Continued Evolution of H3 Launch Vehicle to Achieve Globally Preferred Launch Service

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H3 launch vehicle has been developed to replace H-IIA and H-IIB as Japan's flagship launch vehicle (rocket). The first flight of H3, launched in March 2023, failed due to the second stage engine ignition failure. However, after investigating the cause and implementing necessary countermeasures, the second through fifth vehicle have been launched successfully. As of September 2025, a new configuration for H3, featuring different numbers of the first stage main engines and the solid boosters, is undergoing final preparations for its first launch. Furthermore, plans to upgrade H3 launch vehicle in a step-by-step manner, to enhance its value to satellite operators and make it the internationally preferred launch service, are underway.

1. Introduction

Development of H3 launch vehicle began in 2014 to replace H-IIA and H-IIB as Japan's flagship launch vehicle. Mitsubishi Heavy Industries, Ltd. (hereinafter referred to as MHI) has been coordinating development of the vehicle as the prime contractor and has also been developing the engine system with the Japan Aerospace Exploration Agency (hereinafter referred to as JAXA).

During the LE-9 engine qualification firing test in May 2020, two issues occurred, and resolving the issues required some time. As a result, launch of the first vehicle was postponed until 2023 from the original planned launch of 2021. Following the first stage firing test (captive firing test: hereinafter referred to as CFT) in November 2022, the first test vehicle, TF1 was launched in March 2023. However, the launch failed due to the second stage engine ignition failure. After investigating the cause and implementing countermeasures, the second test vehicle, TF2 was successfully launched in March 2024 (Return to Flight). Since then, four consecutive flights up to the fifth flight have been successfully completed. Currently, final preparations of the new configuration H3 (details described in the next chapter) are underway.

Meanwhile, the international surrounding environment has significantly changed since the beginning of development of H3 launch vehicle. Currently, Falcon 9 launch vehicle by SpaceX leads the competition by a wide margin in terms of launch frequency and cost. To maintain the independence of H3 as Japan's flagship launch vehicle and as a business, reliably launching government missions while also securing stable orders for commercial satellites is essential. Aiming to become the internationally preferred launch service in the future, MHI plans to upgrade H3 launch vehicle in a step-by-step manner in order to continuously enhance its value and acquire new customers (commercial orders).

Status of development of H3 launch vehicle is reported and plans for its enhancement (step-by-step upgrade) program are summarized in this report.

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2. Overview of H3 launch vehicle

Configuration of H3 launch vehicle is shown in **Figure 1**. To seamlessly respond to a wide range of customer needs, H3 launch vehicle is designed to allow the number of solid rocket boosters and the number of first stage main engines to be selected. As a result, launch capability to a geostationary transfer orbit of approximately 2 to 7 tons (with the condition of ΔV to the geostationary transfer orbit = 1,500 m/sec) is possible. Vehicle configuration is denoted as H3-abc, where *a* is the number of the first stage main engines (2 or 3), *b* is the number of the solid rocket boosters (0, 2, or 4), and *c* is the fairing size (W: wide, L: long, or S: short). The W-size fairing has an overall length of approximately 16.4m, equivalent to L-size fairing, and the diameter of 5.4 m. With this increase from L-size, 5.2 m, capability to transport large payloads has been enhanced. Minimum vehicle configuration is H3-30S (no solid booster), and configurations of H3-22L, H3-24L, and H3-24W achieve high launch capability according to the number of the solid boosters. This enables flexible support, not only for government missions, but also for domestic and international commercial customers with satellites of varying weights.

