The PanCam instrument on the 2018 Exomars rover: Scientific objectives

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Overview

The Exomars Panoramic Camera System is an imaging suite of three camera heads to be mounted on the ExoMars rover`s mast, with the boresight 1.8 m above ground. As late as the ExoMars Pasteur Payload Design Review (PDR) in 2009, the PanCam consists of two identical wide angle cameras (WAC) with fixed focal length lenses, and a high resolution camera (HRC) with an automatic focus mechanism, placed adjacent to the right WAC. The WAC stereo pair provides binocular vision for stereoscopic studies as well as 12 filter positions (per camera) for stereoscopic colour imaging and scientific multispectral studies. The stereo baseline of the pair is 500 mm. The two WAC have 22 mm focal length, f/10 lenses that illuminate detectors with 1024 × 1024 pixels. WAC lenses are fixed, with an optimal focus set to 4 m, and a focus ranging from 1.2 m (corresponding to the nearest view of the calibration target on the rover deck) to infinity. The HRC is able to focus between 0.9 m (distance to a drill core on the rover`s sample tray) and infinity. The instantaneous field of views of WAC and HRC are 580 µrad/pixel and 83 µrad/pixel, respectively. The corresponding resolution (in mm/pixel) at a distance of 2 m are 1.2 (WAC) and 0.17 (HRC), at 100 m distance it is 58 (WAC) and 8.3 (HRC). WAC and HRC will be geometrically co-aligned. The main scientific goal of PanCam is the geologic characterisation of the environment in which the rover is operating, providing the context for investigations carried out by the other instruments of the Pasteur payload. PanCam data will serve as a bridge between orbital data (high-resolution images from HRSC, CTX, and HiRISE, and spectrometer data from OMEGA and CRISM) and the data acquired in situ on the Martian surface. The position of HRC on top of the rover`s mast enables the detailed panoramic inspection of surface features over the full horizontal range of 360° even at large distances, an important prerequisite to identify the scientifically most promising targets and to plan the rover`s traverse. Key to success of PanCam is the provision of data that allow the determination of rock lithology, either of boulders on the surface or of outcrops. This task requires high spatial resolution as well as colour capabilities. The stereo images provide complementary information on the three-dimensional properties (i.e. the shape) of rocks. As an example, the degree of rounding of rocks as a result of fluvial transport can reveal the erosional history of the investigated particles, with possible implications on the chronology and intensity of rock-water interaction. The identification of lithology and geological history of rocks will strongly benefit from the co-aligned views of WAC (colour, stereo) and HRC (high spatial resolution), which will ensure that 3D and multispectral information is available together with fine-scale textural information for each scene. PanCam will further reveal physical soil properties such as cohesion by imaging sites where the soil is disturbed by the rover`s wheels and the drill. Another essential task of PanCam is the imaging of samples (from the drill) before ingestion into the rover for further analysis by other instruments. PanCam can be tilted vertically and will also study the atmosphere (e.g., dust loading, opacity, clouds) and aeolian processes related to surface-atmosphere interactions, such as dust devils.

Fig. 1: PanCam test during the AMASE 2009 Expedition to Svalbard.

