GEOREFERENCED M-CAM IMAGES OF THE FIRST BEPICOLOMBO MERCURY SWINGBY.

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Introduction: On October 1, 2021, the ESA/JAXA BepiColombo spacecraft successfully accomplished its first Mercury's swingby, with the closest approach (CA) taking place at 23:34 UTC at 199 km altitude. During this maneuver, more than 50 images of the planet were captured by two of the three Monitoring Cameras (M-CAMs) mounted on the BepiColombo Mercury Transfer Module (MTM). These are the first images of Mercury after more than six years since the NASA MESSENGER mission last pictured the planet. Because the spacecraft approached the planet from the nightside, the surface only becomes visible in images taken starting 5 minutes after the closest approach, when the spacecraft was already at an altitude of about 1180 km. These conditions provided a regional view of two adjoining regions —the Kuiper and the Discovery quadrangles— at varying lighting conditions (from dawn to noon) that let us appreciate some of the main features of Mercury that will be an objective for the BepiColombo mission [1,2].

Georeferencing Methods: We used Geographic Information System (GIS) software ArcGIS Pro to manually select control points on M-CAM images to be precisely georeferenced onto MESSENGER basemaps derived from the Mercury Dual Imaging System (MDIS) datasets. To minimize control point localization errors, we used ad-hoc projections for each M-CAM frame. The selected projections use a "Vertical Near Side Perspective Projection" centered on the camera calculated boresight at a finite distance (i.e., the spacecraft altitude). This projection permits simulation of the planet's horizon from a spacecraft point of view at the time of the image. Precise calculation of the camera boresight and pointing was possible thanks to the Spectrometer and Imagers for MPO BepiColombo Integrated Observatory System (SIMBIO-SYS) instrument tools [3]. Manual selection of control points not only permits a high georeferencing accuracy, but also offers a chance to detect any surface change since Mercury was last imaged by MESSENGER/MDIS.

Results: We manually georeferenced the four M-CAM images released by ESA the day after the flyby [4], which also represent the best views of Mercury acquired during the flyby. M-CAM2 images mainly cover the Kuiper quadrangle ("image2" and "image6"), while M-CAM3 images cover the Discovery quadrangle ("image 1" and "image8"). We grouped these images into two pairs, one representing the view 5 min after CA and one representing the view 10 min after CA (Fig. 1a). The first pair provides dramatic shadows highlighting the morphology of Mercury ("image1" and "image2", Fig. 1b), including some known lobate scarps such as Astrolabe Rupes. The second pair provides a wider view of the captured regions providing a continuous view of the planet's terminator ("image6" and "image8", Fig. 1c).

Future Developments: There will be 5 further swingbys before orbit insertion (5 December 2025) providing M-CAM imaging opportunities covering a range of latitude and longitudes at a variety of incidence angles. We will use these to identify and interpret features not, or only imperfectly, revealed in MESSENGER images and to revise current and recent geological mapping. Fault scarps, whose visibility is known to be prejudiced by illumination bias [4] are of particular concern, and swingby 1 has demonstrated the utility of high incidence angle images for revealing *catenae* that are poorly understood and probably polygenetic [5]. These swingby images will be also useful to redefine some of the targets selected for BepiColombo observations, in particular those of the SIMBIO-SYS instrument [3].

References:
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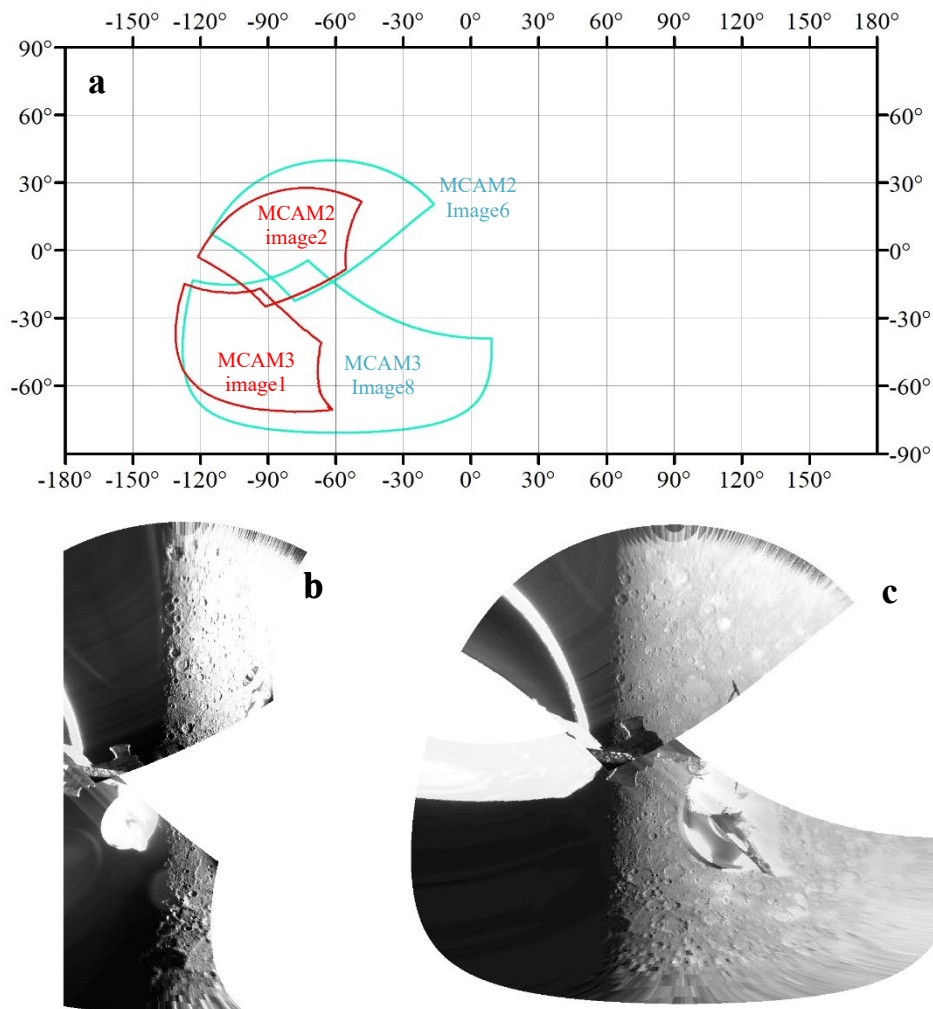
Figure 1. BepiColombo/M-CAM frame footprints on the global Mercury equirectangular grid (a), where red footprints represent the first pair of images 5 in after CA (b, intentionally cut at west, beyond Mercury's terminator) and turquoise represents the second pair of images 10 min after CA (c). Note that some spacecraft components are in the foreground. M-CAM frames credits: ESA.