ExoMars
Atmospheric Chemistry Suite
Overview

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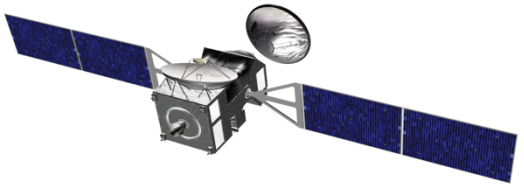
ExoMars Project

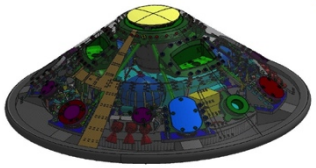
Project configuration

ExoMars

2016 Launch

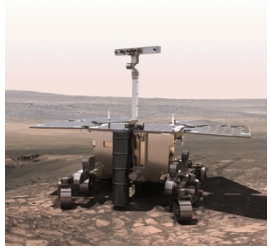


Trace Gas Orbiter

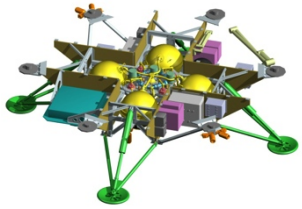


EDL Demonstrator Module (EDM)

2018 Launch



The Rover



Landing Platform

2016 Trace Gas Orbiter

Orbit circular

The Mission (Russian perspective)

- **Completion of previously planned missions:**
  - Investigation of the Mars structure and climate at the surface (Mars-96 □ Mars-Net).
  - Atmospheric science, search for methane, climate monitoring from the orbit (Phobos-Grunt).
- **New science goals:**
  - Exploration of Mars habitability.
  - Subsurface water mapping with higher resolution.
  - Volcanism (search for volcanic gases).
- **Development of a joint (ESA-Roscosmos) ground segment for interplanetary missions.**
- **Integration of Russian and European experience in technology development for interplanetary missions and in quality control.**
- **Preparation for the next steps in Mars exploration:**
  - Reconnaissance of landing sites, subsurface water as a resource.
  - Monitoring of radiation during cruise and on the surface

ExoMars Project

ESA + NASA TGO configuration → ESA + Roscosmos TGO configuration

NOMAD
High resolution occultation and nadir spectrometers

Atmospheric composition (CH4 ,O3 , trace species, isotopes) dust, clouds, P&T profiles

UVIS (0.20 – 0.65 μm) λ/Δλ ~ 250	SO	Limb	Nadir
IR (2.3 – 3.8 μm) λ/Δλ ~ 10,000	SO	Limb	Nadir
IR (2.3 – 4.3 μm) λ/Δλ ~ 20,000	SO		

MATMOS
High-Resolution FT spectrometer

Vertical distribution of water, methane and trace species

Infrared (2.3 – 12 μm) λ/Δλ ~ 130,000	SO

EMCS
Limb radiometer

Monitoring of atmospheric structure, water and aerosols

MAGIE
Wide-angle camera

Monitoring of clouds and ozone

HiSCI
High-resolution camera

Mapping of sources; landing site selection

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IR (2.3 – 4.3 μm) λ/Δλ ~ 20,000	SO		

CaSSIS
High-resolution camera

Mapping of sources; landing site selection

ACS
Suite of 3 high-resolution spectrometers

Atmospheric chemistry, aerosols, surface T, structure

Near IR (0.7 – 1.7 μm) λ/Δλ ~ 20,000	SO	Limb	Nadir
IR (Fourier, 2 – 25 μm) λ/Δλ ~ 4000 (SO)/500 (N)	SO		Nadir
Mid IR (2.2 – 4.5 μm) λ/Δλ ~ 50,000	SO		

FREND
Collimated neutron detector

Mapping of subsurface water

TGO. Russian contribution. FREND.

Fine **R**esolution **E**pithermal **N**eutrons **D**etector (**FREND**) – a neutron detector with a collimation module that significantly narrows the field of view of the instrument, thus allowing to create higher resolution maps of hydrogen-abundant regions on Mars. Additionally, dosimeter module for monitoring of radiation levels is installed.

