Mars Express Science Ground Segment overview: the mission's evolution, new challenges and future perspectives

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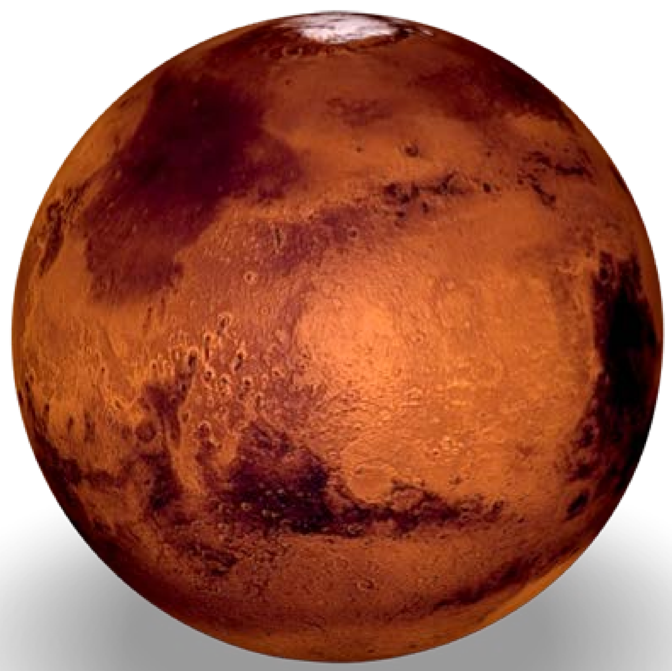
Abstract

We present an overview of more than 13 years of mission operations from the perspective of the Science Ground Segment (SGS), including the evolution of the mission planning system and summarizing the new challenges ahead for the years remaining until the end of the mission. In addition, we emphasize the planning for the eclipse and solar conjunction season during the Summer of 2017. In comparison with the SGS planning for other missions, we present some observation statistics and conclude with the planned system improvements and future mission perspectives.



17360 orbits, more than 5000 days of operations

First time an ESA mission is coexisting with its successor mission (TGO)

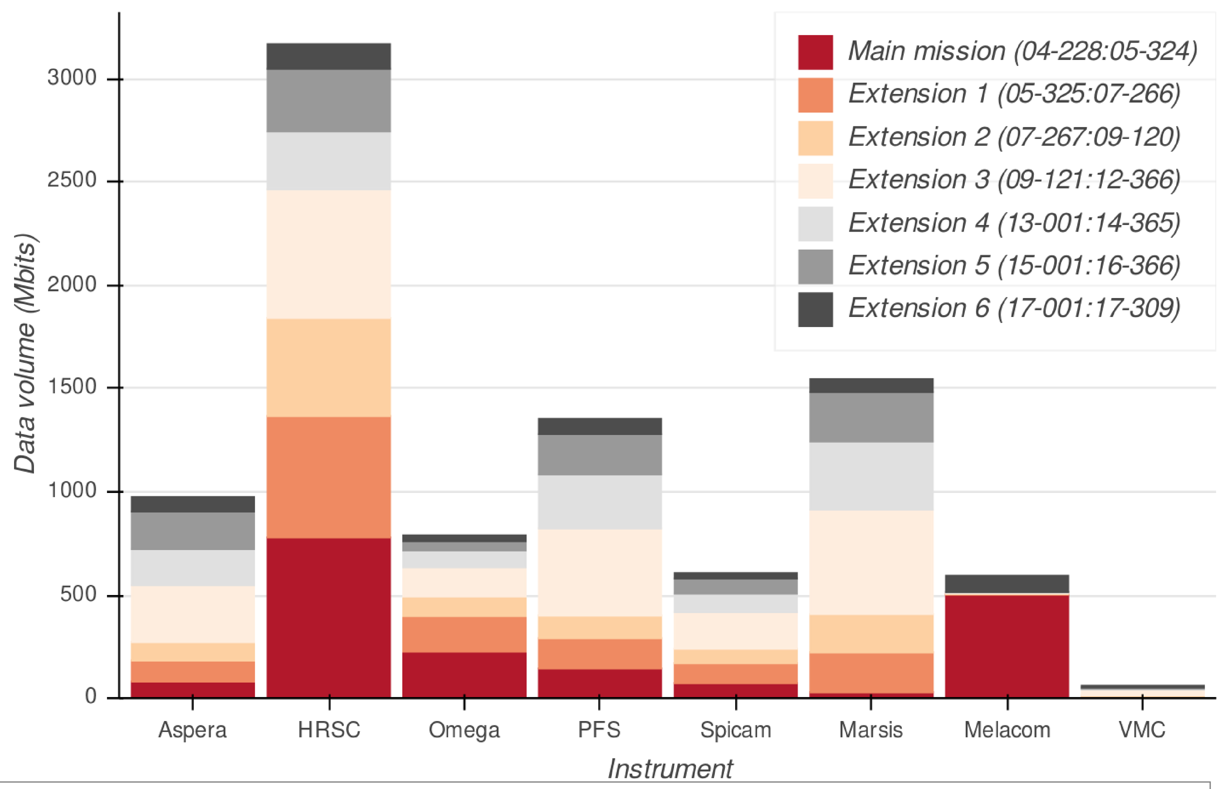
Approved 2017-18 extended mission at the moment

