H-IIB Launch Vehicle No. 3 (H-IIB F3) Overview

Japan Aerospace Exploration Agency (JAXA)
Mitsubishi Heavy Industries, Ltd. (MHI)

Objective of H-IIB F3 Launch

- Mission
  To inject the H-II Transfer Vehicle "KOUNOTORI3" (HTV3, a cargo transporter to the International Space Station,) into the scheduled orbit
- Scheduled launch date and time
  Launch date: July 21 (Sat.,) 2012
  Launch time: around 11:18 a.m. (*1)
  Launch window: July 22 (Sun.) thru August 31 (Fri.,) 2012 (*2)
  *1 The launch time is determined by the latest International Space Station (ISS) orbit
  *2 The launch time during the launch window will be decided through international coordination concerning the ISS operation.
- Launch site
  Launch pad: Launch Pad2, Yoshinobu Launch Complex, Tanegashima Space Center
  Tracking stations: Ogasawara Downrange St., Uchinoura Space Center, Guam Downrange St.
- Inherited points and changed points from KONOTORI2 to 3
  1) The second stage controlled re-entry test for the H-IIB F3 will be performed for data acquisition including repeatability. (Please refer to p.4 to 5 for more details.)
  2) JAXA decided not to perform a cryogenic test from the H-IIB F3. (Please refer to p.6 for more details.)
  3) Because a component of the avionics, that was developed for the H-IIA Launch Vehicle and also used for the H-IIB, was out of production, we redeveloped the avionics. (Please refer to p.7 for more details.)
  4) The FLSC (flexible linear shaped charge)-II holder design was changed as a result of studying countermeasures concerning the SRB-A separation issue detected during the H-IIB F2 launch. (Please refer to p.8 for more details.)

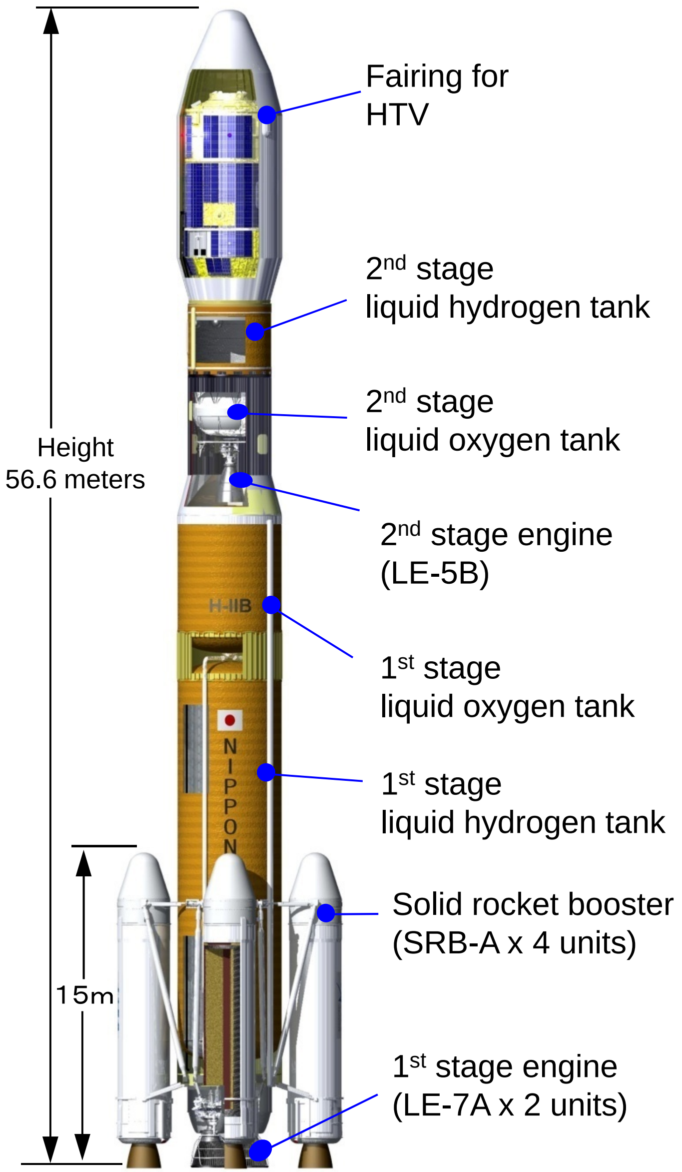
H-IIB F3 Flight Plan

	Event	Time after liftoff			Distance	Altitude	Inertial speed
		Hr.	Min.	Sec.	km	km	km/s
(1)	Liftoff		0	0	0	0	0.4
(2)	Solid Rocket Booster Burnout*		1	54	51	53	1.9
(3)	Solid Rocket Booster 1st Pair Jettison**		2	4	64	61	1.9
(4)	Solid Rocket Booster 2nd Pair Jettison**		2	7	68	63	1.9
(5)	Payload Fairing Jettison		3	40	245	120	2.9
(6)	Main (First Stage) Engine Cutoff (MECO)		5	47	707	184	5.6
(7)	First and Second Stages Separation		5	54	746	189	5.6
(8)	Second Stage Engine Ignition (SEIG)		6	1	781	194	5.6
(9)	Second Stage Engine Cutoff (SECO)		14	20	3725	289	7.7
(10)	KOUNOTORI3 Separation		15	11	4080	287	7.7
(11)	Second Stage Engine 2nd-time Ignition (SEIG2i)***	1	39	5	—	307	7.7
(12)	Second Stage Engine 2nd-time Cutoff (SECO2)	1	39	58	—	305	7.6

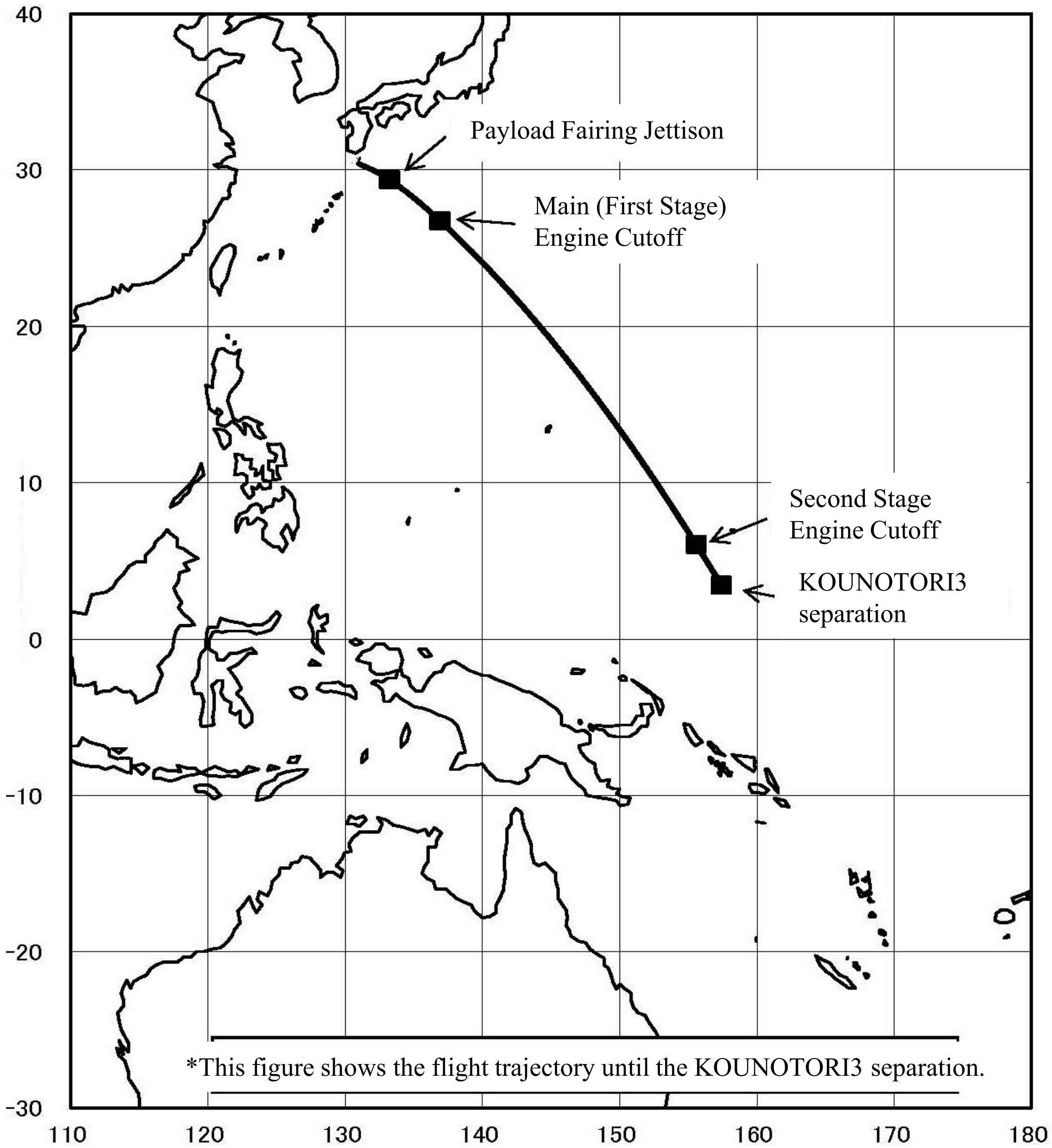
*) When the maximum combustion pressure was 2%, **) At the time when the thrust strut is cut, ***) When idle mode combustion starts

