# M-V Launch Vehicle – Archived 4/2011

## Outlook

- JAXA exploring replacements for the M-V, including the J-2(GX) and the Advanced Solid Rocket (ASR)
- Nine (of 11) satellites were successfully delivered by single- and multi-payload M-V launches
- J-2(GX) was to supersede the M-V in 2005; however that move has been delayed

## Orientation

**Description.** The M-V is a three-stage solid-propellant expendable launch vehicle with an optional kick stage in case of high-energy orbit.

**Sponsor.** JAXA is responsible for the M-V's design and development work.

**Status.** The rocket's first launch took place in 1997. Planet-B/Nozomi successfully launched in 1998. The Astro-E X-ray observatory was launched from Kagoshima Space Center in 2000, but was unsuccessful. Muses-C/Hayabusa launched in May 2003. Astro E2 was launched in July 2005. Two launches were performed in 2006, but none took place in 2007 or 2008.

**Total Produced.** Seven M-Vs have been produced; two were used for testing.

**Application.** Like its M-series predecessors, the M-V launches relatively small science satellites into low-Earth orbit. Because of its greater payload capability, however, it is also capable of sending spacecraft on lunar and planetary missions.

**Price Range.** An individual M-V launcher costs approximately $56 million; however, the Muses-C/ Hayabusa costs an estimated $60 million to launch.

## Contractors

### Prime

| | |
|---|---|
| **IHI Corporation** | http://www.ihi.co.jp, 2-1, Ohtemachi 2-chome, Chiyoda-ku, Tokyo, 100-8182 Japan, Tel: + 81 3 3244 5111, Fax: + 81 3 3244 5131, Prime |

### Subcontractor

| | |
|---|---|
| **IHI Aerospace Co Ltd** | http://www.ihi.co.jp/ia/, Shin-Ohtemachi Bldg, 2-1, Ohtemachi 2-chome, Chiyoda-ku, Tokyo, 100-8182 Japan, Tel: + 81 3 6204 8000, Fax: + 81 3 6204 8810 (Rocket Component Integrator) |

## M-V Launch Vehicle

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|---|---|
| **Mitsubishi Heavy Industries (MHI) Ltd** | http://www.mhi.co.jp, 16-5 Konan 2-chome, Minato-ku, Tokyo, 108-8215 Japan, Tel: + 81 3 6716 3111, Fax: + 81 3 6716 5800 (First Stage Motor Combustion Chamber) |
| **Mitsubishi Precision Co Ltd** | http://www.mpcnet.co.jp, Mita 43MT Bldg 3-13-16, Mita, Minato-ku, Tokyo, 108-0073 Japan, Tel: + 81 3 3453 6421, Fax: + 81 3 3453 6434 (Onboard Computer & Fiber-Optic Accelerometer) |

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Contractors are invited to submit updated information to Editor, International Contractors, Forecast International, 22 Commerce Road, Newtown, CT 06470, USA; rich.pettibone@forecast1.com

# Technical Data

**Design Features.** Until 1987, ISAS (Institute of Space and Astronautical Science) was restricted to producing expendable launch vehicles with an outside diameter no greater than 1.4 meters. This restriction had more to do with the politics surrounding the establishment in the 1960s of ISAS' sister space organization, the National Space Development Agency of Japan (NASDA) than with anything else. Because ISAS' launch needs grew, in 1987 the Space Activities Commission, which coordinates the two agencies, reviewed its guidelines and determined that ISAS could build launchers with a diameter of up to 2.5 meters. The M-V's design reflects the new guidelines.

Unlike the M-3SII that it succeeds, the three-stage M-V forgoes the use of solid-propellant strap-on rocket boosters in favor of a single-rocket design. The M-V's propellant capacity is increased considerably over the M-3SII's, while its overall length is expanded by only 2.2 meters.

The M-V's first stage uses a two-segment solid-propellant rocket motor casing made of HT-230 maraged steel. Three-axis attitude control is provided by the motor's movable nozzle and roll control unit. Propellant capacity is 70,000 kilograms.

The single-piece second-stage motor casing is also made of HT-230 maraged steel. It has a 30,000-kilogram propellant capacity and uses an extendable nozzle. Attitude control is provided by a secondary thrust vector control unit.

The 2.3-meter-diameter third-stage motor is made of carbon-fiber composite material and has a capacity of 10,000 kilograms of solid propellant. It employs a two-step extendable nozzle. Depending on the mission, the third stage uses a three-axis attitude control system or employs spin stabilization.