Mars Express (MEX) Operational Highlights

2003	Science operations started after 4 days of LEOP. Observations of Earth and Moon.
2004	First Phobos flyby, identification of water ice and CO_2 at South Pole.
	Methane and recent volcanic activity observation support.
2005	Mapping water-rich minerals, mid-latitude glaciers and auroras discovery over magnetic anomalies. Marsis boom deployment.
2006	CO2 ice clouds detection and global mapping O_3.
	Energy survival due to solar conjunction
2007	VMC camera reactivated and atmospheric escape rates determination.
	Subsurface radar imaging of ice caps. Mars webcam operations.
2008	Mission's first 3D images of Martian subsurface released. Sharpest Phobos mapping.
2009	Phobos and Deimos together, detection of the boundary between Mars upper atmosphere and space
2010	77 km Phobos flyby, subsurface water ice mapped across Mars.
2011	Curiosity rover landing site studied. Discovery of supersaturation of water vapour in the atmosphere.
	Solar conjunction special operations.
2012	Molecular O_2 in the night side atmosphere, gravity analysis of magma densities under volcanoes
2013	Global mineralogical maps produced.
	Phobos flyby at 58 km.
2014	Siding Spring avoidance and observations, Oort cloud comet observations.
2015	10 years of auroral data. UV auroras detected. VMC educational campaign.
2016	40 km Siloe Patera crater discovery to be collapsed centre of an enormous volcano.
	VMC goes pro.
2017	Heavy power constraints due to Eclipses and solar conjunction. Continuing science exploitation.
	New strategies for VMC operations.
2018	ExoMars TGO – MEX joint science observations plan.

Downlink statistics

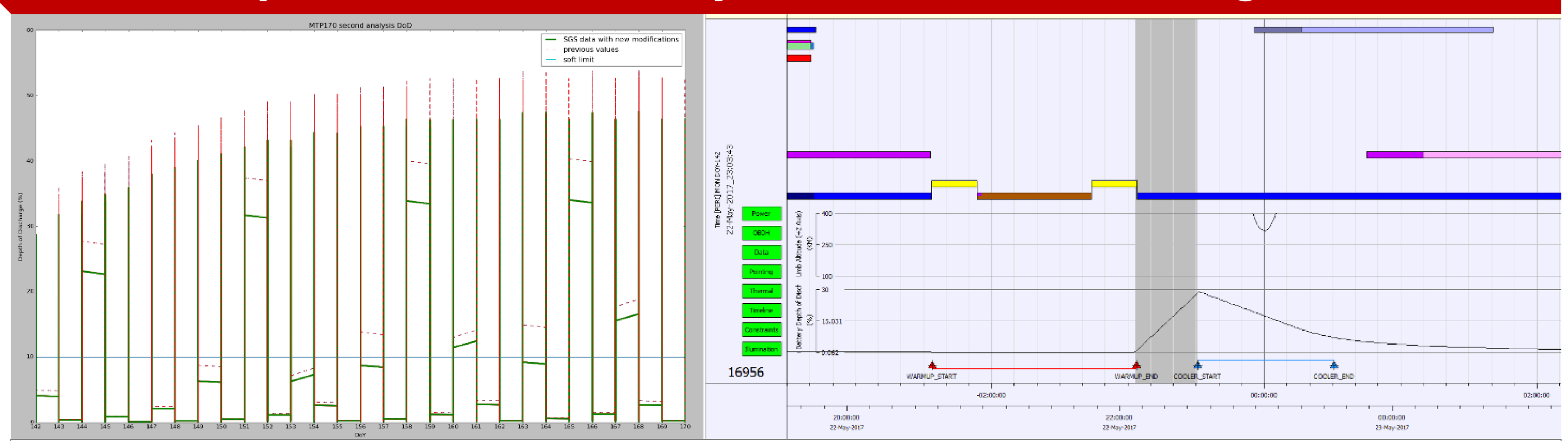
Total mission data volume distribution per instrument



Versatility in SGS is the key for success. Along the different Martian seasons data volume varies in function of illumination conditions, eclipses, etc..

