SPECIAL REPORT

Development works of the H-IIA rocket engine in Mitsubishi Heavy Industries, Nagoya Guidance & Propulsion System (MHI-MEIYU)

Mr. Matsuyama, Liquid Rocket Engine Design Manager MHI MEIYU, was heading to the lunching site of the H-IIA rocket with strong faith. He was holding the charm that his daughter and son gave it to him for launching success, and saying we did every thing we could, the launch of H-IIA Rocket will absolutely succeed!

No. 1: Mr. Matsuyama, MHI-MEIYU liquid rocket design manager talks about rocket engine.

At 4:00 p.m. August 29,2001(Japanese Standard Time), the launching of the first H-IIA rocket, flight number 1, has been succeeded from the Tanegashima Space Center. About 40 minutes after the lift off, Laser R*** Equipment (LRE) was put into a geostationary transfer orbit. It was put into the apogee; 36,190.6 km (planed 36,186.2 km) and the perigee; 251.3 km (planed 251.3 km), this was the accuracy of within 0.1 sigma and was good news extremely for the one who is waiting for satellite launching.

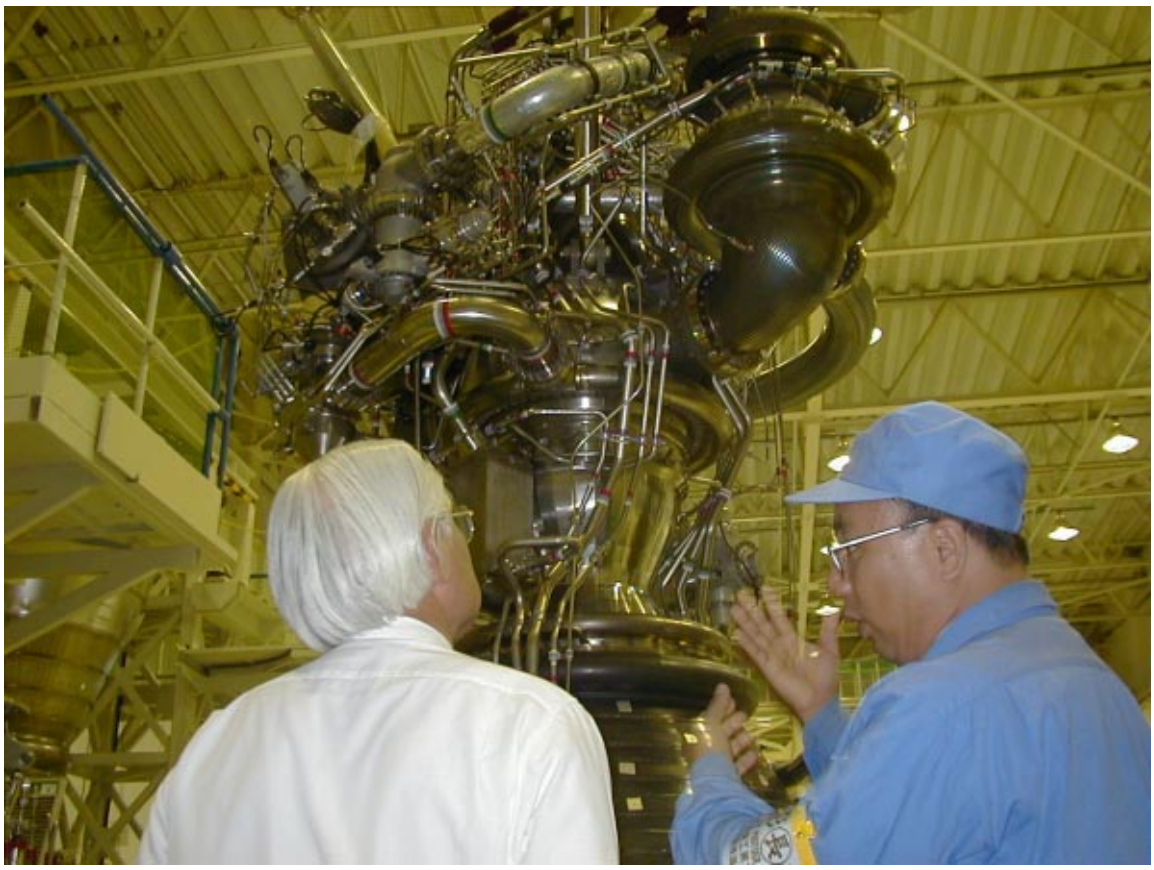
As soon as rest of country hear this good news, AIAA JFSC had settled an interview with Mr. Koichi Matsuyama, Manager of Mitsubishi Heavy Industries, Ltd Nagoya Guidance & Propulsion System works, Liquid Rocket Engine Designing Section Engine& Control Equipment Department, who made a big effort in the development of the LE-7A engine and was contributed to launching success.

