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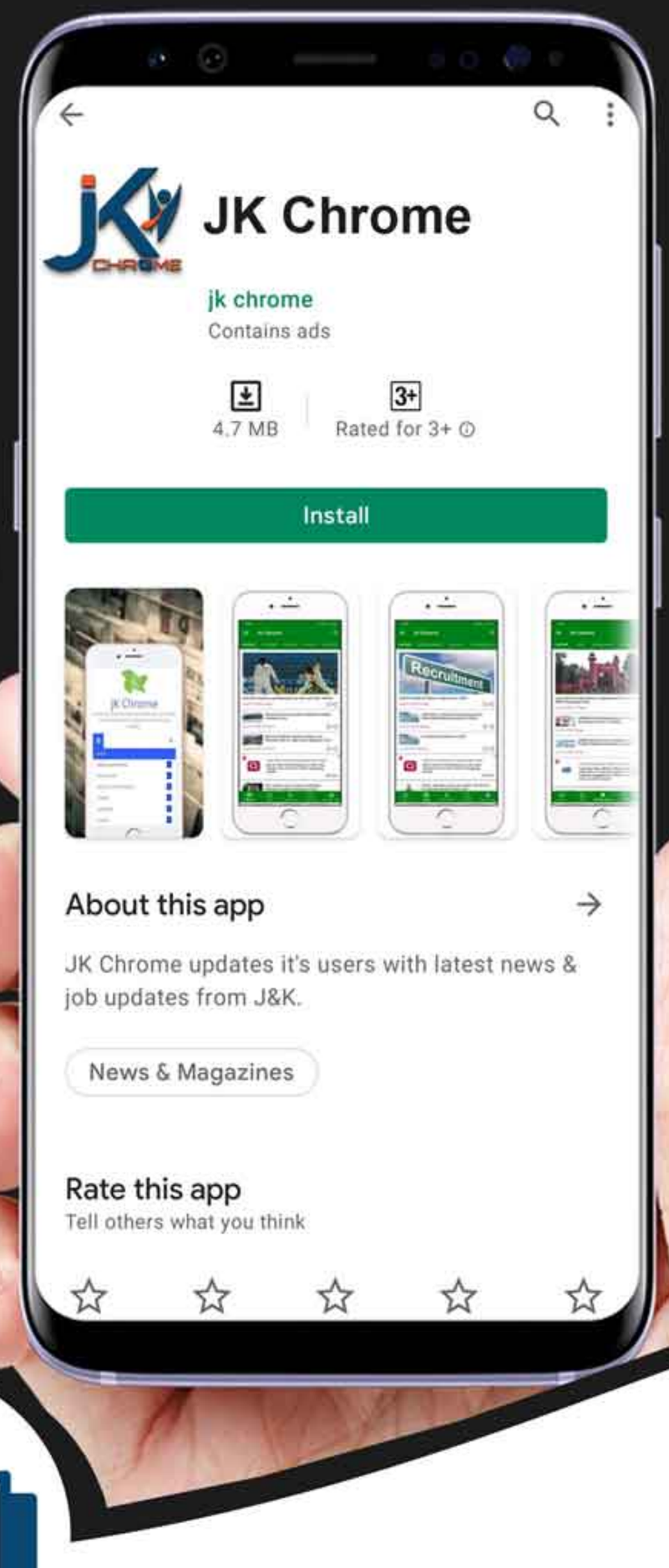

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SCIENCE & TECHNOLOGY NOTES

INDEX

1. SPACE SCIENCE

1. THE INDIAN SPACE RESEARCH ORGANISATION

- **ISRO** is the space agency of the Government of India headquartered in Bengaluru.
- **Vision:** "To harness space technology for national development while pursuing space science research and planetary exploration."
- ISRO was Formed in 1969, ISRO **superseded the erstwhile Indian National Committee for Space Research (INCOSPAR) established in 1962**. The establishment of ISRO thus **institutionalised space activities in India**.
- It is **managed by the Department of Space**, which reports to the Prime Minister of India.

ACHIEVEMENTS AT A GLIMPSE

- ISRO **built India's first satellite, Aryabhata**, which was launched by the Soviet Union on 19 April 1975.
- In 1980, **Rohini became the first satellite to be placed in orbit by an Indian-made launch vehicle, SLV-3**.
- ISRO subsequently developed two other rockets:
    1. The Polar Satellite Launch Vehicle (PSLV) for launching satellites into polar orbits and
    2. The Geosynchronous Satellite Launch Vehicle (GSLV) for placing satellites into geostationary orbits.
- These rockets have launched numerous communications satellites and earth observation satellites.
- Satellite navigation systems like GAGAN and IRNSS have been deployed.
- In January 2014, ISRO used an indigenous cryogenic engine in a GSLV-D5 launch of the GSAT-14.
- ISRO sent a lunar orbiter, Chandrayaan-1, on 22 October 2008 and a Mars orbiter, Mars Orbiter Mission, on 5 November 2013, which entered Mars orbit on 24 September 2014, making India the first nation to succeed on its first attempt to Mars, and ISRO the fourth space agency in the world as well as the first space agency in Asia to reach Mars orbit.
- On 18 June 2016, ISRO set a record with a launch of 20 satellites in a single payload, one being a satellite from Google.
- On 15 February 2017, ISRO launched **104 satellites in a single rocket** (PSLV-C37) and created a world record.

