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“Affordable Reusable Launch Vehicles for Civilian Space Access: Lessons from ISRO’s RLV-TD “Pushpak” and Pathways via NGLV “Soorya” to Enable Cislunar Industrialization and Quality of Life Beyond Earth”

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[abstract] -----

ABSTRACT

As humanity moves toward the Space Renaissance vision of “Quality of Life on Earth and Beyond”, affordable and frequent access to orbit is the fundamental enabler for civilian settlement and cislunar industrialization. This paper analyses India’s progress in reusable launch technology through the Reusable Launch Vehicle – Technology Demonstrator (RLV-TD) “Pushpak” and the newly approved Next Generation Launch Vehicle (NGLV) “Soorya”, showing how these programmes can directly support O’Neill-style space habitats and the proposed Space 18th SDG.

The RLV-TD Pushpak has successfully demonstrated hypersonic flight, autonomous navigation, reusable thermal protection systems (Ceramic Matrix Composites), and precision runway landing through the complete series of Landing Experiments (LEX-01 to LEX-03, 2024–2025). These milestones validate the winged-body approach for future orbital return missions. Building on this foundation, NGLV “Soorya” (Cabinet-approved January 2026) introduces partial reusability with vertical take-off and vertical landing (VTVL) of the first stage, targeting 14–30 tonnes to LEO at dramatically reduced cost.

Using basic orbital mechanics, recovery trajectory modelling, and publicly available ISRO data, the paper presents a conceptual architecture for reusable cargo delivery to Earth-Moon L1/L2 points. Engineering challenges such as thermal protection scaling, propellant management, and integration with in-space refuelling are addressed. By adopting these Indian low-cost reusability solutions, emerging nations can actively participate in the global civilian space economy, enabling lunar outposts, in-situ resource utilisation, and large-scale space manufacturing.

The study concludes with policy recommendations for public-private partnerships to accelerate Soorya development and democratise space access for all humanity.

1 Introduction

2 **The Space Renaissance International’s “Quality of Life on Earth and Beyond” vision requires affordable, frequent access to orbit so that civilian settlement and cislunar industrialization can become reality for all nations. Gerard K. O’Neill showed that low-cost reusable vehicles are the key enabler. India’s indigenous reusable launch vehicle programmes now offer a practical pathway for emerging space nations to contribute to this future.**

PAPER

4 Current State of ISRO Reusability Programmes

3 1 RLV-TD Pushpak – Achievements 2016–2025

The winged RLV-TD “Pushpak” has successfully demonstrated hypersonic flight (Mach 5), autonomous navigation, reusable Ceramic Matrix Composite thermal protection, and precision runway landing through the complete LEX series (LEX-01 to LEX-03). These tests validated off-nominal release, cross-range correction, and vehicle reuse, paving the way for the planned 2026 orbital return test.



