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AE6103 Module-01

Topic: List the Launch Vehicles available with different space agencies worldwide and discuss their capabilities (payload, orbits, etc.) and limitations.

The agencies with extraterrestrial space exploration capabilities are:

1. National Aeronautics and Space Administration (NASA)
2. China National Space Administration (CNSA)
3. European Space Agency (ESA)
4. Indian Space Research Organisation (ISRO)
5. Japan Aerospace Exploration Agency (JAXA)
6. Russian Federal Space Agency (Roscosmos)

Let's look at the launch vehicles of these agencies one by one:

1. **National Aeronautics and Space Administration (NASA)**

a. **Saturn V:**
Configuration- Apollo/Skylab
Organization- NASA
Max. first stage thrust- 34,500 kN
LEO payload- 140 ton
Cost/Ton of Payload (2020, USD mn)- US$8.9

b. **Falcon Heavy:**
Configuration- Recoverable Side Boosters (or expended)
Organization- SpaceX
Max. first stage thrust- 22,800 kN
LEO payload- 57 ton
Cost/Ton of Payload (2020, USD mn)- US$1.6

c. **SLS:**
Configuration- Block 1
Organization- NASA
Max. first stage thrust- 39,000 kN
LEO payload- 95 ton
Cost/Ton of Payload (2020, USD mn)- US$22.1

d. Starship:

Configuration- Recoverable booster and upper stage
Organization- SpaceX
Max. first stage thrust- 89,000 kN
LEO payload- 200 ton
Cost/Ton of Payload (2020, USD mn)- US$<0.04

2. ISRO:

a. Polar Satellite Launch Vehicle (PSLV):

Gross weight- 320t
Overall height- 44.4m
Diameter- 2.8m
No. of stages- 4
Payload to SSPO- 1750kg
Payload to Sub GTO- 1425kg
Thrust:

- PS1- 4800kN
- PS2- 799kN
- PS3- 240kN
- PS4- 7.3x2kN

Cost- US$ 19-29 million

b. Geosynchronous Satellite Launch Vehicle (GSLV):

Overall height- 51.73m
Lift-off mass- 420t
No. of stages- 3
Payload to GTO- 2250 kg
Payload to LEO- 6000 kg
Thrust:

- GS1- 4800kN
- GS2- 846kN
- CUS- 75kN

Cost- US$ 47 million

c. Geosynchronous Satellite Launch Vehicle Mk-III (LVM3):

Overall height- 43.5m
Vehicle diameter- 4.0m
Heatshield(Payload fairing) Diameter- 5.0m
Lift-off mass- 640t
No. of stages- 3
Payload to GTO- 4000 kg
Payload to LEO- 8000 kg
Thrust:

- Core stage: L110 Liquid stage- 2x725 kN (Vikas engine)
- Solid Rocket Boosters: S200- 2x4900 kN
- Cryogenic Upper Stage: C25- 200 kN

Cost- US$ 63 million

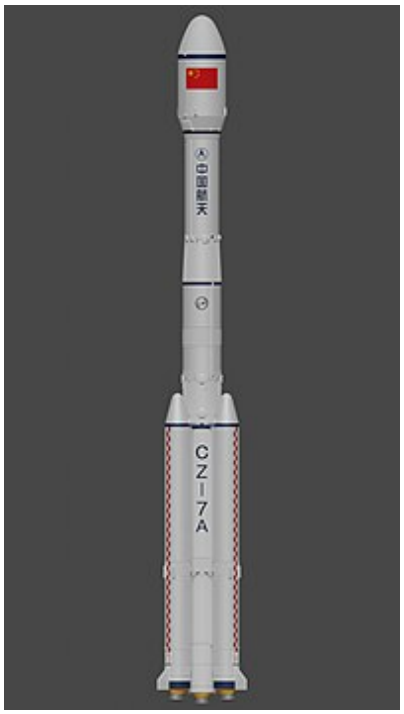
3. **CNSA:**

a. **Long March 7:**

Length- 53 m
Diameter- 7.85 m (including boosters)
Lift-off mass- 597 t
Lift-off thrust- 7200 kN
No. of stages- 2 (plus 4 Strap-on boosters)
Payload to LEO- 14,000 kg
Payload to SSO- 5,500 kg
Cost- US$ 30-81 million

b. **Long March 7A:**

Length- 60.13 - 60.7 m
Diameter- 7.85 m (including boosters)
Lift-off mass- 573 t
Lift-off thrust- 7200 kN
No. of stages- 3 (plus 4 Strap-on boosters)
Payload to GTO- 7,800 kg
Cost- US$ 30-81 million



c. **Long March 8:**

Length- 50.3 m
Diameter- 3.35-7.85 m (including boosters)