A launch failure in 2000 prompted ISAS to upgrade the M-V. The heat-resistant material on the nozzle was changed from traditional graphite to 3-D carbon-carbon material. JAXA is also testing an improved M-25 motor to replace the M-24 second-stage motor.

M-V launches take place at JAXA's Kagoshima Space Center located at Uchinoura on the southern tip of Kyushu Island. Agreements with Japan's strong fishing lobby restrict missions to two 49-day windows annually, one in January/February, one in August/September.

| | Metric | U.S. |
|---|---|---|
| **Dimensions** | | |
| First stage length | 13.7 m | 44.9 ft |
| Second stage length | 6.7 m | 21.9 ft |
| Third stage plus payload shroud length | 3.5 m | 11.5 ft |
| First-stage motor diameter | 2.5 m | 8.2 ft |
| Second-stage motor diameter | 2.5 m | 8.2 ft |
| Third-stage motor diameter | 2.2 m | 7.2 ft |
| **Weights** | | |
| First-stage propellant weight | 70,000 kg | 154,322 lb |
| Second-stage propellant weight | 30,000 kg | 66,138 lb |
| Third-stage propellant weight | 10,000 kg | 22,046 lb |
| **Performance** | | |
| Payload to 250 km (155 mi) | 1,800 kg | 3,960 lb |
| Payload to the moon | 600 kg | 1,322 lb |
| Payload to Mars or Venus | 300 kg | 661 lb |

An M-V awaits countdown.

Source: Goddard Space Flight Center

## Variants/Upgrades

**M-V Upgrade.** ISAS began an M-V upgrade program in 1997 to replace the rocket's second-stage HT-230M steel alloy casing with a monolithic carbon-wound filament casing made by Toho Rayon Corp (now Toho Tenax). The switch in materials was intended to save about 900 kilograms in weight, reduce the cost of the second stage by about 60 percent, and increase the rocket's combustion pressure from 60 to 120 atmospheres to yield nearly 15 percent more power.

The second-stage exhaust nozzle was also upgraded – from a liquid injection system to a cheaper mechanical thrust vector control system. This same device is used to control the third stage.

## Program Review

**Background.** Japan's three space agencies, the National Space Development Agency of Japan, the Institute of Space and Astronautical Science, and the National Aerospace Laboratory of Japan, merged in 2003 to form JAXA (Japan Aerospace Exploration Agency). All references to NASDA, ISAS, and NAL in this report are for historical purposes, as control over these entities now resides with JAXA.

The space booster that generally comes to mind when discussing Japan's space program is the H-2A heavy-lift expendable launch vehicle developed by NASDA (see the "H-2A/H-2B" report in this tab). The H-2A is responsible for launching some of the most ambitious Japanese space efforts. In addition, its December 2002 launch of the Australian FedSat communications spacecraft brought Japan into the commercial satellite launch market dominated by the United States, Europe, and Russia.

NASDA's sister space agency, ISAS, sponsored a successful series of small, solid-propellant launch vehicles earmarked exclusively for space science missions. In 1970, ISAS launched Japan's first satellite on an L-4S-type sounding rocket. Since then, Japan has averaged one satellite launch per year.

## M-V Launch Vehicle

As Japan's payload requirements increased in weight, the size and capability of its space boosters increased as well. The L series was succeeded by the Mu series: the M-4S, followed by the M-3C, M-3H, M-3S, M-3SII, and finally, the M-V.

The development of the M-V cost approximately $133 million, while the per-vehicle cost amounts to about $56 million. While that is certainly not inexpensive, it is about half the cost of NASDA's H-1 (now retired), which could carry 3,000 kilograms to low-Earth orbit, compared with the M-V's 2,000 kilograms. For those science payloads over the 2,000-kilogram limit, JAXA relies on its heavy-lift H-2A.

M-V's first payload was the Muses-B satellite, which was launched in 1997 and renamed HALCA (Highly Advanced Laboratory for Communications and Astronomy). The satellite provides very long base interferometry (VLBI) as part of Japan's VLBI Space Observatory Program. Muses-B was followed by the launch of Nozomi (Planet-B) in 1998. This spacecraft was due to arrive at Mars in 2004, carrying 10 instruments to observe the planet's geomagnetic field. However, this mission was scrubbed in late 2003 after JAXA determined that Nozomi had suffered electrical malfunctions, probably due to mass coronal ejections. Astro-E, the third mission planned for the M-V booster, was launched in 2000 but was unsuccessful. As a result, the launch schedule was altered in order to make improvements to the M-V.