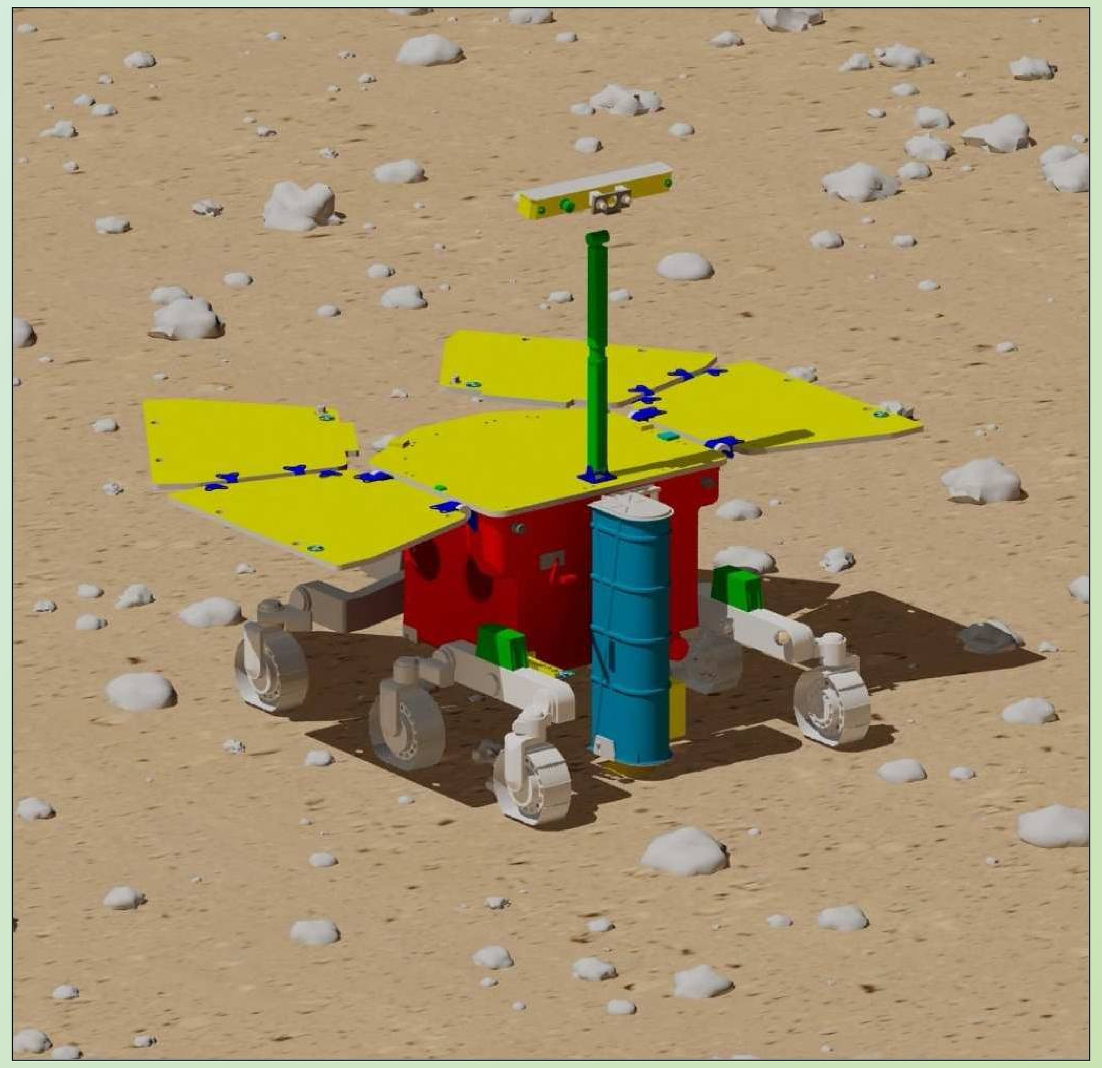

Fig. 2: Model of the Exomars 2018 rover showing the PanCam ontop of the mast.

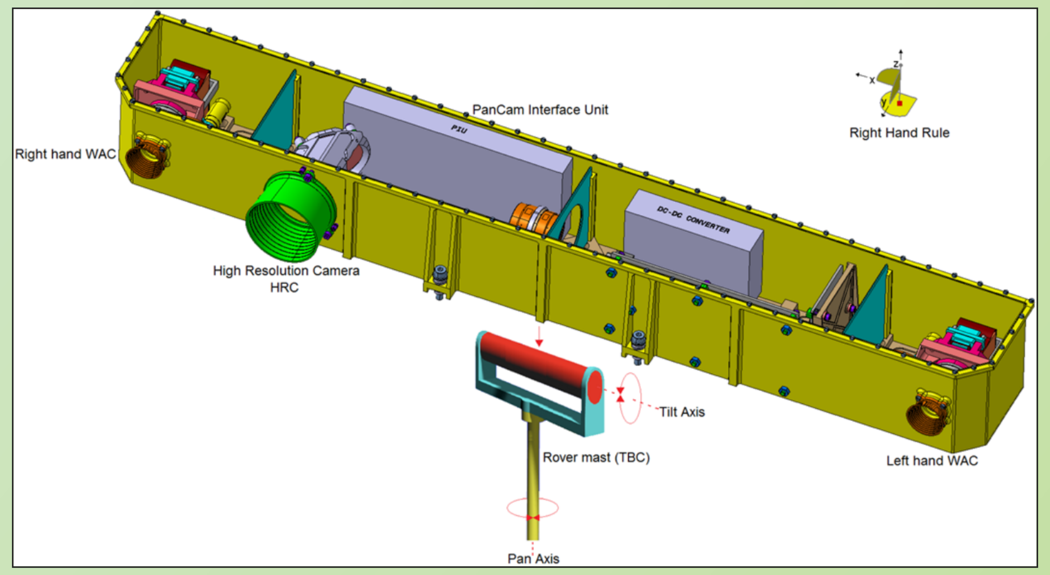

Fig. 3: Sketch of the PanCam suite with HRC and WAC.