- ISRO **launched its heaviest rocket, Geosynchronous Satellite Launch Vehicle-Mark III (GSLV-Mk III)**, on 5 June 2017 and placed a communications satellite GSAT-19 in orbit. With this launch, ISRO became capable of launching 4-ton heavy satellites into GTO.
- Future plans include the development of Unified Launch Vehicle, Small Satellite Launch Vehicle, development of a reusable launch vehicle, human spaceflight (Gaganyaan), controlled soft lunar landing, interplanetary probes, and a solar spacecraft mission.

CHALLENGES AHEAD FOR ISRO

- **Bottleneck situation:** The bottleneck situation for ISRO is that it has 2 **launch pads and only has 1 vehicle assembly**.
- **Interval between two launches:** Earlier the interval between two launches was large; but although it has been brought down, to sustain this, **auxiliary capacity like vehicle assembly building is needed, which is a 90-metre building**.
- **Achieving an increase in number of launches:** To achieve **18+ launches a year,** ISRO need to **create more capacity**.
    - India aims **60 launches in the next five years** which will need **assembled and integrated satellites by ISRO and the private sector in a joint venture**.
- **Cost-effectiveness:** Cost-effectiveness is an issue with **a large number of private entities coming into launch payloads and for which the competition becoming intense**.
- **Slow execution of projects and lack of government support** is hampering India's efforts to compete with China and Russia as a cheaper option for launching satellites.
- **Growth of space industry: Absence of heavy rocket launchers, too few launch facilities and bureaucratic delays** hamper growth of India's space industry.

NEW AREAS OF FOCUS FOR ISRO

- **Reducing in total mission cost:** It should aim for reducing the total mission cost. The satellite cost should be less, so also the cost of the launch vehicle.
- **Reusable launch vehicle:** It is developing the technologies for a future reusable launch vehicle.
- **Applications area:** It should also think of innovative applications.
    - Recently, it has validated a new mobile app to help fishermen. E.g. GEMINI.
    - It tells them where they can find large fish shoals in the sea.
- **Addition in numbers of satellites:** India has 43 satellites in space and to meet the present national requirement, India needs an equal number of satellites in addition.
- **Increasing the launch frequency:** The frequency of launches must definitely increase. For that, ISRO has set 18 launches per year as the target.
- **A healthier budget:** More satellites are required to be put in orbit and they need more launch vehicles. For that, much more money is needed on the launch vehicle side, spacecraft side and on the infrastructure side.
- **Govt may set up new rocket launch pad near Kulasekarapattinam in Tamil Nadu**
- **Public private association:** This year, the priority would be to **allow a public private consortium to build the PSLV rocket.**
    - ISRO has to hasten the effort to bring in private players into satellite and rocket building, to replicate India's software success in aerospace.

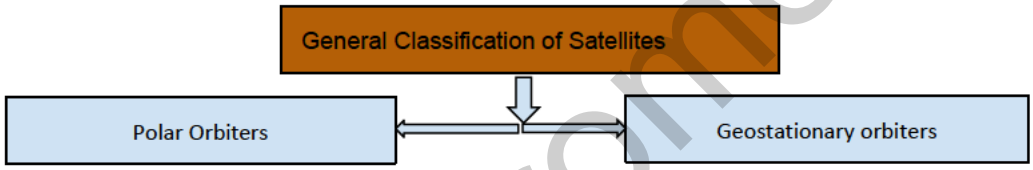
Antrix Corporation Limited (Antrix), incorporated on 28 September 1992 (under the Companies Act, 1956), is a wholly owned Government of India Company under the administrative control of Department of Space (DOS). Antrix is the commercial arm of Indian Space Research Organisation (ISRO). Antrix promotes and commercially markets the products and services emanating from the Indian Space Programme. In the year 2008, the Company was awarded 'MINIRATNA' status.

The current business activities of Antrix include:

a) Provisioning of communication satellite transponders to various users,
b) Providing launch services for customer satellites,
c) Marketing of data from Indian and foreign remote sensing satellites,
d) Building and marketing of satellites as well as satellite sub-systems
e) Establishing ground infrastructure for space applications, and
f) Mission support services for satellites.

2. SATELLITE ORBITS

SATELLITE ORBITS: It refers to the fixed trajectory in which a celestial body e.g. planet Earth (or even a satellite) revolves around the larger body e.g. the Sun, with which it is bound by gravitational force.



