ARCHIVED REPORT

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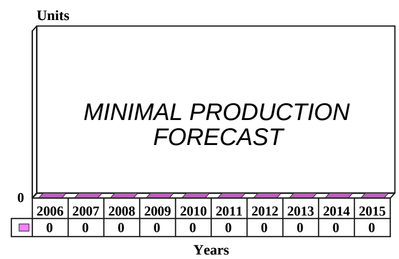
HOPE-X - Archived 4/2007

Outlook

- HOPE-X program development remains frozen
- The two High Speed Flight Demonstrators developed for HOPE-X have been used to test reusable launch vehicle technologies
- HSFD program is viewed as a technological springboard to future Japanese reusable launch vehicle availability around 2020

10 Year Unit Production Forecast
2006 - 2015



Orientation

Description. The H-2 Orbiting Plane-Experimental (HOPE-X) reusable, unpiloted spaceplane was never built. The two small-scale test models of HOPE-X now constitute the basis for the High-Speed Flight Demonstration (HSFD) program for development of a future reusable launch vehicle.

Sponsor. Japan's Aerospace Exploration Agency (JAXA) in Chyofu City, Tokyo manages the HOPE-X program. Other Japanese agencies involved in the project include the Space Activities Commission (SAC), and the Ministry of Education, Culture, Sports, Science and Technology (MEXT), formerly known as the Science and Technology Agency (STA).

The French Space Agency, Centre National d'Etudes Spatials (CNES), Toulouse, France, jointly manages the HSFD Phase II program with JAXA.

Status. HOPE-X development is frozen. JAXA is reviewing the program, and has reassigned the two HOPE-X prototypes to test two-stage reusable booster technologies. A two-stage-to-orbit spaceplane could be developed for availability around 2010.

Total Produced. Two HSFD prototypes.

Application. The HSFD prototypes are testing technologies for the development of a future reusable launch vehicle. They were originally designed to test technology for the unmanned HOPE-X reusable launch vehicle, until the program was frozen in August 2000. Japan is now eyeing them as a stepping stone toward a two-stage-to-launch reusable spaceplane design that could later evolve into a single-stage-to-launch vehicle around 2020.

Price Range. Japan spent $235 million on HOPE-X before the program was frozen. Total program costs had been estimated at $830 million.

Contractors

Prime

Fuji Heavy Industries Ltd	http://www.fhi.co.jp/english, 1-7-2 Nishishinjuku, Shinjuku-ku, Tokyo, 160-8316 Japan, Tel: + 81 3 3347 2111, Fax: + 81 3 3347 2338, Prime

HOPE-X

Kawasaki Heavy Industries Ltd (KHI)	http://www.khi.co.jp, 1-3 Higashikawasaki-cho 1-chome, Chuo-ku, Kobe, 650-8680 Japan, Tel: + 81 78 371 9530, Fax: + 81 78 371 9568, Second Prime

Subcontractor

Aerojet	http://www.aerojet.com, PO Box 13222, Sacramento, CA 95813-6000 United States, Tel: + 1 (916) 355-4000, Fax: + 1 (916) 351-8667, Email: comment@aerojet.com (Orbital Maneuvering Engine)
Electronic Navigation Research Institute	http://www.enri.go.jp, 7-42-3 Jindaishigashi-machi, Chofu, Tokyo, 182-0018 Japan, Tel: + 81 422 41 3165, Fax: + 81 422 41 3169 (Guidance)
Ishikawajima-Harima Heavy Industries Company Ltd (IHI)	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 (H-2 Support For Mitsubishi)
Mitsubishi Electric Corporation	http://global.mitsubishielectric.com, Mitsubishi Denki Building, 2-2-3, Marunouchi, Chiyoda-ku, Tokyo, 100-8310 Japan, Tel: + 81 3 3218 2111, Fax: + 81 3 3218 2185 (H-2/Hope Rocket Intergration; More Powerful Design; Avionics System)
Toshiba Corporation	http://www.toshiba.co.jp, 1-1, Shibaura, 1-chome, Minato-ku, Tokyo, 105-8001 Japan, Tel: + 81 3 3457 4511, Fax: + 81 3 34556 1631 (Avionics System)
Yokohama Rubber Company Ltd	36-11 Shimbashi 5-chome, Minato-Ku, Tokyo, Japan, Tel: + 81 3 5400 47, Fax: + 81 3 3431 48 (Ultra Heat Resistant PMR-15 Composite For Exterior)

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Technical Data

Design Features. The HOPE-X spaceplane was to be launched into low-Earth orbit on the H-2A expendable launch vehicle. The spaceplane's design featured a single, fuselage-mounted tailfin like that used on the NASA Space Shuttles. Like the Space Shuttle, the spacecraft would come with a heat-resistant outer surface capable of coping with the high temperatures of re-entry. Thermal protection systems under investigation included a carbon composite for portions of the vehicle slated to face the highest temperatures of up to 1,700°C (nose cap, wing leading edges, vertical tails, elevons, and body flap). Ceramic tiles able to withstand 1,200°C temperatures could be used for the remaining areas. Also like the shuttle, the HOPE-X would return to Earth unpowered, and since the spacecraft would be unmanned it would require an automatic landing system that would likely use microwave technology.

