Sampling Site Close-Up Camera for Small Body Sample Return Mission

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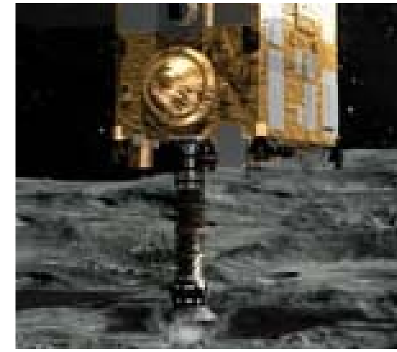
International Symposium Marco Polo and other Small Body Sample Return Missions (19 May 2009, Paris)

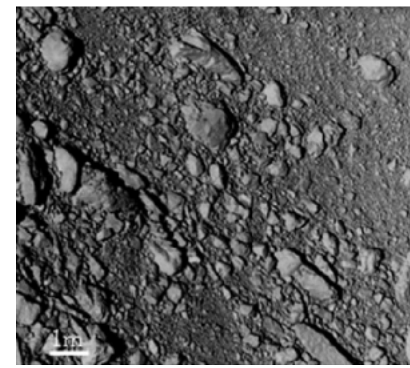
Lessons Learned from Hayabusa Mission

From Hayabusa mission, a Japanese asteroid exploration mission launched in 2003, we obtained many lessons learned:



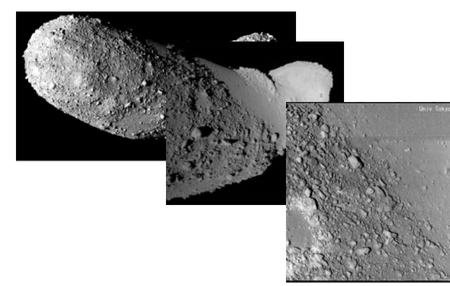
1st Priority

1. Direct and in-situ sampling detection system is preferable for the mission success criteria
   - Requests for direct in-situ confirmation of sampling
   - Images of the features formed by the projectile impact will be strong evidence for the mission success criteria



2nd Priority

2. Increasing demands for more detailed observation of sampling site
   - Geologic / geographic description of the sampling site is desirable



Extra

1. No detailed geologic information of the sampling site. Few clues for localization and identification of the sampling site on the asteroid
   - Geologic context of the sampling site should be clarified

Needs for Close-Up Camera for Next Missions

A close-up camera will be a good candidate for solution of these lessons.

Requirements for the close-up camera are:

1. Direct confirmation of sampling and imaging of features by projectile impact

   1st Priority

   1. Take several images around the sampling site before and after the touchdown
   2. Capture the change occurred on the surface of the asteroid (at least the size of the projectile should be recognized)
   3. The sampling site will be inside of the spacecraft shadow. A light source will be needed.
2. Geologic / geographic description of the Sampling Site

   2nd Priority

   1. Take close-up images of the surface with higher resolution than that accomplished in Hayabusa
   2. If possible, take images of a crater growth
3. Cross-scale images for self-localization and representativeness of samples

