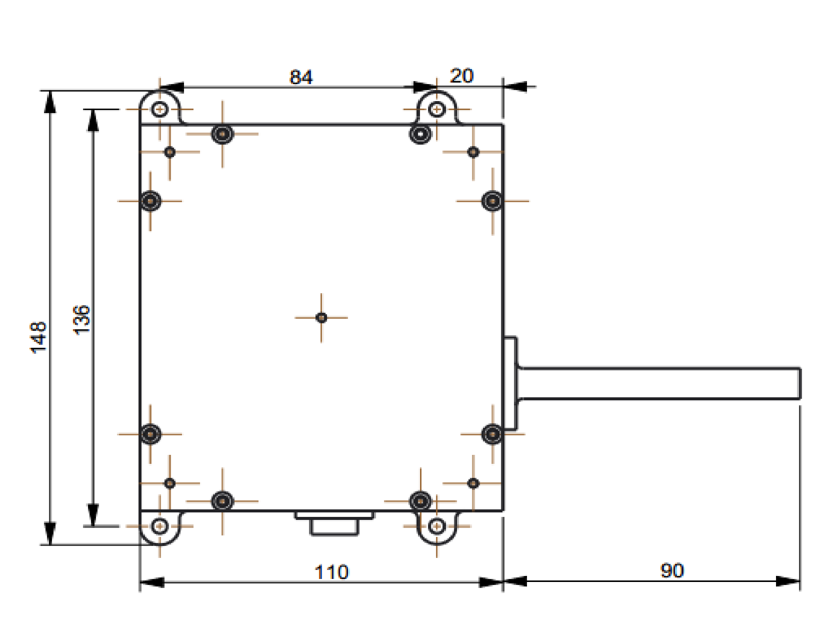
The optical design
is not sensitive to large thermal
and pressure variations

OPEN POINT: auxiliary detector for evaluation of radiation effects!



Mechanical Design - Guidelines

- Minimization of the mass budget
- Limitation of the maximum stress due to mechanical and thermal loading on the mechanical components as per ECSS standards
- Necessity rigid structures to avoid resonance problems during the launch
- Minimization of the thicknesses and the tolerances achievable with specific manufacturing processes
- Pumping system designed ad hoc according to space application standard



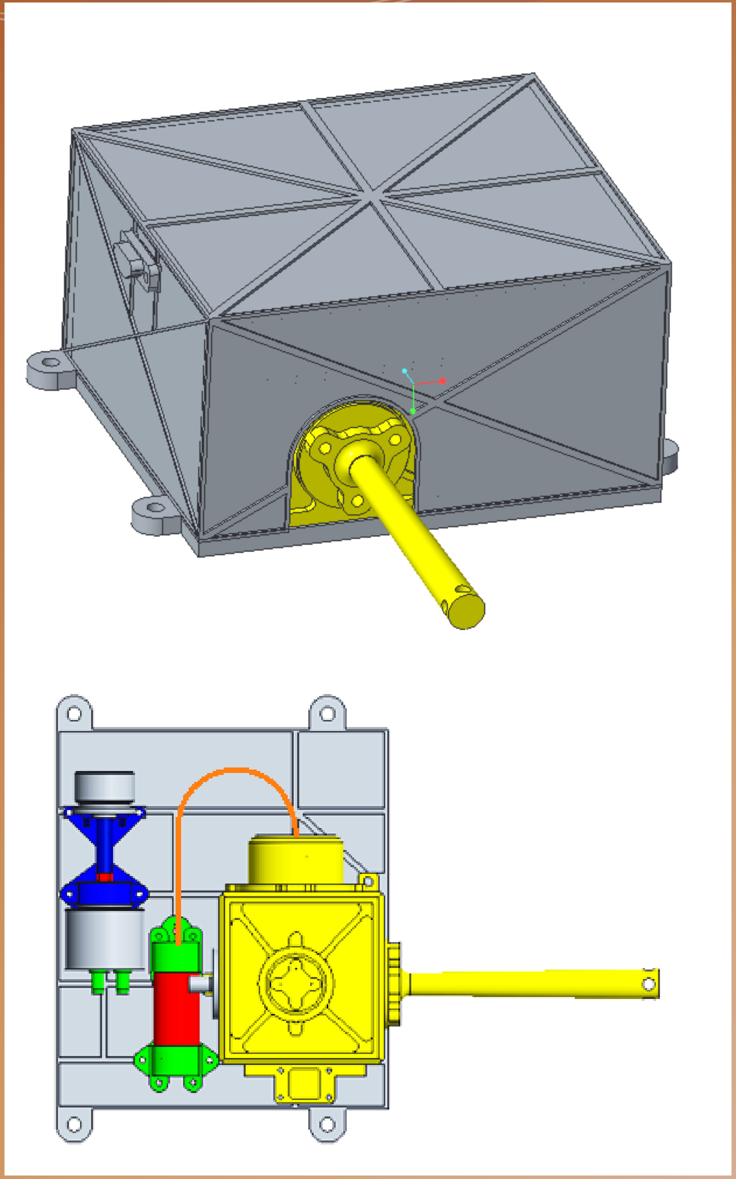
Mechanical Design – CAD Model

Main components:

- Sampling head
- Optical assembly
- Pumping system

Design requirements:

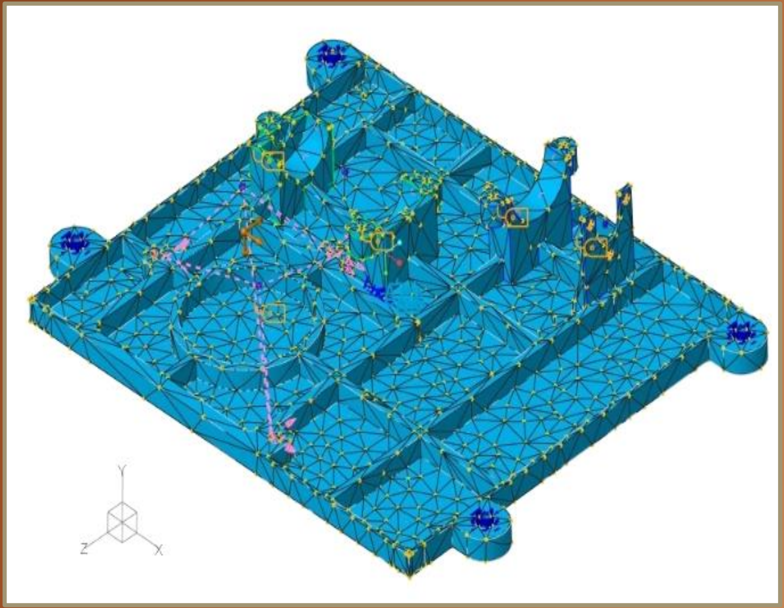
- Dynamic behavior (frequency larger than 150 Hz)
- Mass budget with 20% contingency (500g)
- Resistance vs quasi-static loading of 100g
- Volume 110x150x70 mm^3

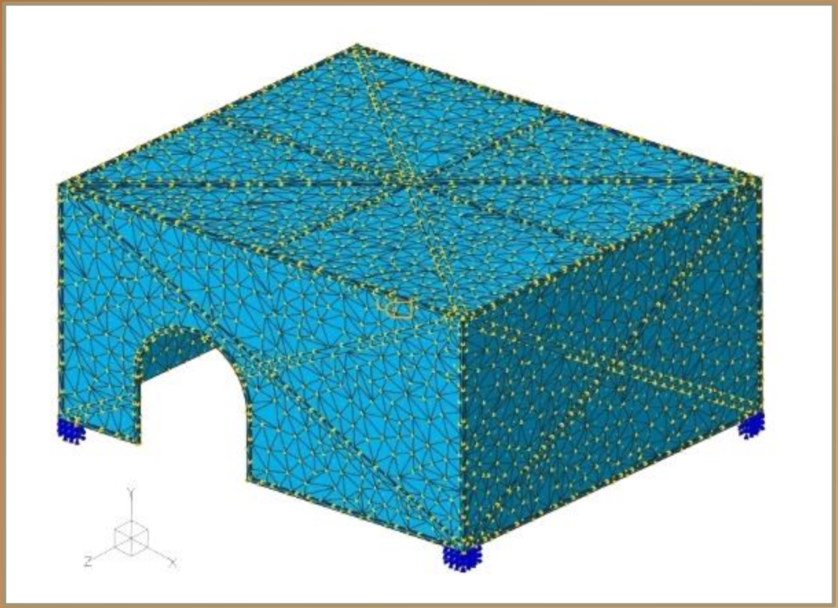


Mechanical Design – FE Models

Optical Bench and Cover 3D FE models:

- **Optics, supports, pump and motors are modelled as lumped masses**

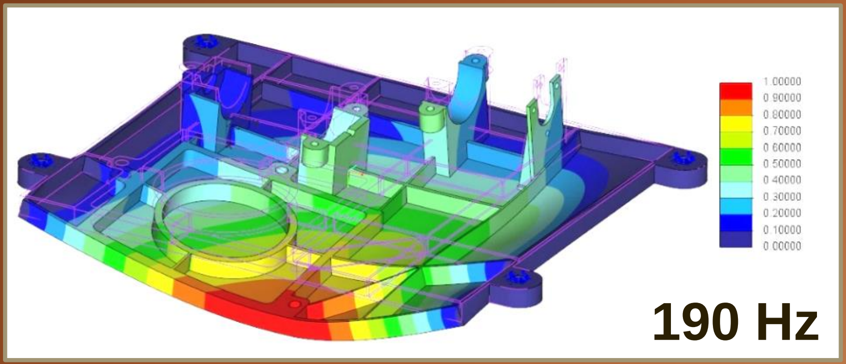


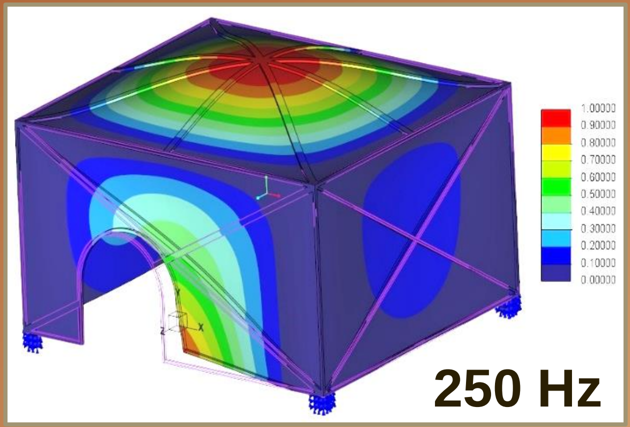


OB and Cover FE meshes

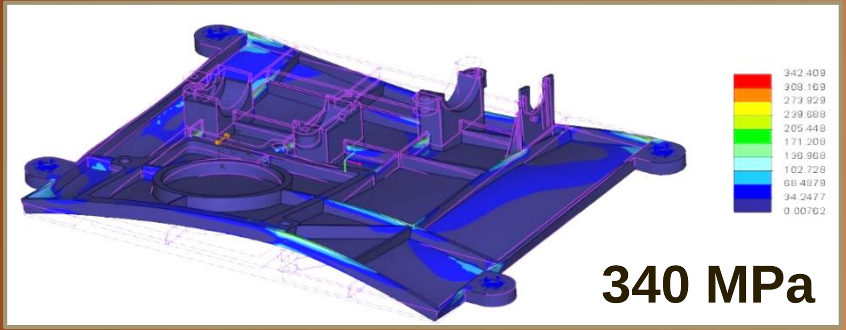
Mechanical Design – FE Models

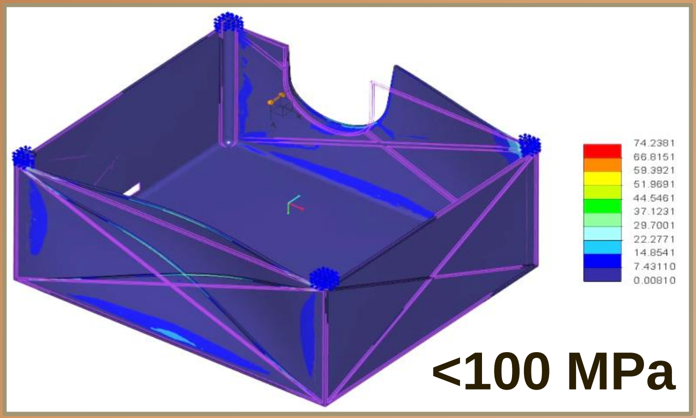
Modal analyses





Quasi-static analyses

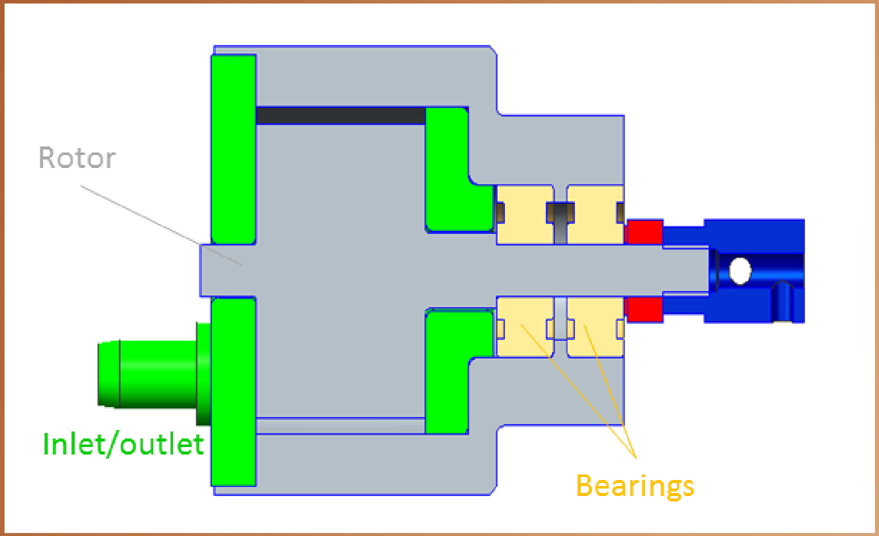




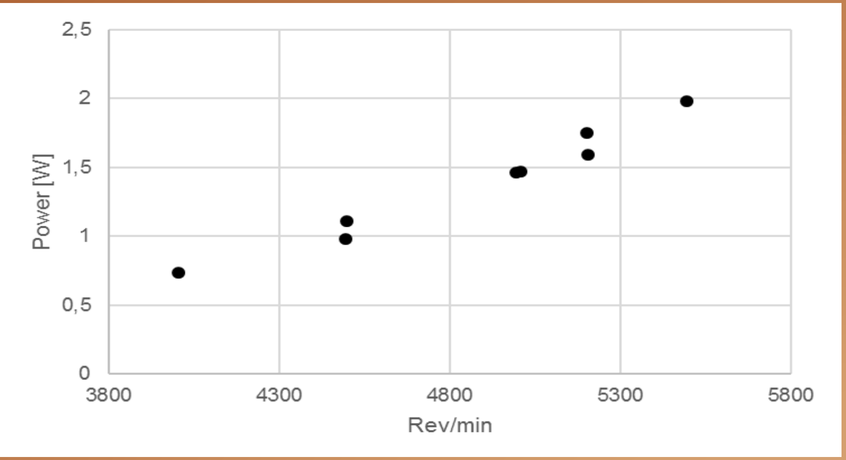
Dynamic and mechanical resistance requirements are fulfilled

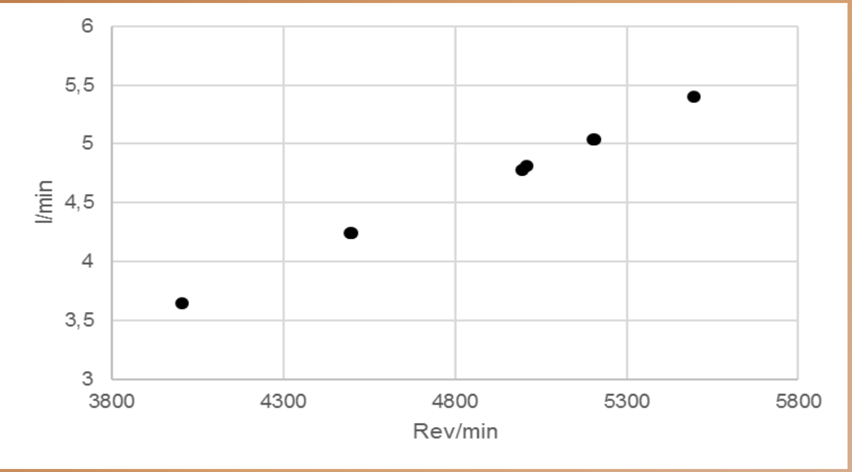
Space qualified pump

- Derived from the Gardner Denver Thomas G 24/04 EB design