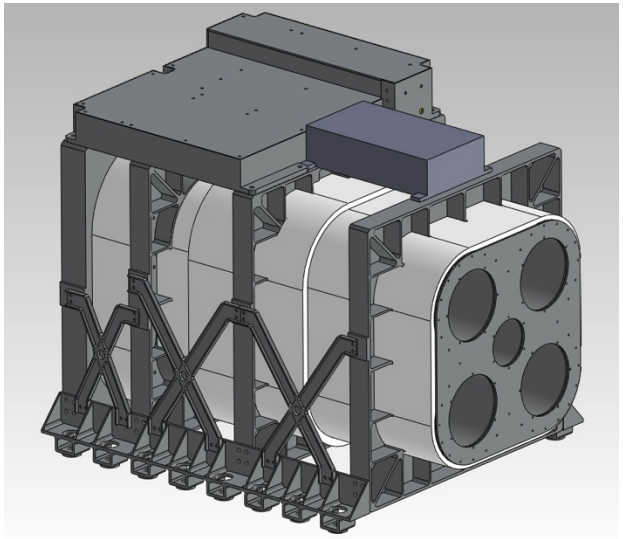
Energy ranges:
Epithermal neutron detectors: 0.4 eV – 500 keV
Fast neutron detector: 0.5 – 10 MeV

Time resolution: 5 s

Spatial resolution: ~ 40 km from 400 km orbit:10 times better than HEND (Mars-Odyssey)