Satellites launched in space around the Earth are generally placed in either of the following orbits depending on their purpose;

a. **Geosynchronous Orbit**
b. **Geostationary Orbit**
c. **Geosynchronous Transfer Orbit**
d. **Polar Orbit**
e. **Sun Synchronous Polar Orbit**

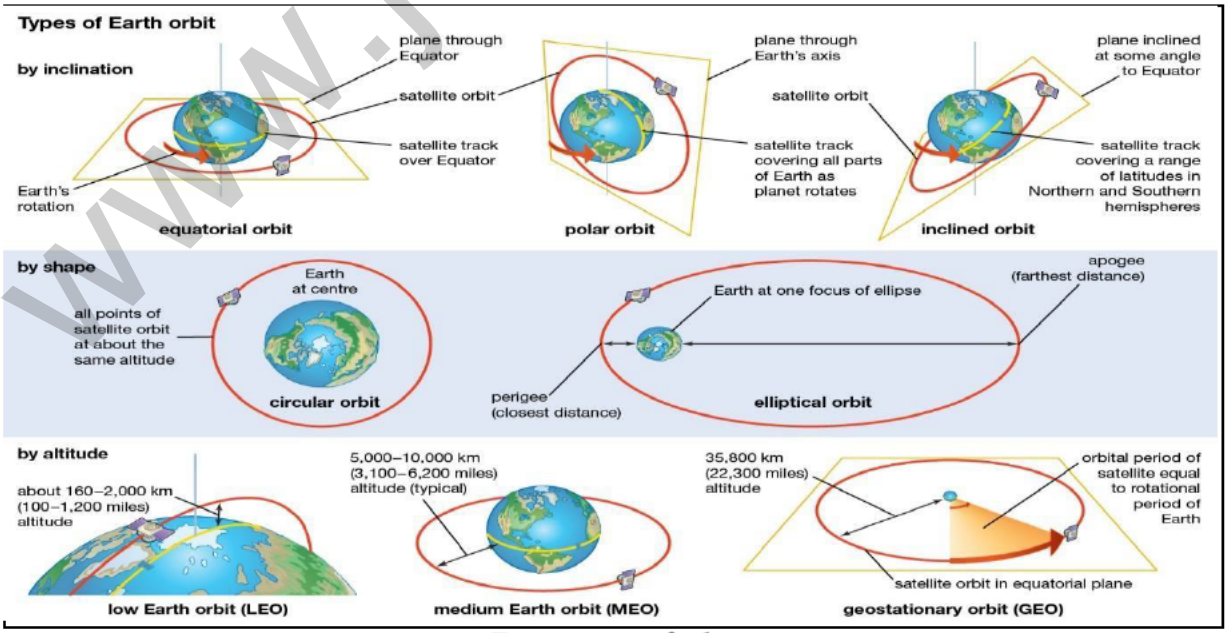


Figure: types of orbit

The **Geosynchronous Orbit and Geostationary Orbit** are defined on the basis of following conditions:

- **Condition 1**: If the satellite is placed at an altitude of **35786 km above the Earth**, where its velocity is such that it takes exactly 23 hrs 56 minutes 4 sec to revolve around the Earth.
- **Condition 2**: If the **Orbital plane and the Equatorial plane lies in the same plane** throughout.

If both the above conditions are satisfied, the satellite is said to be placed in **Geostationary orbit**. If only condition 1 is satisfied, the orbit is called as **Geosynchronous orbit**. Thus, all Geostationary orbits are Geosynchronous as well, while the vice versa is not true.

The Geostationary satellites remain **permanently fixed** with respect to a point on earth while the Geosynchronous satellites have a **varying position** with respect to a point on earth and **wider coverage**.

Geosynchronous Transfer Orbit refers to an elliptical Geosynchronous orbit from where the satellite is transferred to a higher orbit or to Geostationary orbit through **orbit maneuvering**.

The **Sun Synchronous Polar Orbit** or the Polar orbit refers to a **Low Earth Orbit (500-2000km)** in the polar plane. From this orbit, when the satellite observes a given ground location, **the sun is always at the same location** in the sky. When a satellite has a **sun-synchronous polar orbit**, it means that it has a **constant sun illumination** through inclination and altitude. For sun-synchronous orbits, it passes over any given point on Earth's surface at the **same local solar time**.

LAUNCHING OF SATELLITE INTO ORBIT

The satellites are launched vertically, so that it crosses the thickest portion of the atmosphere as quickly as possible. However, once it reaches a desired, predetermined altitude, most of the rockets' propelling power is then used to accelerate it horizontally so that it enters a stable orbit around the planet.