- Design modified accounting for the following criticalities:
  - structural materials are chosen to avoid outgassing, to assure lightness and resistance
  - pumping chamber is modified to assure sealing at the low temperatures
  - radial angular bearings are added to take out the loading during the launch and the landing on Mars



Space qualified pump – Test results
(at standard pressure conditions)





MicroMed Pump breadboard

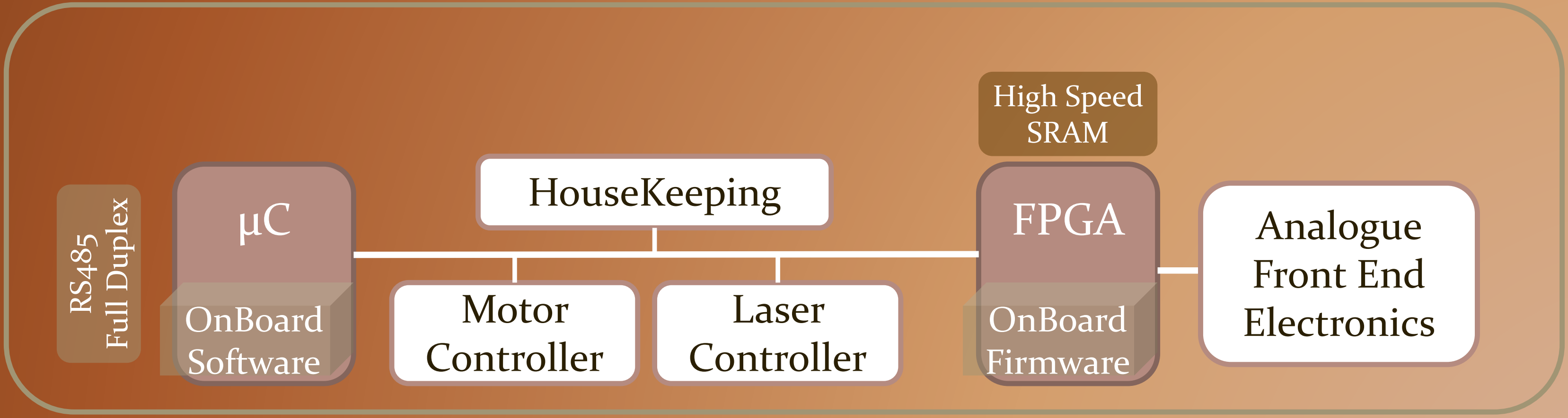
- **Mass 65g (motor included)**
- **Max power <= 5W**
- **Nominal power <=2.4W**

