Small Solid Fuel Rocket "Epsilon"

Epsilon-2 placed the Exploration of energization and Radiation in Geospace "ARASE" in orbit

In 2016, the Exploration of energization and Radiation in Geospace "ARASE" (ERG) was launched into space, and is now challenging observation in the Van Allen belt first in the world. What launched "ARASE" and successfully placed it in orbit is Epsilon-2 developed by JAXA and IA.

Enhanced Epsilon rocket (second rocket) ©JAXA

Cosmic storm

Many people may know the terms "Van Allen radiation belt," "solar wind," "aurora," and so on. However, the nature of them is not understood in detail. The space near the earth is referred to as geospace, where particles such as electrons and protons mainly derived from the solar wind and the terrestrial upper atmosphere are captured by the terrestrial magnetic field. In addition, there are areas filled with high-energy particles, called the inner and outer Van Allen belts, around 0.2 to 1.5 times (1 300 to 10 000 km) and around 2 to 5 times (13 000 to 32 000 km) the earth radius above the equator. A solar flare discharges a corona, and the particles and electromagnetic field are disturbed, thus causing the strong fluctuation of the Van Allen belt. The fluctuation is just the cosmic storm, and causes the failure of a spacecraft such as an artificial satellite and the interference of safety of extravehicular activity of astronauts at a space station. For a familiar example, the fluctuation also causes aurora viewing tour guests to be glad and sad by turns. The ARASE launched in 2016 is attempting to rush into the cosmic storm and solve some mysteries. ARASE is now favorably flying, and challenging the world's first observation.

Epsilon

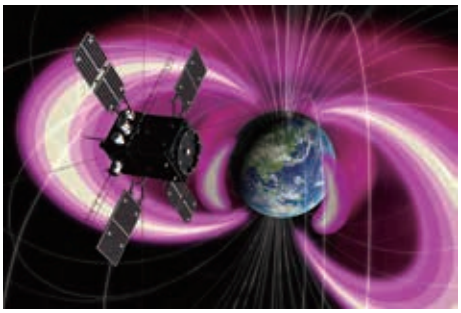
Epsilon is a three-stage solid fuel rocket inheriting Japan's original solid fuel rocket (hereinafter referred to as a solid rocket) technology, and was developed by IHI AEROSPACE Co., Ltd. (IA) under the supervision of National Research and Development Agency, Japan Aerospace Exploration Agency (JAXA) in order to achieve the mission of bringing an exploration satellite like ARASE and various types of space equipment into the space and placing them in orbit. The first flight was conducted in September, 2013, and Epsilon-1 succeeded in the mission of placing the planet probe "HISAKI" in orbit.

Rockets are roughly divided into two classes in terms of the state of fuel, i.e., solid fuel rockets like Epsilon and liquid fuel rockets like H-II A. The liquid fuel rockets have separate tanks for a liquid oxidant (mainly oxygen) and for a

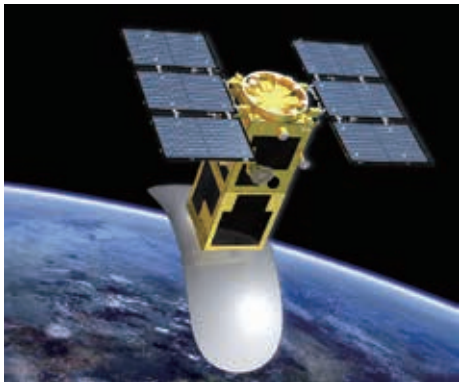
propellant (hydrogen or methane), and mix and combust them to use the resulting gas pressure as propulsive force. The liquid fuel rockets have the advantages of being capable of finely controlling the propulsive force by adjusting the amount of the fuel and of being superior in an index called specific impulse corresponding to the fuel consumption of an automobile, thus making it possible to launch a larger satellite farther away, but difficult to be made compact because structures such as a piping system and a combustion chamber are complicated.

On the other hand, the solid rockets use, as fuel, rubber-like solid explosive in which an oxidant and a propellant are mixed. In simple terms, only with a combustion chamber containing solid explosive and a nozzle for jetting gas, propulsive force can be obtained. The solid rockets have the advantage of simple structure, but once the fuel catches fire, cannot stop it in the middle. In order to place a satellite by a solid rocket in target orbit with accuracy comparable to that provided by liquid fuel rockets, it was necessary to develop advanced control technology.

The number of countries/regions which have developed solid rockets for launching a satellite has been increasing in recent years, but is still four to five in the world, and Japan is one of them. The history of solid rockets in Japan started from the pencil rocket in 1955, and since then, unique technology had been developed until M-V rockets produced remarkable achievements in the 2000s. Unfortunately, the M-V rockets had to be abandoned in 2006 due to a cost problem.



"ARASE" (ERG) ©JAXA



Small radar satellite "ASNARO-2" ©NEC

In order to solve cost and size problems faced by the M-V rockets, Epsilon was developed.

Satellites carried by Epsilon

The mission of Epsilon-3, successfully launched in November, 2017, is to launch the high-performance small radar satellite (ASNARO-2). A hiba arborvitae (asunaro in Japanese) is an evergreen tree of the cypress family and slightly smaller than hinoki cypress (Japanese cypress). In addition, asunaro is given an image of a bright future because it grows like "Tomorrow it will become a hinoki cypress." The artificial satellite ASNARO (Advanced Satellite with New system Architecture for Observation) having such a good name symbolizing hopes for the future is one of quickly deliverable, high-performance, small-sized, and low-cost earth observatory satellite series promoted by the Ministry of Economy, Trade and Industry.

Among the series, ASNARO-2 is mounted with the X-Band Synthetic Aperture Radar of the world's highest level capable of observing the whole earth for 24 hours, day and night, and on rainy days, even on stormy days, and its capability seems to already exceed HINOKI. It was launched at Uchinoura in Kagoshima Prefecture together with Epsilon-3.

After that, an Epsilon rocket also has a mission in FY 2018. The mission is to launch small satellites, which has been demanded recently, and specifically, to simultaneously launch multiple satellites.

Small satellites can be divided into three classes in terms of weight, i.e., up to 200 kg class called small satellites, up to 60 kg class called microsatellites, and 1 to 5 kg class called nanosatellites (CubeSats). One of the advantages of small satellites is easy to develop even in familiar organizations such as private sectors and universities, and the demand for launching small satellites has been increasing in recent years. However, a small satellite is launched in accordance with the main satellite plan as ride-share launch, and therefore we cannot freely determine the launch condition, such as launch time or orbit. Accordingly, in order to make it possible to flexibly meet such small satellite requirements, we are studying various technologies for the next Epsilon rocket, such as the improvement of the liquid stage PBS and the mechanism for separation in an attitude/orbit meeting each satellite's requirements. IA is continuing to bring various satellites into space using Epsilon rockets.

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