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Successful Epsilon Rocket Launch in Japan

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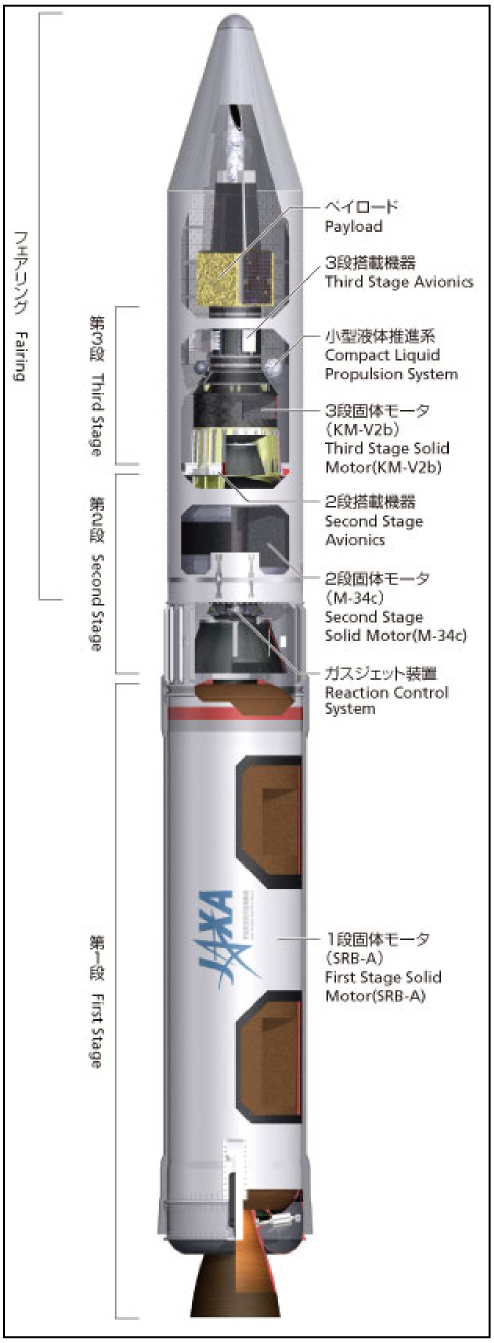
Preface

The first Epsilon rocket was successfully launched at the Uchinoura Space Center in Kimotsuki, Kagoshima Prefecture, on September 14, at 2 PM. About one hour after liftoff, the Epsilon launch vehicle released the small satellite SPRINT-A, a spectroscopic planet observatory, into orbit. The solid-fuel rocket was developed by the Japan Aerospace Exploration Agency (JAXA) and IHI Corp., a Tokyo-based manufacturer of ships, aerospace equipment and heavy machinery. It is the first launch of a new Japanese rocket in 12 years, following that of the H-IIA in 2001. The main goal of the Epsilon Rocket Project is to realize a cost efficient launch vehicle, through standardization of the rocket’s components and by greatly simplifying the launch system using artificial intelligence (AI).

Simplification & Cost Reduction

In September 2006, the last M-V rocket, No. 7, transported the “Hinode” Solar Physics Satellite to space to take X-ray telescope pictures of the total solar eclipse in Australia. The project was suddenly cancelled due to its high cost, hitting about 7.5 billion yen per launch. "I was so frustrated by the situation," said Dr. Yasuhiro Morita, now project manager of the Epsilon launch vehicle.



The Epsilon launch vehicle is only 24.4 m high, shorter than the 30.8-m M-V rocket. The Epsilon launch vehicle is a three-stage solid-fuel rocket. It uses upgraded versions of technology used in the M-V and H-IIA rockets. At the first stage, it uses the existing H-IIA solid rocket booster and an upgraded version of the upper stage of the M-V launch vehicle as the second and third stages. The first stage engine, for example, is large and costly but has little to do with the accuracy of the rocket's positioning. For this reason, the team decided to use the H-IIA rocket's booster as the Epsilon's first stage motor, then let the second and third stage motors cover other upgraded functions.