CEB - Central Electronics Board

MicroMED CEB is based on micro-controller with high speed co-processor FPGA:

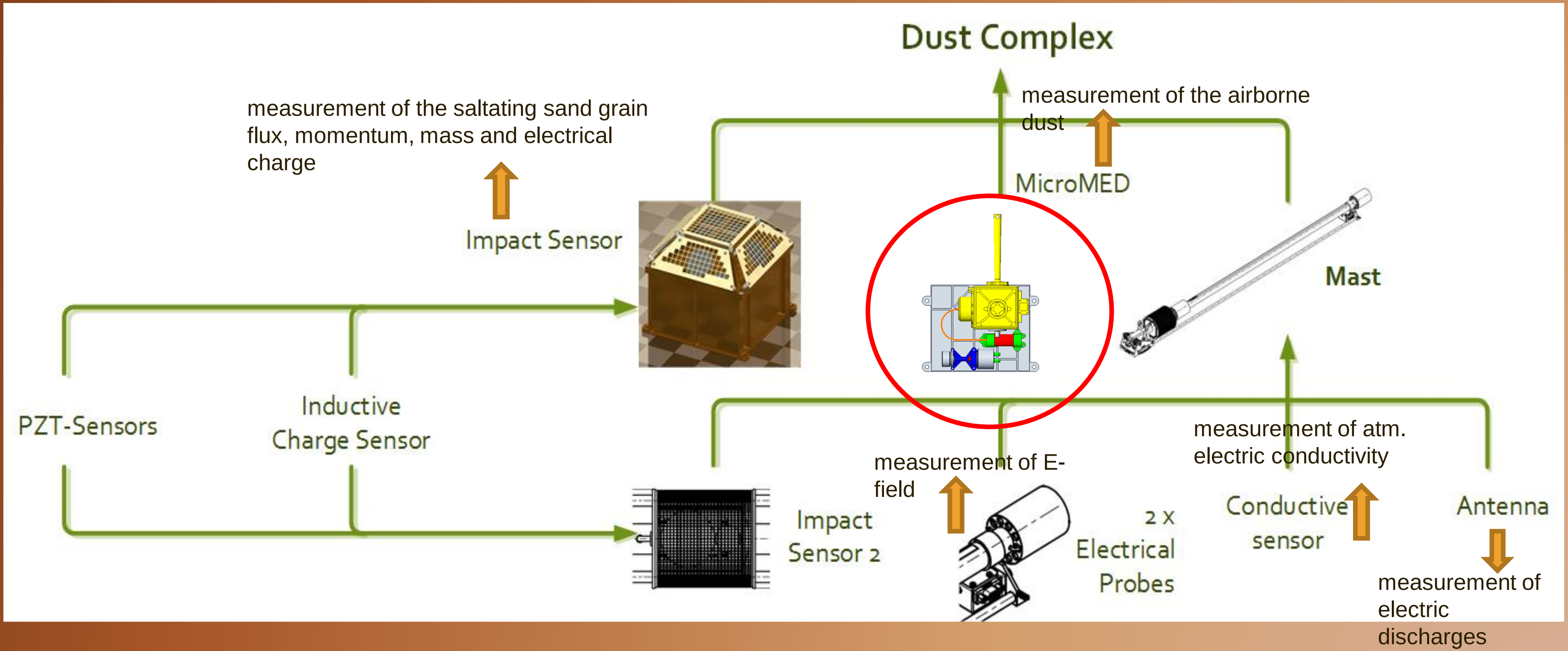
- Enhanced processing capabilities
- High speed analog acquisition
- Self mitigation scheme
- Advance motor and laser control capabilities
- Power saving modes

ALL DETAILS IN NEXT PRESENTATION BY INTA!