The H-IIB F3 will shift its pitch side to 108.5 degrees of azimuth soon after liftoff, then fly over the Pacific Ocean according to the flight plan. The launch vehicle will then jettison the solid rocket boosters, payload fairing and the first stage. After igniting the second stage engine, the H-IIB F3 will insert the KOUNOTORI3 into its scheduled orbit. Following the completion of its main mission of injecting its payload, the controlled re-entry test of the second stage will be performed, and the second stage will be dropped into the South Pacific Ocean.

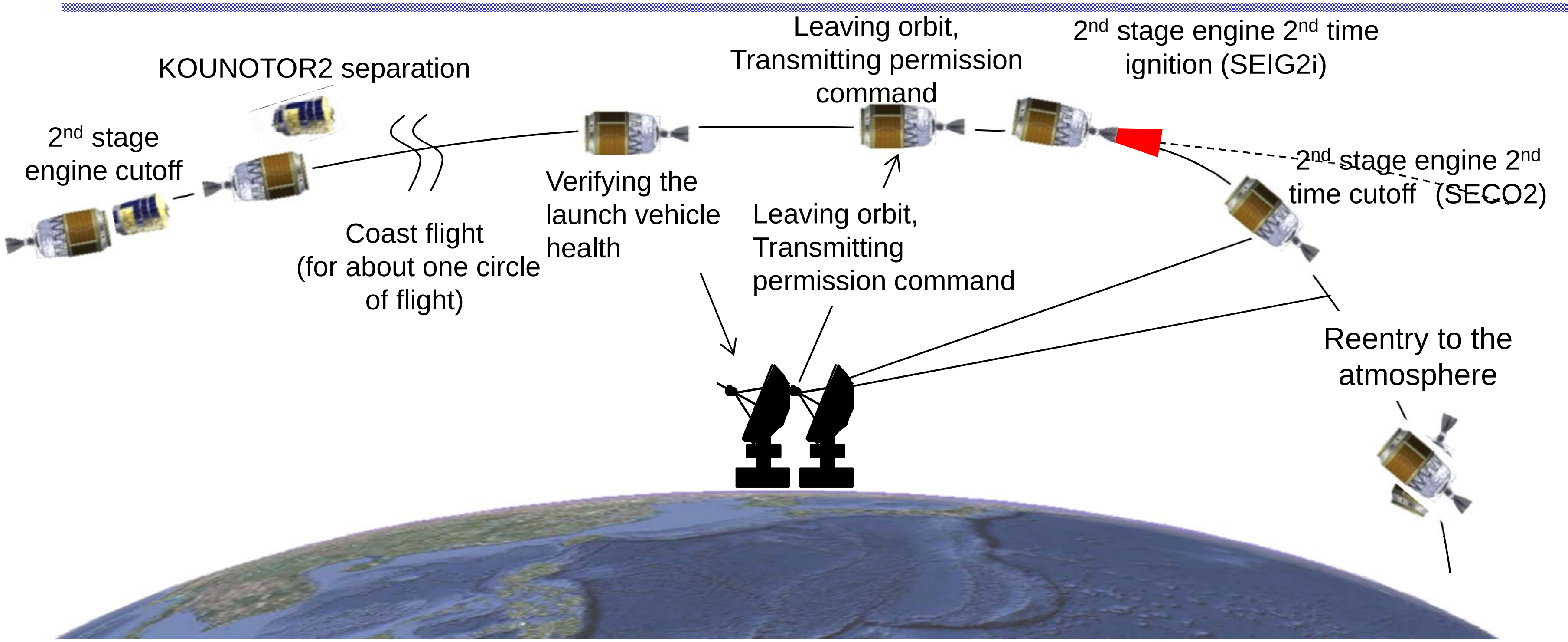
H-IIB F3 Flight Trajectory



H-IIB Launch Vehicle



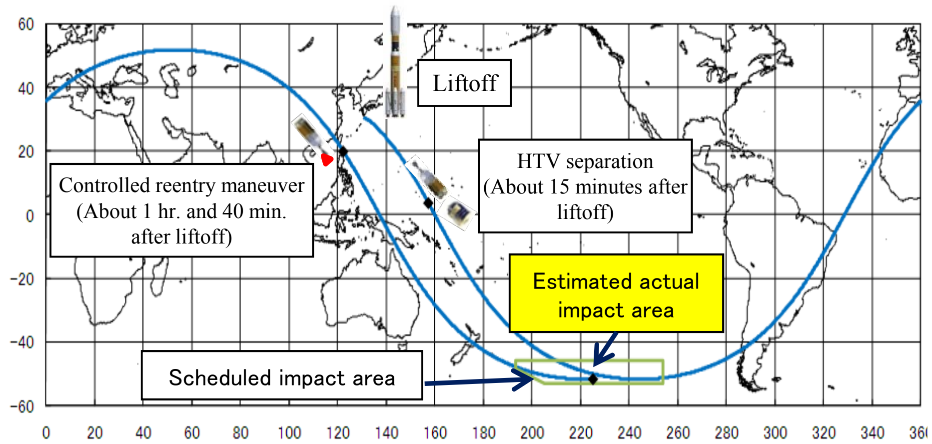
Second Stage Controlled Re-entry Test



H-IIB F2 2nd stage re-entry test result and other countries' rocket upper stage re-entry test status

Event	Time after liftoff	
	Actual (quick report)	Scheduled
2nd stage engine 2nd time ignition (SEIG2i)	1 hr. 39 min. 9 sec.	1 hr. 39 min. 4 sec.
2nd stage engine 2nd time cutoff (SECO2)	1 hr. 40 min. 10 sec.	1 hr. 40 min. 4 sec.

Launch vehicle	Test status
ARIANE 5 (ATV Mission only)	The test was held at low orbit mission in Mar. '08, and Feb. '11 (ATV.) It will be held regularly for future ATV missions.
DELTA 4	The test was held at the sun-synchronous orbit mission in Dec. '06. The re-entry test hasn't been performed since then.