In the summer of 2000, the Japanese Space Activities Commission radically changed the HOPE-X program, merging it with the NAL's (National Aerospace Laboratory) Supersonic Transport (SST) and Hypersonic Transport Propulsion System Research (HYPR) engine programs. Under the new plan, which has yet to be officially confirmed, the new orbiter would be a two-stage-to-orbit vehicle, riding into the upper atmosphere piggybacked aboard the Hypersonic Transport (HST), which would use air-breathing engines. Once separated from the HST, the orbiter would use its own rocket engine to boost itself to low-Earth orbit. Following the mission, the orbiter would return, unpowered, and glide to a landing strip.

	Metric	U.S.
HST & Orbiter Estimates		
Dimensions		
HST length	65 m	213 ft
Orbiter length	39 m	128 ft
HST wing span	30 m	98 ft
Orbiter wing span	17 m	56 ft

Weights		
HST launch weight (less Orbiter)	140,000 kg	308,645 lb
Orbiter launch weight	122,000 kg	268,961 lb

Propulsion A pair of bipropellant thrusters provides onboard propulsion for orbital maneuvering. Propellants under consideration include nitrogen tetroxide and monomethelhydrazine, and nitrogen tetroxide and hydrazine.

High-Speed Flight Demonstrator Vehicles. The HSFD program is verifying key technologies in the final phase of returning from space. It consists of two HSFD vehicle programs, Phase I and Phase II. Both are 25-percent scale models of the HOPE-X. Their antennas and other external devices are designed not to affect their aerodynamic characteristics. A common fuselage – the core system for Phase I and II – has been adopted for cost reduction and for use in future programs.

Equipped with a Teledyne Continental Motors J69-T406 turbojet engine and landing gear, the Phase I vehicle takes off and lands on a runway. It features a flight control computer that determines the flight direction and attitude and controls certain onboard equipment. It also carries an integrated IMU (inertial measurement unit) with D-GPS, telemeters, and command receivers for radio communications with the ground stations.

The Phase II vehicle is unpowered. While it has many of the same components as the Phase I model, it lacks the jet engine and the landing gear. It is air-dropped, and released into free fall to study its behavior at speeds of about Mach 1 as it plummets 13 miles. Parachutes would then be deployed, and airbags (rather than wheels) cushion its landing. In addition, about 30 pressure sensors are installed on the surface of the fuselage and the base plane to acquire aerodynamic data during the flight at a transonic speed. Testing on this vehicle began in early 2003. Initial plans called for three or four of these drop tests.

	HSFD Phase I Vehicle		**HSFD Phase II Vehicle**	
	Metric	**U.S.**	**Metric**	**U.S.**
Dimensions				
Length	3.8 m	12.5 ft	3.8 m	12.5 ft
Wing span	3.0 m	9.8 ft	2.4 m	7.9 ft
Height	1.4 m	4.6 ft	1.2 m	3.9 ft
Total mass	735 kg	1,621 lb	500 kg	1,103 lb
Wing area	4.4 m^2	14.4 ft^2	3.1 m^2	10.2 ft^2
Propulsion				
Thruster	4,410 N		none	

Variants/Upgrades

OREX (Orbiting Re-entry Experiment). Capsule launched in 1994 on an H-2 rocket to test HOPE's thermal protection system.

HYFLEX (Hyper Flight Experiment). An unpowered lifting body test plane, 4.4 meters long and costing about $45.2 million. Launched on a Japanese J-1 rocket in 1996, HYFLEX studied hypersonic flight and re-entry after being released at a 110-kilometer altitude. It tested whether consistent, stable flight can be achieved on re-entry when transferring from hypersonic to subsonic flight. HYFLEX sank in the ocean off Japan before it could be recovered.

ALFLEX (Automatic Landing Flight Experiment). A one-third model of HOPE used to develop an unmanned landing system. Japan conducted a series of helicopter drop tests during the summer of 1996 from a 2,000-meter runway at Woomera Airport in central Australia.

High Speed Flight Demonstrator (HSFD). Two 25-percent scale models of HOPE-X are being tested to demonstrate future RLV technologies.

HOPE-X

Program Review

Background. As part of its effort to develop an indigenous space industry, Japan is developing a small, unmanned spaceplane. JAXA (previously NASDA) began preliminary definition of the HOPE vehicle in 1987. Designs of 20,000-kilogram and 25,000-kilogram manned versions were considered early in the project, but were rejected to minimize the amount of modifications that would be required to adapt HOPE to the H-2 rocket booster and bring the booster itself up to the required man-rating standards. The newer H-2A, a less costly version of the H-2, became the launch vehicle of choice for HOPE.

