Calibration setup for testing the 3D reconstruction capability of a space stereo camera

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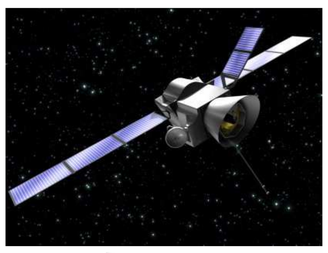
Abstract

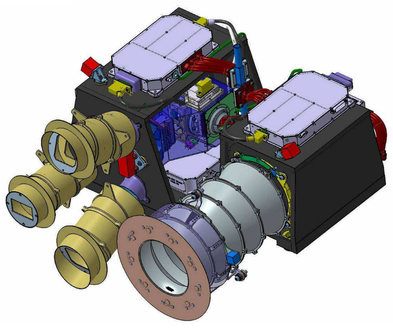
The Stereo Camera (STC) of the SIMBIO-SYS imaging suite of the BepiColombo ESA mission to Mercury is based on an innovative and compact design in which the light independently collected by two optical channels separated by ±20° with respect to nadir falls on a common bidimensional detector.
The calibration process of this instrument is more complex than a standard space camera: in fact, not only it is necessary to provide the standard calibration (focal length, PSF, distortion map, ...) for both channels, but it is also fundamental to verify the capability of the instrument to reconstruct a 3D surface with the desired accuracy. For this, we studied, designed and realized a laboratory setup representative of the STC flight conditions. With this setup we have been able to validate the stereo procedure with an STC evaluation model, and the obtained results have demonstrated the goodness of this calibration technique. We are presently in the process of applying the same technique also to the STC flight model.

Bepicolombo, Simbiosys and STC

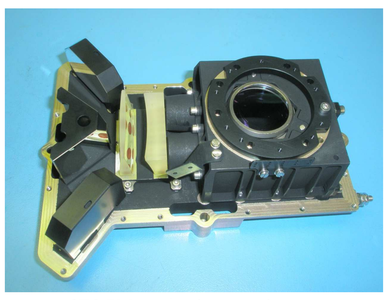
Bepicolombo is an ESA/JAXA space mission to Mercury to be launched on 2015.
It consists of two Orbiters:
- Mercury Planetary Orbiter (MPO, under ESA responsibility)
- Mercury Magnetospheric Orbiter (MMO, under JAXA responsibility)



SIMBIOSYS (Spectrometer and Imagers for MPO BepiColombo Integrated Observatory SYStem) is the instrument suite on MPO dedicated to imaging and spectroscopic observations.



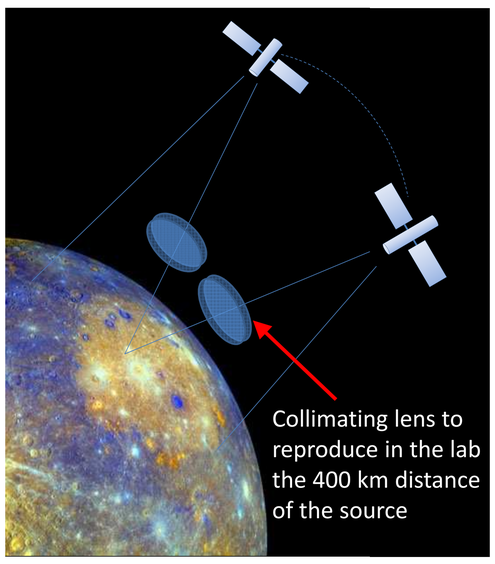
STC (STereo imaging Channel) is a two-channel imaging system dedicated to realize the full map of Mercury surface. It is equipped with both panchromatic and colored filters, all located on a single detector.
STC has been designed with two optical paths having the chief ray at ±20° to nadir to acquire images of the same areas from different perspectives to be able to get elevation information by stereoscopic techniques, and determine the Mercury surface Digital Terrain Model (DTM).
With the best spatial scale of 50 m/px at periherm, the attainable DTM vertical accuracy is 80 m.



STC FM under integration.

