COVERAGE AND POINTING ACCURACY OF SMART-1/AMIE IMAGES

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Summary: The SMART-1 spacecraft started from 15 March 2005 with a lunar orbit 400-3000 km for a nominal science period of six months, with 1 year science extension. During these 18 months, the AMIE camera aboard the spacecraft acquired about 32.000 images. We report on the coverage at various resolutions and the pointing accuracy.

Lunar coverage

The SMART-1 spacecraft [1-5] operated in an eccentric polar orbit with the perilune close to the South pole. Therefore the highest resolution was achieved in the South polar area. The AMIE experiment [5-8] allowed imaging at varying resolution along the orbit. Fig. 1 shows the footprints of all images with a resolution better than 50 meters per pixel. With such a high resolution, the small but scientifically quite interesting area south off 87S and various spots in the southern hemisphere are covered. If we relax the lower resolution limit to 100 meters per pixel, the covered area extends to the complete Southern hemisphere, cf. Fig. 2. Finally, global coverage is achieved with a resolution better than 250 meters per pixel, as shown in Fig. 3.

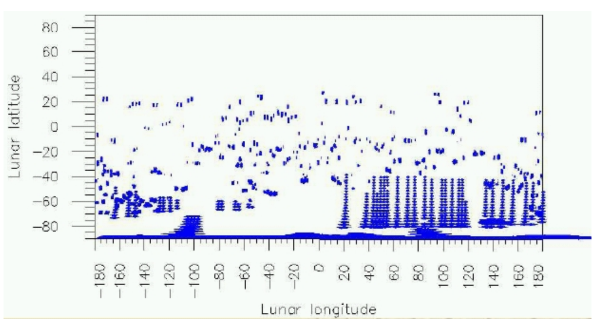

Fig. 1: Lunar coverage obtained with AMIE camera at a resolution better than 50 meters per pixel.

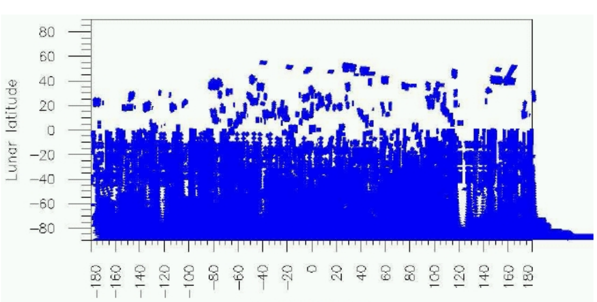

Fig. 2: Lunar coverage obtained with AMIE camera at a resolution better than 100 meters per pixel.

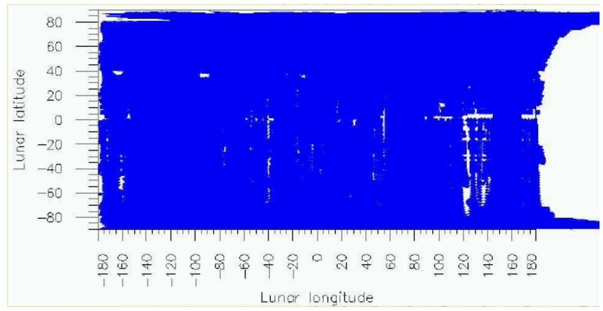

Fig. 3: Lunar coverage obtained with AMIE camera at a resolution better than 250 meters per pixel.

Offsets from the Clementine base map

Based on the SPICE kernels for the SMART-1 spacecraft and for the AMIE instrument, SPICE can be used to project the AMIE images onto the Moon's surface. As reference for the AMIE images, the AMIE team uses the Clementine base map, which has been compiled by the USGS from images taken by the Clementine spacecraft. AMIE team members had reported considerable offsets between the AMIE images and the Clementine base map. These offsets had at least partly been caused by erroneous preliminary versions of the instrument frame kernel. A new kernel was prepared by ESA Science Operations and thoroughly tested. The kernel passed successfully various tests, also the projection of an image onto the Moon's surface and a comparison with the Clementine base map.

However, the particular test of projecting an image onto the Moon was only conducted for one single, more or less randomly selected image. For other images, AMIE team members saw still offsets from the Clementine base map, even with the new kernel. Also at ESA Science Operations, where many images have been compared with the Clementine base map in the course of checking the timing of the images, considerable offsets have been found.

We have computed latitude and longitude of each pixel of 395 images. To match the image to the Clementine base map, we visualize the base map in simple (equidistant) cylindrical projection and overlay the AMIE image on top of it. By blinking the AMIE image on and off, we recognize any offset from the base map. Then we shift the AMIE image in latitude and longitude until it matches the base map, see Fig. 4.