Mass: 36 kg

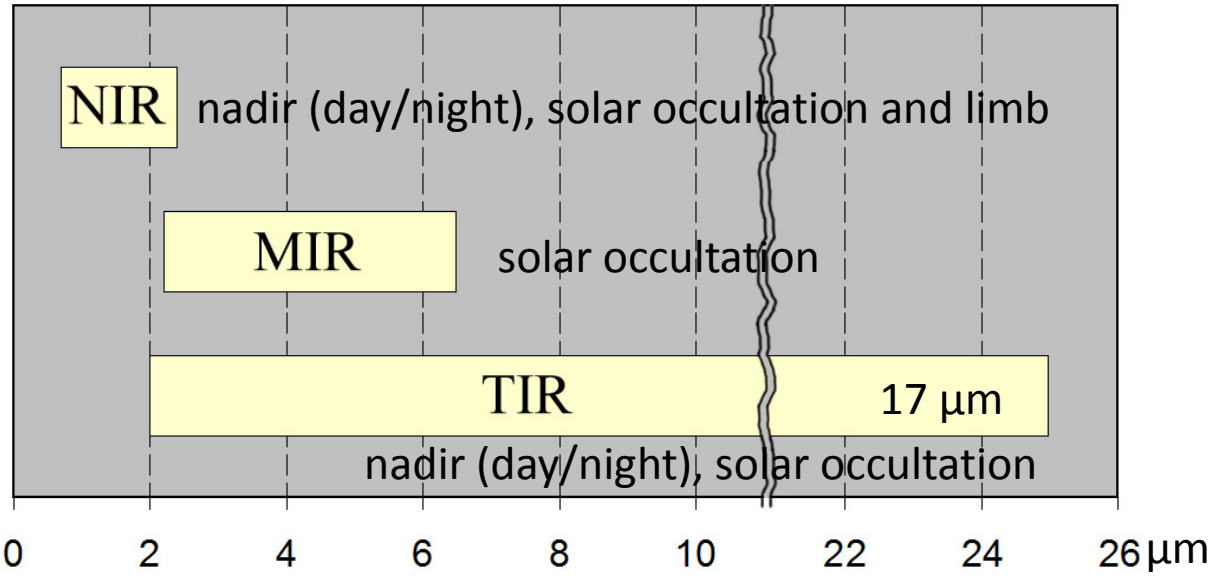
Power: 11W

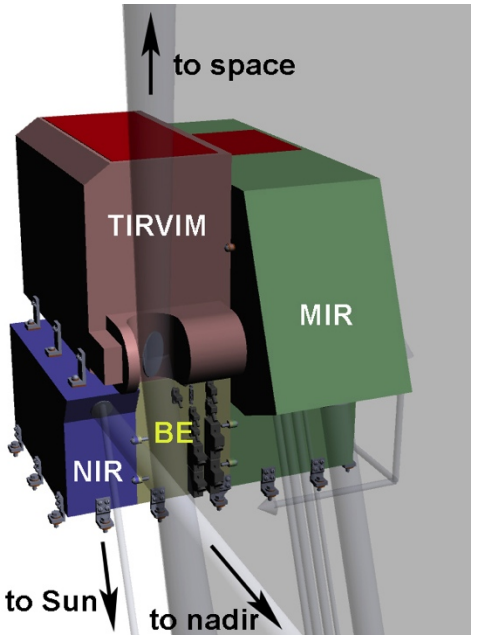


Key questions of Mars science and ACS

- Internal structure/Volcanism
  - By measuring minor gases of potential volcanic origin
- Climate: present and evolution
  - By characterizing atmospheric state, climate, and isotopic ratios (D/H in particular)
- Past and present habitability

	Spectral range	Inst. range	resolution
ACS/MIR	2.2-4.3 µm	0.28-0.3µm	>50 000
ACS/NIR	0.73-1.6 µm	~0.17 µm	>20 000
ACS/TIRVIM	2.05-17 µm	full range	0.2cm-1 occ 0.2-1.6 cm-1 nadir