Since the gravitational pull of Earth is highest in the LEO, satellites in the LEO are more strongly pulled by the planet than those in the MEO or geostationary orbit. Because of this, the satellites in the LEO travel much faster (i.e., they have a high orbital velocity) than the ones in higher orbits. And whereas if it orbits at high Velocity at higher altitudes, Centrifugal force may be observed and will lose its orbit.

The rocket has to get into various orbits of smaller radius before reaching the orbit of required radius. The four orbit stages involved in the satellite launch procedure are as follows:

1. Circular low earth orbit
2. Hohmann elliptical transfer orbit
3. Intermediate drift orbit
4. Circular Geostationary orbit

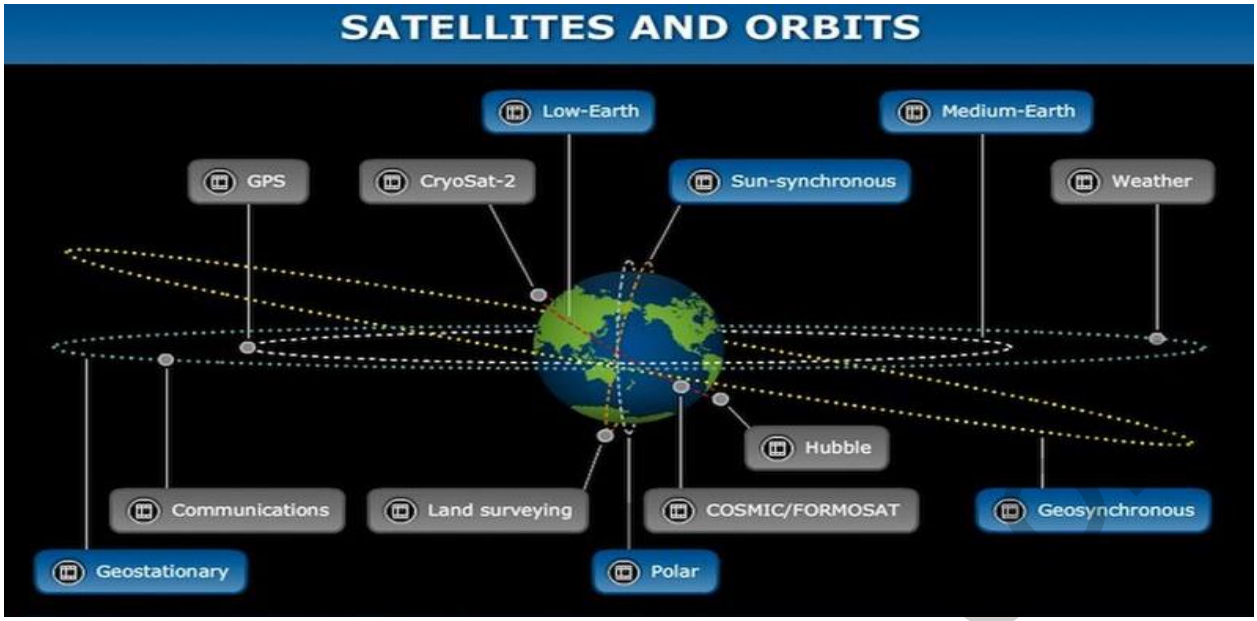


Figure: satellites in their orbits

3. SATELLITE LAUNCH VEHICLE

3.1. POLAR SATELLITE LAUNCH VEHICLE PSLV

- PSLV is the 3rd generation launch vehicle of India.
- It is the 1st Indian launch vehicle to be equipped with liquid stages.
- An expendable launch system developed by ISRO
    - The vehicle typically consists of several rocket stages, discarded one by one as the vehicle gains altitude and speed.
    - Designed to be used only once (i.e. they are "expended" during a single flight),
    - Their components are not recovered for reuse after launch.
- To launch Indian Remote Sensing (IRS) satellites
- PSLV can also launch satellites weighing up to 1750kgs.

STAGES OF PSLV

PSLV launch vehicle has 4 Stage:

- **First Stage: PS1:** PSLV uses the S139 **solid** rocket motor.
- **Second Stage: PS2:** PSLV uses an Earth storable **liquid** rocket engine for its second stage, known as the **Vikas engine.**
- **Third Stage: PS3:** The third stage of PSLV is a **solid rocket** motor that provides the upper stages high thrust after the atmospheric phase of the launch.
- **Fourth Stage: PS4:** the uppermost stage of PSLV, **comprising of two Earth storable liquid engines**.

SIGNIFICANCE

- After its first successful launch in October 1994, PSLV emerged as **the reliable and versatile workhorse launch vehicle** of India with 39 consecutively successful missions by June 2017.
- During 1994-2017 period, the vehicle has launched 48 Indian satellites and 209 satellites for customers from abroad.