STC stereo validation concept

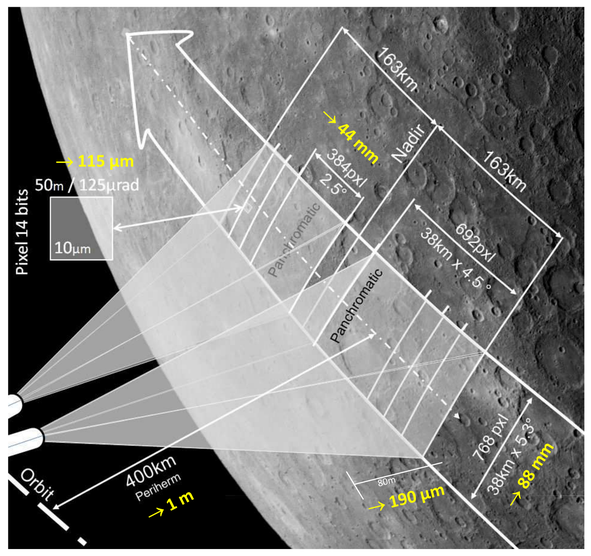
In order to estimate and characterize the actual stereo reconstruction capabilities of STC, an indoor stereo validation setup has been conceived.



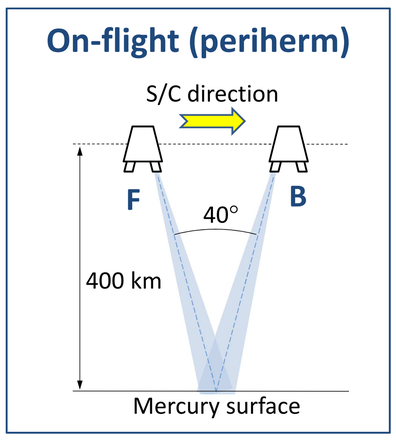
Target distance:
400 km → 1 m

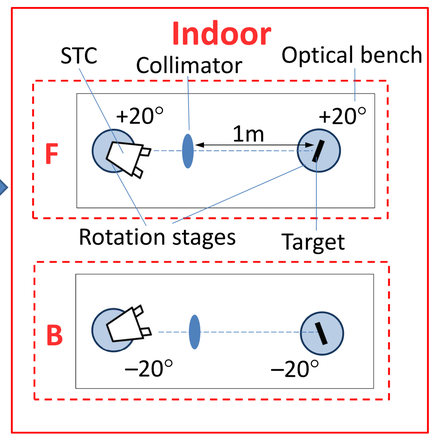
Horizontal resolution:
50 m/px → 115 µm/px

Vertical stereo accuracy:
80 m → 190 µm



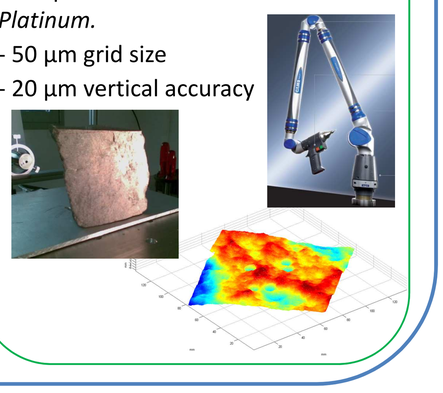
This setup is able to reproduce the flight observing condition of the instrumen. Using a "known" target (either basalt or anorthosite), it is possible to actually reconstruct and characterize a DTM.