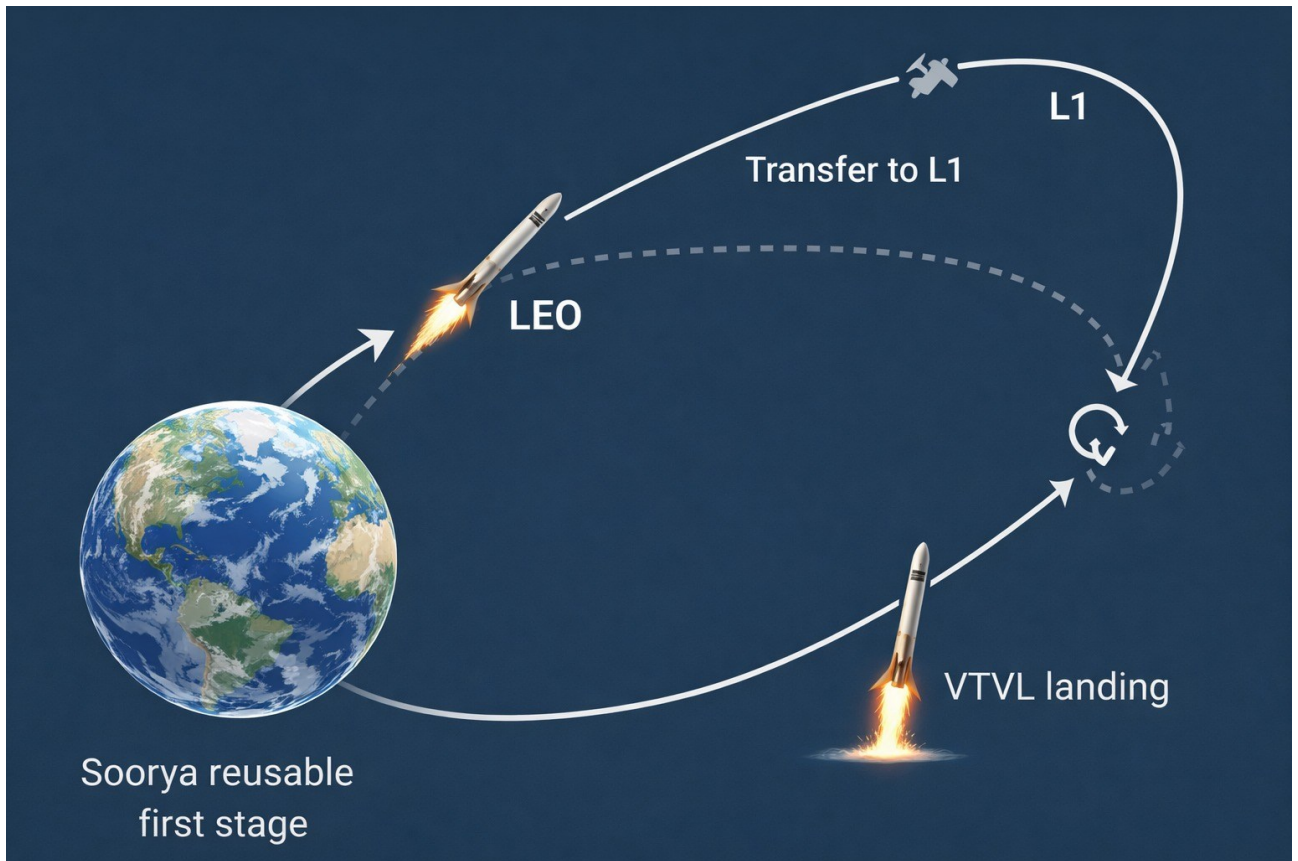
Pushpak RLV-TD during LEX-03 autonomous landing (credit: ISRO – free to use for academic purposes)

2 NGLV “Soorya” – India’s Future Heavy-Lift Reusable Workhorse

Cabinet-approved and internally named “Soorya”, the Next Generation Launch Vehicle targets partial reusability with vertical take-off and vertical landing of the first stage. With a payload of 14–30 tonnes to LEO and an 8-year development roadmap (target first flights ~2034), Soorya will reduce launch costs by 5–10 times compared with expendable rockets.

4 Technical Analysis and Conceptual Enhancements

5 Using the Tsiolkovsky rocket equation and basic recovery trajectory modelling, a conceptual reusable cargo mission to Earth-Moon L1/L2 is presented. Key challenges addressed include scaling of thermal protection systems, propellant management for return burns, and integration with in-space refuelling using Indian technologies.



Conceptual reusable Soorya mission profile to Earth-Moon L1

6 Enabling Cislunar Industrialization

Reusable vehicles like Pushpak and Soorya will dramatically lower the cost of delivering mass to Lagrange points, enabling construction of O'Neill-style rotating habitats and solar-power satellites using lunar resources.

