Making Space Development More Familiar!

"Easy-to-use" rockets technology featured in the Epsilon rocket

At 2:00 PM on September 14, 2013, an Epsilon rocket followed a straight line flying into space, cutting through the blue sky while leaving a white trail behind. As planned, this rocket placed the planetary observation satellite "Hisaki" into the target orbit, and was Japan's successful launching of a solid-fuel type rocket after an interval of 7 years. The Epsilon rocket is a successor to the M-V rocket, and IHI Aerospace Co., Ltd. is in charge of the body of the system. With a newly developed launch control system, the launch preparation period of future rockets has been greatly shortened.

Epsilon rocket (Provided by: JAXA)

Solid-fuel rocket uniquely developed by Japan

Rockets can generally be divided into two types according to the characteristics of the rocket fuel. A first feature of the Epsilon rocket is that it is a solid-fuel rocket (solid propellant rocket).

Liquid-fuel rockets such as the H-IIA have separate tanks for the liquid oxidizing agent (mainly oxygen) and the propellant (hydrogen or methane). The merits of a liquid-fuel rocket are that the propulsive force is obtained by mixing and combusting these liquids to produce gas pressure. The propulsive force can be controlled precisely by adjusting the amount of fuel, as it has an index called specific impulse that corresponds to the gas mileage of an automobile and can launch large satellites further into space. However, construction of components such as a complex piping system and the combustion chamber cannot be avoided.

On the other hand, a solid-propellant rocket uses a “rubber-like explosive” in which an oxidizing agent and propellant are mixed as the fuel. Simply stated, as long as there is a combustion chamber in which the explosive is located and a nozzle for exhaust gas, a propulsive force can be obtained. In Japan, there is a history of unique development of this kind of solid-propellant rocket technology, beginning with a pencil rocket developed in 1955 by Professor Hideo Itokawa of Tokyo University, which led to the development of the M-V (Mu-Five) world’s largest class of solid-propellant rocket) that has played an active role in the 2000’s.

A merit of a solid-propellant rocket is its simple construction, however, once the fuel has been ignited, it is not possible to adjust the propulsive force during flight. Therefore, in order to place a satellite carried by the rocket into a target orbit with precision comparable to a liquid-fuel rocket, a high level of control technology is necessary. The Epsilon rocket integrates this control technology together with solid-propellant rocket technology.

Aim for an “Easy-to-use” rocket

The Epsilon rocket has a length of 24.4 meters, diameter of 2.6 meters, and while inheriting the technology of the M-V rocket, the world’s largest class of solid-propellant rocket (length: 30.8 meters), it was developed to be smaller in size. The reason for this was as technology for electronic devices advanced, satellites with the same specifications and performance have become more compact. At the same time, the aim was for the rocket to be “easy-to-use” with an improved body construction and launching efficiency, as well as capability of space exploration and transporting observation satellites more readily and frequently.

The specific development objective is as follows:

① Improve the precision of placing a satellite into orbit so as to be on the same level as that of a liquid-fuel rocket.

② Provide a user-friendly payload environment for satellites.

③ Improve usability to a further extent by taking advantage of the characteristics of a solid-propellant rocket.

Achieving a user-friendly rocket

First, in regards to point ①, a liquid propellant propulsion stage (a liquid-fuel Post Boost Stage: PBS) that is located above the third-stage (final stage) motor (incidentally, the engine in a solid-propellant rocket is called a motor) is prepared as an option. As a result, while being a solid-