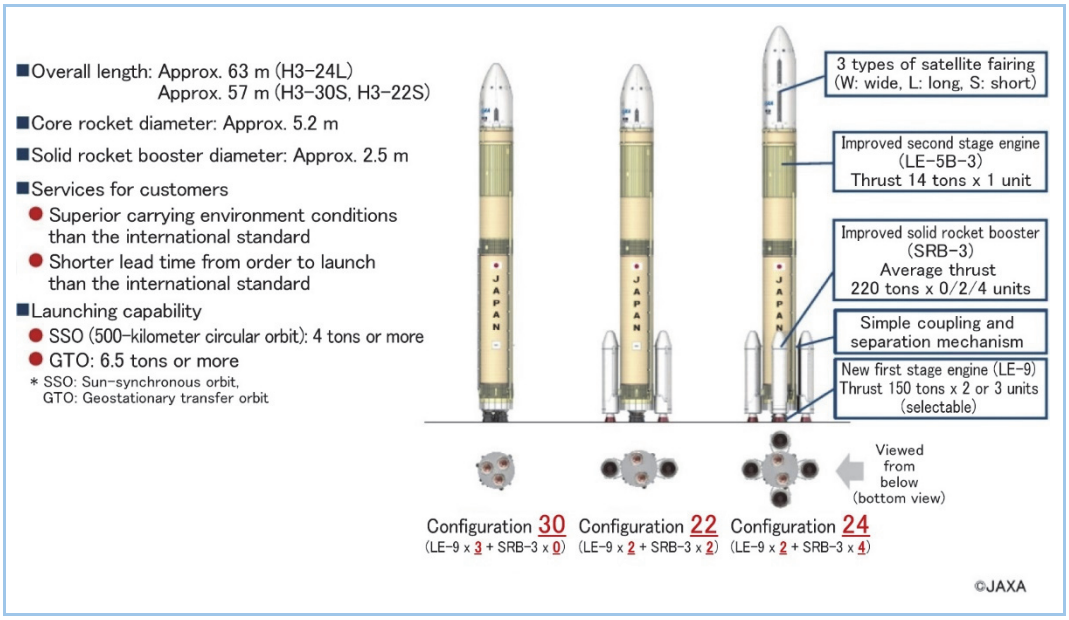


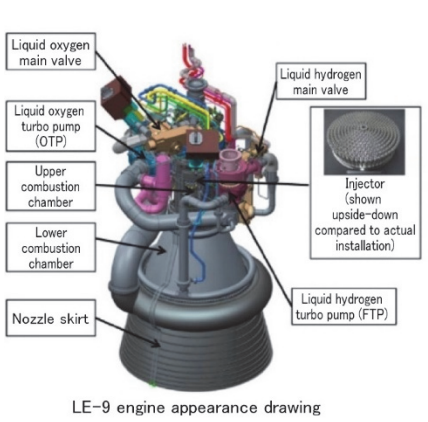
Figure 1 Overview of H3 launch vehicle [2]

3. H3 launch vehicle development status

This chapter reports on the development progress since the previous report [1]. As of September 2025, development of H3-22 was completed with the successful launch of the TF2, and preparations for the first launch of H3-30 and H3-24W are underway.

(1) LE-9 development status

Main specifications of LE-9 engine are shown in **Figure 2**. During the qualification model firing test in May 2020, problems regarding an opening in the combustion chamber wall and fatigue fracture in the liquid hydrogen turbo pump (fuel turbo pump: FTP) occurred. Countermeasures for opening in the combustion chamber wall were established in March 2021. FTP turbine fatigue fracture has been addressed by strengthening blade rigidity and damping characteristics for impending TF1, TF2, and the subsequent some launches. Furthermore, for the Type 2 engine to be used in the further future vehicle, both improved performance (specific impulse) and suppression of turbine vibration by refining the FTP turbine design, as well as a reduction in product costs through the application of additive manufacturing technology and the other measures, are planned. As of September 2025, the feasibility verification test for the Type 2 engine has been successfully completed, and preparations for the qualification model firing test are underway.



LE-9 engine appearance drawing

	Type 1 (test vehicle No.1)	Type 1A (test vehicle No.2 and later)	Type 2
FTP	Minimal design change (called "Arrow Zero") Improved rigidity and stronger damping	Same as Type 1	Permanent measure spec *1, 2
OTP	Level 1 design change (called "Arrow One") Flow irregularities at the turbine inlet are inhibited	Permanent measure spec (same as Type 1)	Permanent measure spec (same as Type 1)
Injector	Machining processed	Same as Type 1	Permanent measure spec *2
Other components	Type 1 spec.	Permanent measure spec (in principle, components have already demonstrated results in development tests)	Permanent measure spec

*1 The permanent measure spec FTP is planned to reduce risk by basing designs that have been proven through testing in the past.

*2 The permanent measure spec injector and turbo pump are planned to further apply additive manufacturing technology and other measures reduce product costs.

