LUNAR EXPLORATION IN ESA. J. D. Carpenter, B. Houdou, R. Fisackerly, D. De Rosa, B. Patti, J. Schiemann, B. Hufenbach, B. Foing, ESA ESTEC, Keplerlaan 1, 2201AZ, Noordwijk, The Netherlands (james.carpenter@esa.int).

Introduction: The multiple orbital missions of the last decade coupled with present activities and future plans of various agencies and actors to target the lunar surface, indicate the emergence of a renaissance in lunar exploration. Through participation in this new era of lunar exploration ESA seeks to provide Europe with access to the lunar surface.

This is best achieved through an exploration programme which combines the strengths and capabilities of both robotic and human explorers. Preparations include a combination of human and robotic activities, the development of cooperation with international partners and the development of core capabilities and exploration products.

Exploration Products: Building on more than a decade of technology investments, ESA is deriving core exploration products, which can be provided to the missions of partners for flight before the end of the decade.

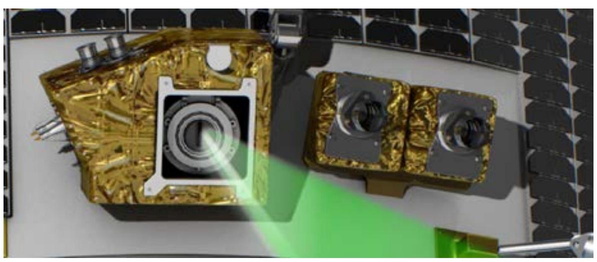

Figure 1. PILOT uses image based navigation techniques and hazard detection using LIDAR to enable precise and safe access to landing sites.

PILOT (Precise and Intelligent Landing Using On-board technologies): PILOT provides a navigation and guidance solution to allow safe and precise access to any given location on the lunar surface. PILOT uses a combination of relative and absolute navigation techniques using images for navigation. Hazard identification is performed using LIDAR. Such a system allows access to sites of high interest for science and exploration, for which special extent is highly limited, but also allows coordinated surface access for multi element missions.

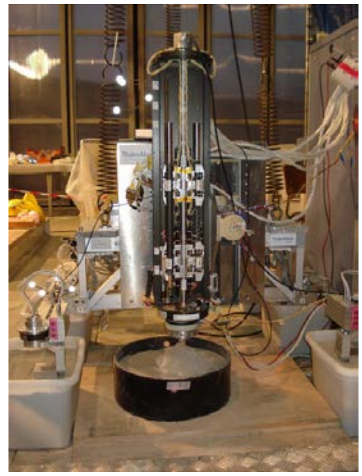

Figure 2. Breadboard of the Exomars drill from which the PROSPECT drill is derived.

PROSPECT (Package for Resource Observation, in-Situ analysis and Prospecting for Exploration Commercial exploitation and Transportation): PROSPECT provides access to and comprehensive analysis of potential resources anywhere on the Moon, including the lunar poles. It uses a drill, derived from Exomars and Rosetta heritage, to access the subsurface to depths of up to 2m. Samples from this depth are then extracted and passed to a chemical processing and analytical suite. Drilling and sampling activities are performed with a view to enabling analysis of volatiles at very low temperatures. Following optical imaging and IR spectral analysis samples are heated to extract volatiles gasses by pyrolysis and processed chemically through combustion, oxidation and reduction reactions to extract chemicals of interest from minerals. Qualitative compositional analysis then compliments accurate and precise isotopic analysis, comparable with that achieved in terrestrial laboratories. The analytical systems are derived from flight hardware on Rosetta, Beagle 2 and Exomars.

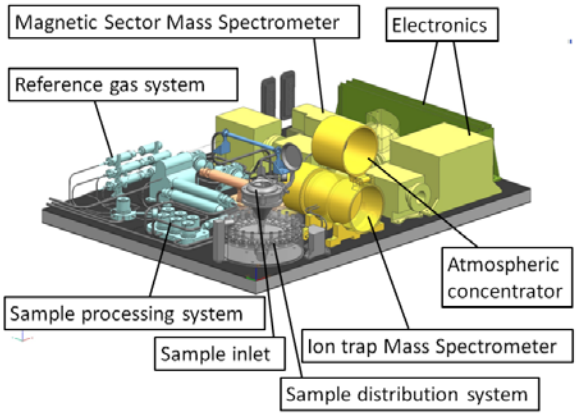

Figure 3. CAD representation of the chemical processing and gas analysis subsystem of PROSPECT package, which is derived from the PTOLEMY on Rosetta and GAP on Beagle 2.

SPECTRUM (Space Exploration Communications Technology for Robustness and Usability between Missions): SPECTRUM provides a communications link between a lander or other exploration asset on another celestial body, and an orbiting platform. The system is suitable for application on missions performed by space agencies and private entities alike.

The system includes a complete UHF Orbiter-Lander subsystem and the associated communications link, including all the equipment on-board both the orbiter and the lander.

The transponder is a key component of such a UHF communications subsystem. The SPECTRUM transponder is derived from heritage from the European unit for the surface elements of the ExoMars mission.

Human Exploration Activities: ESA's multiple activities on the ISS (including teleoperation of surface assets) and contribution of the service model of the US led Multi-Purpose Crew Vehicle, which is planned for a first unmanned lunar flight in 2017, are also important steps towards achieving access to the Moon. All of these activities are performed with a view to generating the technologies, capabilities, knowledge and heritage that will make Europe an indispensible partner in the exploration missions of the future.

Investigations are also underway into the utilization of human tended infrastructure in cis-lunar space in support of robotic lunar surface missions, including surface mobility and sample return.

Figure 4. Orion-MPCV, including the ESA provided service module, in orbit at the Moon.

International partnerships: Future exploration of the Moon by ESA will only be possible through international partnerships. ESA's approach is to build those partnerships and establish roles for the future.

In the area of human exploration a partnership has been established with NASA on the MPCV service module.

In robotic exploration ESA is planning to contribute to the Russian led robotic missions, Luna-Glob, Luna-Resurs orbiter and Luna-Resurs lander. Contributions to these early missions should be followed by contributions at the level of mission elements to a joint Lunar Polar Sample Return mission.

This partnership with Russia will provide access for European investigators to the opportunities offered by the Russian led instruments on the missions, as well as providing Europe with a unique opportunity to characterize and utilize polar volatile populations and advance important technologies and capabiltities for exploration. A longer term goal is to ensure that samples of high scientific value, from as of yet unexplored and unsampled locations, shall be made available to the scientific community.

Ultimately these robotic activities are being performed with a view to enabling a future more comprehensive programme in which robotic and human activities are integrated to provide the maximum benefits from lunar surface access.

Conclusions: The surface of the Moon is an important exploration destination for ESA, which is working to secure roles in future exploration missions with international partners.

Core ESA competencies exist in precision landing, communications and the search for future resources, as well as key areas relating to human transportation, habitation and operations.