Brief history of spacecraft

Basically a space vehicle is defined as the machine designed to fly in outer space. Space vehicles may be used for so many purposes such as :

- Communications
- Earth observations
- Meteorology
- Navigation
- Space Colonization
- Planetary Exploration
- Transportation of human and cargo

Hubble telescope

Source: wiki

- In the case of airplanes, we may recall that airplane speed and height increased with years

- This is due to technological developments in the field of aviation, which made it possible to go so higher and faster that a vehicle can really go beyond atmosphere, that is, in space where only gravity is in work

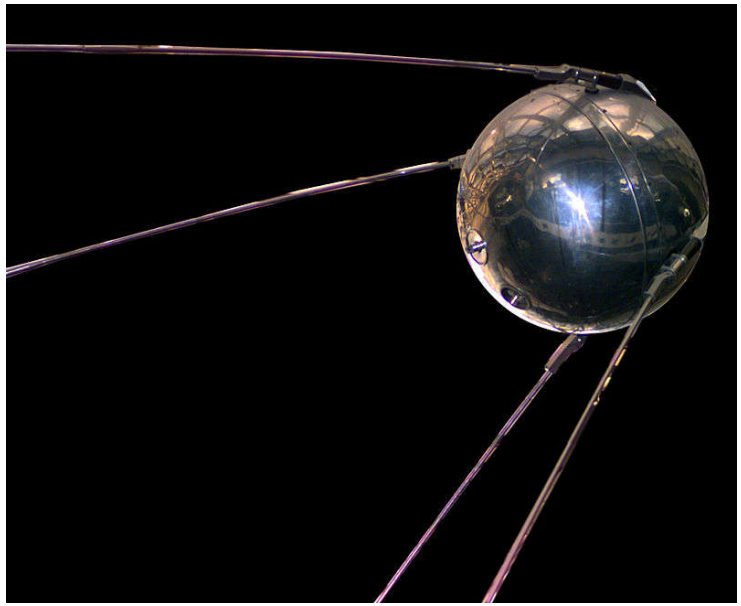
- Finally formal space age began on Oct. 4, 1957 with the Russian success of launching an artificial satellite, *Sputnik I*, in an orbit around the earth

Sputnik 1

- **Sputnik 1** was the first artificial Earth satellite & marked the start of the space age.

- The Soviet Union launched it into an elliptical low Earth orbit on 4 October 1957, orbiting for three weeks before its batteries died, then silently for two more months before falling back into the atmosphere.

- It was a 58 cm (23 in) diameter polished metal sphere, with four external radio antennas to broadcast radio pulses



Replica of Sputnik 1

- The impact of this success was quite immediate compared to the case of airplanes

- Within 12 years, people had walked on the moon; it was also possible to send some unmanned probe to the surface of the Venus and Mars

- Spacecrafts are of different types as is the case for airplanes

  - Manned Spacecraft
  - Unmanned spacecraft
  - Spaceplanes

- **Some manned spacecrafts**
  - Vostok I
  - Freedom 7
  - Gemini
  - Skylab
  - Apollo
  - Mercury
  - International Space Station

International Space Station

Vostok I

- **Vostok 1** was the first spaceflight of the Vostok programme and the first manned spaceflight in history.

- The Vostok 3KA space capsule was launched from Baikonur Cosmodrome on April 12, 1961, with Soviet cosmonaut Yuri Gagarin aboard, making him the first human to cross into outer space.

Launch of Vostok I

Skylab

- **Skylab** was the United States' space station that orbited the Earth from 1973 to 1979, when it fell back to Earth amid huge worldwide media attention.