Instrument measurement objectives

PanCam measurements consist of one or more images acquired as an image sequence. Each image sequence may require one or more filters and one or more pan-tilt mechanism positions. Typical image sequences expected in flight are the following:

o HRC single image (RGB colour)
o HRC image mosaic (X x Y positions RGB colour)
o WAC single image (left or right eye)
o WAC stereo pair (2 x 660 nm filters) - stereo sequence building block
o WAC generic image sequence for one eye (n filters at X x Y positions)
see following specific examples:

- WAC single filter panorama (e.g. 1 x UV fluorescence filter - TBC)
- WAC stereo filter panorama (2 x 660 nm filters at 6 positions)
- WAC RGB filter panorama (460, 540 & 660 nm filters at 6 positions)
- WAC geology panorama (12 filters at 6 positions)
- WAC solar imaging sequence (6 filters at 6 solar positions)

Scientific Investigations

The baseline PanCam uses wide angle stereo imaging to acquire morphological information on it surroundings, while multiple narrow band filters allow mineral composition of rocks and soils and the concentration of water vapour and the dust optical properties to be measured. Such filters could also be used to detect biological pigments if any have survived, in sufficient abundance, to the present day. These base line properties additionally allow acquisition of information to support rover navigation. These capabilities allow a multidisciplinary set of scientific objectives in physics, geology, geomorphology, biology, mineralogy, and to an extent chemistry:

o The stereo capabilities can be used to produce Digital Terrain Models (DTM) for morphometric analyses (e.g., layering, rocks).
o Highest resolution imaging of distant or inaccessible features.
o Mapping of areas that will not be sampled in situ.
o DTM for planning of effective sampling strategies on rough natural surfaces.
o Observation of drilling/coring activities.
o Observation of sample fraction before analysis by other instruments.
o Analysis of rock texture and color.
o Analysis of rock and soil mineralogy/petrology.
o Observation and monitoring of atmospheric properties (water vapour and optical depth).
o Determination of rover position.
o Using illumination from UV LEDs on the boom at night, the WAC might detect fluorescence from certain minerals and remnant organic pigment molecules if present in sufficient quantities.

Imaging Capabilities

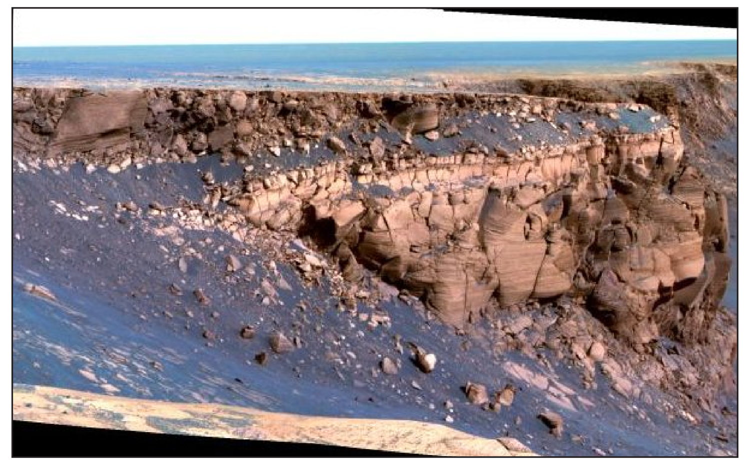

Fig. 3: Layering at "Cape St. Vincent" captured by NASA's MER Opportunity is one of the many promontories that jut out from the walls of Victoria Crater, Mars. The material at the top of the promontory consists of loose, jumbled rock, then a bit further down into the crater, abruptly transitions to solid bedrock. This transition point is marked by a bright band of rock, visible around the entire crater. (NASA/JPL/Cornell) [6]

Fig. 4: Rover drilling holes can be used to analyse outcrops. (NASA/JPL-Caltech/Cornell/USGS) [6]

Fig. 6: Observations of rover wheels and tracks can reveal physical properties of the surface material. (NASA/JPL-Solar System Visualization Team) [6]