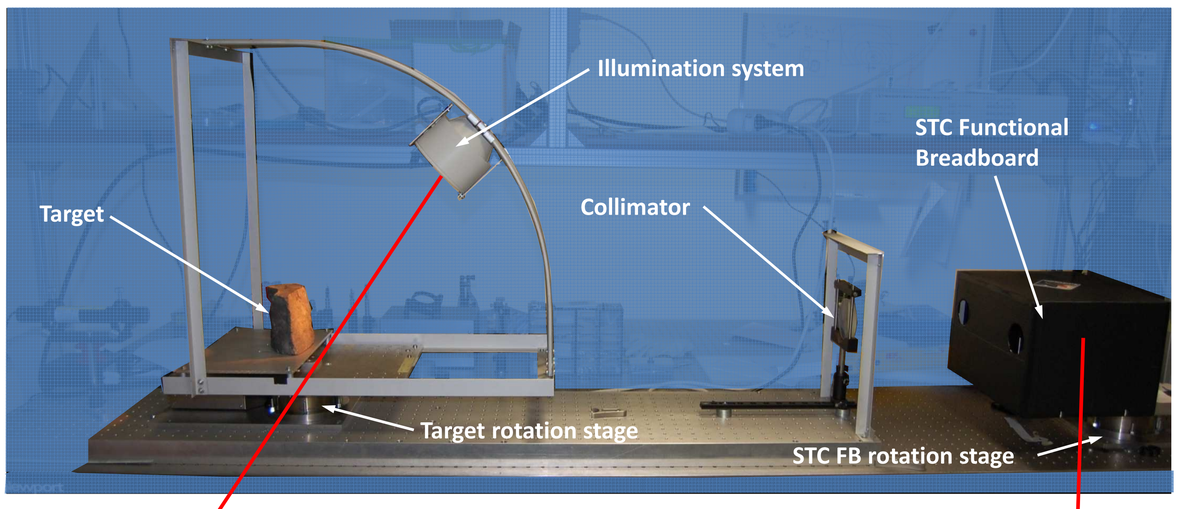


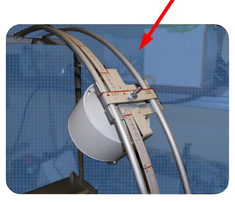
Target

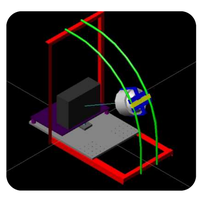
Multiple LASER Scanner *FaroArm Platinum.*
- 50 µm grid size
- 20 µm vertical accuracy

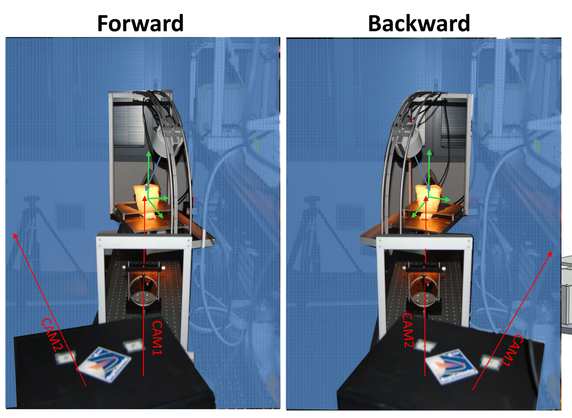


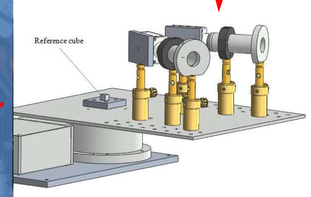
Experimental setup





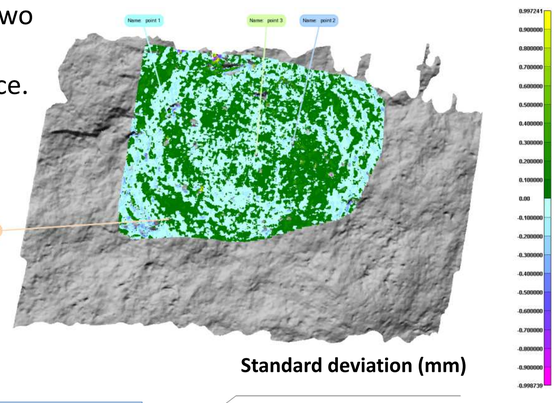






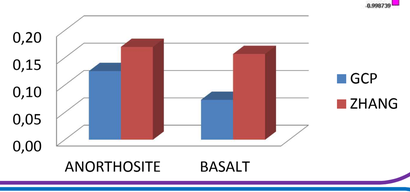
Results

DTMs of the targets have been obtained using two different algorithms (Zhang and GCP), and they have been compared with the "known" reference.



The rms error on the DTM elevation is well below the requirement, to confirm the goodness of the implemented method.

	GCP		ZHANG	
	STD DEV (mm)	#POINTS	STD DEV (mm)	#POINTS
ANORTHOSITE	0.125	193457	0.169	141341
BASALT	0.072	207025	0.156	138118



Conclusions

An innovative setup for the validation of stereo reconstruction capabilities of the SIMBIO-SYS STC has been developed and tested in the lab with a functional breadboard of the instrument. The obtained results showed an overall reconstruction error lower than the specifications derived from the instrument scientific requirements. This confirmed both the quality of the designed stereo camera and the goodness of the implemented stereo validation method; the latter allowed for the first time to test on ground the stereo capability of a flight instrument.
The described setup is presently at the Selex Electronics System in Campi Bisenzio (Italy) where the Simbiosys flight model is being integrated. Here the flight instrument calibration will be performed, and also the stereo reconstruction capability will be checked.

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