No. 2: the interview with the Mr. Matsuyama

Mr. Matsuyama graduate from Kobe University graduate school in 1983 and joined MHI. Soon after, he started his career at MHI and involved to the development of LE-7, the former rocket engine of LE-7A. He is one of the leading engineers of Japanese domestic rocket engine technology development.

As most of you already knew, the H-IIA rocket concept corresponds to the transport demands to the multi-purpose transport to the space, i.e.)To supply goods to International Space Station as well as to launch satellites in the 21st century with a low cost.

Making the most lessons from the experiences, the failure of H-II/F # number 8 in November, 1999, and H-II/F # number 5, in February, 1998, it was given that the development strength activity, quality reassessment activity are the key to tackled with the development of the pure domestic developed rocket for the space development project in Japan.
H-IIA has 2 types of rocket, one is the standard type and another is the reinforcement style. The standard type of rocket launches the 4 tons satellites to the Geostationary Transfer Orbit (GTO), similar to H-II rocket. The reinforcement style is designed as it can launch the satellites of 7 tons to the Geostationary Transfer Orbit (GTO) by adding and equipped a large liquid rocket booster to the standard type.



No.3: Mr. Matsuyama, explain the LE-7A rocket engine

No.4: The LE-5B engine for the HII-A rocket number 3

Successful launch of H-IIA Rocket No. 1

The purpose of the mission number 1, in this time, is to take enough flight data and evidence and to demonstrate the function and performance that show us the H-IIA rocket has good performance and enough capability to carry the satellite into Geostationary Transfer Orbit by using the most fundamental structure of standard type H-IIA rocket.

It should be noted that behind the success of launch, without the effort of rocket development engineers, Mr. Matsuyama and many of his associates, could not be in complete.

Prior to launch

1) Anomaly was found at 2 stages liquid oxygen tank pressure adjustment valve
It is caused the delay of rocket launch from August 25th to 29th

On the day of launching

2) Anomaly of a liquid hydrogen system plumbing connection device was found and caused its launching time became postponement at 16:00 from 13:00.
However, overcoming this difficulty with the grim mental power of a person concerned it guided it to success.

From LE-7 to LE-7A

The development of rocket engines reaches to the success of H-IIA launch; there were a lot of difficulties and sacrifices.
To develop the LE-7, former engine of LE-7A, it required total of 16 engines which consists of 4 types of model, the Prototype Model, Experiment Model (No. 1), Experiment Model (No. 2) and Qualification Model. There are 3 engines, which were lost in a moment during a burn out test. It was a meantime nothing but pure white screen was shown in the monitor, right after it's test was started.
It was 2 years before the first launching, and it was the most difficult time for every single engineer involved in this project. There was the loss of a valuable human life at the burn out test of engine in developing site.
To develop an engine which combustion by combining the combustion gas (+500 C/140 air pressure) and liquid oxygen (–180C/180airpressure) by the very thin wall has a lot of difficulties to overcome.
It is already took 12 years of time, meanwhile the economical situation in the world was dramatically changing although the development of the H-II rocket was thought as success and was the price that is not able to join the international satellite launching market by sharply stronger yen.
Thereupon, H-IIA rocket and LE-7A engine, which should be economically competitive in the world market, are necessary to develop.

Development of LE-5B, LE-7A

The data that gave settle the item that collects wisdom idea from the experience of the development, production, inspection of LE-7 and should reflect to the development work of LE-7A became of an enormous amount. In many king files, it became 1 meter and more. For example, to use the 3D CAD, it simplifies the adjustable configuration of thermal/stress design and makes higher reliability.
For the production level, the key was to make it easy as much as possible, which means decrease the number of the welding place.
As a result, it was decreased the welding place where there were about 260 places in LE-7 to 60 places in LE-7A.

Also from the experience of LE-7, find and diet the unnecessary process while keeping the equal reliability, so does the cost-down.
In 1994, it began the development work of LE-7A; the first burn out test was begun in 1996. After all, although overcome numerous difficulty, it was one year and 6 months delay from the plan, they guided to engine completion.