- Launched and operated by NASA, Skylab included a workshop, a solar observatory, and other systems necessary for crew survival and scientific experiments

A photograph of skylab taken by its crew members

Apollo

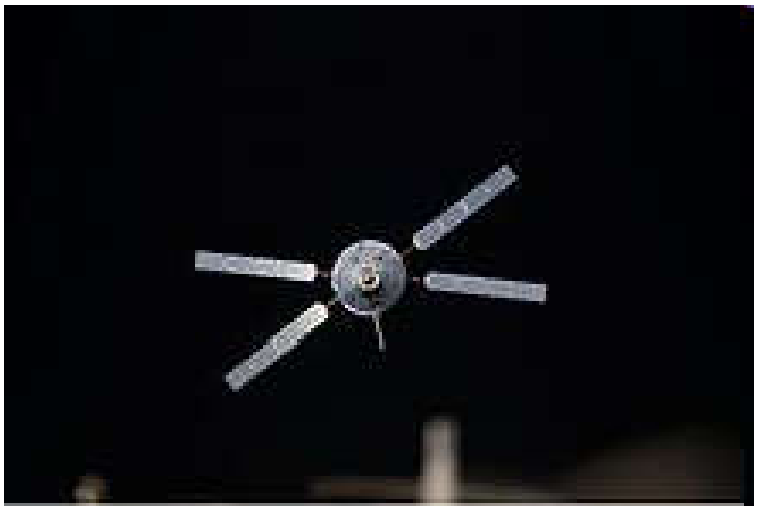
- The **Apollo spacecraft** was composed of three parts designed to accomplish the American Apollo program's goal of landing astronauts on the Moon

- The design was based on the Lunar Orbit Rendezvous approach: two docked spacecraft were sent to the Moon and went into lunar orbit. While the LM separated and landed, the CSM remained in orbit. After the lunar excursion, the two craft rendezvoused and docked in lunar orbit, and the CSM returned the crew to Earth.

The Apollo 17 CSM seen in lunar orbit from the ascent stage of the Lunar Module

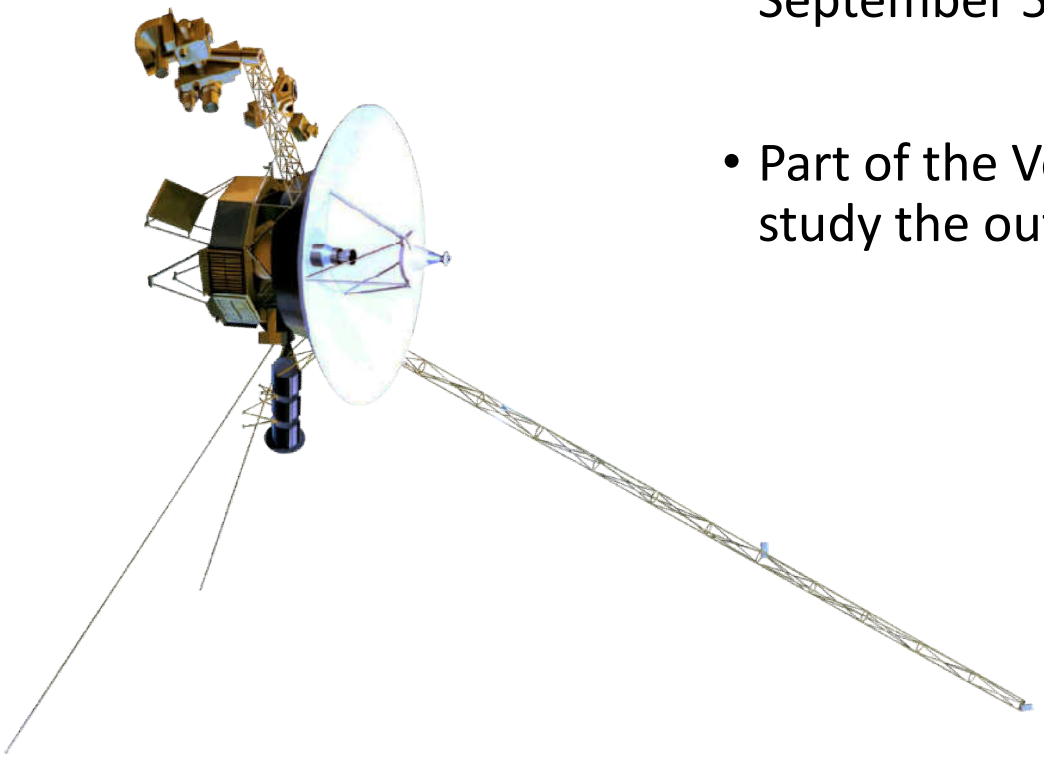
- **Some unmanned spacecrafts**
  - Voyager
  - Chandrayaan
  - Explorer
  - Sputnik
  - Viking

