EPSC Abstracts
Vol. 12, EPSC2018-191, 2018
European Planetary Science Congress 2018


# Concept of nano-probes exploration in small-body mission

Jiangchuan Huang, Fan Guo, Huixi Liao, Jinan Ma, Linzhi Meng, Tong Wang and Xiaoyu Jia
China Academy of Space Technology, Beijing, China (gf3527@126.com)

## Abstract

During the past decade, China Academy of Space Technology (CAST) has been continuing to advance researches on small-body exploration, and has achieved some success, such as asteroid Toutatis fly-by in Chang'e-2 mission on Dec. 13th, 2012. Recent one new mission is proposed and being designed through some self-funded projects. This presentation will start with the mission overview, several scientific problems of small-body are elaborated, science objectives of the mission are concluded, and configuration of scientific payload is presented. Next the profile and flight procedure of the spacecraft are introduced briefly. Because nano-probes have many benefits such as low cost, low risk, short development duration, providing complementary information of exploration and etc., the concept of multi-stage and multi-function nano-probes is proposed, including nano-landers and nano-orbiters, is an excellent way of cooperation in the mission. Different kinds of exploration form such as close range orbiting, surface in-situ and subsurface penetration are discussed, and scientific values and preliminary configuration of payloads are concluded. Finally, the top requirements of the Nano–probes are summarized, expected for cooperation with other institutes in various ways in the mission.

## 1. Introduction

During the past decade, China Academy of Space Technology (CAST) has been promoting researches on small-body exploration through some self-funded projects and has achieved some success, such as Toutatis asteroid fly-by in Chang'e-2 mission on Dec. 13th, 2012.

Recently leaded by the Principle designer of the Chang'e-2, a new mission design has been proposed. The principles of mission are:

- Innovative Science
- Multi-phase, preceding phase: quick outcome; latter phase: high value
- Multi-functional space probe that can accommodate multi-task and multi-target
- International cooperation

## 2. Mission overview

### 2.1 Science Objectives and instruments

In order to solve several hot issues in the science of small bodies, the total science objectives are proposed. And then the configuration of scientific payloads is proposed in detail, including name, function and corresponding scientific problems intended to be solved.

### 2.2 Spacecraft overview

The whole spacecraft is consisting of two parts, the main-probe and several sub-probes. The main-probe can land repeatedly. Total function and flight procedure of the main-probe is introduced briefly.

## 3. The concept of nano-probes

### 3.1 Benefits of using nano-probes

Thanks to the rapid development of microelectronics technology, nano-probes such as CubeSats with relatively low function and low R&D costs begin to play more and more important role in space technology. Benefits using nano-probes in our mission are described as following:

- Low cost, low risk and short development duration
- Provide complementary information of exploration
- Extend the duration of exploration (orbiting or in-situ)
- Excellent platform of cooperation in mission

## 3.2 Concept overview

Nano-probes can be divided into two categories, nano-lander and nano-orbiter. They are attached to the main-probe. Figure 1 is the profile of the nano-probes concept. After releasing the orbiter for landing observation, the main-probe will begin to decent and finally anchor itself on the surface of the asteroid. The main-probe has the ability to stay long on the surface, so the nano-lander can be separated from the main-probe with a very small relative velocity to the asteroid.

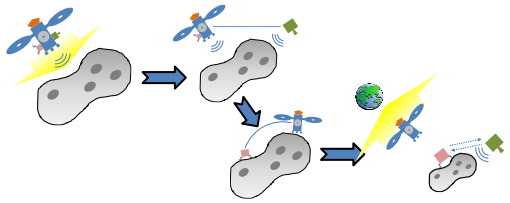

Figure 1: Nano-lander and nano-orbiter attached to the main-probe.

## 3.3 Discussion of different kinds of nano-probes

**a. Close range orbiting**

Close range orbiting can scan the entire surface rapidly with high spatial resolution. It also can relay the nano-lander's signal to earth for a long time, even after the departure of main-probe.

**b. Surface in-situ**

Surface in-situ can make nano-lander become a site, can continuously provide in-situ measurements such as temperature, magnetic field and so on. The possible scientific payloads are thermal IR radiometer, magnetometer and thermometer.

Combing the nano-orbiter or nano-lander with the main-probe, it is proposed to use the nano-probes to accommodate the bi-static radar instrument. This system provide us a way not only to estimate the inner 3D construct of the small bodies, such as "onion shell" model and the loose "rubble piles" model, but also to estimate the mean permittivity of each component. The radar is one of the main instruments capable of sounding asteroids to characterize internal structure from sub-meter to global scale.

**c. Subsurface penetration**

Subsurface penetration can make a chance to explore the inner micro-structure of small bodies with high resolution. For example it can obtain the particle morphology, mineral composition or physical parameters of the regolith corresponding to depth. The possible scientific payloads are X or gamma ray spectrometer, accelerometer, thermocouple and mass spectrometer.

## 3.4 Requirements of the nano-probes

It's expected that survival time of the orbiter and the lander should be long enough for extended operations following departure of the main-probe. The lander can continuously provide in-situ measurements. The orbiter acts as the relay satellite, relaying the signal back to earth. More mass will be distributed to the orbiter for it will directly communicate with earth. As the main-probe anchors itself on the surface and then release the nano-landers, it's expected to reduce the design difficulties for the landers as well as their mass. The requirements of the nano-lander and nano-orbiter are summarized.

# 4. Summary and Conclusions

Over the past the few years, CAST has been working on mission design of small-body exploration. One new mission is proposed and being designed through some self-funded projects, may solve several hot issues in small-body science. The exploration concept of multi-stage and multi-function nano-probes is presented, is an excellent way of cooperation in the mission. Different kinds of exploration form such as close range orbiting, surface in-situ and subsurface penetration are discussed. Due to the technology complexity, vast investment and high risk, we're willing to cooperate with other institutes in various ways, and jointly develop the international deep space exploration, to benefit for human being, including mission design, science issue research and development of science payloads, etc.