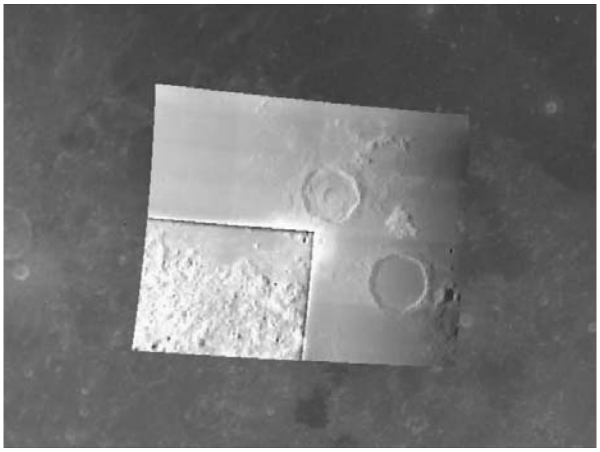

Fig. 4 : AMIE raw image, mapped to the lunar surface and matched to the Clementine base map.

From the shifts in latitude and longitude in degree, we compute the magnitude of the offset in km. The result is shown in Fig. 5. We notice a strong consistency between different orbits, thus the offset from the Clementine base map depends clearly on the location on the Moon.

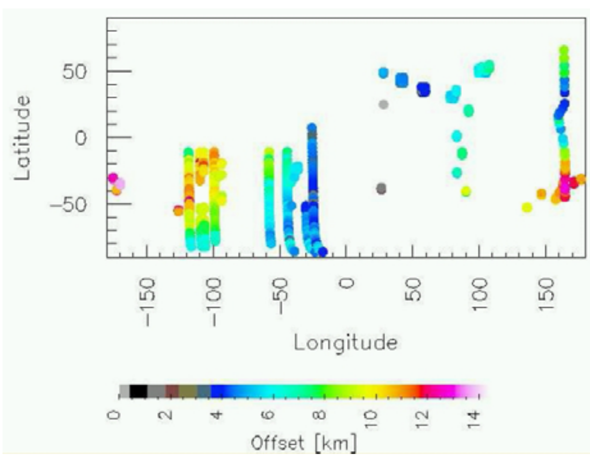

Fig. 5 : Magnitude of the offsets between AMIE images and the Clementine base map. Each dot represents one image.

A preliminary analysis of the accuracy of the Clementine base map was presented by A. C. Cook et al. at the AGU 2002 fall meeting. The authors note considerable differences between the original location of the Clementine images on the Moon as determined from the archived SPICE kernels and the control network resulting from the USGS' effort to create the mosaic. While they find good agreement in the `Apollo zone' (comparable to the pointing accuracy of the SC of the order of one kilometer), they find about 10~times larger deviations in other areas. The authors offer the explanation that only in the `Apollo zone' absolute positioning control is available and that the mosaicing process builds up large errors away from this zone. They strongly question whether it is reasonable to allow positioning differences much larger than the pointing accuracy. A map illustrating the differences is shown in Fig. 6.

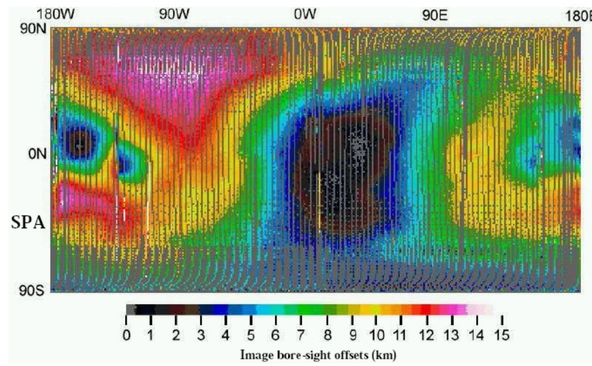

Fig. 6 : Differences in image centres from archived SPICE kernels and USGS/RAND control network (from a presentation by A. C. Cook).

If we compare the map of erroneous deviations of the Clementine base map mosaic from the original image positions with the map of AMIE offsets from the Clementine base map (Fig. 5), we notice a very good agreement. From this we can conclude that the considerable offset of the AMIE images from the Clementine base map is caused by inaccuracies of the Clementine base map itself. The AMIE pointing information given by the SPICE kernels is correct; at least any error is much smaller than the observed offset from the Clementine base map.

References: [1] Foing, B. et al (2001) Earth Moon Planets, 85, 523. [2] Racca, G.D. et al. (2002) Earth Moon Planets, 85, 379. [3] Racca, G.D. et al. (2002) P&SS, 50, 1323. [4] Foing, B.H. et al (2003) Adv Space Res. , 31, 2323. [5] Foing B. et al (2006) Adv Space Res. 37, 6. [6] Pinet, P. et al (2005) P& SS, 53, 1309. [7] Josset, J.L. et al (2006) Adv Space Res 37, 14. [8] Shkuratov, Y. et al (2003) JGRE 108, E4, 1.