(No.5: Table of the rocket engine performance for HII-A)

engine	LE-5B	LE-7A
thrust	14 ton	109.5 ton
diameter, length	1.7m, 2.7m	2m, 3.4m
mass	285 kg	1715 kg
usage	H-IIA second	H-IIA first
main technologies	liquid oxygen/hydrogen	liquid oxygen/hydrogen
	multiple firing	high power
	low cost	low cost
		high fleasibity

The development of the LE-7A engines of H-IIA Rocket No.1 completed in September 2000 and moved to the acceptance test in October.
It was originally planned to launch the H-IIA Rocket No.1 in February 2001. However, the problem that the erosion to the cooling pipe base material of the nozzle skirt was happened in December furthermore comes to occur, although 2 anomalies occurs during the acceptance test and counter measure was taken in November.

It made National Space Development Agency of Japan (NASDA) to decide the half a year postponement of H-IIA Rocket No.1 launch and made more detailed total inspection to carry out whether the element of anxiety has not remained in H-IIA rocket yet, working with each manufacture to inspect.

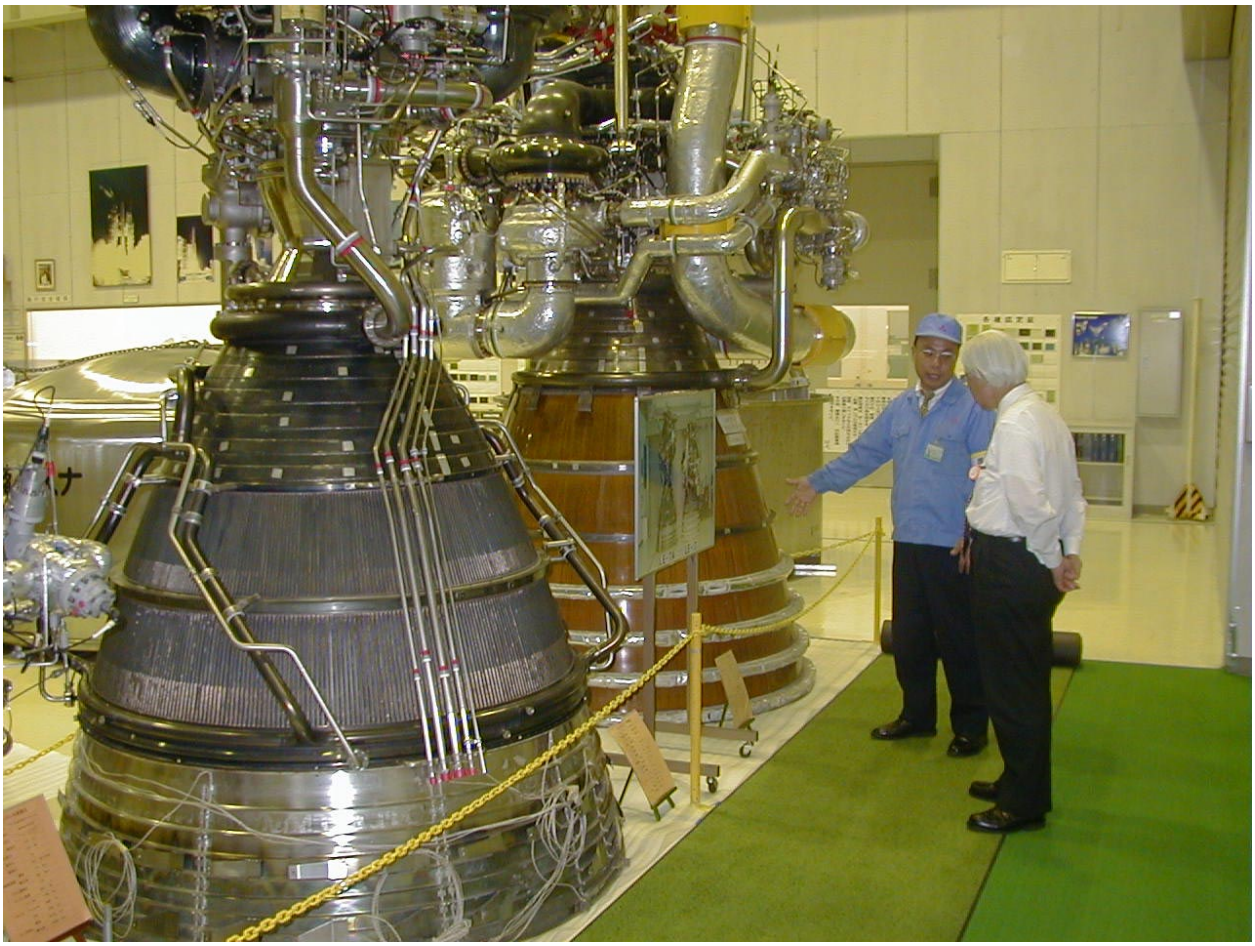
LE-7A engine that was produced as for the H-IIA Rocket No. 1 is diverted for development and the engine was totally re-produced. The re-production work was finished in March 2001 and the acceptance test was completed on schedule.
After transferring the engine to its launch vehicle, it was discovered that the lack of cleanness at the plumbing part, then the engine was re-moved and did modification work. It was happened that the fault of inspection method for Appling the washing process at the plumbing supplier. Then, the schedule became so critical as plumbing reconstruction work was done through all night.