Figure 2 LE-9 engine development status [2]

(2) Vehicle system development status

In order to confirm the function and the performance of the first stage propulsion system and verify the entire sequence of operations up to launch with the vehicle combined with the equipment, the first stage captive firing test CFT*1) was conducted in November 2022 using two LE-9 Type 1 engines. As planned, simultaneous firing of the both first stage engines was performed for 25 seconds and acquisition of the necessary data was successfully completed. The main configuration of CFT is shown in **Figure 3**.

*1) CFT (captive firing test): A test where the launch vehicle is moved to the launch pad according to the same procedures as the launch day, propellants are loaded, and the first stage engine firing test is conducted with the vehicle secured to the launch pad.

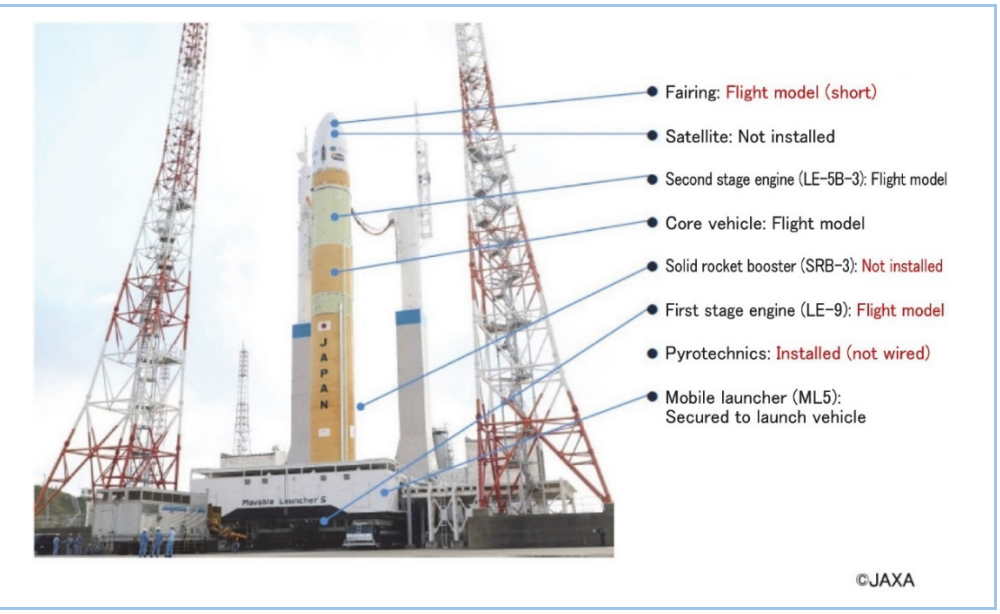


Figure 3 The main configuration of the first stage captive firing test of TF1 [3]

(3) "Return to Flight" after failure of TF1

After countermeasures for the unexpected results identified in CFT were completed, TF1 was launched on March 17, 2023. However, the launch failed due to engine ignition failure of the second stage. Immediately after the ignition signal was sent for the second stage engine, the second stage propulsion system controller (hereinafter referred to as PSC2) detected a power supply abnormality and cut off power to the downstream components. The root cause was identified as an overcurrent occurring in the downstream components of PSC2. Details of this event are described in **Figure 4**. Failure scenarios were extracted based on the flight data and the design results. Three failure scenarios were ultimately identified based on the results of the verification tests and the other analyses. After confirming comprehensiveness of the investigation, countermeasures were implemented for all these scenarios.