Lift-off mass- 356.6 t
Lift-off thrust- 4800 kN
No. of stages- 2 (plus 0–2 Strap-on boosters)
Payload to LEO- 8,100 kg
Payload to SSO- 5,000 kg
Payload to GTO- 2,800 kg
Cost- US$ 30-81 million

d. Long March 11:

Length- 20.8 m
Diameter- 2 m
Lift-off mass- 58 t
Lift-off thrust- 1188 kN
No. of stages- 4 solid
Payload to LEO- 700 kg
Payload to SSO- 350 kg
Cost- US$ 30-81 million

4. **Roscosmos:**

a. **Angara 1.2:**

Manufacturer- Khrunichev
Launch weight- 171.5 t
Height(maximal)- 41.5 m
Payload (LEO 200 km)- 3,500 kg
Payload (SSO)- 2,400 kg
Thrust (at sea level)- 1.92 MN
No. of stages- 2
Cost- US$31 million

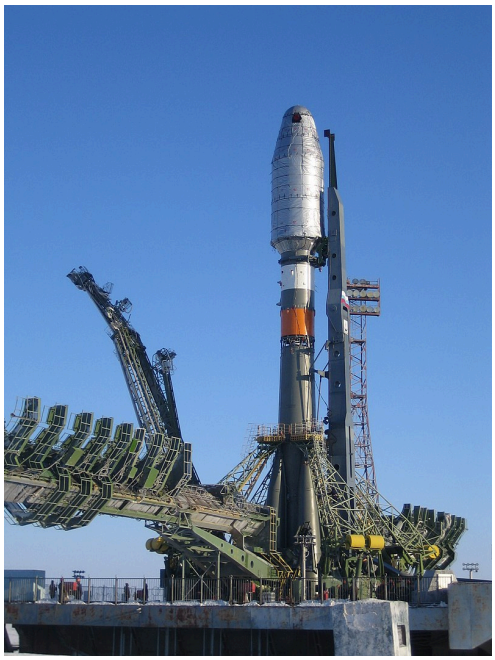
b. **Angara A5:**

Manufacturer- Khrunichev
Launch weight- 759 t
Height(maximal)- 55.4 m
Payload (LEO 200 km)- 24,000 kg
Payload (GTO KVTK)- 7,500 kg
Payload (GTO Briz-M)- 5,400 kg
Thrust (at sea level)- 9.61 MN
No. of stages- 2
Cost- US$100 million

c. **Proton-M:**

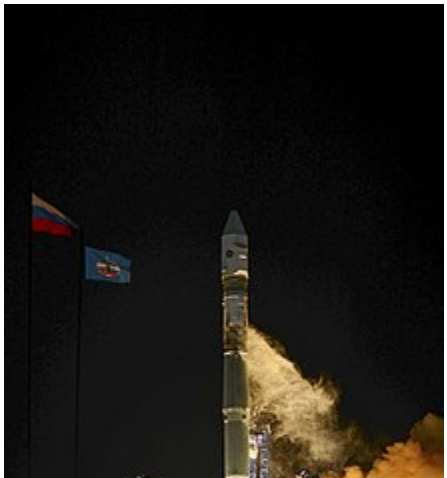
Manufacturer- Khrunichev
Height- 58.2 m
Diameter- 7.4 m
Launch weight- 705 t
Payload (LEO)- 23,000 kg
Payload (GTO 1800 m/s)- 6,920 kg
Payload (GTO 1500 m/s)- 6,300 kg
Payload (GSO)- 3,250 kg
Maximum Thrust- 10,532 kN
No. of stages- 3 or 4
Cost- US$65 million

d. **Soyuz 2.1a:**
Manufacturer- Progress Rocket Space Centre
Height- 46.3 m
Diameter- 2.95 m
Launch weight- 312 t
Payload (LEO from Baikonur)- 7,020 kg
Payload (LEO from Kourou)- 7,800 kg
Payload (GTO from Kourou)- 2,810 kg
Payload (SSO form Kourou)- 4,230 kg
Maximum thrust- 4,149 kN
No. of stages- 2 or 3
Cost- US$80 million