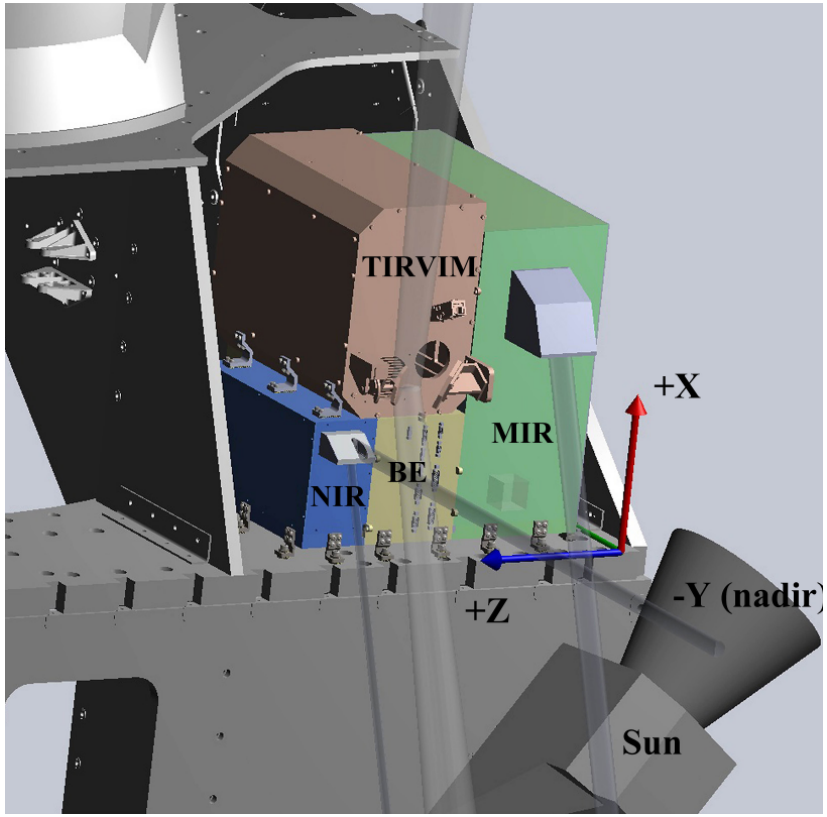


The legacy of ACS

- Venera-15 → Mars 96 → Mars Express → Phobos-Grunt : PFS, AOST (Fourier-Spectrometry)
  - Planetary Fourier Spectrometer (initiated by V.I. Moroz): two channel 2” Fourier-spectrometer for atmospheric chemistry and atmospheric structure
  - PFS is the catalyzer of methane discovery in 2004
  - ACS/TIRVIM is the scaled version of AOST/Phobos-Grunt
- Phobos 88 →Mars 96 → Mars Express : Auguste, SPICAM (Solar Occultations)
  - The versatile instrument initiated by J. Blamont employing solar occultations for profiling and sensitive measurements
  - Profiles of water, aerosol, ozone, etc
- Venus Express, ISS, Phobos-Grunt : SOIR, VIRTIS-H, Rusalka, TIMM-2
  - Echelle/AOTF spectrometry in solar occultation initiated by Korablev&Bertaux, underlying NOMAD and two ACS channels

ACS Accommodation at the Spacecraft

- occupies the MATMOS slot on the upper deck
- four separate blocks integrated into a single unit
- two solar occultation apertures (NIR and MIR)
- one nadir aperture (NIR)
- 1-D scanner in XY plane to observe open space, internal BB, nadir and sun (TIRVIM)
- radiators



ACS: Organization of the Project

- ACS if fully funded by Roscosmos (since last decade of 2012)
- CNES funds the proximity electronics of ACS-MIR detector (since recently)
- cancellation of CSA contribution: Solar imager channel discontinued

ACS Team

Science Team

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Yurii Ivanov (GAO NANU)

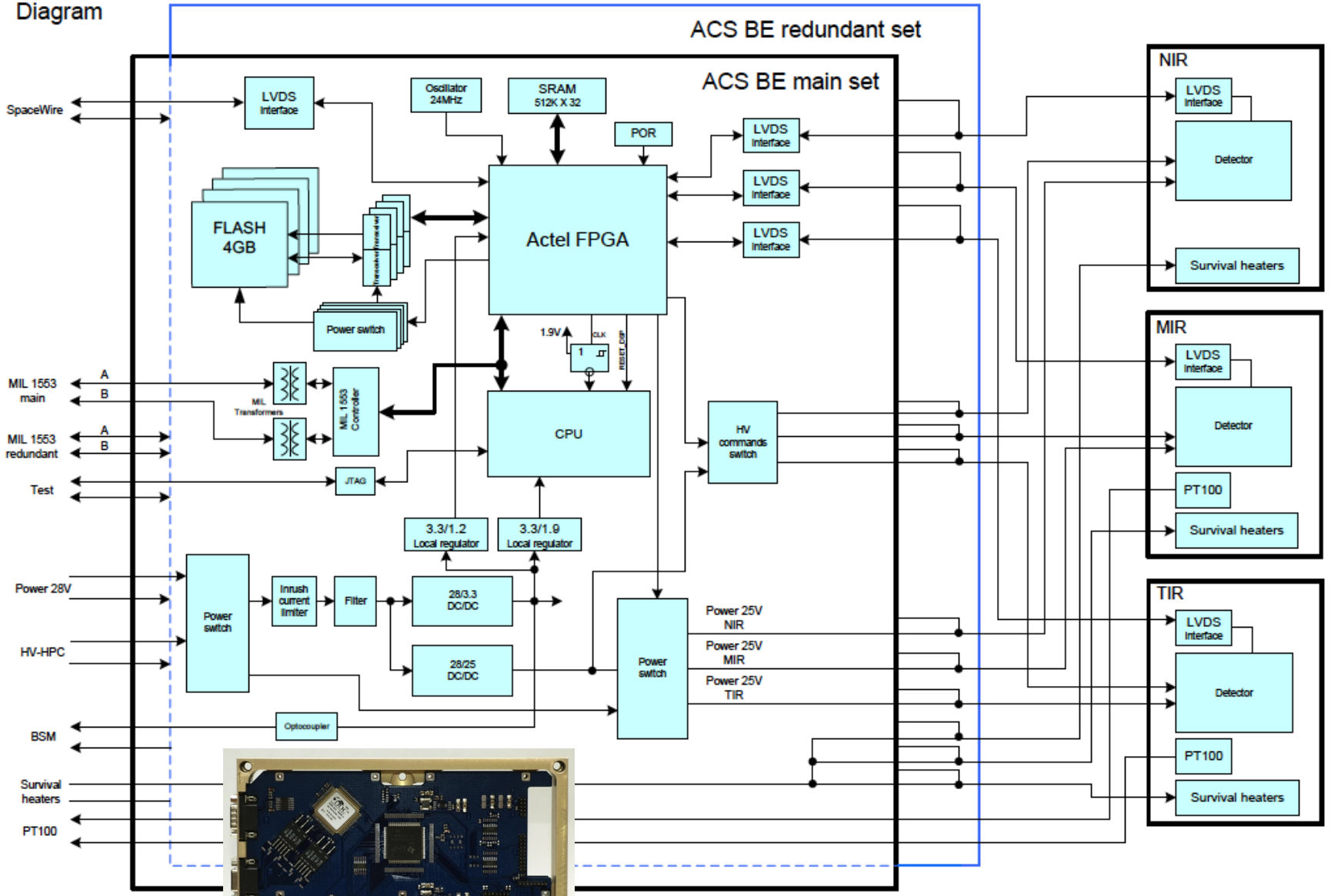
Jean-Pierre Goutail, Mustapha Meftah Laurent Lapauw (LATMOS)