2nd stage controlled reentry test outline

Second Stage Controlled Re-entry Test

- After completing the main mission, the launch vehicle will make a flight around the Earth, ignite the second stage engine for the second time, and perform the controlled re-entry test over the South Pacific Ocean.
- For the second stage controlled re-entry test, JAXA will inform the launch schedule to related authorities of countries who are in charge of the second stage re-entry impact area (New Zealand and Chile) in order to secure the safety of ships and aircraft.
- This controlled re-entry mission is considered a technological development for safe disposal of the second stage that has completed its mission.
- As the HTV is a low earth orbit mission, we confirmed that the test can be performed without impacting the main mission; therefore, we will utilize the regularly scheduled launch of the HTV to conduct a test for continuously accumulating technological knowledge for controlled re-entry following the test with the H-IIB F2.
- Basically, the test will be held only after confirming that the launch vehicle is flying without any problems and the estimated dropping point is within the pre-determined impact area.
- JAXA will verify the health of the H-IIB3 not only through onboard equipment but also from the Tanegashima ground station when the launch vehicle flies into the station's view area after a round trip around the earth following the HTV3 separation, then lift the ban on the controlled re-entry maneuver (or reverse thrust for speed reduction.) By sending a permission command, the maneuver will be carried out and the 2nd stage will fall into the South Pacific Ocean.
- The reverse thrust to leave the orbit will be performed by the second stage LE-5B-2 engine idle mode combustion (by providing propellant with a thrust of gas instead of turning on the turbo-pump.)
- The launch vehicle health confirmation and permission command transmission will be performed as part of flight safety operations.

Cancellation of Cryogenic Test

- The cryogenic test is performed until we can verify that launch vehicle's design and production quality are reliable and stable enough. The test aims at minimizing unconfirmed or uncertain issues prior to the countdown operation on the launch day, thus we use an actual flight vehicle for the test and verify the health of the total launch system including the launch vehicle and ground facilities and the interface among each system while propellants are actually loaded onto the launch vehicle.
- For the H-IIB F2, we reported the result of the cryogenic test at the Tanegashima Space Center as shown below.
- During the H-IIB development phase, we were able to acquire data under the cryogenic environment and confirm the interface, while constructing stable launch bases with the H-IIB F1 and F2. Therefore, in principle, we decided not to conduct the test for the H-IIB F3 and the following flights.
- For the H-IIA, the cryogenic test was held up to the 12th flight. Through accumulated launch experience, the procedures were firmly established, so the cryogenic test was not conducted from the 13th flight.

H-IIB F2 Cryogenic Test

on Dec. 16, 2010

<Major verification results by Cryogenic Test>

No.	Item	Confirmation points	Verification results
1.	Operability and procedures until launch with launch vehicle (LV) and launch pad facility connected	-The LV was transported to the launch pad in the same manner as the actual launch and all operations were carried out based on the procedures with the LV and pad facilities connected to confirm the procedures and any abnormalities with function or data, if any, in the LV and facility. Major points were as follows. 1) Automatic propellant loading function 2) Helium pressurant tank high pressure leak check under room temperature and cryogenic environment 3) Valve operation under cryogenic environment 4) Automatic countdown sequence	We were able to achieve our goal of confirming the procedures by carrying out all operations in the same manner as the actual launch just prior to engine ignition while connecting the LV and the pad facility. Major verification results were as follows. 1) Automatic propellant loading function was verified as working properly. 2) Pressure decrease of the Helium pressurant tank was verified to be lower than the specification value both in the room temperature and cryogenic environment. 3) Valves functioned properly under the cryogenic environment. 4) The automatic countdown sequence was tested twice and both went well. - First simulated liftoff time 8:30 - Second simulated liftoff time 10:43
2.	Interface bet. LV and launch pad facility		
3.	Interface bet. LV and tracking facility	1)Radio frequency (RF) link with tracking facilities 2)Interface confirmation with tracking facilities regarding the second stage controlled re-entry test	1) RF link bet. LV and the tracking facilities was good. 2) Interface bet. LV and tracking facilities was good.

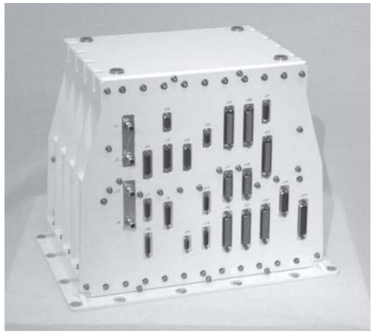
Avionic Redevelopment

- For the H-IIB Launch Vehicle No.3, we have efficiently redeveloped a new guidance control computer (GCC) and inertial measuring unit (IMU) by setting the common specifications to the computer board for both of them.
- For the main (central) processing unit (MPU), the major part of the launch vehicle, we also adopted the MPU for space vehicles that was developed by JAXA. Thus its design technology has been possessed by us, so that we can eliminate our concerns that we may need another large-scale redevelopment when some commercially procured parts are no longer available.
- the H-IIB F3 is newly loaded with a Real Time Operating System (RTOS) developed by JAXA Engineering Digital Innovation Center (JEDI center.) The RTOS is an operating system that works on the microprocessor HR5000 for space use with a new-type GCC and IMU.
- The RTOS is a system whose mechanism blocks the ripple effect of negative impact to other software when one software experiences an anomaly. Hence it is equipped with a function that can contribute to improve the overall space vehicle system reliability.
- The RTOS conforms to μiTRON4.0, and it is developed by JAXA as part of the TOPPERS project in cooperation with the Embedded and Real-Time Systems Laboratory, Graduate School of Information Science, Nagoya University (Professor Takada and Assistant Prof. Tomiyama's team.) The RTOS is a system whose mechanism blocks the ripple effect of negative impact to other software when one software experiences an anomaly. Hence it is equipped with a function that can contribute to improve the overall space vehicle system reliability.

【Major redeveloped avionics】

Installed position	Equipment name
Second stage	2nd stage guidance control computer
	Inertial sensor unit
	2nd stage actuator controller
First stage	1st stage guidance control computer
Other location	Data collection equipment, telemetry transmitter, Onboard cameras, Onboard software

【New Guidance Control Computer】



Countermeasures for SRB-A Jettison Issue

～Excerpt from the report to the Space Activities Commission on May 11, 2011～

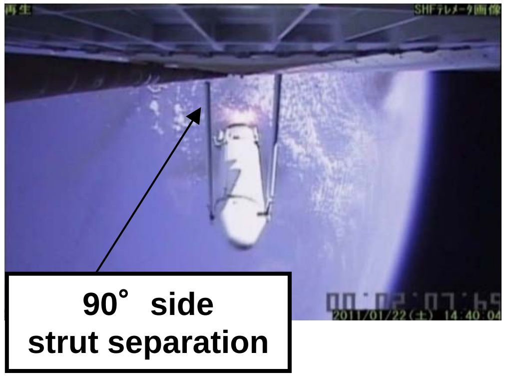
(1) During the launch of the H-IIB F2 (on Jan. 22, 2011,) we observed a slight separation timing difference between the right and left struts of the first solid rocket booster-A (SRB-A) pair, and, consequently, the launch vehicle experienced roll/yaw rotation. (However, the disturbance was small, thus there was no impact on the mission.)

(2) The two confined detonation fuses (CDF) for the H-IIB SRB-A strut separation have different routes because of the installation specifications that take redundancy into consideration, thus the two are different in length. These are unique specifications to the H-IIB. As a result of the cause investigation, we found that the V-shape flexible linier shaped charge-II (FLSC-II) for charging the CDFs detonated on one side, and that caused distortion at the separation part and one strut took longer to be separated.