An important improvement of the Epsilon launch vehicle is the reduction in the weight of the propellant container, known as the motor case. The M-V rocket’s motor case was the world’s lightest rocket in its class. For the Epsilon launch vehicle an even lighter motor case was designed by optimizing the manufacturing process. An improved method was used inducing glue penetration so that the mold can be solidified without applying pressure. This has made the manufacturing process cheaper and simpler. In addition the usage of tougher carbon fiber made the motor case lighter and stronger. Overall these changes lead to higher performance structure and lower cost.

Furthermore, the Epsilon launch vehicle needs a reduced and standardized number of rocket components, which are compatible with other types of rockets. The rocket assembly was simplified so the launch vehicle can be transported to the launch center in an almost fully assembled state. This also reduced the time needed at the launch pad to only one week after the first stage of the rocket is put in place.

Incorporation of Artificial Intelligence

The Epsilon development team has made rigorous cost-cutting efforts. In addition, for the first time artificial intelligence (AI) has been installed on each stage of the Epsilon rocket that does all the pre-liftoff assessments. When all the checks are completed, the AI informs the main computer. Engineers are now only needed to press the "launch" button on the computer screen after confirming the "OK" messages.

Even though rockets are seen as leading-edge technology, the approach to their functionality and design is rather conservative. Rockets use technologies from many generations ago, because it has long been a notion that new technology should be tested over an extended period of time before being used in actual launch vehicles. Consequently, the latest AI has not yet been employed in rockets. The Epsilon launch vehicle, on the other hand, is designed with AI that performs many operations autonomously. The most significant development in the Epsilon launch vehicle is the capability of running control checks, enabling rocket-launch control using a remote computer, called “mobile launch control”. Thanks to the computerization of the control room, in the near future only two engineers will be needed for seven days to prepare for a launch. In the days of the M-V project, it took about 100 workers 42 days to do all the pre-launch inspections.

Applying AI also makes it possible to send back detailed information about the rocket’s functioning in space. For example, in orbit the deviation is controlled with a nozzle that expels combustion gas. The nozzle is electrically controlled, and by looking at the corrugated pattern of the electric current, it is possible to know if the rocket is moving correctly. These patterns of electrical activities can further be used to judge normality or abnormality of the rocket, providing information for future improvement of the vehicle.

Achievement & Future Plans

The Epsilon launch vehicle was developed in two stages. The objective of the first stage is to launch a small scientific satellite, SPRINT-A, for planetary observation. The Epsilon launch cost reductions of the first launch in 2013 is about 3.8 billion yen, almost 50% less than the 7.5 billion yen price tag for the M-V launch vehicle. For low Earth orbit satellite launches, the launch capacity of the Epsilon rocket is up to 1’200 kg, about two thirds of the M-V launch vehicle, which had a capacity of 1’800 kg targeting the low Earth orbit. The small satellites, such as the one launched in 2013, have a total mass of approximately 300 kg to 500 kg. Taking into account the expense of the launch capacity, the total cost performance will be improved by 25%. The objective of the second stage of the development plan is to launch a rocket for under 3 billion yen by 2017.

For future improvement, research is ongoing to make rocket parts even smaller. Another important focus of rocket development is the improvement of solid fuel. The aim is a type of solid fuel that will melt as many times as it is heated, and harden again at room temperature allowing a fresh start if necessary. The goal for the near future is to bring the ambitious vision of the Epsilon launch vehicle to further improve cost and take of reliability. “I don’t think that people imagined 30 years ago that airplanes would be flying as frequently as they are today. It is my dream to make rockets that can take off as easily as airplanes.” Dr. Yasuhiro Morita envisions the future of the Epsilon rocket project.

Significance for Switzerland & ESA

The European Space Agency (ESA), where Switzerland is a member state since 1976, is conducting a similar program of a launch vehicle for small satellites. The Advanced Generation European Carrier Rocket, called Vega, was developed to achieve a similar launching cost of 32 million euro, which corresponds to approximately 4.2 billion yen. The Vega launch vehicle’s height is 30 m and it is designed to carry 300 kg to 1’500 kg of payload into the low Earth orbit. The European project strikes with the flexibility of their launch system, being able to deal with a wide range of missions and payload configurations. The Japanese advance of using artificial intelligence (AI) for the automation of the rocket and its launch processes might also be of great interest for the European space community. The similarity of the two projects suggests that know-how transfers may be beneficial for both projects in the future.

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