Unmanned ATV-2



Source: wiki

Voyager



- ***Voyager 1*** is a space probe launched by NASA on September 5, 1977.
- Part of the Voyager program to study the outer Solar System

Model of a small-bodied spacecraft with a large, central dish and many arms and antennas extending from it

Chandrayaan

- Chandrayaan was India's first lunar probe. It was launched by the Indian Space Research Organization in October 2008, and operated until August 2009 .

Chandrayaan-1

- The mission was a major boost to India's space program, as India researched and developed its own technology in order to explore the Moon

Spaceplanes

- Vehicles designed only for manned spaceflight are often called spaceplane, for example space shuttle

NASA Space shuttle Atlantis

Source: wiki

- These spaceplanes are sent using solid rocket boosters

Source: wiki

Subsystems of space vehicles

A space vehicle comprises of various subsystems which depend on the profile of the space vehicle. Some of the subsystem are as follows;

Life support system: Spacecraft intended for human spaceflight must also include a life support system for the crew. Life support system creates a living condition in space vehicle and provides air, food and water. Components of the life support system are life-critical, and are designed and constructed using safety engineering techniques.

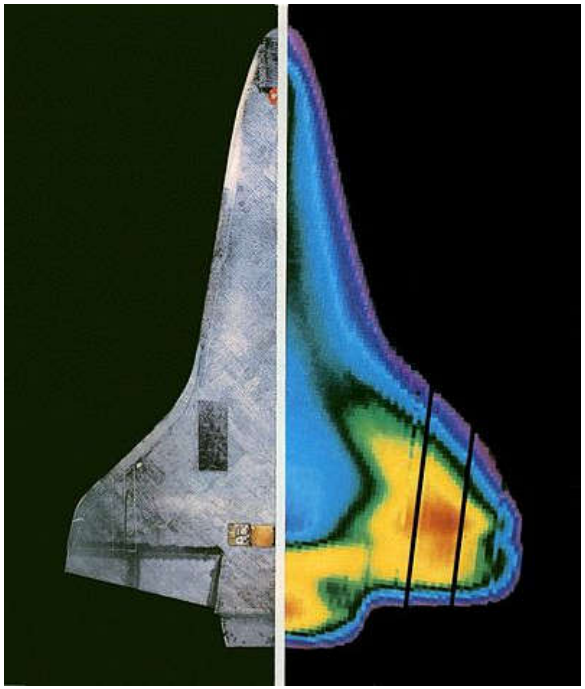
Subsystems of space vehicles(cont.)

Communications : Spacecraft utilize various communications systems for communication with terrestrial stations as well as for communication between spacecraft in space.

Power : Spacecraft need an electrical power generation and distribution subsystem for powering the various spacecraft subsystems. For spacecraft near the Sun, solar panels are frequently used to generate electrical power.

Subsystems of space vehicles(cont.)

Thermal control system : Spacecraft must be engineered to withstand transit through Earth's atmosphere and the space environment. They must operate in a vacuum with temperatures potentially ranging across hundreds of degrees Celsius. Material requirements are such that either high melting temperature, low density materials such as beryllium and reinforced carbon–carbon or (possibly due to the lower thickness requirements despite its high density) tungsten or ablative carbon–carbon composites are used



Subsystems of space vehicles(cont.)

Space Vehicle propulsion system : Spacecraft may or may not have a propulsion subsystem, depending on whether or not the mission profile calls for propulsion. Typically though, LEO spacecraft includes a propulsion subsystem for altitude adjustments (drag makeup manoeuvers) and inclination adjustment maneuvers. A propulsion system is also needed for spacecraft that perform momentum management maneuvers. Components of a conventional propulsion subsystem include fuel, tankage, valves, pipes, and thrusters.

