LUNAR DATA SIMULATION FOR SMART-1

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ABSTRACT

The value of the data collected on a planetary mission does not depend only on the data by itself or its amount, but also on its joint analysis, comparison and integration with previous and/or expected data. The SMART-1 mission has also been prepared to get an opportunity for new science. We have done a search on the past missions that studied our satellite, the Moon. Therefore, previous lunar missions like Luna, Apollo, Hiten, Clementine or Lunar Prospector offer the possibility of comparing the existing lunar databases. This also helps in selecting for SMART-1 a wide range of lunar targets between the hundreds of Mares, Sinus, Catenas and Crateres.

On the other hand, simulation is necessary in order to reach this aim, and a simulation program has been developed to plan the SMART-1 payload operations and to pre-evaluate SMART-1 representative data and science return.

Finally, we discuss perspectives how to enhance SMART-1 return in order to get the best results building on the knowledge of the Past with the present ESA technology.

The approved SMART-1 scenario is a lunar mission, including 6 months operations in lunar orbit. The mission is to be launched as Ariane 5 piggyback into GTO (Geostationary Transfer Orbit). The SEPP is used to spiral out from GTO (during some 14 months), then achieve lunar swingby, lunar capture, spiralling in to a near polar lunar orbit with apolune of 10.000 km and perilune of 300-1.000 km.

1.1 Scientific Instruments

- AMIE: Asteroid Moon micro-Imager Experiment (also supporting investigation on On Board Autonomous Navigation (OBAN) and Laser-Link Experiment)
- SIR: SMART-1 Infra-Red Spectrometer
- D-CIXS: Demonstration of a Compact Imaging X-ray Spectrometer
- EPDP/SPEDE: Electric Propulsion Diagnostic Package / Spacecraft Potential Electron and Dust Experiment
- KaTE: X/Ka-band Telemetry and Telecommand Experiment

2. PAST LUNAR MISSIONS

- Apollo - NASA Manned Lunar Program (1963 - 1972)
- Hiten - ISAS Flyby, Circumnavigation and Impact Mission to the Moon (1990)
3. PRIMARY LUNAR DATABASES

Every one of the Past Lunar Missions got useful data, but nowadays we can remark the quality and width of three of them (in order of data volume importance):

3.1 **Clementine’s**

It took over 1.8 million of pictures of the lunar surface with its different cameras and respective wavelengths with bandwidths:

- Ultraviolet / Visible Camera (UV/Vis) : 415 nm (40 nm), 750 nm (10 nm), 900 nm (30 nm), 950 nm (30 nm), 1000 nm (30 nm)
- High Resolution Camera (HIRES) 415 nm (40 nm), 560 nm (10 nm), 650 nm (10 nm), 750 nm (20 nm)
- Near Infrared Camera (NIR) 1100 nm (60 nm), 1250 nm (60 nm), 1500 nm (60 nm), 2000 nm (60 nm), 2600 nm (60 nm), and 2780 nm (120 nm).
- Long-Wave Infrared Camera (LWIR) 8—9.5 μm

http://nssdc.gsfc.nasa.gov/planetary/clementine.html

![Fig. 1. Copernicus. Mosaic of UV/VIS cameras.](image)

3.2 **Lunar Orbiter's**

Its two cameras provided quite useful data and pictures, more than 30 years ago:

- High Resolution Camera (HR) and Medium Resolution Camera (MR)

http://nssdc.gsfc.nasa.gov/planetary/lunar/lunarorb.html

3.3 **Lunar Prospector's**

Some information can be found at:

http://nssdc.gsfc.nasa.gov/planetary/lunar/lunarprosp.html

4. PTB AND EPS

SMART-1 mission has taken into account these two powerful tools developed by EuroSim and adapted to and by ESA.

4.1 **Project Test Bed**

Project Test Bed is a simulator whose main task is to support a Science Operations Centre in the planning of the science operations. It allows, for instance:

- Simulating the spacecraft in its space environment
- Recording flight dynamics and science events in a timeline
- Calculating and recording data needed for science planning (illumination conditions, etc.)

![Fig. 2. Simulation by PTB of SMART-1 flying over Hommel's Crater](image)
4.2  Experiment Planning System

Experiment Planning System is a software tool developed for the creation of the experiments operations for a specific time period. It does this by allowing to enter an operation timeline, which is a list of experiment operations and a specific time for when the operation has to be executed, and check for constraints violations on each of the experiments.

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Fig. 4. AMIE filters

Initially a technology demonstration of a miniaturized micro-imager, AMIE on SMART-1 now has significant science objectives, covering the study of the Moon's morphology, topography and surface texture. The science community realized the potential of such a camera operating in a multi-spectral mode. AMIE has thus been equipped with three filters, in the red (750 nm) and infrared (915 & 950 nm). It will also operate in white light. A test image was obtained on laboratory minerals (see Figure 5).

Fig. 3. Input Timeline of AMIE experiments (fragment)

5.  AMIE CAMERA

AMIE is a micro-camera experiment that will contribute to the characterization of surface mineralogy and geology, in combination with other SMART-1 experiments providing the regional context for major geologic features. It is of special interest for imaging the polar permanent shadows and illumination conditions in areas of quasi-eternal light.

The original AMIE concept foresaw a panchromatic, 1024 x 1024 pixel image with a medium field of view of 5.3 degrees by 5.3 degrees. The camera will provide a high spatial resolution, some 50 m/pixel. The scheme of the FOV is on Figure 4.

Fig. 5. Basalt and olivine. Photographed by AMIE camera - all filters -
AMIE will be opening new ground in the field of multi-spectral lunar observation. Whereas the multi-spectral camera aboard the American Clementine mission had constant illumination conditions, SMART-1's orbit will offer multi-angular imaging. AMIE's views at different angles correlated with Clementine data of the same lunar areas will allow scientists to establish photometric models, allowing the interpretation of such spectral data.

6. CONCLUSION

Halfway through the year 2004 SMART-1 will reach the Moon. That moment will mean the success of the Solar Electrical Propulsion (SEP) and the beginning of the first geological and mineral studies over the surface done from a European spacecraft.

Hundreds of simulations and studies have been done to prepare the incoming experiments; then it will be time to check if the assumptions taken were correct, and the goals affordable. Past missions - Clementine, Lunar Orbiter - have provided the scientist community a huge database of images over the electromagnetic range. AMIE, SIR and D-CIXS experiments of SMART-1 mission will be able to take records and compare them with the existing ones, as well as enlarging the lunar knowledge on these and other fields.

7. REFERENCES

- RACCA, G., FOING B.H., SMART-1 : The First Time of Europe to the Moon, EarthMoon & Planets 85, 379, 2001
- VILAR, E., Planning and optimisation of payload operations for the SMART-1 & Rosetta missions, RSSD, ESTEC, Stage report, Aug 02.