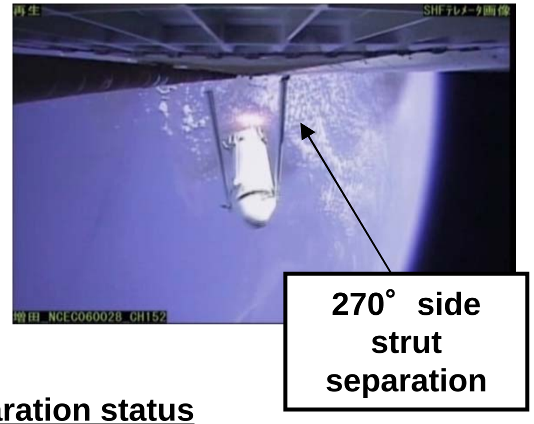
(3) For the separation mechanism itself, the same specifications were applied for the H-IIA. We studied the impact of this incident, and, although in the case of the H-IIA, the length of the two CDFs is the same, thus a similar incident should not occur, we should consider a case of one-side detonation when we think of the redundancy. Hence we determined that some measures are also necessary for the H-IIA.

(4) For the above reason, we changed the design of the separation mechanism (FLSC-II holder) in order not to cause distortion at the separation part, and confirmed the appropriateness of the new design through an acceptance test that concurrently functioned as a verification test in June 2012.

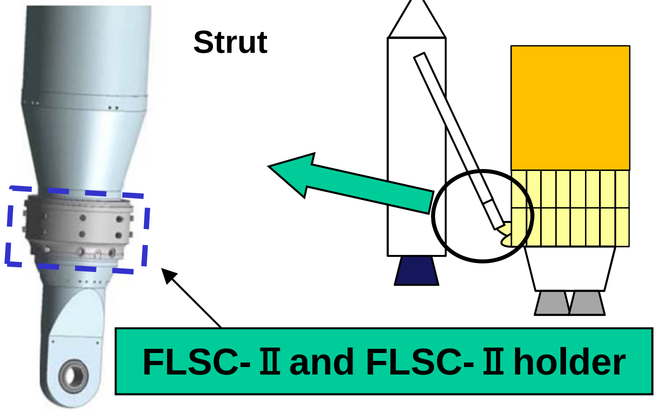
(5) Consequently, the newly designed FLSC-II holder has been applied to the H-IIA F19 and following launch vehicles.



About 0.45 sec. delay



H-IIB F2 SRB-A separation status



Design change

空へ挑み、宇宙を拓く JAXA

H-IIB F3 Operation Status

三菱重工 この星に、たしかな未来を

1st stage erection

2nd stage erection

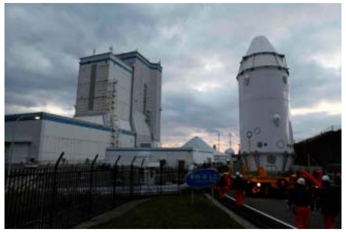
Transportation within Tanegashima
(Completed on Mar. 17, 2012)

LV revealed to the media
(On Mar. 8, 2012)

Above: F3 fairing
Left: 1st stage core vehicle

1st & 2nd stages eredtion
(Completed on Mar. 18, 2012)

SRB-A installed
(completed on Mar. 24, 2012)



Photos are from F2 operations

Operatiopn resumed
(May 21, 2012 ～)

Payload fairing encapsulation
(Scheduled in early July)

Encapsulated payload mating with the LV
(Scheduled in early July)

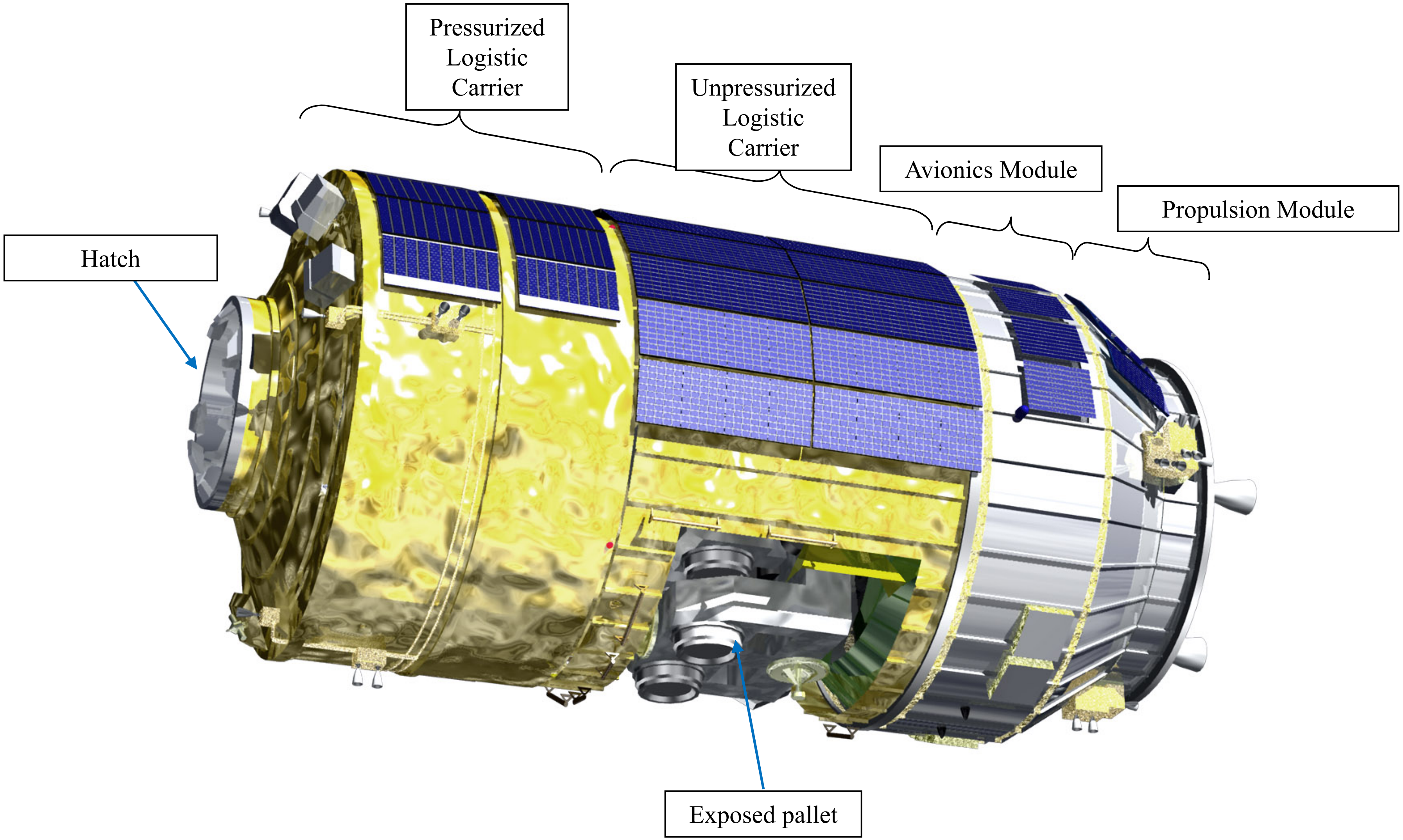
Final function test
(scheduled in early July)

Photos are from H-IIB F2 operations

Final launch preparation

HTV3

Overview of the H-II Transfer Vehicle "KOUNOTORI3"
(HTV3, a cargo transporter to the International Space Station)



