EPSC Abstracts
Vol. 13, EPSC-DPS2019-824-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

SMART-1 Highlights & Apollo Celebration

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Abstract

SMART-1 results have been relevant for lunar science and exploration, in relation with previous missions (Apollo, Luna) and subsequent missions (Kaguya, Chang'E1-2, Chandrayaan-1, LRO, LCROSS, GRAIL, LADEE, Chang'E3-4 and future landers). We present SMART-1 highlights that celebrate APOLLO legacy after 50 years.

Overview of SMART-1 mission and payload:

SMART-1 was the first in the programme of ESA's Small Missions for Advanced Research and Technology [1,2,3]. Its first objective has been achieved to demonstrate Solar Electric Primary Propulsion (SEP) for future Cornerstones (such as Bepi-Colombo) and to test new technologies for spacecraft and instruments. The SMART-1 spacecraft has been launched on 27 Sept. 2003, as an Ariane-5 auxiliary passenger and injected in GTO Geostationary Transfer Orbit. The SMART-1 spacecraft reached on 15 March 2005 a lunar orbit 400-3000 km for a nominal science period of six months, with 1 year extension until impact on 3 September 2006. SMART-1 science payload, with a mass of some 19 kg, features many innovative instruments and advanced technologies [1-12].

SMART-1 mission top 12 record firsts:

1-first Small Mission for Advanced Research and Technology; with spacecraft built and integrated 2.5 years and launched 3.5 years after mission approval;
2-first mission leaving the Earth orbit using solar power alone (with Solar Electric Primary Propulsion);
3-most fuel effective mission (60 l of Xenon)
4-longest travel (13 month) to the Moon!;
5-first ESA mission reaching the Moon and first European views of lunar poles;
6-first European demonstration of a wide range of new technologies: Li-Ion modular battery, deep-space communications in X- and Ka-bands, and autonomous positioning for navigation;
7-first lunar demonstration of an infrared spectrometer and of a Swept Charge Detector Lunar X-ray fluorescence spectrometer ;
8-first ESA mission with opportunity for lunar science, elemental geochemistry, surface mineralogy mapping, surface geology and precursor studies for exploration;
9-first controlled impact landing on the Moon with real time observations campaign;
10-first mission supporting goals of the International Lunar Exploration Working Group (ILEWG) in technical and scientific exchange, international collaboration, public and youth engagement;
11-first mission preparing the ground for ESA collaboration in Chandrayaan-1, Chang' E1-2, landers and future international lunar exploration.
12-first Earth and Moon family portraits of during cruise and lunar eclipse (Figs 1-2) and Earthrise

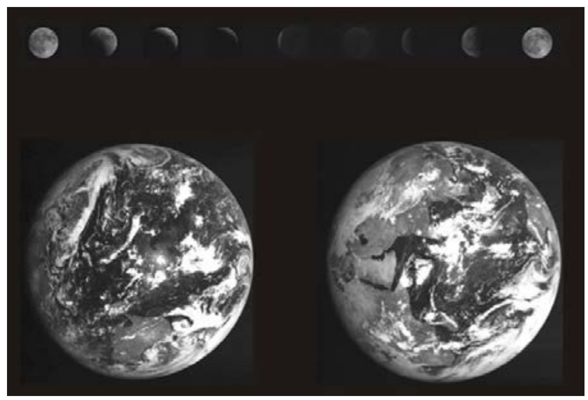

Fig.1: Total lunar eclipse Earth-Moon views from SMART-1 during its cruise journey (rotating Earth before/after eclipse): a tribute to Apollo Earth views

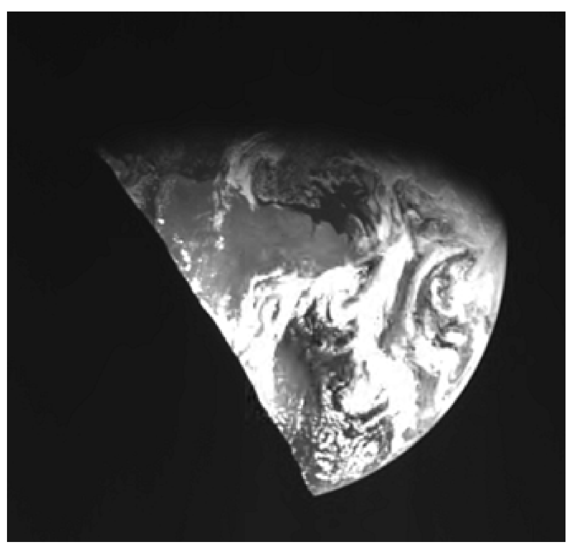

Fig. 2: SMART-1 Earthrise video shot obtained 4 days before impact: a tribute to Apollo 8 iconic Earthrise
http://www.planetary.org/multimedia/space-images/earth/20130210_smart1earthrise3.html