Severe budget reductions in Japan's space activities forced the cancellation of the HOPE program in 1997. Rather than produce the full-up HOPE spaceplane and the HOPE-X experimental spacecraft, a Science and Technology Agency recommendation called for adapting HOPE's technology to the HOPE-X. Consequently, HOPE-X would now have a cargo bay, docking avionics and an improved heat shield. In addition, the HOPE-X was slated to fly into space 10 to 20 times, instead of just once as originally planned.

Initial plans called for the launch of HOPE-X in 2000, but budget shortfalls pushed the date to 2004. In the summer of 2000, JAXA revised its plans again, stating that HOPE-X had been shelved. Japan began investigating the development of a hypersonic transport airplane on which a larger orbiter would ride piggyback to high altitudes. Once aloft, the orbiter would separate from the HST and use its own power to reach low-Earth orbit.

This new orbiter development program is reportedly broken down into several phases. Under Phase 1, Japan will conduct R&D on the orbiter's reusable rocket engines, perform scaled demonstrator flights, produce an experimental HST airframe, and develop air-breathing HST powerplants, presumably using technology gleaned from the HYPR engine program. This phase would run through 2005.

Development of a subscale HST demonstrator would proceed under Phase 2, from 2006 to 2010, along with development of a full-scale experimental orbiter. The orbiter would have a payload capacity of 8,000 kilograms – enough to carry large satellites into orbit or to transfer equipment and supplies to the International Space Station. Finally, a full-scale, two-stage RLV would be developed after 2010.

HSFD Phase I. The High Speed Flight Demonstration (HSFD) project is part of Phase 1 of the new orbiter development program. The two prototype vehicles developed under the program are subscale models of the HOPE-X vehicle. HSFD uses the two experimental vehicles – one powered, one not – to acquire and validate autonomous flight control technologies for winged re-entry vehicles.

Phase I testing of the powered vehicle began in October 2002 and concluded two months later. It verified the vehicle's navigation systems, validated its communication functions around a landing site, and accumulated technical know-how about unmanned autonomous flight.

Phase II Drop Test and Hard Landing. Phase II, conducted jointly between JAXA's NAL and CNES, began in early 2003 with an air-drop test of the unpowered model at the Esrange test site in Sweden in July of that same year. The vehicle was lifted by a stratospheric balloon operated by CNES, and released 30 kilometers above the Earth. Its freefall acceleration reached transonic speeds, allowing it to acquire various aerodynamic data.

Everything appeared to be proceeding according to plan, and all that was left to do was to deploy the parachutes and gently touch down. Only one of the three deployed properly, and the intended deceleration was not achieved. The HSFD crashed into a field and broke its left wing and nose cone. JAXA is still debating whether it will continue with the test flights in this configuration. One thing is certain: the HSFD tests, and data collected, will be used for future Japanese RLV projects.

Funding

Japan spent $238 million on HOPE-X before the program ground to a halt in August 2000. Japan is not proposing a new reusable launch vehicle plan nor releasing a budget for one until its three space agencies merge this year. In the meantime, the HSFD program will cost about $23.4 million (JPY2.8 billion). $11.7 million was already appropriated in FY02, and another $2.67 million (JPY320 million) was requested for FY03. Japan budgeted $22.4 million for the two rounds of drop tests.

Timetable

Month	Year	Major Development
	1987	NASDA begins preliminary definition phase of HOPE project
Sep	1988	Test of highly maneuverable space (HIMES) orbiter research vehicle fails
Feb	1992	Successful test of HIMES scale model
	1994	Launch of OREX vehicle aboard H-2 ELV
	1996	Flight tests of HYFLEX and ALFLEX
	2000	HOPE-X program undergoes radical change, moves to RLV concept
	2003	HSFD damaged in hard landing during drop test
	2020	Development of RLV based on HST/Orbiter combination

Forecast Rationale

Forecast International contacted Eiko Naruke at JAXA to discuss the HOPE-X program and its future. She indicated that the HOPE-X program, while still frozen, will be a stepping-stone to a new RLV, and that JAXA will continue to pursue a vehicle that can either accommodate manned spaceflight or be modified to do so. The driving force behind this idea is one of economics more than any real desire to simply keep up with the United States, Russia, and China. The HOPE-X offers little in the way of future revenues for Japan. With this in mind, it is very likely that Japan will seek more international cooperation on its redefined RLV project in order to broaden its commercial potential. France, which has been working with JAXA's NAL on the Phase II drop tests of the HSFD II vehicle, may expand its participation once a new RLV program is fleshed out.

For the time being, no production is planned. In 2003 Japan had hoped to field a true RLV around 2010, but recent data indicates that planners at JAXA view 2020 as a more realistic goal. Forecast International agrees with this assessment. The tests being performed on the two HSFD vehicles are providing valuable data to further this goal while Japan's space agencies settle into their massive integration.

Barring any new developments, this report will be archived in 2007.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR PRODUCTION

		High Confidence Level				Good Confidence Level			Speculative			
Space System	**thru 05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Total 06-15**
NASDA												
ORBITER (FOR JAPAN HST)	0	0	0	0	0	0	0	0	0	0	0	0
Total Production	0	0	0	0	0	0	0	0	0	0	0	0