LUNAR EXPLORATION ORBITER (LEO): PROVIDING A GLOBALLY COVERED, HIGHLY RESOLVED, INTEGRATED, GEOLOGICAL, GEOCHEMICAL, AND GEOPHYSICAL DATA BASE OF THE MOON.

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Introduction: The German initiative for the Lunar Exploration Orbiter (LEO) originated from the national conference “Exploration of our Solar System”, held in Dresden in November 2006. Major result of this conference was that the Moon is of high interest for the scientific community for various reasons, it is affordable to perform an orbiting mission to Moon and it insures technological and scientific progress necessary to assist further exploration activities of our Solar System. Based on scientific proposals elaborated by 50 German scientists in January 2007, a preliminary payload of 12 instruments was defined. Further analysis were initated by DLR in the frame of two industry contracts, to perform a phase-zero mission definition.

The Moon, our next neighbour in the Solar System is the first choice to learn, how to work and live without the chance of immediate support from earth and to get prepared for further and farther exploration missions. We have to improve our scientific knowledge base with respect to the Moon applying modern and state of the art research tools and methods. LEO is planed to be launched in 2012 and shall orbit the Moon for about four years in a low altitude orbit.

Scientific approach: The Moon is an integral part of the Earth-Moon system, it is a witness to more than 4.5 b.y. of solar system history, and it is the only planetary body except Earth for which we have samples from known locations. The vast amount of knowledge gained from the Apollo and other lunar missions of the late 1960's and early 1970's demonstrates how valuable the Moon is for the understanding of our planetary system. Even today, the Moon remains an extremely interesting target scientifically and technologically, as ever since, new data have helped to address some of our questions about the Earth-Moon system, many questions remained. Therefore, returning to the Moon is the critical stepping-stone to further exploring our immediate planetary neighborhood.

Understanding the origin and evolution of the terrestrial planets including Earth requires information about early differentiation volcanism and related tectonism. However the physics and chemistry of these processes and its chronological sequences are not completely know. The Moons composition is, due to the lack of water and it’s restricted geological active phase, relatively simple and thus provides insight into planetary processes that are much more obscured on other bodies. In particular, Earth and Venus exhibit extremely young surfaces, containing almost no record of the early evolution of a planet. Thus, evidence on how planets differentiate, of how early magma oceans operate as well as on secondary differentiation and initial volcanism is restricted to the Moon. Earth and Moon form a common planetary system that is unique among the terrestrial planets. Both bodies exchange gravitational energy. Is there a direct correlation of the specific evolution of Earth including life and the existence of the Moon? The Moon is thought to be the product of an early planetary collision of a mars-sized body with Earth. However this model needs to be confirmed by measurable “ground truth”. Datation of planetary surface and thus of planetary processes like emplacement of lava, collision events, and breaking of the crust depends on the distribution and frequency of impact craters. This statistical method is based on the long record of impacts known from the lunar surface and correlations with the absolute age of lunar samples. However, particularly small impact craters that are needed to improve the accuracy of theses dating method are not mapped out globally. As the moon has no atmosphere its surface will not only collect impacts of smallest scale but is hit by sizes down to the particles of the solar wind. The surface debris called regolith has thus collected information about activities in our space environment over time until the beginning.

A necessary further step in investigating the Moon is getting a global and integrated view of its geology, geochemistry and geophysics at highest resolution down to meter scale. In particular, we need to significantly improve our understanding of the lunar surface structure and composition, surface ages, mineralogy, physical properties, interior, thermal history, gravity field, regolith structure, and magnetic field. A low altitude orbiting spacecraft, equipped with a wealth of high-resolution remote sensing instrumentation, can achieve such a goal. Highest resolution geological, geochemical and geophysical mapping will provide the unambiguously needed information to plan landings and future utilization of the Moon.

Numerous space-faring nations have realized and identified the unique opportunities related to lunar exploration and have planned missions to the Moon within the next few years. Among these missions, LEO will be unique, because it will globally explore the Moon in unprecedented spatial and spectral resolution. LEO will significantly improve our understanding of the lunar surface composition, surface ages, mineralogy, physical properties, interior, thermal history, gravity field, regolith structure, and magnetic field. The Lunar Explorations Orbiter will carry an entire suite of innovative, complementary technologies, including high-resolution stereo camera systems, several spectrometers that cover previously unexplored parts of the electromagnetic spectrum over a broad range of wavelengths, microwave and radar experiments, a very sensitive magnetometer and gradiometer, and a subsatellite. The Lunar Explorations Orbiter concept is technologically challenging but feasible, and will gather unique, integrated, interdisciplinary data sets that are of high scientific interest and will provide an unprecedented new context for all other international lunar missions. With its high visibility, LEO will foster the growing acceptance of space exploration in Germany and will capture the imagination of the general public.

The most visible mission goal will be the global mapping of lunar surface with high spatial as well as spectral resolution. Therefore in addition to a stereoscopic global mapping in the meter range a screening of the electromagnetic spectrum within a very broad range will be performed. In particular, spectral mapping in the ultraviolet and mid-infrared will provide insight in mineralogical and thermal properties so far unexplored in these wavelength ranges. Fine scale analysis of the lunar regolith by radar sounding will provide structural information about the regolith layer. The determination of the dust distribution in the lunar orbit will provide information about processes between the lunar surface and exosphere supported by direct observations of lunar flashes. The geophysical properties of the Moon will be investigated by recording the magnetic and gravitational field with so far unrivalled accuracy due to the low orbit, stable spacecraft, sub-satellite and specific tracking. Measuring of the radiation environment will finally complete the exosphere investigations. Combined observation based on simultaneous instrument adjustment and correlated data processing will provide an integrated geological, geochemical and geophysical database that yield the comprehensive scientific source for any further lunar exploration.

Summary: LEO is featuring a set of unique scientific capabilities w.r.t. other planned missions including: (1) 100% global coverage of all remote sensing instruments with stereo resolutions of 1 m HRSC and ground resolution of the spectral bands of < 10 m. (2) Besides the VIS-NIR spectral range so far uncovered wavelengths in the ultraviolet (0.2 – 0.4 µm) and mid-infrared (7 - 14 µm) will be globally map the lunar surface. (3) Subsurface detection of the regolith with a vertical resolutions of about 2 m down to a few hundred meters (radar) and on mm-scale within the first 2 meters (microwave-instrument) will investigate the regolith. (4) Detailed measurements of the gravity field and magnetic field from a low orbit (50 km) by the satellite a subsatellite simultaneous Earth tracking, supported by a gravimeter and two independent magnetometers will provide high precision and in addition will enable to geophysical investigate the far side. (5) The long mission duration of 4 year yields multiple high resolution stereo coverage and thus monitoring of new impacts; this is supported by a flash detection camera searching directly for impact events and dust detection in the exosphere.

LEO is currently in a definition phase. The mission scenario foresees a launch beginning 2012, a five-day lunar transfer, a two-month commissioning phase and a four years mapping phase.