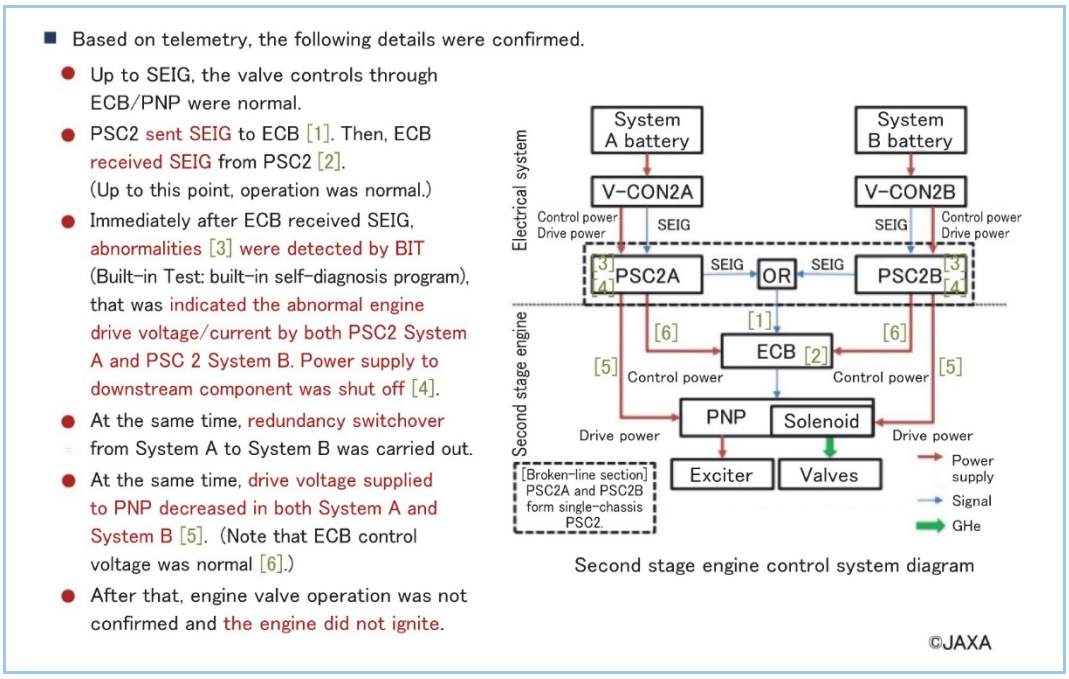


Figure 4 TF1 second stage engine ignition failure [4]

Three failure scenarios and countermeasures:

(1) A minor short circuit occurred inside the downstream component (hereinafter referred to as exciter), followed by a complete short circuit after transmission of the ignition signal.
Countermeasure: Increased insulation and stricter inspection of the electrical components within the exciter.

(2) An overcurrent occurred when power was sent to the exciter.
Countermeasure: Screening of the transistor components within exciter.

(3) An overcurrent occurred within PSC2 System A and propagated to System B.
Countermeasure: Removal of the constant-voltage diode in PSC2.

TF2 was launched on February 17, 2024. The second stage engine ignited and operated normally, resulting in a successful launch. TF2 launch results are shown in **Figure 5**. Subsequent launches of the second to fifth vehicle (all with configuration H3-22: two first stage main engines and two solid rocket boosters) were carried out successfully.