e. **Soyuz 2.1b:**
Manufacturer- Progress Rocket Space Centre
Height- 46.3 m
Diameter- 2.95 m
Launch weight- 312 t
Payload (LEO from Baikonur)- 8,200 kg
Payload (LEO from Kourou)- 9,000 kg
Payload (GTO from Baikonur)- 2,400 kg
Payload (GTO from Kourou)- 3,250 kg
Payload (SSO from Kourou)- 4,900 kg
Payload (TLI from Kourou)- 2,720 kg
Maximum thrust- 4,149 kN
No. of stages- 2 or 3
Cost- US$80 million

f. **Soyuz 2.1v:**
Manufacturer- Progress Rocket Space Centre
Height- 44 m
Diameter- 3 m
Launch Weight- 158 t
Payload (200km x 51.8° LEO)- 2,850 kg
Payload (200km x 62.8° LEO)- 2,800 kg
Maximum Thrust- 1,534 kN



No. of stages- 2
No. of boosters- 4
Cost- US$80 million

5. **ESA:**

a. **Ariane 5:**

Operator- Arianespace
Height- 55 m
Payload fairing(diameter): Two sizes- 5.4 m and 4.57 m
Launch weight- 777 t
Payload (260 km 51,6° LEO)- 20,000 kg
Payload (GTO)- 10,000 kg
Maximum Thrust- 2x5000 kN
No. of stages- 2 or 3
Cost per Launch- €150-200 mn

In 2021, Ariane 5 ECA launched the James Webb Telescope on its way to L2(sun-earth).

b. **Ariane 5 ECA:**

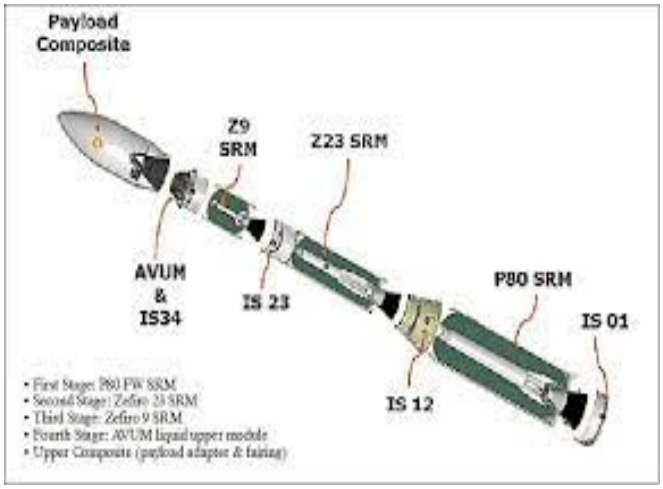
Operator- Arianespace
Height- 53 m
Diameter- 5,4 m
Launch weight- 780 t
Payload (260 km 51,6° LEO)- 20,000 kg
Payload (GTO)- 10,000 kg
Maximum Thrust- 2x5000 kN
No. of stages- 3
Cost per Launch- €150-200 mn

c. **Ariane 5 ES:**
Operator- Arianespace
Height- upto 50 m
Diameter- upto 5.4 m
Launch weight- 760 t
Payload (including dispenser)- 3,400kg (2950 kg + 450 kg for dispenser)
Cost per Launch- €150-200 mn

The Ariane 5 ES (Evolution Storable) is derived from the generic Ariane 5 but uses a more powerful lower composite and a small upgraded storable propellant stage, allowing reignition and long coast phases.

d. **Vega:**
Operator- Arianespace
Height- 30 m
Diameter- 3 m
Launch weight- 137 t
Payload (700 km circular at 90° LEO)- 1,500 kg
No. of stages- 4
Cost- US$37 million

In a proof of concept flight in 2020, Vega demonstrated a new modular payload dispenser called the Small Spacecraft Mission Service (SSMS) designed to meet the need for affordable routine rideshare



missions to space for multiple small satellites.

e. **Soyuz:**
Operator- Roscosmos and Arianespace
Height- 46.3 m
Diameter- 2.95 m
Weight- 308 t
Payload
No. of stages- 3
Cost- US $35-80 million

It was launched from Europe's Spaceport in French Guiana, and it was the first time that a Soyuz was launched from a spaceport other than Baikonur or Plesetsk.

6. **JAXA:**

a. **Epsilon:**
Overall height- 24.4 m
Diameter- 2.5 m
Total weight- 91 t
Payload to LEO- 1,200 kg
No. of stages- 3
Cost- USD $ 20-30 mn

There are a few other launch vehicles by JAXA too, but they are either inoperational or in development phase.