Launch Vehicle : The launch vehicle propels the spacecraft from Earth's surface through the atmosphere into an orbit; the exact orbit being dependent on the mission configuration. The launch vehicle may be expendable or reusable

Launch Vehicles

- It is a vehicle used to carry some payload from earth surface to outer space
- These vehicles are characterized by the mass they carry to the space
- There can be two types of launch vehicles
  - Expandable launch vehicle
  - Reusable launch vehicle

- Some examples of launch vehicles
  - Zenith-2
  - Soyuz
  - PSLV
  - Saturn V

Space Program in India

- The leading body in this regard is the Indian Space Research Organization (ISRO)
- Two leading personality in this respect is worth mentioning: Vikram Sarabhai and Dr Homi Bhaba
- The Indian National Committee for Space Research (INCOSPAR) was established in 1962 with Vikram Sarabhai as its chairman
- India’s space program moved rapidly in 1960s; results are several space vehicles what India developed

Satellite Launch Vehicle (SLV)

- SLV was a 4-stage solid-fuel light launcher
- SLV was designed to reach a height of 500 km and carry a payload of 40kg. It was first launched in 1979

Augmented Satellite Launch Vehicle (ASLV)

- It was a 5-stage solid propellant rocket
- It is capable of placing a 150 kg satellite on LEO. Its first launch was on 1987

Polar Satellite Launch Vehicle (PSLV)

- It is better known by its abbreviation PSLV, which can launch Indian remote sensing (IRS) satellite into sun synchronous orbits
- It can also launch small satellites into geostationary orbit (GTO)
- Its reliability is proven by the fact that it has launched 30 spacecraft (14 Indian and 16 from other countries) into a variety of orbits so far

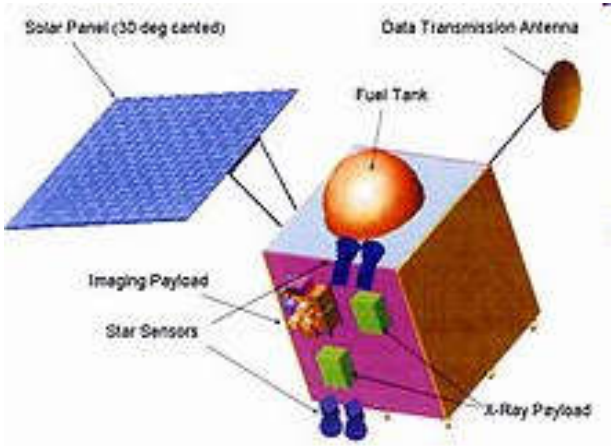
Source: wiki

Geosynchronous Satellite Launch Vehicle (GSLV)

- It is currently under development by ISRO
- Its basic purpose is to launch heavy satellites into geostationary orbit
- It will allow us to be less dependent on foreign launch vehicle for heavy satellites

Source: wiki

Chandrayaan I



- India's first moon mission, Chandrayaan-I was launched successfully 22nd October, 2008 from Shrihari Kota
- It orbited the moon at a height of 100 km from the moon surface
- It carried 11 instruments
- PSLV-CII was used to launch the spacecraft