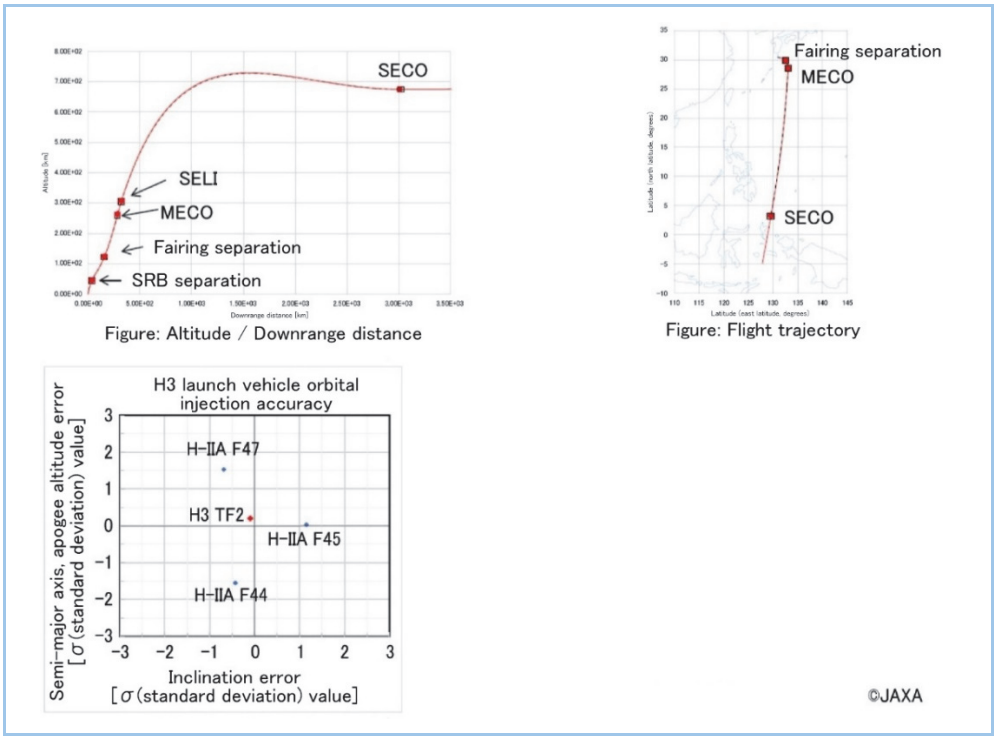


Figure 5 TF2 flight results [6]

(4) Future development plan

In July 2025, CFT of H3-30 test vehicle was conducted. As planned, firing for 25 seconds was achieved, and data acquisition was successfully completed. Currently, evaluation of the data obtained from the firing test and the necessary measures are underway. Furthermore, the first launch of H3-24 is planned for October 2025, and as of September 2025, the final assembly and the functional testing are being conducted at Tanegashima Space Center.

4. H3 launch vehicle enhancement development

H3 launch vehicle is Japan's flagship launch vehicle and has been assigned a role in achieving the government missions centered on the national security, which is indispensable in maintaining the independence of Japan's space transport system. The international launch service market is currently dominated by Falcon 9 launch vehicle by Space X. In order to maintain stable business viability, enhancing the value and appeal of H3 launch vehicle is necessary to attract government and commercial demand, both domestically and internationally, in addition to handling Japan's government satellites.

In the launch service market, H3 launch vehicle faces obstacles such as limitations in the types of satellites that can be handled, constraints in launch frequency and scheduling, and insufficient launch capacity in meeting customer demands. Consequently, H3 launch vehicle enhancement development program was initiated to upgrade (continually evolve) H3 launch vehicle through short-cycle and step-by-step developments in order to address these obstacles and satisfy the drastically changing demands of customers.

H3 launch vehicle enhancement development program applies a continuous, step-by-step development process (block upgrade method) that takes into account changing customer demands. The program aims to conduct flexible system development with timely and gradually upgrading into the market by updating mission requirements and system definitions, at the same time, short-cycle development to respond promptly to external environments and needs, such as market and competitor trends, and reducing development risks through front-loading are planned. An overview of the enhancement development is shown in **Figure 6**.

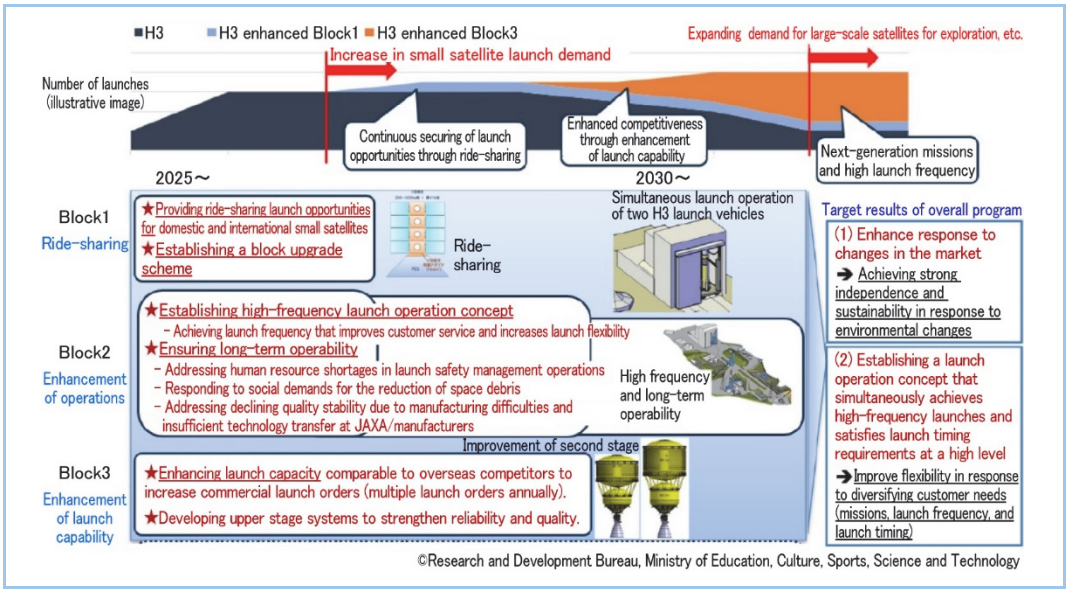


Figure 6 Overview of H3 launch vehicle enhancement development program [7]