Japan's ISS and HTV Launch Schedules

空へ挑み、宇宙を拓く JAXA

三菱重工 この星に、たしかな未来を

2008	2009	2010	2011	2012	2013	2014

"Kibo" assembly

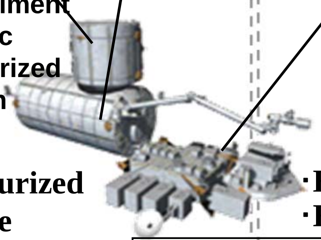
6 astronauts stay at ISS since May '09

Spece Shuttle retire (July '11)

1st flight (1J/A) H20.3.11

F2 (1J) 6.1

F3 (2J/A) H21.7.16



HTV1 Sep 11 '09

HTV2 Jan 22' 11

HTV3 July 21 ' 12 (Scheduled)

7 HTVs in total are scheduled to be launched between '09 and '16 by launching one HTV per year.

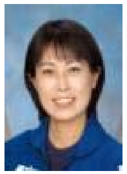
Kibo operation and utilization

Astronaut Doi 1J/A **(Complete)**

Astronaut Hoshide 1J **(Completed)**

Astronaut Wakata Expedition (2J/A assembly) **(Completed)** (Mar. – July '09)

Astronaut Noguchi Expedition **(Completed)** (Dec. '09- June '10)



Astronaut Yamazaki Shuttle 19A mission **(Complede)** (Apr. '10)

Astronaut Furukawa Expedition **(Completed)** (June- Nov. '11)

Astronaut Hoshide Expedition (Scheduled) (About four months from July '12)

Astronaut Wakata Expedition (Scheduled) (About six months from the end of '13 as a first Japanese ISS commander)

Abbreviations

HTV	H-II Transfer Vehicle
SRB-A	Solid Rocket Booster
FSW	Friction Stir Welding
TIG	Tungsten Inert Gas (Welding Method)
EMC	Electromagnetic Compatibility
PDR	Preliminary Design Review
CDR	Critical Design Review
PQR	Post Qualification Review
BFT	Battleship Firing Test
CFT	Captive Firing Test
GTV	Ground Test Vehicle
SFA2	No2 Spacecraft and Fairing Assembly Building
LP2	Launch pad No.2
VAB	Vehicle Assembly Building
ML	Mobile Launcher
LOX	Liquid Oxygen
LH2	Liquid Hydrogen
OTP	Oxidizer Turbopump
L/V	Launch Vehicle

(Reference) H-IIB's Standing

■Japan's policy for its space transportation system

The H-IIB Launch Vehicle is regarded as Japan's mainstay launch vehicle, along with the H-IIA, to be principally promoted as the country's key technology by the Japanese government "to maintain our own transportation ability to take necessary satellites and other objects to space whenever the need arises, to establish and maintain global leading mainstay launch vehicles, and to set up an autonomous space transportation system."

■H-IIB development objectives

- To launch the H-II Transfer Vehicle (HTV) as a transporter to the International Space Station)
- To secure international competitiveness by providing and coping with various launch capabilities along with the H-IIA

JAXA – MHI developmet coopreation

■ Development policy

- Leveraging technologies acquired through H-IIA development
- Low-cost, low-risk, and short-time development

(Reference) H-IIB Development History

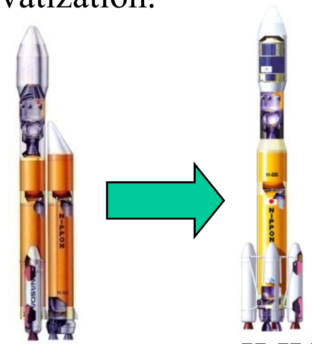
■ Development background

(1) Aug. 1996: "Planning and Coordination Meeting, Study and Review Result" (Space Activities Commission, SAC)
To start developing an augmented type H-IIA to launch the HTV or a three-ton class geostationary orbit satellite

(2) June 2002: "Basic plan for future space development and application" (Council for Science and Technology Policy)
"Objective and direction of our country's space development and application" (SAC)
When developing a launch vehicle with more launch capability than that of the H-IIA standard type (H-IIA augmented type), it should be developed based on the H-IIA standard type through cooperation between the public and private sectors with the private sector playing a leading role.

(3) April 2003: "H-IIA privatization operation team final report" (Research and Development Bureau" Ministry of Education, Culture, Sports, Science and Technology, Japan)
We decided to adopt a development process led by the private sector (for the H-IIB.) Also, the responsibility sharing after the development phase shall be in a similar manner as that after the H-IIA privatization.

(4) Aug. 2003: "Review result of the H-IIA launch capability enhancement" (SAC, Plan and Review Meeting)
While the HTV design phase had been progressing, the launch capability requirement for the HTV increased from the original 15 tons to 16.5 tons. The launch requirement from the private sector has also been expanding (about eight tons to the geostationary transfer orbit) in order to be more competitive. For satisfying the above needs, a trade-off was performed. As a result, it was decided it would be appropriate to change the launch vehicle configuration from the H-IIA Augmented type to the H-IIA Improved type (as shown in the right figure.)



H-IIA Augmented type **H-IIA Improved type**

(5) Sep. 2005: A basic agreement was signed between JAXA and MHI concerning the framework of the cooperative development between the private and public sectors while putting more emphasis on the private sector.

(Reference) H-IIB Overview

■ Large-size rocket based on H-IIA technology to satisfy both public and private sector needs

◆ **Public sector needs: to launch HTV (cargo transporter to the ISS)**

○ Cargo transportation to the ISS (including Japanese Experiment Module "Kibo")

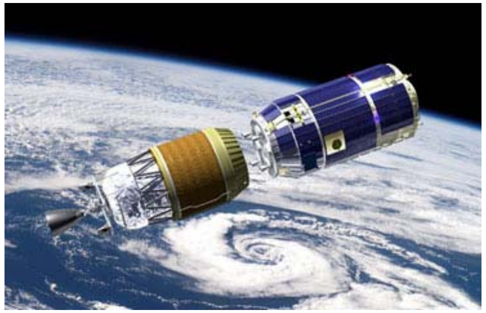
○ Fulfilling shared international responsibility of cargo supply to the ISS

○ Launching one HTV per year from 2009 till 2015 (Seven HTVs in total)

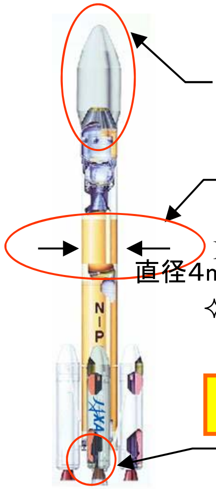
◆ **Private sector needs: to secure international competitiveness**

○ To cope with launch demands of a 6-ton class satellite into the geostationary transfer orbit.

○ To reduce launch costs by launching two mid-size satellites on one launch vehicle.



H-II Transfer Vehicle
"KOUNOTORI"（HTV）



H-IIA (204)

Using existing technology

✧ **Enlarged payload fairing**
12 meters to 15 meters in total height

✧ **Expanding 1st stage core vehicle diameter to 5.2 meters**
Improving launch capability and quality

✧ **Refurbishing launch site facilities to deal with a larger 1st stage**

Newly introduced technology

✧ **Clustered 1st stage engine**
・Improving launch capacity

H-IIB

H-IIA (204)		H-IIB
About 12 tons	【HTV launch capacity】	About 16.5 tons
5.8 tons	【Launch capacity to GTO】	About 8 tons

Note: HTV orbit: 300 x 200 elliptical orbit

【Development Organization】

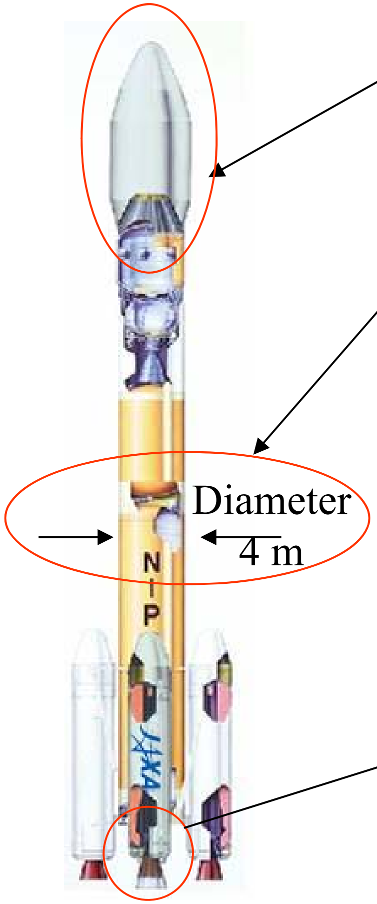
Development plan and system specification compilation by joint team

Japan Aerospace Exploration Agency JAXA
・Setting the system spec.
・Conducting high-risk development tests.
Two engine simultaneous firing test, test launch, etc.
・Maintaining launch related facilities.