   Extra

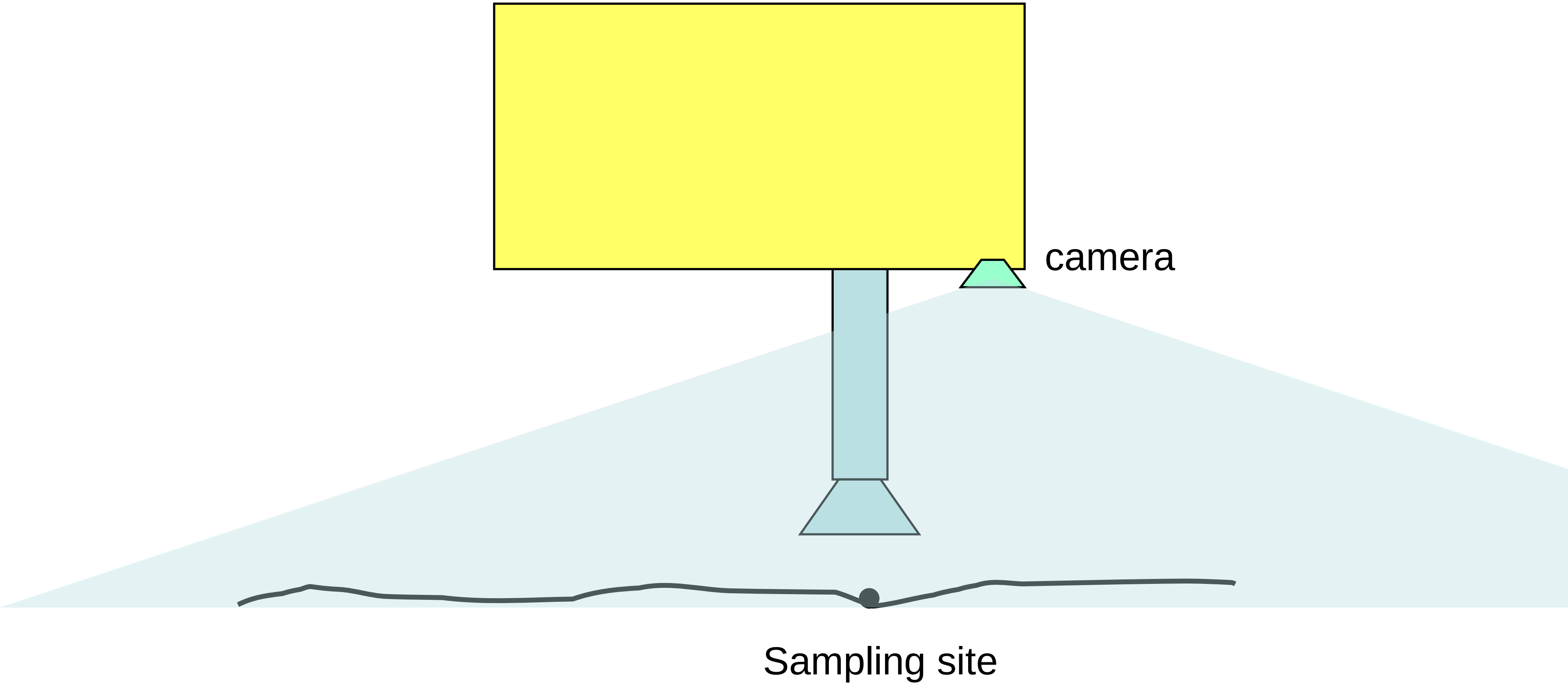
   1. Identify the position of sampling site on the global model
   2. Obtain cross-scale images

These are not satisfied by navigation cameras mounted on Hayabusa, because they are not capable of close-up imaging in the touchdown

→ Another new camera is needed

Concept of Close-Up Camera

- The camera will be mounted on the asteroidal (i.e. anti-sun) face of the spacecraft.
- It images the sampling point and peripheral surrounding environments



Wide-Angle Optical Systems

- We must establish
  - detailed imaging of the sampling site
  - the wide-angle peripheral visual field for self-localization

- These differential demands can be satisfied simultaneously by
  - a fish-eye lens

