Powered Flight by Ion Engines of Hayabusa Spacecraft and Deep Space Exploration in Near Future

Hitoshi Kuninaka[1]

[1] ISAS/JAXA

http://www.ep.isas.jaxa.jp/

1. Hayabusa Explorer

The deep space exploration is expanding to miner celestial objects from major planets. And advanced space missions such as the rendezvous, landing and return are focused on shifting from a simple fly-by. These missions of a high order toward the deep space require high maneuver capability. If we design such a mission using conventional chemical thrusters, the spacecraft is occupied by a large amount of fuel and needs an extremely large launch vehicle. These spacecraft flies by inertia after the initial acceleration by the launch vehicles, so that they are called Artificial Planets in deep space and Artificial Satellites around Earth. The technology advancement dramatically changed the space missions. The electric propulsion efficiently generates thrust force with less propellant consumption. Thrust per propellant consumption rate is indicated by the specific impulse. The ion engines myu10 generate 3,000sec of specific impulse in comparison with the chemical thrusters 300sec. The spacecraft installing the electric propulsion have a capability to cruise themselves in space without the large launch vehicles for the initial acceleration. It should be categorized Space Ships.

The asteroid explorer Hayabusa was launched into the deep space by M-V rocket on May 9, 2003. It will execute a round trip space mission between Earth and the asteroid Itokawa propelled by four microwave discharge ion engines myu10, of which the space flight was realized based on the R&D during 15 years. The myu10 in space is evaluated the thrust 8mN, the thrust factor 93%, the specific impulse 3,200sec and the thrust power ratio 23mN/kW. IES (Ion Engine System) succeeded the Hayabusa spacecraft pass through a perihelion on February and fly by Earth on May 2004. On February 2005 it arrived at the aphelion 1.7 AU from Sun so that IES is the electric propulsion to reach farthest space in the solar system. The total numbers of operational time reached 25,800 hours and generated 1,400m/s delta-V consuming 22kg propellant. The Hayabusa spacecraft succeeded to rendezvous with the asteroid on September 12, 2005. It is the historical event in the technology of the space flight. Though a lot of failures at the moments of touch-down and lift-off on November, Hayabusa aims to return to Earth on 2010 by means of the delta-V by the ion engines.

2. Microwave Discharge Ion Engines

The microwave discharge ion engines myu10 have the technological features are summarized as follows.

1) Xenon plasmas are generated by ECR microwave discharge without solid electrodes, which are ones of life critical components and origins of the flakes causing the grid short in the conventional ion engines. Elimination of the solid electrode makes the ion engines durable and high reliable.

2) Neutralizers are also driven by ECR microwave discharge. Deletion of the hollow cathodes releases the ion engine system from the performance degradation due to oxygen contaminating propellant and time limitation for air exposure during the satellite assembling.

3) A single microwave generator feeds simultaneously both an ion source and a neutralizer. This feature reduces the system mass and simplifies the control logic.

4) DC power supplies for ion acceleration are reduced three. This feature also has the advantage of lightweight system and simple operational logic.

5) Carbon-carbon composite material is applied to the electro-static grid system. The clearance between the grids is kept stable regardless of temperature due to zero thermal expansion.

3. Deep Space Transportation System

Hayabusa spacecraft conveyed 30kg payload to the asteroid. Much powerful electric propulsion will transport heavier payload to a target. This will derive a new concept Deep Space Transportation System (DSTS) in comparison with a conventional Space Transportation System covering between Earth surface and LEO or GEO. The electric propulsion technology will promote DSTS.

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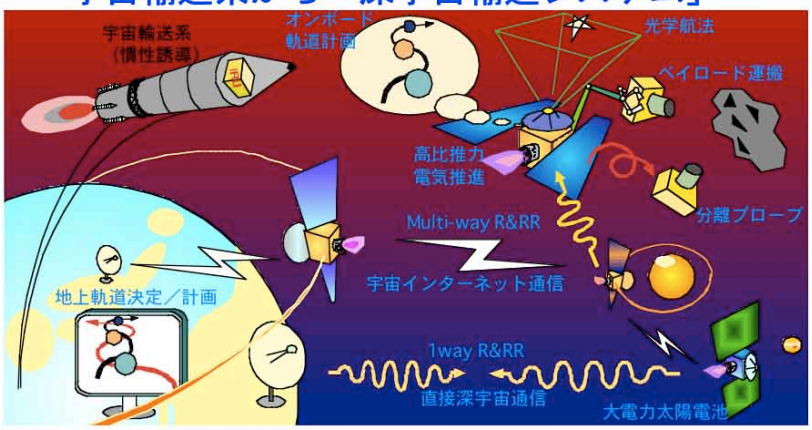

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