Mitsubishi Heavy Industries MHI
・In charge of development after detailed designing phase
・Maintaining manufacturing facility

- IHI — IHI: ・LE-7A turbopump ・LE-5B turbopump
- IHI Aerospace — IA: ・Solid rocket booster ・Pyrotechnics ・Gas jet
- Kawasaki Heavy Industries — KHI: ・Payload Faring
- NEC — NEC: ・GCC ・Telemetry transmitter ・Radar transponder ・Destruct command receiver
- Japan Aviation Electronics — JAE: ・Inertial sensor unit
- Mitsubishi Precision — MPC: ・Electronics package ・Rate gyro package
- Mitsubishi Space Softwaer — MSS: ・Guidance program

(Reference) Changes from H-IIA



H-IIA

✧Enlarged payload fairing

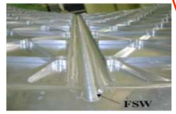
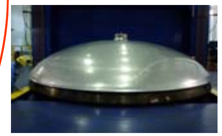
- For covering the HTV, the height of the faring was extended from 12 m to 15 m without changing the diameter.

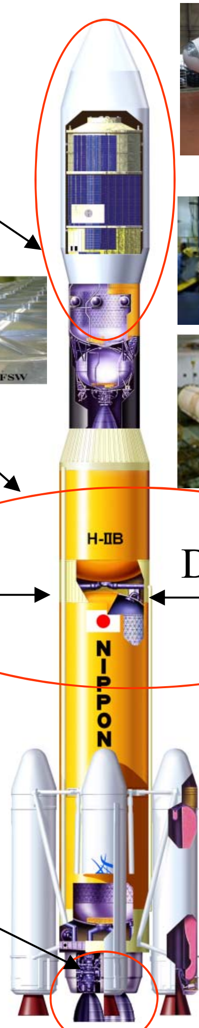
✧Expanding first stage vehicle diameter to 5.2 m

- Propellant loading capacity became 1.7 times more to increase launch capacity.
- The dome-shaped part (mirror plane) in the front and back of the propellant is now domestically produced instead of procured from overseas to improve quality and procurement flexibility.
- To increase the quality, the tank welding method was changed to the friction stir welding (FSW) method (from the tungsten inert gas welding).

✧Clustered first stage engine (LE-7A)