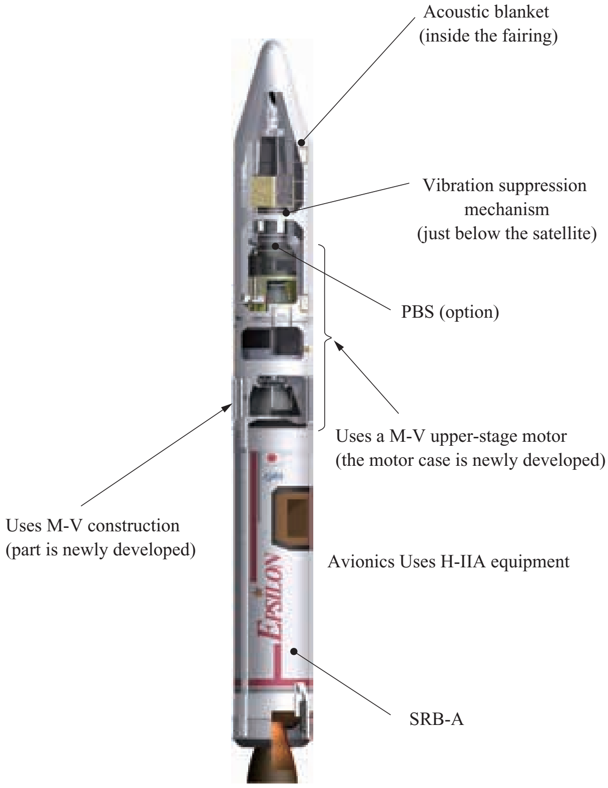
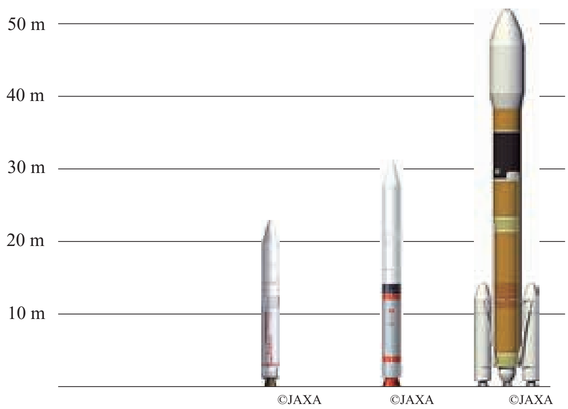
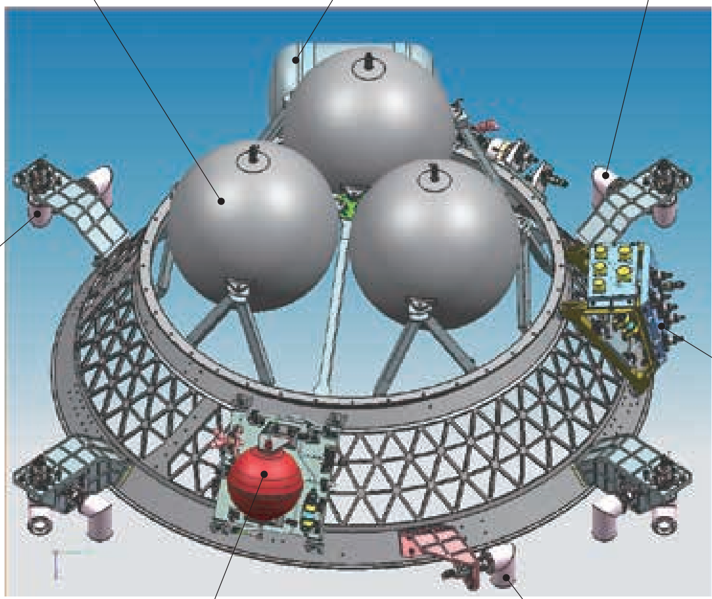


Diagram of an Epsilon rocket
(Provided by: JAXA)



	Unit	Epsilon	M-V	H-IIA
Overall length	m	24.4	30.7	53
Weight	t	91	139	285
Launch performance (low orbit)	t	1.2	1.8	10
Launch cost	Hundred million yen	38	75	100
Rocket manufacturing period	Year	1 or less	3	1.5
Launch operation period	Day	7	42	30

Comparison of rockets



Liquid-fuel post boost stage

propellant rocket, it has become possible in the final stage to perform fine adjustment for placing a satellite into orbit.

This final propulsion state is also related to making the rocket user friendly in point ②.

The fuel of the previous generation M-V rocket was solid propellant up to the final stage. Therefore, when a satellite is released into space, it was necessary for the satellite itself to have a propulsion apparatus that was capable of performing fine adjustment of the orbit. For the rocket user, or in other words, the user of the satellite, the extra load of the propulsion apparatus had to be mounted on to the satellite, which also added extra time to its development. In the case of the Epsilon rocket, the satellite does not require propulsion apparatus.

Furthermore, the environment where the satellite is stored was also improved. During a launch, the rocket vibrates a lot due to the intense combustion of the motor and is also affected by the explosive noise. A satellite must be equipped with the durability to withstand these kinds of shock. In the Epsilon rocket, a newly developed vibration suppression mechanism is installed so that the vibration of the bottom part of the rocket is not easily transmitted to the area where the satellite is located. An acoustic blanket has also been attached to the inside of the fairing that covers the satellite. By analyzing the data after launching, it was found that these sufficiently lessened vibration and noise.