- Besides, the vehicle successfully launched two spacecraft – **Chandrayaan-1 in 2008 and Mars Orbiter Spacecraft in 2013** – that later traveled to Moon and Mars respectively
- **Commercial operations:**
    - It represents the **incredible commercial opportunities that lie before ISRO,** especially at a time when the world is straining to send stuff into space as cheaply as possible.
    - From the 44 satellites for foreign countries that it launched between January 2014 and December 2016, Antrix, **the ISRO's commercial arm, has made around €98 million** (Rs693 crore).
- Transporting satellites to space can be done at **low cost**.

CONSTRAINTS FACED BY PSLV

- Payload capacity of PSLV is limited to 1500 kg therefore India is **not able to target lucrative high payload market.**
- **Limited GSLV capabilities:** ISRO use foreign launch vehicles draining foreign exchange

PSLV AND RECENT LAUNCHES

PSLV or the Polar Satellite Launch Vehicle was developed by ISRO by **1993**. These are rockets used to launch Earth Observation and mapping satellites (called **Remote Sensing Satellite**) into **Sun-synchronous Low Earth Orbit** and also to **Geostationary Transfer orbit** (although for lighter satellites).

- It is a **four-stage** rocket which uses **solid and liquid fuel**, having six strap-ons/boosters. It can launch **upto 3800 kg payload in LEO, upto 1750 kg payload to Sun synchronous orbit** and upto **1200 kg payload to Geostationary Transfer orbit**.
- Out of its 46 missions, 43 have been successful which includes **Chandrayaan I and Mangalyaan missions**.

HYSIS

It was launched aboard **PSLV-C43** in November 2018 and is placed in a **sun-synchronous low earth orbit**. It weighs around 380 kg.

Significance:

- It is an **earth observation satellite** with the primary goal of studying the earth's surface in the visible, near infrared and shortwave infrared regions of the electromagnetic spectrum.
- Most importantly, it will provide **hyperspectral imaging services** for various applications in **agriculture, forestry** and in the assessment of geography such as **coastal zones and inland waterways.**

MICROSAT-R

It was launched by ISRO's PSLV C-44 in January 2019. The satellite weighted 740 kg. It was the **first of its kind to be fully developed by DRDO** for **military purposes.** Also, it is placed in a much lower **polar orbit of 274 km** above the earth surface. It is also an an imaging satellite but for **military use only.**

In another **first**, PSLV-C44 **reused its spent fourth stage** as a platform for carrying out microgravity experiments and **to put Kalamsat V2 into orbit**. Kalamsat V2, a student payload, is the **world's lightest satellite** weighting only 1.26 kg, to be successfully placed into the orbit.

3.2. GEOSYNCHRONOUS SATELLITE LAUNCH VEHICLE (GSLV)

- GSLV, the **4th Generation** Launch Vehicle of India is a **3-stage** vehicle with **4 liquid strap-ons**

STAGES OF GSLV

- The first stage consists of a large **solid rocket,** derived from the PSLV first stage.
    - It is augmented by four liquid fuelled strap-on boosters.
    - Each booster is powered by a Vikas engine and remains connected with stage 1 during the flight.
- The second stage is a **liquid fuelled stage featuring storable propellants**.
- The indigenously developed **cryogenic Upper Stage (CUS)**, which is flight proven, forms the third stage of GSLV Mk II.
    - The Cryogenic Upper stage employs the vital technology that **enhances the payload capability** to make the vehicle suitable for launching communication satellites.

WHY DO WE NEED CRYOGENIC UPPER STAGE (CUS)?

- PSLV launch vehicle has 4 stages. But by using only solid and liquid propellants, India was **not in a position to create more amount of thrust** which is required to launch a heavier satellite.
- This is the reason GSLV was developed where the first stage is **solid** followed by **liquid stage** and 3rd stage is a **cryogenic stage**.
- **Cryogenic Upper Stage means the third and the final fuel stage in cryogenic engine.**
- Cryogenic rocket engine **provides more thrust** than conventional liquid rocket engines but the fuel and oxidizer need to be supercooled in order to keep them in a liquid state.
- Cryogenic fuels are also very clean as they give out only water and heat while burning.

WHY DO WE NEED GSLV?

- Most contemporary communications satellites are normally in the weight category of four to five tons and therefore require a more powerful launcher.
- India's future missions to the Moon, Mars and Venus are also expected to involve the launch of satellites in the same weight category.
- It will be a forerunner to India sending its astronauts to space.

ACHIEVEMENTS

- From January 2014, the vehicle has achieved four consecutive successes.
- GSLV's capability of placing up to 5 tonnes in Low Earth Orbits broadens the scope of payloads from heavy satellites to multiple smaller satellites.