- Two engines are clustered for more thrust to increase launch capacity

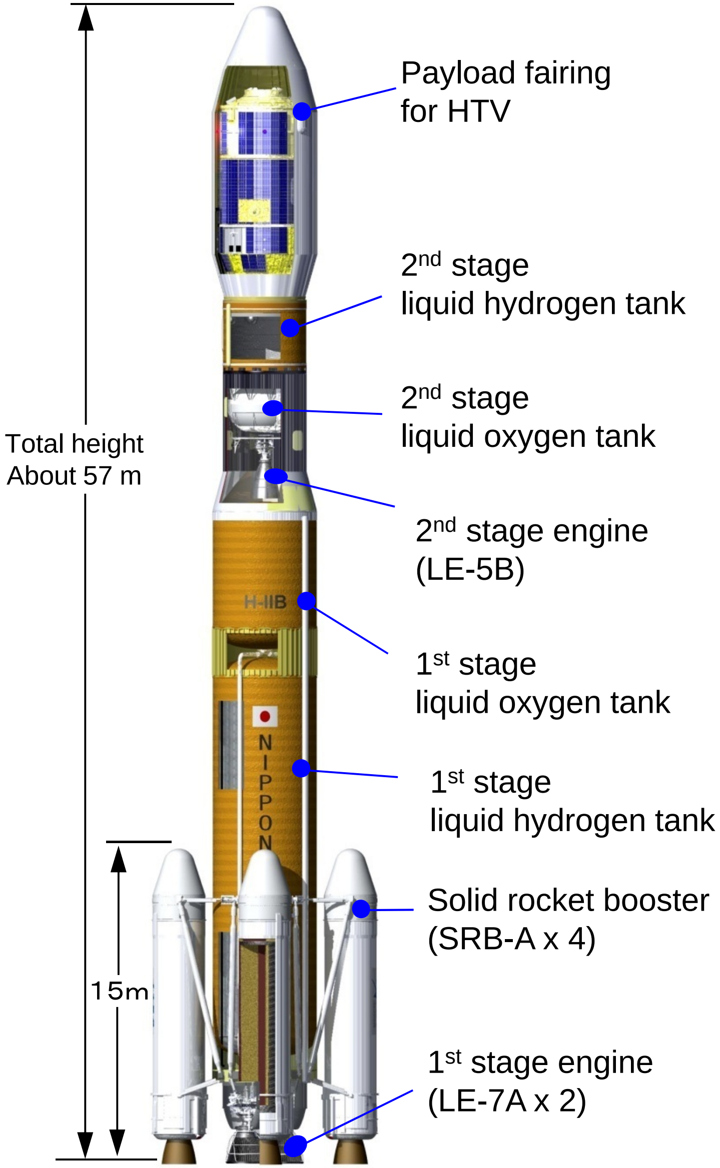






H-IIB



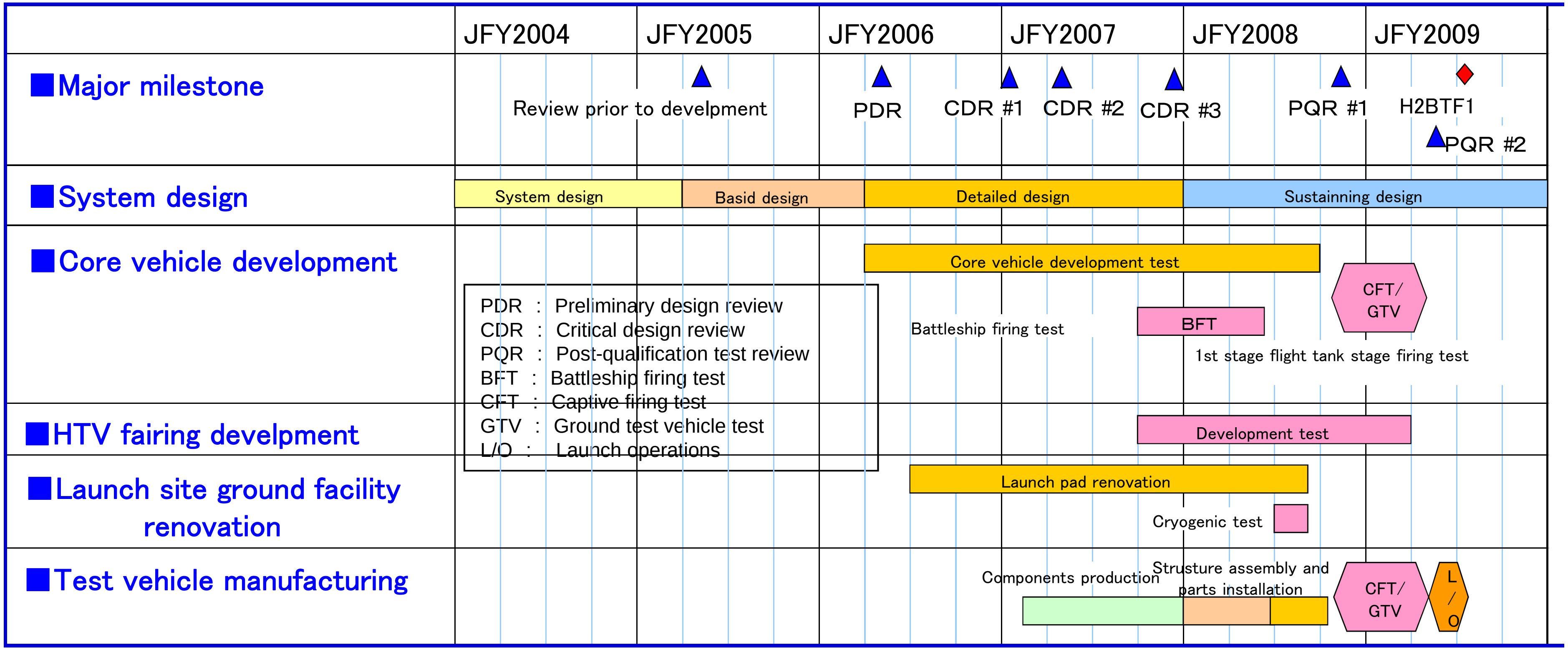
(Reference) H-IIB Major Characteristics

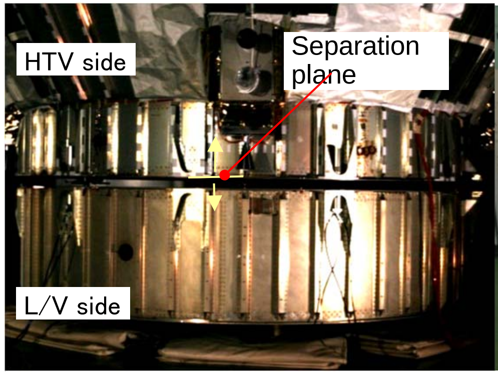


H-IIB Launch Vehicle

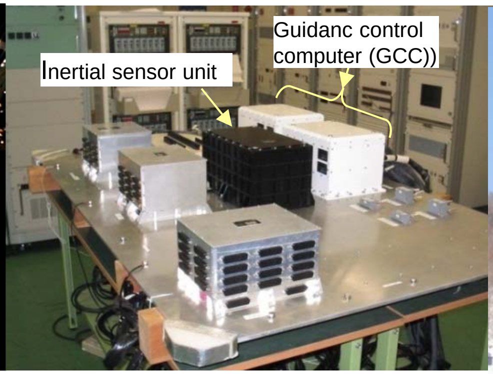
	H-IIB	H-II A 204 (Reference)	Note
Total height Total mass	56.6 m About 530 tons	About 53 m About 445 tons	Without payload mass
Fairing Name Diameter Length	 5S-H type 5.1 m 15 m	 5S type/4S type 5.1 m/4m 12 m/12 m	
Second stage Tank diameter Propellant mass Engine Thrust Specific impulse	 4 m 16.7 tons LE-5B 137 KN 448 seconds	 4 m 16.7 tons LE-5B 137 KN 448 seconds	Both H-IIA/B in vacuum
First stage Tank diameter Propellant mass Engine Thrust Specific impulse	 5.2 m about 176 tons LE-7A x 2 1098 KN × 2 440 seconds	 4m About 100 tons LE-7A x 1 1098 KN 440 seconds	In vacuum
SRB-A Propellant mass Installed No.	 About 66 tons per SRB-A 4 SRB-As	 About 66 tons per SRB-A 4 SRB-As	Same for both H-IIA/B

(Reference) H-IIB Developmend Process

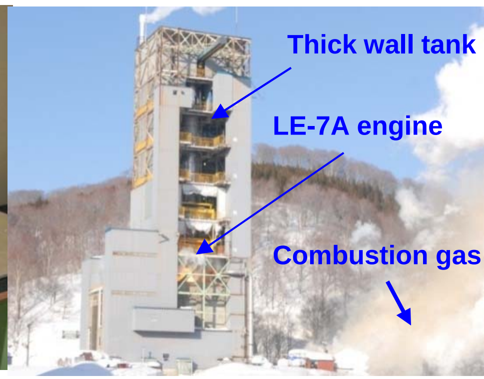




HTV separation part separation test (Just after separation)



GCC system test



Battleship firing test


1st stage flight tank stage firing test

(Reference) H-IIB F1 (Test Flight)

- The H-IIB F1 (Test Flight) was launched at 2:01:46 a.m. on September 11 (Fri.), 2009 (Japan Standard Time) from Launch Pad 2, Yoshinobu Launch Complex, the Tanegashima Space Center.
- The H-IIB flew on the scheduled flight path smoothly and at about 15 minutes and 10 seconds after liftoff, the HTV1 (Technical Demonstration Vehicle) was inserted into its schedule orbit.
- The H-IIB F1's successful flight was an outstanding achievement as the success rate of a maiden flight is normally less than 70 percent, and the H-IIB F1 also carried an actual mission payload although it was the test flight, which is very rare for other countries' launch vehicles.
- This was the first maiden flight that was launched on schedule for Japan's mainstay launch vehicles.

The H-IIB F1 moving to Launch Pad 2 of the Yoshinobu Launch Complex a day prior to the launch day/ Liftoff

空へ挑み、宇宙を拓く JAXA

(Reference) H-IIB F1 Flight Result

三菱重工 この星に、たしかな未来を

Event	Time after liftoff	
	Actual (Quick report)	Scheduled
Liftoff	0 min. 0 sec.	0 min. 0 sec.
SRB-A (*1) burnout	1 min. 5 sec.	1 min. 49 sec.
SRB-A 1st pair jettison	2 min. 5 sec.	2 min. 4 sec.
SRB-A 2nd pair jettison	2 min. 8 sec.	2 min. 7 sec.
Payload fairing jettison	3 min. 42 sec.	3 min. 37 sec.
1st stage engine cutoff (MECO)	5 min. 47 sec.	5 min. 44 sec.
1st /2nd stages separation	5 min. 56 sec.	5 min. 52 sec.
2nd stage engine ignition (SEIG)	6 min. 3 sec.	5 min. 59 sec.
2nd stage engine cutoff (SECO)	14 min.19 sec.	14 min. 16 sec.
HTV1 separation	15 min. 0 sec.	15 min. 6 sec.

Injection orbit	Planned value	Injection error	Actual value(*2,*3)
Apogee altitude	300.0 km	± 2 km	299.9 km
Perigee altitude	200.0 km	± 10 km	199.8 km
Inclination	51.67 degrees	± 0.15 degrees	51.69 degrees

(*1) Solid rocket booster
(*2) The orbit was determined based on data acquired from HTV1.
(*3) Altitude is based on the radius of the earth's equator, 6378 km.

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(Reference) H-IIB F2

三菱重工 この星に、たしかな未来を

- H-IIB F2was launched at 2:37:57 p.m. on January 22 (Sat.), 2011 (Japan Standard Time) from Launch Pad 2 at the Yoshinobu Launch Complex, the Tanegashima Space Center
- The H-IIB flew on the scheduled flight path smoothly and at about 15 minutes and 14 seconds after liftoff, the KOUNOTORI2 (HTV2) was inserted into its scheduled orbit.
- After injecting the KOUNOTORI2, the H-IIB ignited the second stage engine for the second time and conducted the controlled re-entry test of the second stage as scheduled. The test was successful and JAXA became the third organization in the world to acquire this cutting edge technology.
- Following the retirement of the Space Shuttle, the HTV launched by the H-IIB will became the sole transportation means for large-size cargo to the International Space Station, thus the HTV launch and its international contributions are highly evaluated around the world.

