Vikram-1 Small-Satellite Launch Vehicle (SSLV)

Mains: *GS-III – Science & Technology*

Why in News?

India launched its first private orbital rocket Vikram 1 on July 18.

What about Vikram-1 SSLV?

- **Vikram-1 rocket** – It is India's *first privately developed* multi-stage orbital launch vehicle to a low-Earth orbit.
- **Developed by** – Skyroot Aerospace, a Hyderabad-based private space company.
    - So far, all orbital rockets India had launched as part of its space programme had been state-funded and led by ISRO.
- **Mission Aagaman** – It is dubbed 'Mission Aagaman' (meaning arrival), marking India's entry into an elite group of nations with private orbital launch capability, making it *only the 3rd country* in the world, after the United States & China.

Features

- **4-stage rocket** – It is a four-stage orbital launch vehicle - first three stages use solid fuel, and the fourth uses liquid fuel.
- **Structure** – It is a seven-storey-tall rocket built with an all-carbon composite structure and is engineered for rapid manufacturing and high launch pace.
- **Propulsion** – Powered by in-house developed propulsion systems, including 3D-printed engines and high-thrust solid-fuel rocket boosters.
- **Payload Capacity** – It can carry up to 350 kg to Low Earth Orbit (LEO), 290 kg to a 500-km sun-synchronous orbit and 480 kg to a low-inclination orbit at similar altitude
- **6 Payloads Deployed**
    - Embrace by Cosmoserve Space - Robotic-arm demo for space debris capture.
    - SOLARAS Satellite by Grahaa Space - Satellite mission.
    - SCOPE Satellite by Skyroot Aerospace - Experimental satellite.
    - uD3PP and mD3RN by Germany's Dcubed - Deployable technology demonstrators.
    - Cosmic Bloom by Cosmos Diamonds
    - Micro Art Tribute by Ajay Kumar Mattewada.
- **Symbolic Jewels** – Lab-grown diamond lotus & an 18-karat gold micro-rocket bearing rice-grain sculptures of *Sarabhai, Raman and Kalam* — the three names Skyroot gives its rockets and engines.
- **Flight Performance** – Vikram-1's maiden flight met every milestone, including the

process called 'long coast' a tricky phase holding attitude without thrust) and the final burn of the printed engine.

- For a debut mission aimed only at clearing the tower and gathering data, reaching orbit was an overachievement.
- Other rockets like Electron, Firefly Alpha, and ISRO's SSLV stumbled on their first attempts.

Vikram-1, India's first *- privately developed orbital rocket, all-carbon composite design, fully 3D-printed engine, longest monolithic stage, and ultra-low-shock separation systems.*

What is Skyroot's 3D-printed engine and why it matters?

- **3D Printing** – Rocket engines have traditionally been forged, machined and welded from dozens of parts.
- In 3D printing (additive manufacturing), a laser fuses metal powder layer by layer to form a single-piece component.
- **Advantages**
  - It eliminates the bolts, seals, and joints that often cause leaks and failures in conventional designs.
  - Skyroot test-fired its Raman engine in 2020; the fully 3D-printed injector reduced the mass by 50%.
  - Cut components and production time by 80% compared to conventional manufacturing methods.
  - Enables complex internal cooling channels (e.g., regenerative cooling in Vikram-1) that cannot be made using conventional drilling.
  - Prototypes produced in days, not months, so a startup can test, fail and redesign at a pace that would have been anathema to ISRO's supplier chains.

What is the significance of Vikram's "all-carbon-composite" body?

- **Carbon-Fibre Composite** – It is a filament of near-pure carbon set in resin.
- It offers specific strength (strength per unit weight) many times that of aerospace aluminium or maraging steel.
- Every kilogram saved in structure means more payload capacity.
- The material resists fatigue and corrosion and can be laid up by automated machines into seamless tubes — Vikram-1's Stage-1 is India's longest single-piece composite rocket stage.
- **Disadvantages**
  - High cost of material and curing infrastructure.
  - Strength runs along the fibres - a poorly designed laminate is strong one way and brittle another; and
  - Invisible damage risk - a delamination from a knock in transport can lurk invisibly beneath a perfect surface.
  - Requires ultrasonic inspection where dents in aluminium are visible.

Is this comparable to ISRO's PSLV & SSLV?

Feature	Vikram-1	PSLV	SSLV
Developer	Skyroot Aerospace	ISRO	ISRO (licensed to HAL).
Height	22 m	44 m	Approx.34 m
Mass	Approx.30 tonnes (lightweight)	320 tonnes (heavy workhorse)	Approx.120 tonnes
Architecture	4 stages: 3 solid + 1 liquid (restartable Orbital Adjustment Module)	4 stages: alternating solid & liquid, restartable PS4	3 solid + 1 small restartable liquid
Payload Capacity	350 kg to LEO	1,750 kg to polar orbit	500 kg to LEO
Materials	All-carbon composite airframe	Maraging steel	Conventional casings
Innovation	100% 3D-printed engine, longest monolithic carbon stage, ultra-low-shock separation	Proven reliability, large payload versatility	Small-satellite focus, conventional build
Philosophy	Market-driven, rapid iteration, venture-backed	State-designed, long-term reliability	State-designed, licensed production.

Who else is building private rockets in India?

- **Healthy Rivalry** – Skyroot Aerospace & Chennai's AgniKul Cosmos, incubated at IIT Madras, runs a parallel course.
- **India's Private Space Ecosystem** – Since the 2020 reforms and IN-SPACe's creation in 2022, India's space startups have multiplied from a handful to more than 400.
- **Dependency Shift** – Until July 18, 2026, all relied on ISRO rockets.
- A private launcher turns ISRO from gatekeeper into landlord & turns access to orbit from a national programme into a market.
- **Market Opportunity** – The small-satellite launch business is supply-starved worldwide, whereas Skyroot pitches itself as a cab service to space.

What are the business challenges ahead?

- **Domestic Demand** – India's small satellite launch demand is limited; even ISRO does not launch 12 small satellites a year today.
- India's own commercial space ecosystem is only just beginning to expand and includes potential future collaborators like Pixxel, Bellatrix Aerospace, and Dhruva Space.
- Even so, the domestic market remains relatively limited.
- **Market Dynamics** – Past forecasts (2015–2021) predicted a strong demand boom for 100–500 kg satellites.
- **Projection** – By 2035, small satellites may form one-third of launches, but less than 10% of total launch mass.
- The reality is that demand has grown, but profits become uneven; revenues from launch vehicles lag behind satellite manufacturing.
- **Cost Pressures** – Many small-satellite makers are flying their payloads as rideshares

on larger rockets, especially SpaceX Falcon 9, which are cheaper, reducing the appeal of dedicated small-satellite launchers.

- Dedicated launches offer flexibility and custom orbits, but at a premium cost.
- **Struggle to Secure Contract** – Startups across Europe, the U.S., China, Japan, and Australia are also developing small-satellite launchers & many have folded away after struggling to secure launch contracts from what is already a small pool of customers.
- Vikram-1 will also compete with ISRO's own new Small Satellite Launch Vehicle.
- **Margins** – Launch services are low-margin and capital intensive, especially when compared to satellite manufacturing, downstream applications, data services, and communications.
- **Compliance Cost** – Costs for debris mitigation and other regulatory obligations add further hurdles.
- **Global Competition** – Competing against established players like SpaceX, Rocket Lab, and emerging startups in Europe, China, and the U.S.

References

1. The Hindu | What makes Skyroot's Vikram-1 launch unique?
2. The Hindu | Skyroot faces a steep climb to business success