1 Carrier Vehicles and Scientific Instruments for the Moon

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The Moon has recently become (again) a planetary body of major interest for the planetary community. Many scientific questions that remained open after the first moon rush have been, almost literally, washed back to the surface. The possible existence of water ice deposits at the lunar poles has important implications for future manned exploration missions. The origin and process of water enrichment is of considerable scientific interest. However, before a human outpost makes use of these resources it is advisable to facilitate robotic missions to explore the true nature of the lunar polar regions.

In addition to the polar regions other localities, which so far remain largely unexplored, still contain important scientific implication for the formation and evolution of the moon. Another important aspect involves the whole of the lunar surface for its possible use as a test bed for technologies which may be exploited on more distant planets in the near-and midterm.

Over the past few years there have been no dedicated programs in Europe that focused specifically on technology developments for the lunar environment. However recently there have been important steps forward in areas such as vehicle and scientific instrument development made within various support programs of the European Space Agency. This paper will therefore concentrate on these recently matured technologies.

A common key feature of all these activities is to minimize resource requirements to the largest possible extent through the strict application of a high level of integration and miniaturization. The Nanokhod rover is a perfect example of a highly integrated design between the carrier vehicle and the scientific payload. This tethered rover has a weight of 3 kg which also includes three scientific payload elements and can operate within a 50-meter radius around the lander unit. The rovers' payload compartment contains an Alpha Proton X-ray Spectrometer, a Mössbauer spectrometer and a newly developed micro camera which provides a close-up imaging capability as well providing a support service to the navigation system. An alternative payload element is an extremely small Laser Mass Spectrometer (LMS). A breadboard version of this instru-

ment is currently under investigation. Both, rover and payload is subject to mechanical and extreme environmental test campaigns.

In addition to the Nanokhod rover a sub-surface vehicle element is also under development at breadboard level. The Instrumented Mole System (IMS) is based on a soil-penetrating device, the mole, towing a payload compartment down to a depth of 5 meter. In a parallel development activity a Heat Flow and Physical Properties Package (HP^3) demonstrates that a meaningful scientific payload can be integrated into the small payload compartment. This package comprises an active temperature measurement module, a densitometer to determine the density of the penetrated regolith and a device to determine the precise location of the mole. As with the rover an alternative payload element is a small Attenuated Total Reflection infrared spectrometer (ATR).

Finally with a similar goal of penetrating surface layers in mind, a melting probe is also under development which should allow the subsurface exploration of icy layers. It will be capable of carrying scientific instrumentation through the surface ice so as to decipher the stratigraphy of the ice and dust deposition on planetary bodies.

All these European Space Agency projects will develop hardware models from which a flight instrument development programme suitable for harsh environments such as the Moon can be rapidly implemented.