(1) Block 1: Expansion of satellite mission variety

Satellites have become smaller and more diverse than predicted at the beginning of H3 launch vehicle development. Consequently, the need to launch various small satellites at a low cost has become apparent. The ability to handle ride-sharing missions (simultaneous launching of multiple small satellites) is urgently needed in response to the changing needs and is expected to be achieved shortly. Launch opportunities for multiple small satellites, for which demand is growing, will be achieved through the ridesharing mission of H3.

(2) Block 2: Enhancement of launch service

By continuously improving launch operations to resolve issues, stable launches as an attractive launch vehicle, while maintaining international competitiveness, can be achieved. In order to ensure launch operations with high convenience for customers, such as improved on-time launch rates and flexibility in launching, and to secure business viability, high-frequency launch operations, such as launching 6 to 8 or more vehicles per year and consecutive launches at intervals as short as two weeks, will be established through operational improvements and environmental enhancements.

(3) Block 3: Enhancement of launch capability

In response to enhanced launch capabilities by competitors and changing market demands for launch capacity, launch capability will be enhanced by developing improvements for the second stage system (such as increasing propellant load of the second stage and developing a new second stage engine). As the range of missions widens through transportation capacity enhancement and connecting to new needs, the number of commercial launch orders received will increase (Target: Multiple orders annually). An overview of Block 3 is shown in **Figure 7**.

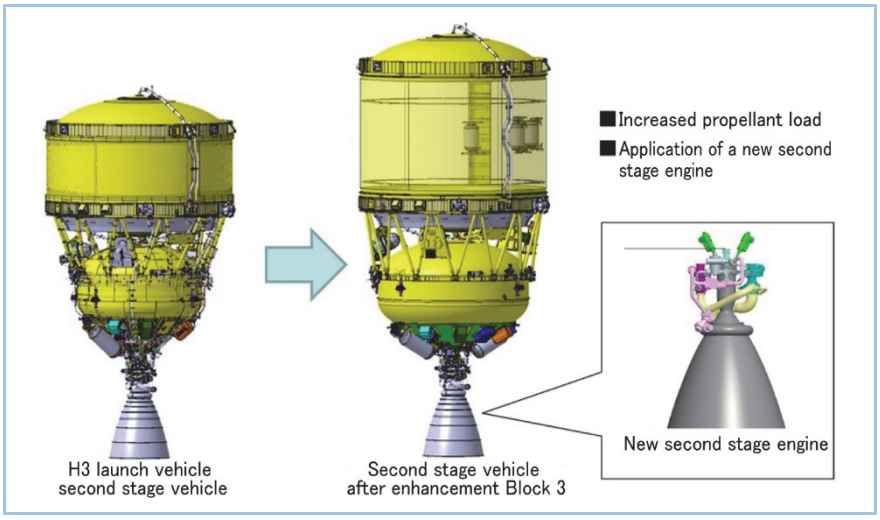


Figure 7 Overview of development of enhancement Block 3

5. Conclusion

This report described the development status of H3 launch vehicle and the development plan for H3 enhancement program. Development of H3 launch vehicle has been largely completed and is now in the final preparation phase for the remaining H3-30 and H3-24 first flights. Meanwhile, the international satellite launch service market is dominated by Falcon 9 from SpaceX in terms of launch frequency and cost. In order to establish H3 launch vehicle as Japan's flagship launch vehicle with independence in the future, it is essential to obtain not only satellite orders for government missions but also commercial satellite orders on a stable and regular basis.

In H3 launch vehicle enhancement program, enhancing the value of H3 launch vehicle is planned by developing three stages of the block upgrades in a shorter period than the previous developments with the aim of becoming the internationally preferred launch service utilizing the strengths of H3 launch vehicle, such as its reliability. After a difficult development period, H3 launch vehicle is finally approaching the mass production phase. MHI, not satisfied with current achievements, will continue to pursue the evolution of launch vehicles, aiming to become the internationally preferred launch service.

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