SIGNIFICANCE OF GSLV

- Proved the capability of ISRO
- GSLV will **cost just 1/3rd of money spent on foreign agencies** =>
    - It will **reduce satellite launch cos**t as well as will save forex.
    - It will enhance India's capability to be a competitive player in the multimillion-dollar commercial launch market. It will help in earning foreign exchange.
- The GSLV will **help ISRO put heavier communication satellites of GSAT class into orbit**.
- **Reduction of dependence on foreign agencies** gives strategic boost in this high-tech sector.
- **Government can use Indian space program for the soft power the diplomacy. E.g. launch of South Asia satellite.**

	PSLV	GSLV
Generation	Third generation launch vehicle	Fourth generation launch vehicle
Type of satellites	Deliver the "Remote-sensing" satellites to Sun-Synchronous orbits.	Deliver the "Communication-satellites" to Geo-synchronous orbits.
No. of stages	Four-staged vehicle with 2 solid and 2 liquid stages	Three-staged vehicle with a solid, liquid and cryogenic stage
Variants	• PSLV-G • PSLV-CA • PSLV-XL	• GSLV Mk-I • GSLV Mk-II • GSLV Mk-III
Lift-off mass	230-320 tonnes	400-600 tonnes
Height	44 m	49.13 m
Diameter	2.8 m	4 m

Figure: comparison between PSLV and GSLV

ISRO's GSLV Mk III

ISRO successfully launched GSAT 29 in 2018 which is a **communication satellites** placed in **Geostationary orbit**. (The mechanism and structure of GSLV and PSLV have covered extensively under Chapter 2).

Geostationary Satellite Launch Vehicle (GSLV) Mk III

It is a **three-stage** heavy lift launch vehicle developed by ISRO to carry **upto 4-ton** weight satellites into **GTO** or about **10 tons** to **Low Earth Orbit** (LEO).

Stage 1: Two S200 solid rocket boosters to provide the huge amount of thrust required for lift off.

Stage 2: Core Stage: L110 Liquid Stage

Stage 3: **Cryogenic** Upper Stage: C25

SIGNIFICANCE OF GSLV MK III

- It has made India capable of launching four-tonne satellites into geostationary orbit, relieving it from **depending on foreign players** to launch its heavy satellites and hence **saving forex**.
- It also brings India into the multibillion-dollar **global commercial satellite launch market,** where it can now compete with its **cheaper and reliable** launch capacity.
- The heavy launcher has the potential also to be used in a **Indian human space programme,** hence **Gaganyaan** mission will be launched aboard this launcher.
- It will serve as **prequel for developing even heavier capacity** launch vehicles in the future.
- It will give **boost to R&D** in space science in the country apart from **reducing cost** of heavy satellite launches.

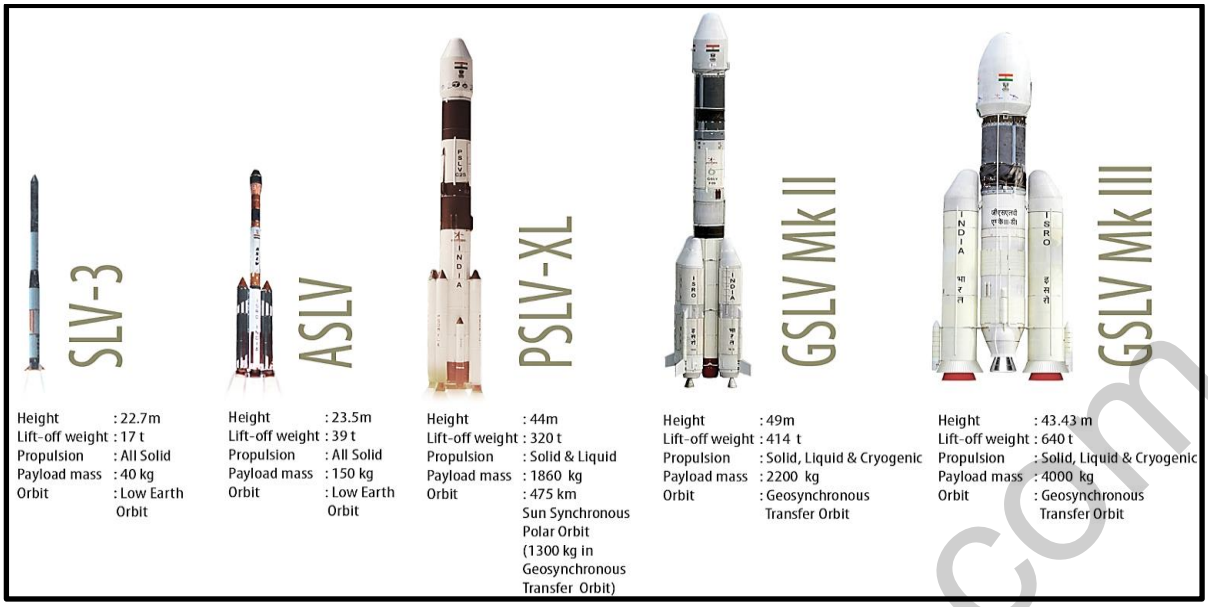


Figure: Indian satellite launch vehicles

Few successful GSAT launches.