SMART-1, Apollo sites & photometric phase

Multiangular photometry of Mare regions (including from Apollo landing sites) was matched with a particulate medium reflectance model taking into account the strochastic geometry and volume scattering phase function [14]. The study of specific regions at different phase angles allowed to detect variations in phase function steepness due to anomalous roughness [13, 15]

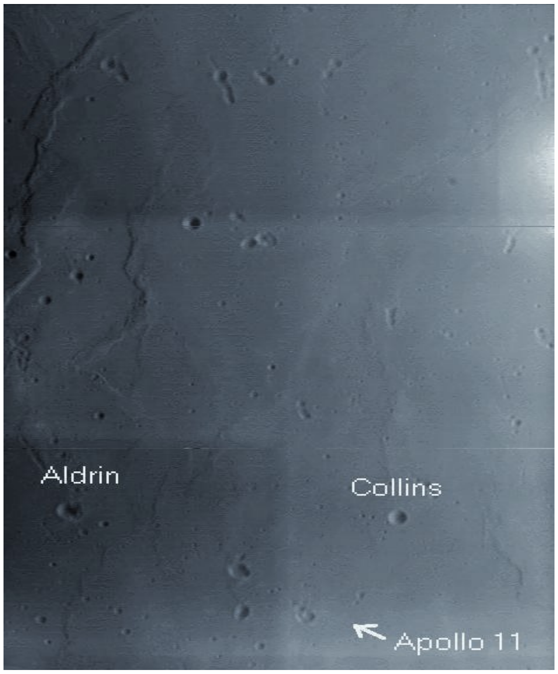

Fig. 3: SMART-1 view of Apollo 11 landing site and surrounding area, used for cross-calibration between instruments and multiangular phase function studies

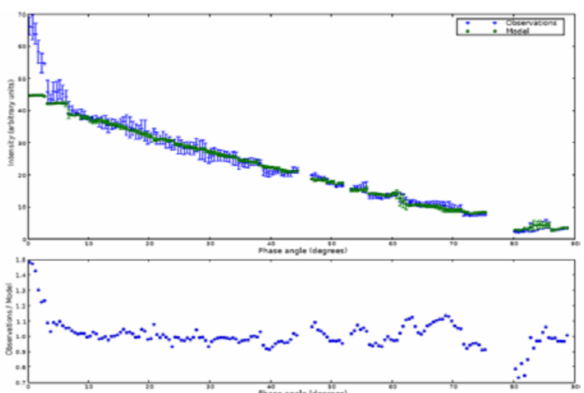

Fig 4: SMART-1 Multiangular photometry of Mare regions matched with a particulate medium reflectance model that helps combining data obtained in different light illumination geometry.

SMART-1 Lunar North and South polar studies

Repeated high resolution polar images were obtained, and combined to monitor the illumination & map potential polar sites for future exploration (Fig 5). This permitted to identify a SMART-1 peak of quasi-eternal light and to derive its topography vs Shackleton rim.

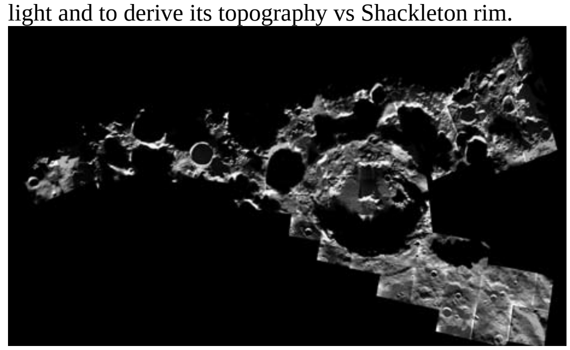
Fig. 5: Mosaic of south polar region (Ellouzi & Foing)

SMART-1 impact campaign, debris and crash scene

A final complex manoeuver allowed to target the final touchdown within 2 km accuracy, and in optimum location to organize a ground-based observation campaign that detected the impact flash, the ejected bouncing debris flowing in real time [15]. Finally the exact SMART-1 crash scence could be identified on LRO images [17]. The remains of spacecraft remains are still to be found and investigated by rovers or humans to complete the SMART-1 impact experimental study !

Inspired by the Apollo legacy, the SMART-1 team fed forward subsequent missions Kaguya, Chandrayaan-1&2, Chang'E 1-2, Lunar Reconnaissance Orbiter, LCROSS impactor, and to prepare Chang'E 3-4, GLXP and subsequent lunar landers as well as future human activities and lunar bases towards a sustainable and permanent Moon Village [18].

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Links: http://sci.esa.int/smart-1/, http://sci.esa.int/ilewg/