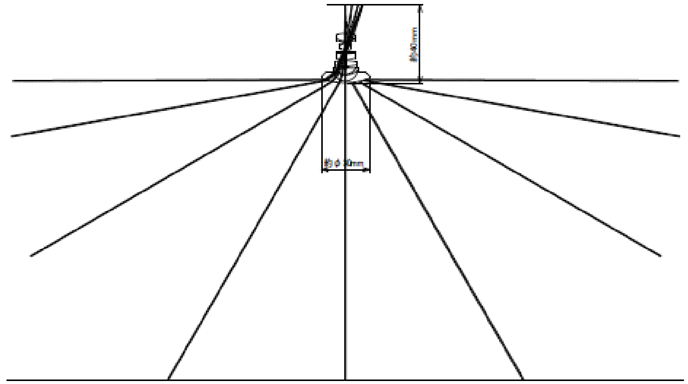
  or
  - an omnidirectional camera

- several options can be considered

Fish-Eye and Omnidirectional Cameras

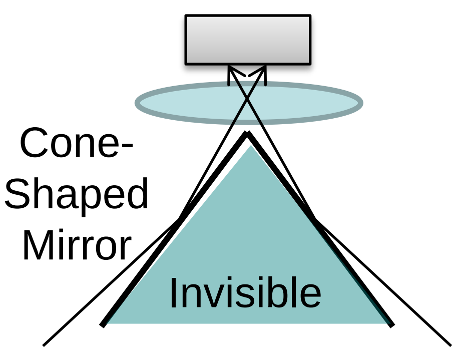
Fisheye Lens

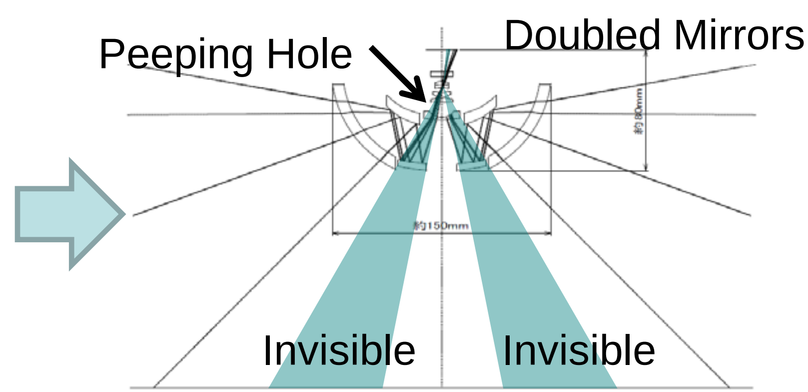
Fisheye lens has very wide view angle (up to180deg)



Omnidirectional Camera

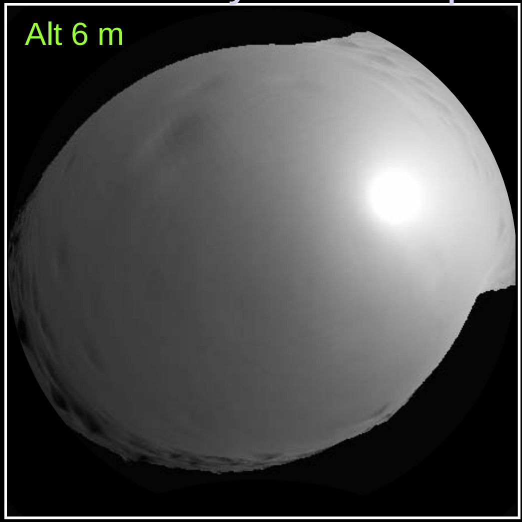
Omnidirectional camera can image surroundings with a mirror, but usually the center is invisible → A peeping hole on the mirror will be effective