MicroMED - sub-unit of the Dust Suite Instrument

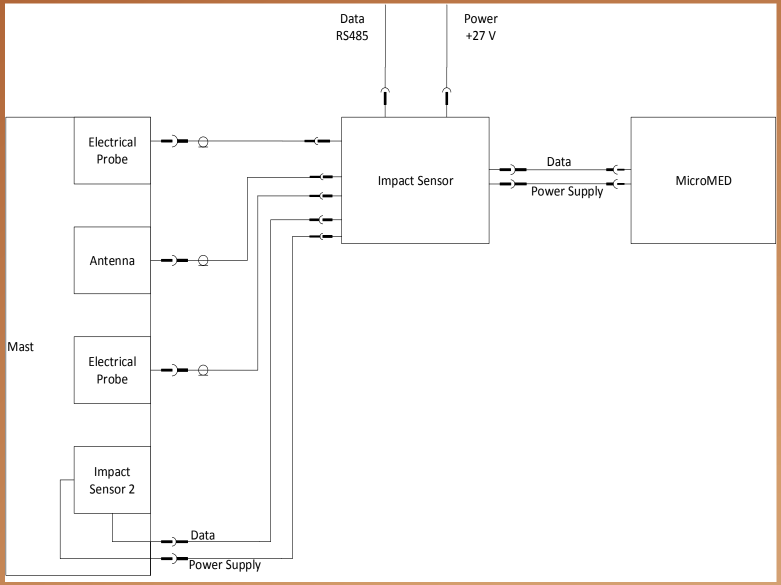
The Dust Suite is a suite of sensors aimed to study the Aeolian processes on Mars, that includes several sensors for dust properties measurement.

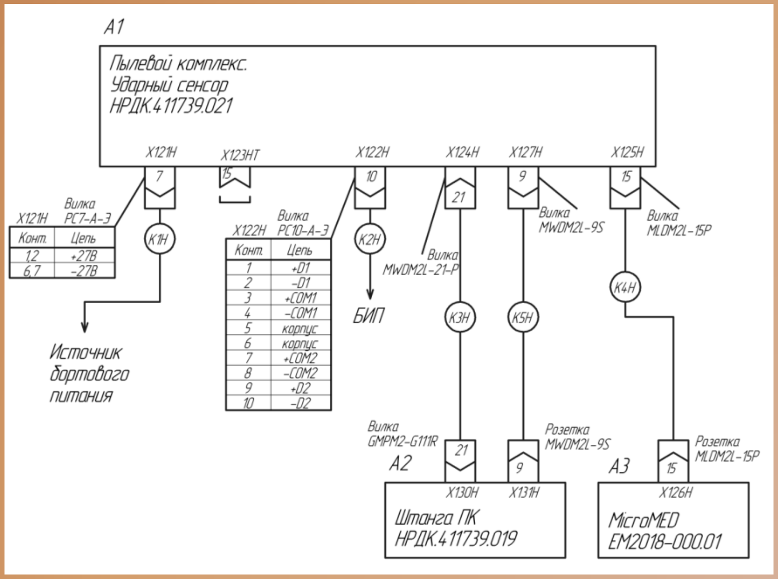


MicroMED I/Fs with the Dust Complex/Suite Instrument

- MicroMED is connected to the DC Impact Sensor
- Connector: “Micro-D”, MWDM2L-15P
- Power Interface: +5Vdc and +12Vdc
- Data Interface: RS485

PIN #	Name	Description
1	+5 V	MicroMED Power +5Vdc
2	PWR_RTN	MicroMED Power Return
3	+5 V	MicroMED Power +5Vdc
4	PWR_RTN	MicroMED Power Return
5	PWR_GND	
6	COM A	Impact Sensor to MicroMED Positive RS-485 Signal
7	COM B	Impact Sensor to MicroMED Negative RS-485 Signal
8	DAT A	MicroMED to Impact Sensor Positive RS-485 Signal
9	DAT B	MicroMED to Impact Sensor Negative RS-485 Signal
10	DIG_GND	
11	uMED_PRT	MicroMED PRT Temperature sensor signal
12	uMED_PRT_RTN	MicroMED PRT Temperature sensor signal return
13	PWR_GND	+12Vdc Power Cable Shield
14	PWR_12V_RTN	MicroMED +12V Power Return
15	+12 V	MicroMED Power +12Vdc



