Geophysical Research Abstracts,
Vol. 10, EGU2008-A-02792, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-02792
EGU General Assembly 2008

ASTEX - A study of a mission to visit two near-Earth asteroids

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Introduction: ASTEX is a recently started DLR- funded feasibility study of an in-situ exploration mission to two near-Earth asteroids (NEAs). The selected mission targets are intended to have different mineralogical compositions, more specifically one will be of a “primitive” nature, the other one will be a fragment of a differentiated asteroid. The main goals of the mission are to explore the physical, geological and mineralogical nature of the target asteroids, as well as to provide information and constraints on the formation and evolution history of the targets and of the asteroid belt as a whole. In addition, the mission may be used to develop new technologies, not only to achieve the scientific goals of this particular mission but also to study innovative technologies for future applications. Aims of the study: The primary aim of the study is to define the high-level goals of the ASTEX mission as well as to identify and to analyze mission scenarios which support these goals. The study includes: 1) The identification of potential target pairs, optimized trajectories and orbits around NEAs. 2) The identification of the optimum propulsion system. 3) The selection of the scientific strawman payload of the orbiter and lander(s). 4) The analysis of the requirements and options for the spacecraft bus and the lander system. 5) The identification of the requirements for the operational ground segment. Scientific aims of the mission: Primitive and differentiated asteroids represent two main formation stages of the building blocks (planetesimals) of the terrestrial planets, which are important for our understanding of the origin and evolution of the solar system. Two scientific aspects play an important role,

i.e. the search for, and study of the origin and evolution of, primordial material that may have played a role in the formation of life in the solar system, and the understanding of the processes that have led to differentiated planetary embryos in the asteroid belt. Beside these, the following immediate aims of the mission have already been defined: 1) The determination of the inner structure of the bodies using radar reflection tomography. 2) The search for material relevant to the formation of life. 3) The determination of the basic physical parameters of the targets (e.g., size, shape, mass, etc.). 4) The determination of thermal conductivity, roughness, material strength and other surface physical properties. 5) The visible and near-IR mapping of the surface to determine the morphology, the chemistry, the mineralogy and the geology of the targets. 6) The investigation of the correlation between meteorite classes and asteroid types. 7) The exact determination of the asteroid's orbit using radio tracking of a transmitter located on the asteroid's surface. 8) The provision of essential information for mitigation strategies against hazardous NEAs.

Technological aims of the mission: To meet the scientific goals several innovative technologies need to be developed or optimized in the future: 1) Spacecraft bus designed for approaching multiple targets, and a low-thrust propulsion system (e.g. solar-electric propulsion) which allows long-duration thrusting. 2) Low mass lander system equipped with robotic tools for payload positioning and surface digging. 3) Miniaturized lander payload (panoramic camera, microscope, electron microscope, temperature sensors, Moessbauer spectrometer). 4) Radar for tomographic investigation of the inner structure. Mission scenarios: Currently more than 1200 mission scenarios have been computed within the present study and will be detailed by February 2008. Finally, 4 mission scenarios will be selected and used as a reference for the definition of the required spacecraft bus and the ground segment. The general mission scenario is as follows: After an interplanetary cruise phase of several years the approach phase to the first asteroid will deliver the spacecraft into a safe circular polar orbit around the target. During this orbit phase the results obtained by the remote sensing instruments will be used to select the landing site of the lander. After descent and landing the surface exploration of this target will be performed. After completion of the in-situ and in-orbit measurements at the first asteroid, the spacecraft will move on to the second target for rendezvous. Here, similar in-orbit and on-surface exploration will be performed.