Development of a penetrator for the future seismic exploration missions

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Abstract:

A hard-landing mission using a penetrator has a great advantage, being lightweight compared to a soft landing system. We succeeded in developing seismic observation system on-board which had enough durability under high shock environment up to 5000G. LUNAR-A[1] was the first approved mission as the lunar penetrator mission in 1990, however, it was canceled in 2007 due to the delay of the penetrator development. After that, the penetrator technology was refined on the level of ground experiments in 2011. We re-designed the mission to optimize small class mission using Epsilon launch vehicle and submitted to the M-class mission of JAXA named APPROACH (Advanced Penetrator Probe Applied for a Challenge of Hard landing) mission[2] in January 2018. The APPROACH mission is basically a succession of LUNAR-A mission heritage, although the number of the penetrator is reduced to one(two penetrators onboard in LUNAR-A).The science instruments onboard are seismometer and heat-flow measurement respectively, which was identical to that of the LUNAR-A mission. Even if one seismic station, we speculated to determine crustal thickness at about 10% precision with additional information of lunar impact flash data by the ground and onboard camera of mother spacecraft observations.

The APPROACH mission was not selected. However, further development has been continued until now for the future missions. Especially, recent progress in electronics devices of communication and data processing made us possible to save weight and power consumption drastically. For example, the communication device could be designed at 1/5 to 1/10 in weight compare to that of the LUNAR-A penetrator. As a result, the penetrator could be designed to less than 10kg, compared with the 14kg LUNAR-A penetrator.

On the other hand, development of test equipment of penetration experiment using a DRONE is another achievement recently. In the past, a large facility (e.g. Sandia National Laboratory) which was too costly and required complicated procedures, was used for penetration experiments under suitable condition. The DRONE system which can be operated by ourselves, could deploy a 10kg penetrator to convey more than 1000m height. The maximum velocity is about 100m/s at maximum by free fall penetration experiment, about one third of the lunar penetrator, however, it is convenient for us to conduct preliminary shock experiment of the instruments on board.

It is also under investigation to develop Mars penetrator system which requires different deployment system, and durability of environmental temperature lower than -80degC.

Not only a standalone penetrator mission, we are also considering to deploy the penetrator system as a payload of large missions to make sub-seismic stations to the Moon and Mars. Weight saving of the device and easier development process would lower a threshold for the penetrator’s future deployment to

space missions.

Refecences:

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