Note the graph only represents volume of data that is not correlated with quantities or qualities of science. It must be considered as a tool for trend analysis along different mission phases. Since several years, MEX archive supports archiving of high level science products as service to the science community. Detailed information can be found at the official website.

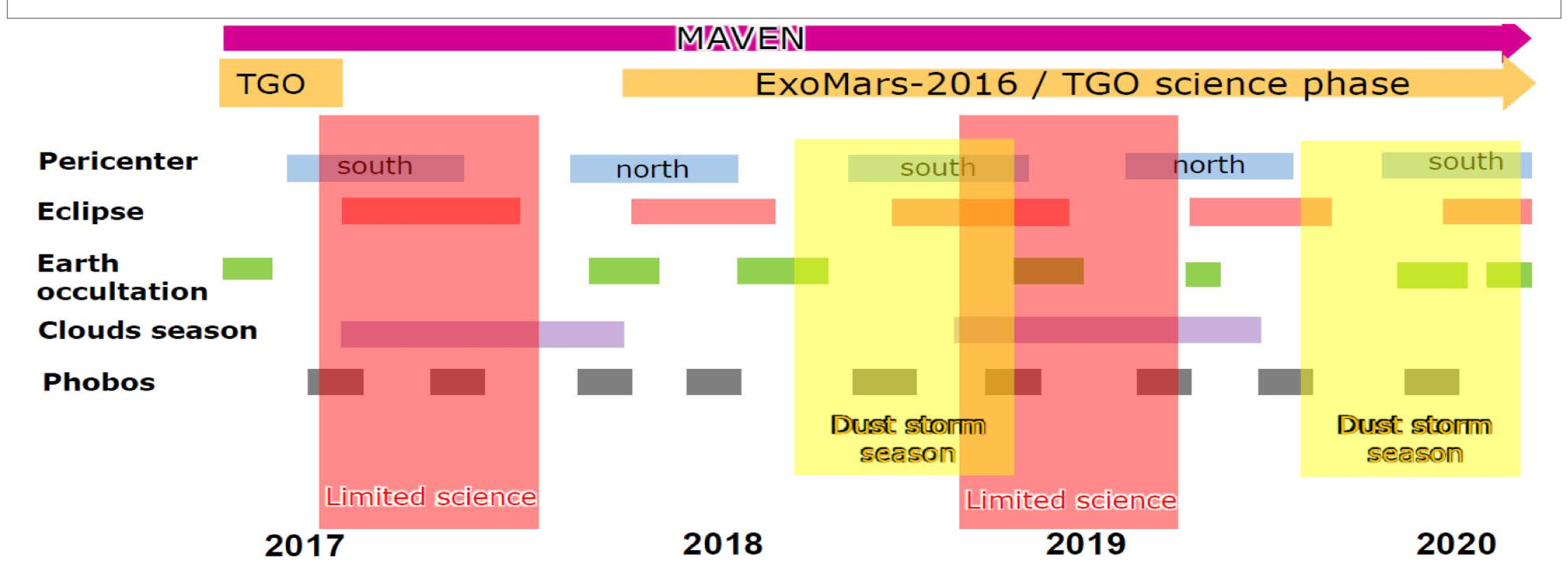
2017 eclipses and solar conjunction: new challenges



Preliminary analysis indicated eclipse season during 2016/2017 it would be critical to maintain the battery depth of discharge limit and safe mode power margin within conservative values. The graph on the left side shows the refinements made in the SGS power modelling in order to optimize the number of observations to the limit. The right side shows the planning system tool adjustments and new events created for such a purpose. While iterating with telemetry from the Mission Operation Centre (MOC) system placed in ESOC, an alarm and recovery system was created in order to safe as much science as possible when conditions forced one reduction of the power consumption at very short term planning as performed along Rosetta missions operations. Warm-up pointing were required 90 minutes before eclipse, and some cooling down periods were placed during the next 75 minutes after the eclipse ended. That significantly reduced the time of observation around periapsis, where he instrument teams were interested in obtaining science.

Future activities

- Preparing TGO joint science phase, providing geological context to the new observations.
- Provide support to Phobos & Deimos science with new pointing designs and system tools.
- Optimizing planning for augmenting high-resolution stereo coverage of the surface.
- Characterizing landing sites for future robotic and manned missions.
- Monitoring observation trends to secure the homogeneity in observations for climatology, ionosphere, plasma environment and dynamical processes on ground and in the atmosphere.



Conclusions

Flexibility is key for science missions in comparison with other missions' planning tools for which automation is vital for their development. Unfortunately, this implies manual processes and requires qualified operators, both engineers and scientists, to achieve the Principal Investigators goals. In order to improve SGS systems across planetary missions, it is vital to maintain accurate reporting and documentation for long-term missions such as MEX and for an optimized transfer of know-how to future, potentially more complex planetary missions.

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