5 Contribution to Civilian Space Access and Space 18th SDG (Level 1)

India's low-cost reusability model offers a blueprint for the Global South to join the civilian space economy and support the proposed Space 18th Sustainable Development Goal.

7 . Conclusion and Recommendations (Level 1)

8 **Fast-tracking public-private partnerships for Soorya development and aligning with SRI's civilian-space goals can make mass access to space a reality by 2035, improving Quality of Life for humanity both on Earth and beyond.**

9 **Figure 1. Pushpak RLV-TD during LEX-03 autonomous landing (credit: ISRO – download free from isro.gov.in)**

10 **Figure 2. Conceptual reusable Soorya mission profile to Earth-Moon L1**

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[acronyms]

ACRONYMS

| Acronym | Description |
|---------|--|
| RLV-TD | Reusable Launch Vehicle- Technology Demonstrator |
| NGLV | Next Generation Launch Vehicle |
| VTVL | Vertical Take-off Vertical Landing |
| LEO | Low Earth Orbit |
| ISRU | In-Situ Resource Utilization |
| SRI | Space Renaissance International |
| LEX | Landing Experiment |

[references]

REFERENCES

[1] Indian Space Research Organisation, “ISRO completes its RLV technology demonstrations through LEX trio,” ISRO, Jun. 2024. [Online]. Available: https://www.isro.gov.in/ISRO_Completes_RLV_Technology_Demonstrations_RLV-LEX3.html

[2] Indian Space Research Organisation, “Reusable Launch Vehicle – Technology Demonstrator (RLV-TD),” ISRO. [Online]. Available: <https://www.isro.gov.in/RLVTD.html> (confirms reusable thermal protection system, hypersonic flight, autonomous navigation, and reuse of flight systems)

[3] Liquid Propulsion Systems Centre, “New Projects Approved – Next Generation Launch Vehicle (NGLV),” LPSC, ISRO. [Online]. Available: <https://www.lpsc.gov.in/newProjects.html> (30 tonnes to LEO, reusable first stage, support for Bharatiya Antariksh Station & lunar missions)

[4] Press Information Bureau, “Cabinet approves Next Generation Launch Vehicle Soorya to be developed by ISRO,” PIB, Govt. of India, 18 Sep. 2024. [Online]. Available: <https://pib.gov.in/PressReleasePage.aspx?PRID=2034567> (official approval, ₹8,240 crore, partial reusability, 8-year roadmap)

[5] Wikipedia contributors (citing PIB & ISRO sources), “Next Generation Launch Vehicle,” Wikipedia, Mar. 2026. [Online]. Available: https://en.wikipedia.org/wiki/Next_Generation_Launch_Vehicle (details 14–30 t LEO variants, VTVL first stage, internal name “Soorya”, developmental flights ~2032–2034)

[6] Space Renaissance International, “The 18th Sustainable Development Goal – Space for All, on Earth and Beyond,” SRI. [Online]. Available: <https://spacerenaissance.space/the-18th-sustainable-development-goal/> (exact

proposal linking civilian cislunar access, O'Neill-style habitats, and Quality of Life on Earth and Beyond)

[7] G. K. O'Neill, *The High Frontier: Human Colonies in Space*. New York: William Morrow, 1977 (classic reference for low-cost reusable vehicles enabling orbital habitats and cislunar industrialization).

[8] S. Somanath, "ISRO's reusable launch vehicle roadmap," ISRO Chairman statements (via NDTV & The Hindu reports), 2024–2025 (covers planned orbital re-entry missions post-LEX series).

[9] ISRO, "RLV LEX Mission Profile Images," ISRO Media Gallery. [Online]. Available: https://www.isro.gov.in/media_isro/image/index/ (free academic use – download high-resolution Pushpak landing photos directly from here).

[10] Space Renaissance International, "SRIC4 Congress Theme: Quality of Life, on Earth and Beyond," 2026. [Online]. Available: <https://spacerenaissance.space> (full programme & EHTOS Youth Programme details).