The next M-V launch, carrying Muses-C, was slated for the fourth quarter of 2002 from the Kagoshima Space Center, but was delayed until May 2003 because of a faulty O-ring. Muses-C, which weighs only about 16 kilograms, is a sample return mission to asteroid (25413) 1998SF36. The satellite mission schedule – to arrive at the asteroid in mid-2005, depart in late 2005, and return to Earth in June 2007 – suffered some delays as a result. Since its launch, the Muses-C has been renamed Hayabusa by JAXA.

An Astro-E replacement program, Astro-E2, was begun in April 2001. The replacement satellite was launched in July 2005 from Kagoshima on an upgraded M-V with a redesigned first stage.

### *Venus Orbiter Planned for M-V*

The Planet-C spacecraft is a Venus orbiter designed to observe the atmospheric dynamics of the planet – in particular, the upper atmosphere super-rotation. After launch in 2008 on an M-V booster, an Earth swingby is planned, with arrival at Venus in 2010.

Winds of Change. In October 2003, NASDA, ISAS, and NAL joined forces to become the Japan Aerospace Exploration Agency (JAXA) as part of Japanese Prime Minister Junichiro Koizumi's consolidating reform plan. This cost-cutting measure was intended to streamline Japanese space efforts, eliminate overlap among programs, and help the island nation emerge from the ashes of its past launch failures. The three firms share their technologies and pool their individual strengths: NASDA contributes its experience in manned missions and rocket and satellite technology; NAL, its expertise in aeronautical research and in rocket engine and space vehicle development; and ISAS, its scientific faculty.

### *Recent Launch Activity*

The most recent M-V launches occurred in February and September 2006. The Astro-F, successor to the Astro-E2, was launched in February. This satellite is designed for infrared astronomy and tasked with surveying the entire sky. The Cute 1.7 and Solar Sail Payload (SSP) were also included in the February launch payload. These experimental satellites are designed to test applications of commercial off-the-shelf (COTS) technology for space-based communications and solar sail arrays, respectively.

The September launch included the Solar-B, HIT-SAT, and SSSat payloads. The Solar-B, a joint project of Japan, the U.K. and the U.S., is designed to monitor solar physics. The HIT-SAT sub-payload draws on the Cute 1.7 as an amateur scientific experiment. The SSSat payload provides an advanced testbed for solar sail technologies.

All six payloads were successfully launched; however, the SSSat failed to deploy upon reaching orbit.

## Timetable

| Month | Year | Major Development |
|---|---|---|
| Feb | 1997 | First M-V flight with Muses-B radio astronomy satellite |
| Jul | 1998 | M-V launches Planet-B on trip to Mars |
| Feb | 2000 | Launch of Astro-E X-ray spacecraft (failure) |
| May | 2003 | Launch of Muses-C spacecraft on mission to asteroid |
| Jul | 2005 | Launch of Astro-E replacement, Astro-E2 |

| Month | Year | Major Development |
|---|---|---|
| Feb | 2006 | Launch of Astro-F, Cute-APD, SSP |
| Sep | 2006 | Launch of Solar-B, HIT-SAT, SSSat |
| | 2010 | Possible J-2(GX) replacement of the M-V |

# Forecast Rationale

No production of the M-V is expected during the forecast period. The M-V is not a very popular program within the Japanese government. Those critical of the M-V cite the cost of the launcher – nearly $56 million per launch – as being far too expensive. This is an accurate assessment, as both the Russian Rockot and the U.S. Taurus are much more capable launchers and are about half the cost of an M-V. Even the popular Boeing Delta II – which typically costs about $50 million per launch – is cheaper than the M-V.

Japan has begun new efforts to develop launch vehicles that will drastically lower costs. The J-2(GX) has been mentioned as a possible alternative to the M-V to launch scientific spacecraft into orbit. JAXA is also developing the Advanced Solid Rocket. Japan hopes that the ASR will be about one-third cheaper to launch than the M-V, and also provide much simpler operations so that launches can occur more frequently.

With JAXA actively seeking an alternative to the M-V, and because no production of the M-V is expected over the next 10 years, this report will be archived in April 2011.

# Ten-Year Outlook

No forecast.

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