The dust (the size of the dozens micron) with the black color was discovered at the ultra low temperature

test, which occurs from the lack of work environment of functional test. This is in the beginning of August, which was after the rocket system of No.1 completed on July 10 and carried in Tanegashima Island from the MHI Tobishima factory. It was also the moment that all reminds becomes clear and feel strongly that “how the importance of reliability control is”.

The contamination problem occurred in a lot of situation (the rocket engine is the environment of the high pressure oxygen which even the metal has burnt and whatever the small impurities causes to the precise action of the engine control failure) thus, the contamination inspection and examination team “NASDA/ MHI joint team” was established to implement strongly the cleanness control in the parts production process.

In the meantime of his explanation, it was remembered the fact that the 31ea TWTA manufacturing were required in order to get only one good Ka-Band TWTA for ECS(Experimental Communications Satellite) program.



No.6: Compares of 6: LE-7A (the left) and LE-7 engine explained by Mr. Matsuyama

Hand carries the valve in the middle of typhoon! !

The anomaly of 2 stages liquid oxygen tank pressure adjustment valves was discovered at the time of last valve operation test before launch.

It was replaced by the valve that was prepared for the H-IIA Rocket No.2., after the clarifying of its cause, the valve was attached to the filter, adhering that the small contamination of the silicon compound flows out and exerted the influence on the open/close action of the spare system.

When the propulsion system was inspected on September 19, the anomaly of valve was discovered, ant it was around 8 pm in the evening. Disassemble the valve from the launch vehicle, and bring it to the clean room for inspection. As a result, it was found that the contacted movement part was adhering.
It was required to be taken back it to MEI-YUU facility in Nagoya for detailed survey after quick review. However, on the next day, the typhoon number 13 was attacking the Tanegashima Island and all commercial airlines were cancelled. Which means no transportation is available for him to bring it back to Nagoya. The only one way came up to him, which is MHI company owned MU-300 and catches the opportunity to take it. Mr. Matsuyama was on board with holding the important valve that should be transported to Nagoya via Naha and Kagoshima.
However, MU-300 cannot continue to flight at Kagoshima airport. He has to take off the MU-300 and looking for the commercial flight available to fly over to Nagoya, fortunately he could catch the flight ANA that was only one flight to go back to Nagoya on that serious conditions.
Now the concern was that it is mystery where the particle came from. Although it understood that a lot of minute particle caused the adhesion by the expansion observation at the contacted movement part.
However the contamination inspection team was finally discovered that contamination came out from the filter. Then, it was decided to use the another good one, which will be used for No.2 rocket instead of 1st one, and in order to make sure, additional cleaning process was applied for the alternate one through the night. In the morning of 24th, no contamination more than 10 micron could be observed finally, then Mr. Matsuyama leave MEI-YUU facility 3:30pm with alternate good one and arrive it Tanegashima space center at 6pm and reintegration work it onto rocket were done again over night. These hard works could make possible to start the Y-3 count down for the launch on 25th August. During this time, he could take rest only 1 or 2 hours a day.
“It was the key for the solution of this problem to notice that contamination came out from the filter.”
In the production process, some faulty should be discovered during inspection process, with such recognition, it is most important job is to make the failure it zero finally. Mr. Matsuyama was emphasizing that the quality control management including all kind of process is most important in order to achieve zero failure..
Mr. Matsuyama made cleare the people who has question why the small particle of silicon oxide is adhering to the filter that was attached to the valve and became the cause of anomaly clearly, although it is the main function of the filter that should take the small particle off. Understanding! !