GSAT 29

It is a **communication satellite** weighting 3423 kg launched and placed in Geostationary orbit aboard GSLV Mk III rocket in 2018. It was the **20th GSAT series satellite** to be launched out of which 14 are operational as of now, using over **160 transponders** for providing services related to **telecommunications, television broadcasting, weather forecasting, disaster warning and search and rescue operations**.

Significance

- It will provide high-speed bandwidth to **Village Resource Centres** (ISRO's initiative) in rural areas.
- It is also an experimental satellite, with new technologies in **Q (microwave) band and V band** being tried for the **first time**.
- It will also help in providing **better communication services to Jammu and Kashmir and Northeast India,** under Digital India programme, by increasing the number of transponders in the Indian skies.
- It is the **heaviest satellite lifted** and placed in orbit by an Indian launch vehicle.

The GSAT-19

- A communication satellite that will enhance India's communication infrastructure,
- It was placed into a Geosynchronous Transfer Orbit (GTO) with a perigee (closest point to Earth) 170 km and apogee (farthest point from Earth) 35,975 km.
- It will take about two to three weeks to be placed in its intended orbit.
- The satellite weighs 3,136 kg.
- The GSAT-19 carries a **Ka/Ku-band high throughput communication transponder**.
    - The mission would also augment India's communication resources as a single GSAT-19 satellite will be equivalent to having a constellation of six to seven of the older variety of communication satellites in space.

- It also carries a **Geostationary Radiation Spectrometer (GRASP) payload to monitor and study the nature of charged particles** and **the influence of space radiation on satellites and their electronic components**.
- GSAT-19 is going to be powered for the first time with **indigenously-made Lithium-ion batteries**.
    - These batteries have been made so that India's self-reliance quotient can increase.
    - In addition, similar batteries can then be used to power electric vehicles like cars and buses.
- GSAT-19 also features certain advanced spacecraft technologies including "miniaturised heat pipe, fibre optic gyro, Micro Electro-Mechanical Systems (MEMS) accelerometer". These are all important developments being tested so that they become mainstay systems on future missions.

GSAT-11 MISSION

- India's next generation high throughput communication satellite
- It was **successfully launched on December 05, 2018** from Kourou launch base, French Guiana by Ariane-5 VA-246.
- Weighing about 5854 kg, GSAT-11 is the **heaviest satellite built by ISRO**.
- In the series of **advanced communication satellites** with multi-spot beam antenna coverage over Indian mainland and Islands.
- Mission Life: 15 Years
- Type of Satellite: Communication
- Orbit Type: GTO
- Significance:
    - It will play a vital role in **providing broadband services across the country**.
    - It **will also provide a platform to demonstrate new generation applications**.
- GSAT-11 was **launched into a Geosynchronous Transfer Orbit** and subsequently ISRO's Master Control Facility at Hassan taken over the control of GSAT-11 to perform the initial orbit raising maneuvers using the Liquid Apogee Motor of the satellite for placing it in circular Geostationary Orbit.

3.3. REUSABLE LAUNCH VEHICLE

Context: On May 23, 2016, India became the **5th nation to successfully conduct the flight demonstration of a scaled down version of a winged-body reusable launch vehicle**, thereby validating the critical technologies such as **autonomous navigation, guidance & control, reusable thermal protection system and re-entry mission management**.

- This flight represented the first baby step towards the realisation of a future **fully reusable Two Stage to Orbit (TSTO) space transportation system**.
- **Benefit:** A fully reusable Two Stage to Orbit (TSTO) Launch Vehicle, that
    - **This satellite can launch payloads to Low Earth Orbit with 15 times reusability**,
    - It is expected to **reduce the launch cost by approximately 50 – 60% when compared to that of an expendable launch vehicle**.

WHAT IS REUSABLE LAUNCH VEHICLE?

- A Reusable launch vehicle (RLV refers to **a vehicle which can be used for several missions**.
    - Once the RLV completes a mission, **it returns to the earth and can be used again.**

- Expendable Launch Vehicles (ELV): each launch vehicle is launched once and then discarded.

- A RLV is the **space analog of an aircraft**. Ideally **it takes off vertically on the back of an expendable rocket** and **then glides back down like an aircraft**.
  - During landing phase, an RLV can either land on a runway or perform a splashdown.
  - Small wings provide maneuverability support during landing.