The H-IIB F2 moving to Launch Pad 2 of the Yoshinobu Launch Complex/ Liftoff

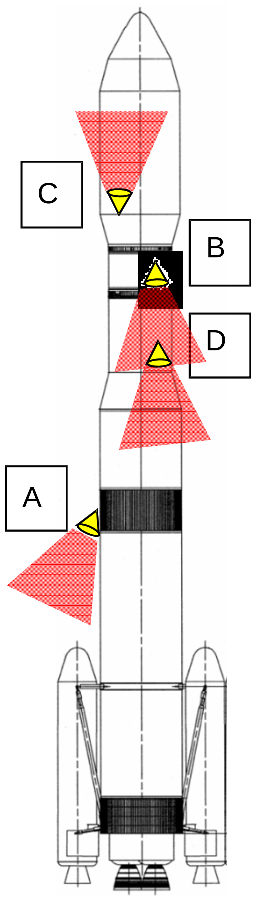
(Reference) H-IIB F2 Flight Result

Event	Time after liftoff	
	Actual (Quick report)	Scheduled
Liftoff	0 min. 0 sec.	0 min. 0sec.
SRB-A (*1) burnout	1 min. 52 sec.	1 min. 0 sec.
SRB-A 1st pair jettison	2 min. 8 sec.	2 min. 7 sec.
SRB-A 2nd pair jettison	2 min. 11 sec.	2 min. 10 sec.
Payload fairing jettison	3 min. 45 sec.	3 min. 40 sec.
1st stage engine cutoff (MECO)	5 min. 51 sec.	5 min. 46 sec.
1st /2nd stages separation	5 min. 59 sec.	5 min. 54 sec.
2nd stage engine ignition (SEIG1)	6 min. 6 sec.	6 min. 1 sec.
2nd stage engine cutoff (SECO2)	14 min. 24 sec.	14 min. 5sec.
KOUNOTORI2 (HTV2) separation	15 min. 14 sec.	15 min. 5 sec.

Injection orbit	Actual value (*2, *3)	Planed value
Apogee altitude	300.2km	300.0 km
Perigee altitude	200.3km	200.0 km
Inclination	51.67 degrees	51.67 degrees

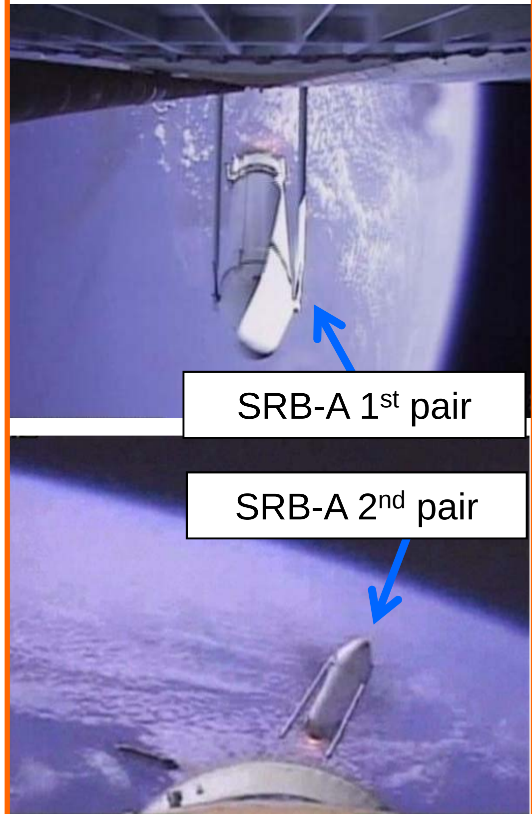
(*1) Solid rocket booster (when the combustion chamber pressure reached at 10 % of the maximum pressure.)
(*2) The orbit was determined based on data acquired from KOUNOTORI2 (HTV2.)
(*3) Altitude is based on the radius of the earth's equator, 6378 km.

(Reference) Images Taken by H-IIB F2 Onboard Cameras

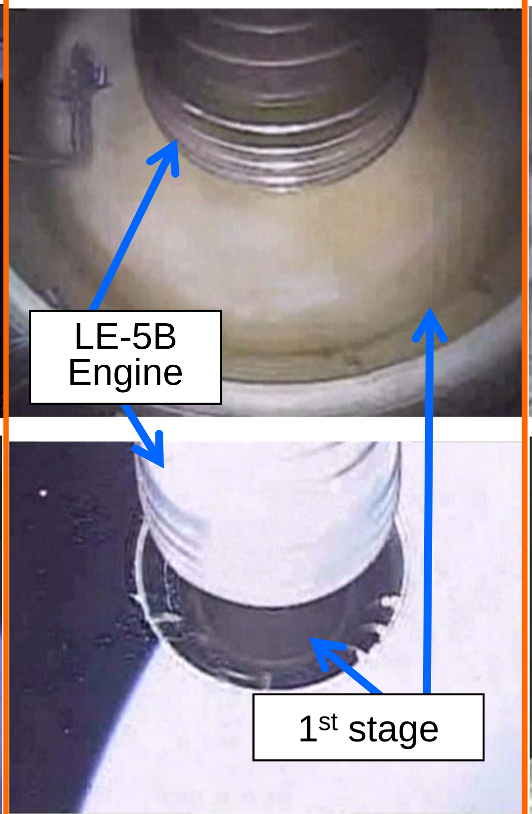


Onboard camera positions

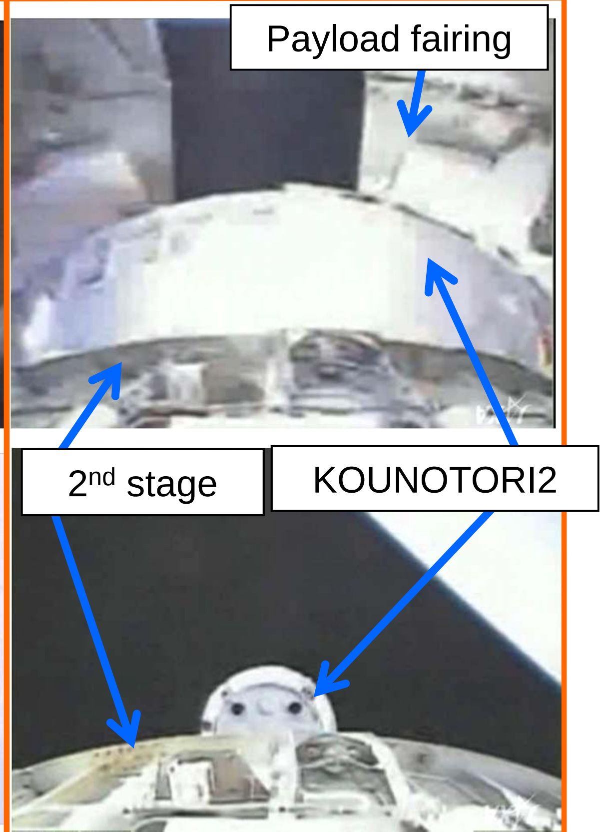
■SRB-A 1st pair jettison ■SRB-A 2nd pair jettison	■1st /2nd stages separation	■Payload fairing jettison ■ KOUNOTORI2 separation



Images shot by Camera A and B (SRB-A shot from above)



Camera D images (Intra-stage part shot from above)



Camera C images (Shot from the bottom of the HTV)