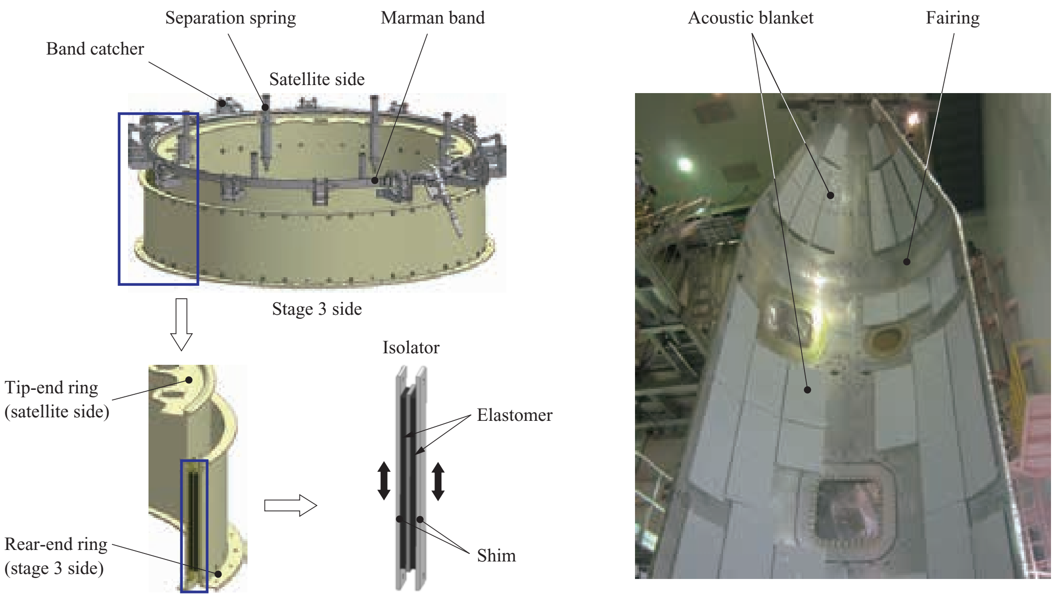
In this way, there is no need for a satellite to be fortified with unnecessary equipment, and thus can be made more lightweight and compact. As a result it also becomes possible for the user to utilize the given weight and dimensional limits to the maximum.

Self-check of the main rocket body by a control function

The most significant technological innovation is the launch control system of (point ③) that aims at “improving usability.” Before a rocket launch, inspection must be performed many times and in several overlapping stages, and conventionally, control consoles on the body and control room were connected to each system such as the ignition system, the attitude control system, the guidance system, the instrumentation and communication system. The results are then confirmed by 5 or 6 engineers at each console. In the case of the Epsilon rocket, the control functions that were on the ground are collectively incorporated into the body of the rocket in the form of Responsive Operation Support Equipment (ROSE). With ROSE, the rocket body itself checks all of the systems mentioned above using a unique program, and determines whether the systems are working sufficiently or not by confirming the integrity of the systems. This means, that at the launch, the operator only needs to perform a final check. This system was newly developed by IHI Aerospace Co., Ltd.

As a matter of fact, the reason the launch scheduled for August 2013 was immediately aborted before the launch happened was because this system was operating properly. The effectiveness of the program was unexpectedly demonstrated and verified.

(a) Satellite separation unit (PAF) vibration suppression mechanism (b) Acoustic blanket (Inside surface of the fairing)



Lessening the satellite environment (vibration suppression mechanism, acoustic blanket)

Entering the small satellite market by improving functions and reducing costs of the rocket body

As can be realized through the operation of the satellite "Himawari," or car navigation GPS, satellite technology is now something that has become indispensable to our lives. Some of the roles of satellites include communications, space exploration, positioning, weather observation and of these, it is predicted that the demand for earth observation satellites by ASEAN countries will particularly increase. Therefore, there is a high demand for rockets such as the Epsilon rocket that is capable of carrying medium-sized to small-sized satellites.

From the aspect of cost, it can be pointed out that the current rocket body still is not sufficiently competitive internationally. However, the development strategy of the Epsilon rocket can be thought of as having two stages, where the plan is that in the first stage, innovative technology in the area of operation that is ahead of the rest of the world will be achieved, and in the second stage, a rocket having international competitiveness will be achieved by improving performance and reducing costs.

The launch of the first rocket mentioned above, verified that user-friendliness, which is the first stage, and operability at the launch site were at a world-class level. Development in order to achieve the second stage is now being carried out.

There are already many requests for space science observation satellite missions by universities and research organizations for academic purposes, and there have also been inquiries from private businesses that want to sell a service of carrying an earth observation satellite into space with the objective of preventing disasters in countries in the South East Asian region. The second Epsilon rocket is scheduled to be launched as early as 2016. In the future, we are paving the way for the Epsilon rocket to become a rocket that will bring space closer to us.

The audience who watch the take-off of the first Epsilon flight

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