An example of a Launch Vehicle Configuration

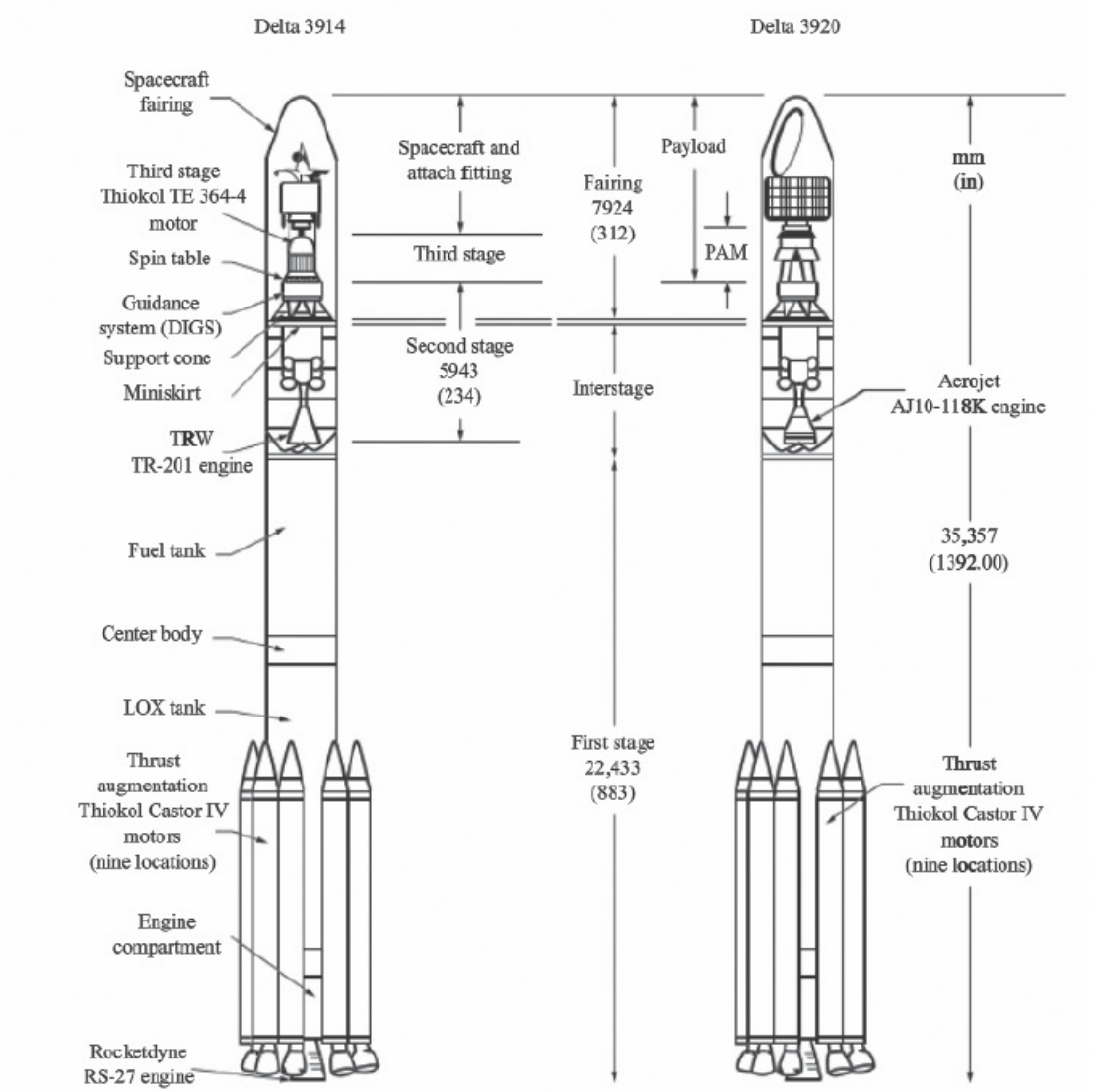


Figure 2.21 Delta 3914 and 3920 rocket booster configurations.
(Source: *From M. D. Griffin and J. R. French,* Space Vehicle Design, *AIAA: Reston, Virginia, 1991.*)

Source: *Introduction to Flight* by John D. Anderson.

Propellants

- **Liquid propellants**
  - **Cryogenic propellants:**
    - **Examples: Liquid H_2 (at or below 20 K) and liquid O_2 (at or below 135 K)**
    - Combination of liquid H_2 – O_2 combination yields a high specific impulse; for example, the vacuum *Isp = 455s. The combustion process in the rocket engine is started with* an igniter, and the burning is self-sustaining after that.
  - **Bipropellants:**
    - Fuel and oxidizer are separate
    - **Examples: Liquid H_2 and liquid O_2**
  - **Monopropellants:**
    - Some chemicals exist in which chemical energy can be released simply by decomposing the molecules; these are called *monopropellants.*
    - **Example: Hydrazine (N_2H_4)**
  - **Hypergolic propellants**
    - Some propellant combinations ignite simply on contact with one another., and these are called *hypergolic propellants.*
    - **Examples: Fluorine (F_2) is hypergolic with most fuels**

Source: *Introduction to Flight* by John D. Anderson.