SOFRADIR, Steel (TBC)

AMOS

Detailed talks on NIR and MIR channels follow

ACS Block Diagram



EIM cards (prototype)

Main Parameters of ACS

Parameter	NIR	MIR	TIRVIM	ACS
Operation modes	Nadir (dayside and nightside), SO, Limb	Solar occultation (SO)	Nadir (dayside and nightside), SO	Nadir, SO, Limb
Field of view (FOV)	20×0.02 arc min	10×0.5 arc min	3° full solar disk in SO	
Spectral range	0.73-1.6 μm	2.2-4.3 μm 5 photometers 0.25-0.9 μm	2-17 μm 1.7-4 μm Nadir "CH_4"	0.25-17 μm full 0.73-17 μm spectral
Instantaneous spectral range	50 ×100 cm^{-1}; 16 nm at 1.37 μm	7 × (0.28-0.32 μm) ex. 3.13-3.46 μm	Full range	
Time to measure one spectrum	2 s Nadir 50 ms SO	0.5-1 s	4 s Nadir 10 s Nadir "CH_4" 2 s SO	
Number of spectra per measurement	≤ 8	1 or 2	1 or 2	
Spectral resolution/resolving power	$\lambda/\Delta\lambda \geq 20{,}000$	$\lambda/\Delta\lambda \geq 50{,}000$	1.6 cm^{-1} Nadir 0.2cm^{-1} Nadir "CH_4" 0.2 cm^{-1} SO ($\lambda/\Delta\lambda \approx$ 15,000 at 3.3 μm)	
Mass	3.3 kg	12.2 kg	11.6 kg	33.5 kg
Power	15W	30W	28W	39-85 W survival 22 W
Volume	12×35×25 cm^3	20×50×60 cm^3	20×44×30 cm^3	52×60×47 cm^3
Data rate	0.1 Gb/day	0.7 Gb/day	0.7 Gb/day	1.5 Gb/day

Data volume

- Reference fig 1.5 Gbit per day imposed by ESA
- E.g. NOMAD: 2.5 Gbit
- Downlink capacity 1.2-31 Gbit depending on distance to Mars with ESA stations only
- Current approach MIR&TIRVIM: 0.7/0.7 Gbit; NIR 0.1 Gbit
- We generate 500 Mbit per ingress or egress baseline is working on 1, max 2 eclipse per day (out of 12)