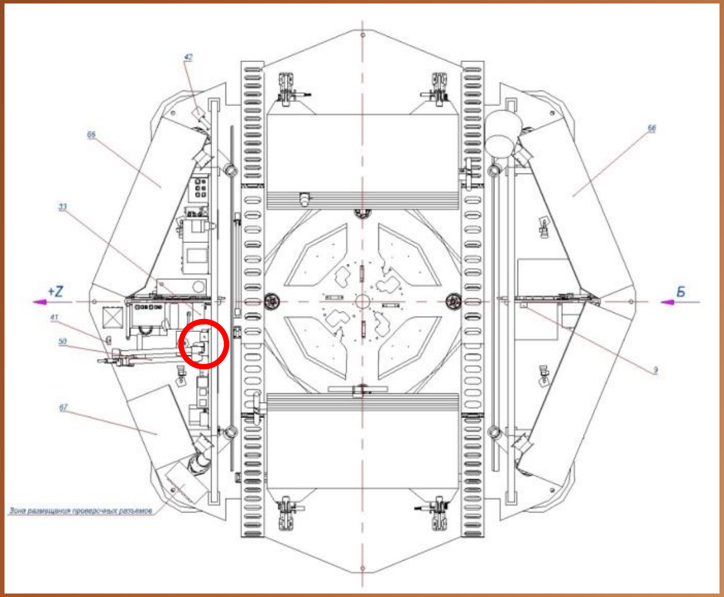


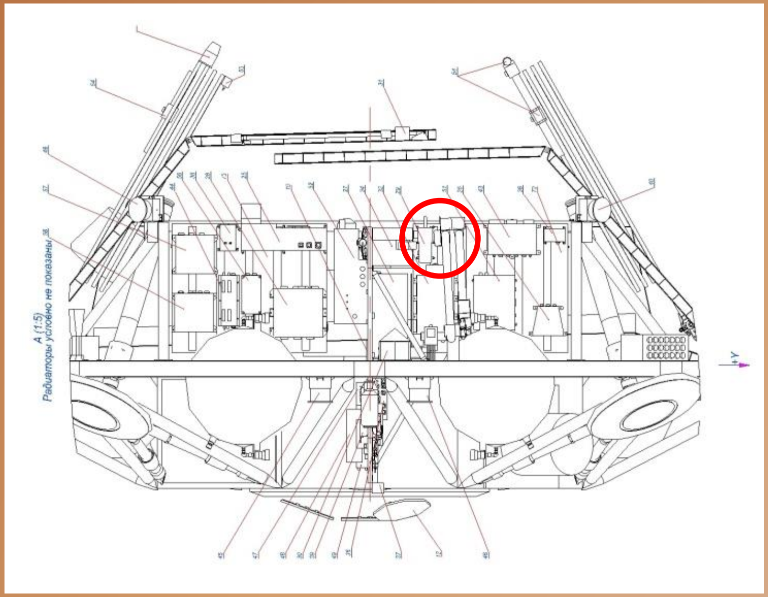
Accommodation - Requirements

- The MicroMED inlet shall be in a vertical position prior to start science operations
- The MicroMED accommodation shall guarantee sufficient free space around the inlet to avoid biasing the instrument measurements: a circular (azimuthal) area with radius ≥ 0.5 m centred on the atmospheric sampling head
- The MicroMED accommodation shall guarantee that no spacecraft-induced particulate material can bias the instrument measurements
- The MicroMED accommodation shall guarantee that the output of its atmospheric sampling pump (located at the bottom of the instrument housing) can be evacuated to free space
- The unit is located at a distance of no more than 3 m (cables lenght) from the Impact sensor

Accommodation – Proposed Solution

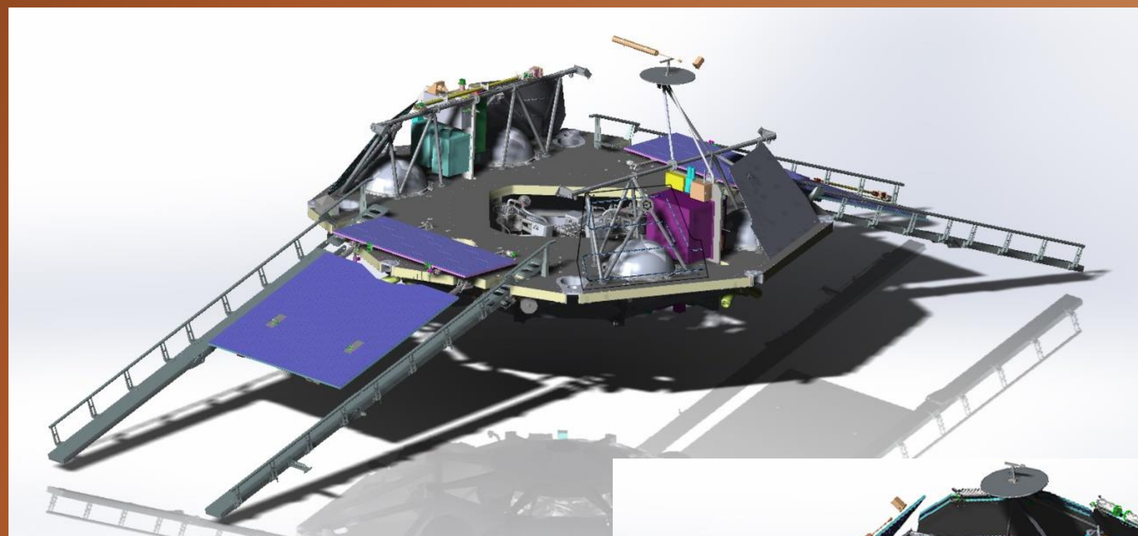
- **MicroMED installed on the Landing Platform**
- **Covered with thermo-insulating material (10cm inlet pipe needed in order to protrude through it)**
- **Temperature range from -40 to + 50 °C (not operating mode) and from -20 to +40 °C (operating mode)**