- **Solid propellants**
  - Fuel and oxidizer are premixed and cast in solid form. Solid rocket boosters of the Space Shuttle use a solid propellant.
  - Solid propellant consists of atomized aluminum powder (16 %) as a fuel and ammonium perchlorate (69.93 %) as an oxidizer. The remainder is iron oxide powder (0.7 percent) as a catalyst and polybutadiene acrylic acid acrylonitrile (14 percent) as a rubber-based binder.

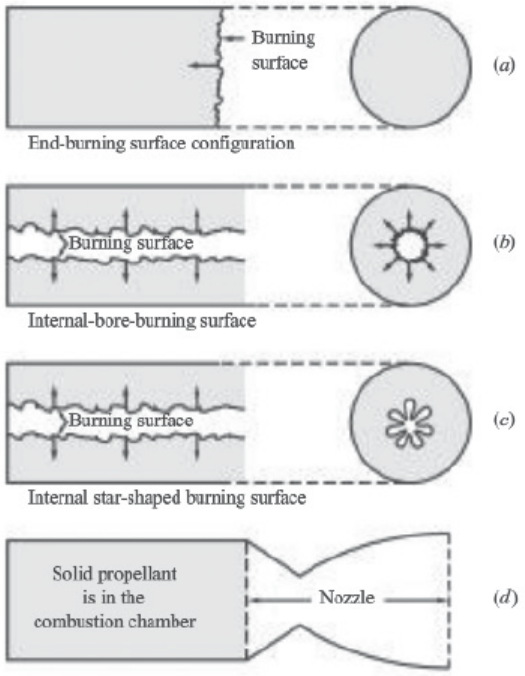


Figure 9.30 Some solid propellant burning configurations.

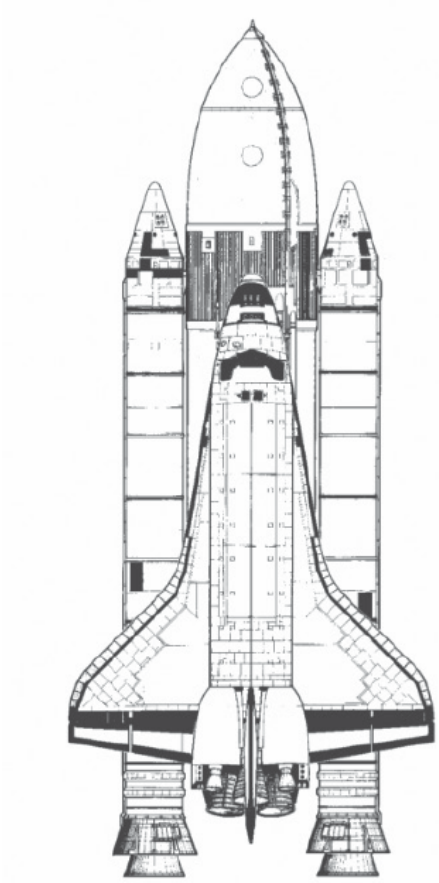


Figure 8.48 The Space Shuttle. (Source: *Rockwell International.*)

Source: *Introduction to Flight* by John D. Anderson.

In comparison to liquid propellants, solid propellants have the following advantages and disadvantages:

- *Advantages*
  - Solid rockets are simpler, safer, and more reliable. There is no need for pumps and complex propellant feed systems.
  - Solid propellants are more storable and stable. Some solid rockets can be stored for decades before use.
  - Solid propellants are dense, and therefore the overall volume of solid rockets is smaller.
- *Disadvantages*
  - The specific impulse of solid propellants is considerably less than that of liquid propellants. For the Space Shuttle's solid rocket boosters, $Isp = 242$ s at sea level. In general, the specific impulse of solid rockets ranges from 200 to 300 s.
  - Once a solid rocket is ignited, it usually cannot be turned off. Also, it is difficult to throttle a solid rocket to vary the thrust. In contrast, liquid rockets are easily throttled, and the thrust can be cut off whenever desired just by manipulating the fuel and oxidizer valves.

Source: *Introduction to Flight* by John D. Anderson.

References:

- Wikipedia
- Google Images
- *Introduction to Flight* by John D. Anderson