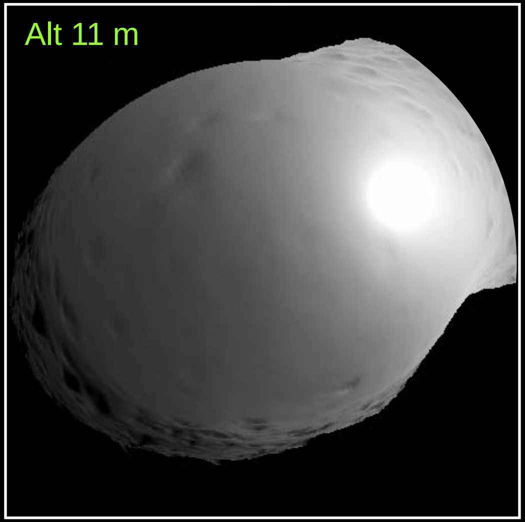


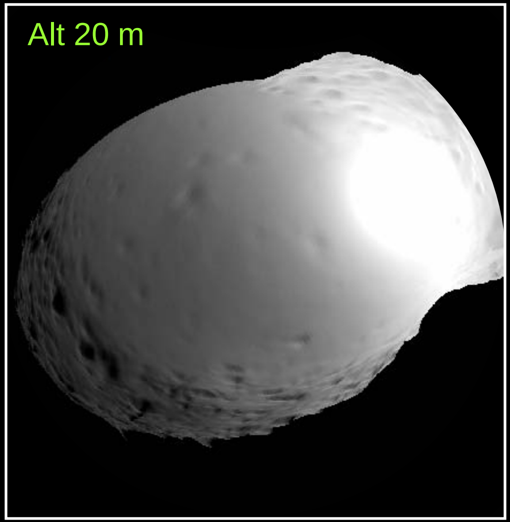


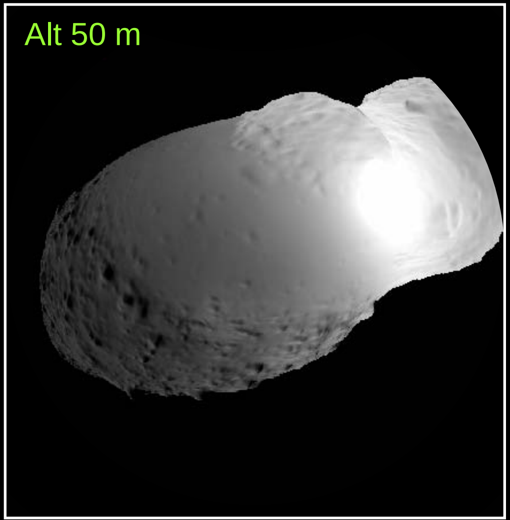
Example: Fish-Eye Lens Simulation

We can see some geologic details near the horizon – they will be some clues for self-localization.   Many other requirements are to be evaluated via this simulation.









Model: Itokawa

Pros and Cons of 2 Types of Optics

Omni-Directional Camera

Pros

- Easy to manufacture
- Small aberration

Cons

- Cannot see the center →Peeping hole
- Invisible regions
- Heavy-weight

Fisheye Lens

Pros

- No invisible regions
- Light-weight

Cons

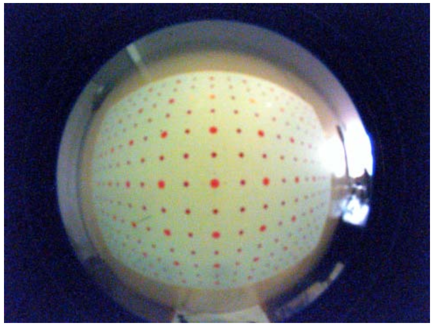
- Many lenses must be needed and calibrated
- Low resolution

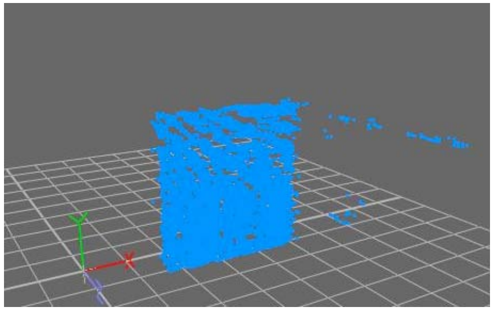
- Invisible regions are not desirable for imaging the sampling site during touch-down
- Higher resolution is better for scientific purposes
- We would like to adopt this camera for the next asteroid exploration mission →Development period should be short; the method with lower TRL is preferable
- Now which to choose is under discussion – we have to evaluate these two optics from perspectives of mission definition, TRL and interface for the mothership.

Current Status and Future Plans

- Optics is now being discussed - reading consistency of requirements and specifications for wide-angle cameras and light sources, in view of TRL, costs, and schedule.
- Planning breadboard model in this FY, if possible
- Preparing 3D mapping based on wide-angle images

These figures show the calibration test for a fisheye camera.

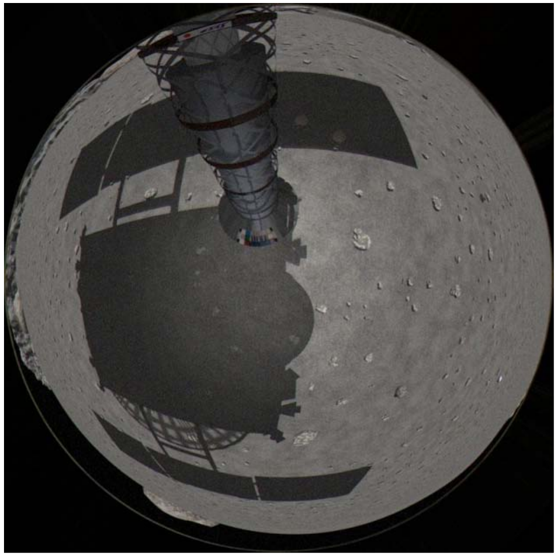




(Demura, 2008)

Assuming a fisheye camera, we are expected to obtain such an image in the touchdown phase, for example.

Thank you for your attention!



(Demura, 2008)