(No. 7: 2 stages liquid oxygen tank pressure adjustment valve)

Mini Skirt - Long Skirt **(Design of nozzle skirt /improved model for H-IIA No.4)**

Being thinking the more improvement, that is consists in the more modification for the 1st stage engine (LE-7A), Mr. Matsuyama said. The modification is to reinforce the design of an engine nozzle skirt.
It is intended that reinforcement and improve to the thrust 112 tons of rating thrusts by making a long skirt aiming at the H-IIA Rocket No.4, in which now the No. 1 machine, although it is the mini- skirt (nozzle skirt), that is aggregate of the numerous pipe which has the wall of 0.5 mm and 109.5 tons with the rating thrust.

I feel realistically that there is most difficulty development job that the technology for even the nozzle skirt that is seen simply in terms of the appearance materializes the structure that bears the 110 tons of thruster with difference of temperature in between minus 250 degrees Celsius and 3,000 degrees Celsius such as temperature designs, cooling fluids, air tightness, strength is not able to speak thoroughly in the mouth.

No. 8-1: The nozzle skirt of the LE-7A engine

No. 8-2: The nozzle skirt of the LE-5B engine

The rocket is the game in 30 minutes!　The Satellite be worry in 10 years after that

The H-IIA standard type rocket is the weight of 285 tons and the height of 53 m in length. It was big shock for me by its size when I sow the Saturn rocket at Cape Canaveral in the first time, the vehicle sent the Armstrong captain into the Moon, from Cape Canaveral, but now again it is the same surprise from its size form the actual seen of the H-IIA Rocket In the MHI Tobishima factory, H-IIA rocket No. 2 and No. 3 were in assembled and it was a wonderful view.

Back the story to the launching sequence again. It was 28 minutes and 2 seconds after the launch; the second burn out of 2nd stage engine was completed.
At this point, the launch activity of the rocket was completed successfully; the people in the control tower were in the cheer of success rose.
11 minutes and 45 seconds later, LRE separation has been done, however it is only about 40 minutes total from beginning of launching activity.
Accordingly, the rocket-launching job is the game in about 40 minutes and the results comes out soon.
However the satellite, which launched by the rocket has deferent story. It will take 10 years after the launch to reach out the achievement since it is required about 10 years stable operation in the orbit.

The author who was involved in Satellite development for many years, hear the word of Mr. Matsuyama and remind his days in young. He wished to have a senior management like Mr. Matsuyama and make his days more.

No.9: Mitsubishi Heavy Industries Nagoya Aerospace system production, Tobishima factory, The H-IIA rocket assembling factory

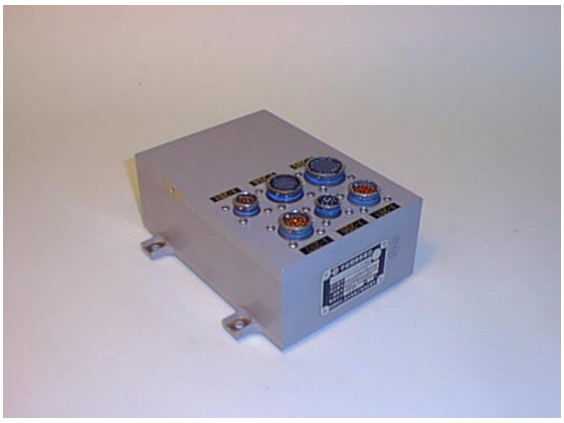
No. 10: HII-A rocket assembling with big supply

alve control electronics

There are controller and numeric package as an electronics function that is controlling the valve in the rocket engine that is composed of a precise machine complex structure.

Searching the devices that look like electronics in many precision machine structures, it was in here! Finally we could find out the electrical parts of function on rocket engine.

Also, it is used for the part of controller, JEPICO Co., delivered those high reliability electronic parts to MHI, it was some moment to feel we are as in the role to the tip of H-2A rocket development. We are very honor of it.



No. 11: Valve control electronics

Is the rocket He or She?　　She is my daughter! !

I asked his opinion to Mr. Matsuyama who explained the development situation of the rocket engine grandly.

The rocket that takes off highly up to the sky grandly with that roaring sound is masculine so, it would be “He” or may be “Hero”! Isn’t it?

No, rocket is “She”. Mr. Matsuyama said without any moment.

As for the Mr. Matsuyama, the rocket is a daughter for him, so that is to say “She”.

I am always concerning that it is just like a feeling at the time, the daughter to be bride when the satellite is launched with a thought of rocket in safe.

I had very much of confident in the Japanese domestic rocket development in the future unless the engineer like Mr. Matsuyama, who has deep philosophy in mind, are involved in.

No. 12: Mr. Matsuyama and I

No. 13: In front of H-IIA rocket 2 stage assembling

(Dr. Susumu Kitazume: SJR editorial committee member and special adviser)