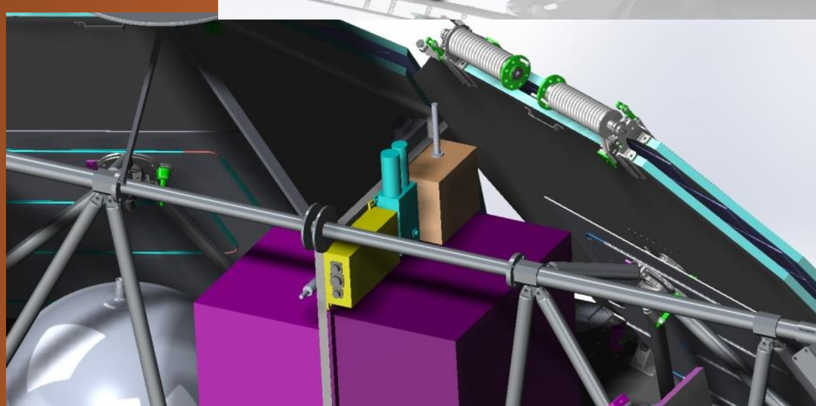


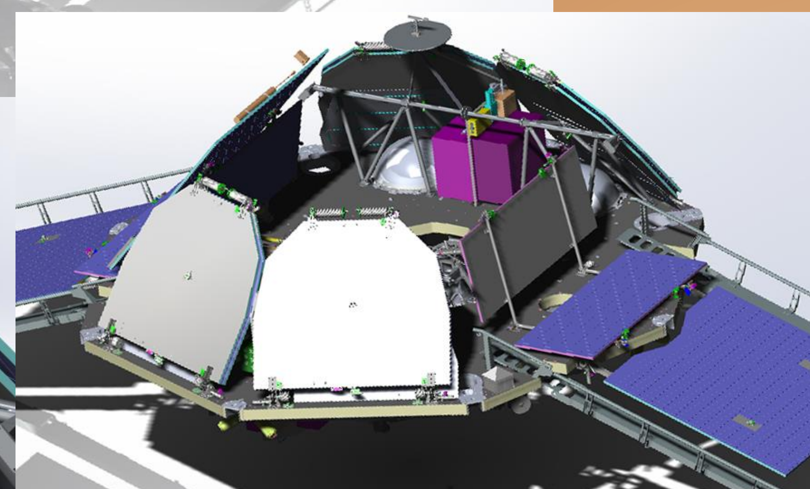
(IKI drawings)

Accommodation – Proposed Solution



(IKI drawings)





Status 1/2

Laboratory Breadboard

- New laser ordered - Tests planned as soon as the laser will be delivered
- Tests with Martian analogue JSC1 in progress
- Fluid-dynamic tests with elongated (10 cm) inlet pipe

Electrical Interface Simulator (EIS)

- Mechanics: provided by the Russian Team
- Electronics: schematic design, PCB routing, procurement and integration completed; SW in progress; functional tests are the next step

Status 2/2

Engineering Model (EM)

- Optics: improved design configuration (based on B/B design and achieving better power density and sampling volume profile) is completed
- Mechanics: OB and FEA baseline are defined. Detailed design is the next step
- Electronics: schematic design and PCB routing (except for the motor controller - still in progress), Procurement completed; Integration, SW and FPGA-VHDL in progress

Space Qualified Pump

- First prototype manufactured and tested at standard pressure conditions
- Vacuum tests are the next step

Milestones

- Electrical Interface Model (EIS): within next August
- Qualification Model (QM): March 2018 (TBC)
- Flight Model (FM): 4th quarter of the 2018 (TBC)