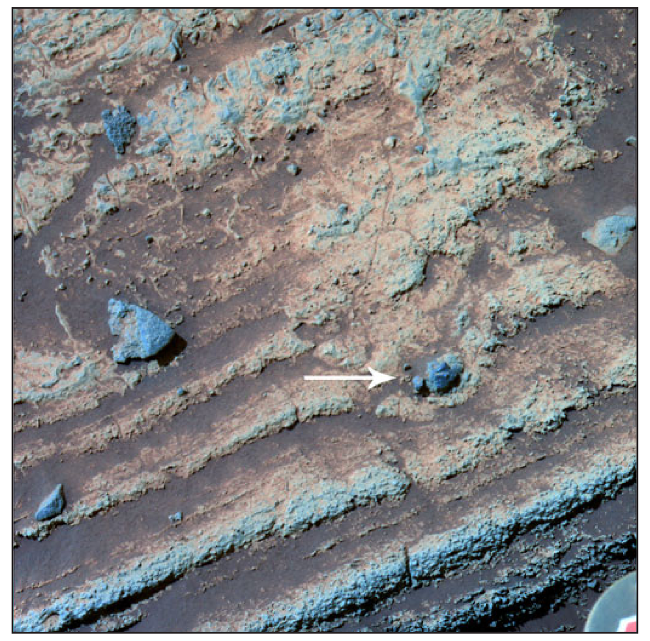

Fig. 5: Evidence of an ancient volcanic explosion at "Home Plate". The lower coarse-grained unit shows granular textures toward the bottom of the image and massive textures. Also shown is a feature interpreted to be a "bomb sag", which is 4 centimeters across. This false color image was obtained using Spirit's panoramic camera. (NASA/JPL-Caltech/USGS/Cornell) [6]

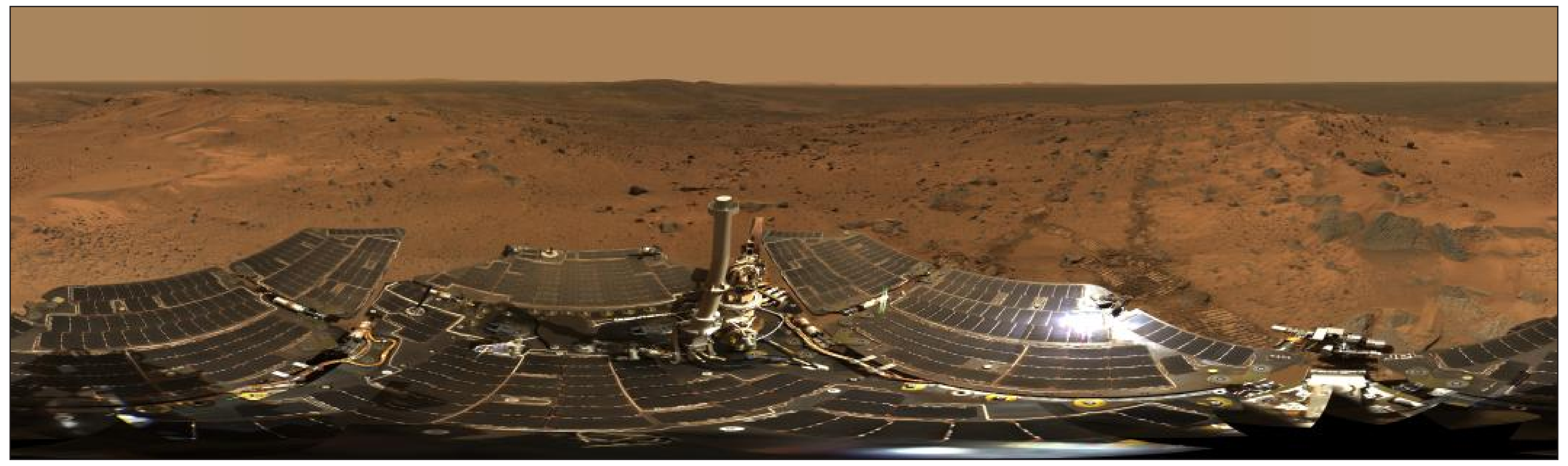

Fig. 7: "Husband Hill Summit", a 360° view of the panoramic camera on NASA's Mars Exploration Rover Spirit inside Mars' Gusev Crater. This image comprises 653 individual images which are combined using a "stitching" software and by means of the knowledge of geometrical distortions. (NASA/JPL-Caltech/Cornell) [6]

References:
[1] NASA Photojournal: http://photojournal.jpl.nasa.gov/index.html