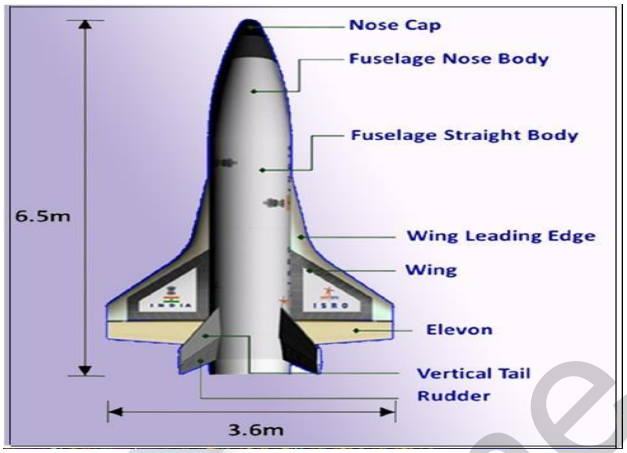


Figure: schematic representation of RLV

CHALLENGES FACED IN ITS DEVELOPMENT

- Low technology development like **insufficient thrust-to weight ratio of engine to escape our gravity**
- Development of **Plug nozzle engines** to retain high specific impulse at all altitudes,
- Use of drop tanks to increase range,
- Use of in-orbit refueling to increase range,
- Use of spherical tanks and stubby shape to reduce vehicle structural mass further.
- Rail boost, use of lifting body designs to reduce vehicle structural mass,
- Use of in-flight refueling.

ISRO'S RLV TECHNOLOGY DEMONSTRATION(RLV-TD) PROGRAMME

- It **has been considered as a first step towards realizing a Two Stage to Orbit (TSTO) fully reusable vehicle**.
- **RLV-TD:** It is **a plane-like reusable vehicle launched by an expendable single stage solid booster**.
- A Winged Reusable Launch Vehicle Technology Demonstrator (RLV-TD) has been configured to act as a **flying test bed to evaluate various technologies**, namely, **hypersonic flight, autonomous landing, powered cruise flight and hypersonic flight using air-breathing propulsion**.
- The RLV will undergo a series of experiments:
  1. **Hypersonic Flight Experiment (HEX):** The first experiment is the launch itself. The RLV will be launched by a solid booster rocket and then released. The booster rocket will fall back into the sea, while the lofted RLV will re-enter the atmosphere independently and be guided to a controlled splashdown.
  2. **Landing Experiment (LEX):** The second experiment will test the RLV's turbofan engine. The RLV-TD will be launched as in HEX, re-enter the atmosphere at hypersonic speed and use aerodynamic braking to decelerate. It will then perform a 2g turn towards its launch site,

and it will start its turbofan engine upon reaching Mach 0.8. It will then cruise back to its launch site at Mach 0.6 and land horizontally on a runway.

3. **Return Flight Experiment (REX):** The third experiment, the RLV-TD will be launched to orbit and then deorbited for a landing on a runway.
4. **Scramjet Propulsion Experiment (SPEX):** The final experiment will test the performances of an RLV-TD fitted with an air breathing scramjet engine.

CURRENT STATUS: HYPERSONIC FLIGHT EXPERIMENT (RLV-TD HEX-01)

- RLV-TD HEX-01 **was flight tested successfully** on May 23, 2016.
- The **'dummy' RLV** was launched into the orbit around Earth, and then glided back onto a virtual runway in the Bay of Bengal, some 500 kilometres from the coast.
- The launch vehicle began its descent followed by atmospheric re-entry at 5 times the speed of sound and then moved smoothly down to the landing spot in the Bay of Bengal.
- **Significance:** It validated the critical technologies such as
    - autonomous navigation,
    - guidance & control,
    - reusable thermal protection system and
    - re-entry mission management.

CHALLENGES AHEAD

- **A Series of experiments yet to be tested:** Hypersonic flight experiment (HEX) will be followed by the **Landing Experiment (LEX), Return Flight Experiment (REX)** and **Scramjet Propulsion Experiment (SPEX)**.
- Biggest challenge for ISRO next will be to **land the shuttle on a runway, just like a plane**.
- In order to do that, **ground infrastructure has to be built, including a runway**, and the **shuttle will need to have the capability to descend from hypersonic speed and land comfortably**.

Figure: trajectory path of RLV

SIGNIFICANCE OF RLV TEST FOR INDIAN SPACE PROGRAM

- Prowess of ISRO: The RLV-TD Program is not just a technology demonstration for India, but **a way to prove how much it has progressed in the field of space exploration**.
- **Reusability: PSLV and GSLV are expendable launch vehicle** but **they got burned after launching satellite** in space. **Reusability of RLV will decrease this cost** to create new launch vehicle for every time. It **would reduce the cost of space missions**.
- **Cheaper than PSLV and GSLV:** RLV will be substantially cheaper than the PSLV which it is likely to replace. The average cost of construction of PSLV is about ₹120 crore. The heaviest version of PSLV, the XL, cost ₹145 crore. GSLV costs about ₹173 crore. It makes **India more competitive in the launcher market**. India will attract more foreign business to launch their satellites.
- For now, the test program **will expand the technological capabilities of India**, enabling it to be a forerunner in space exploration in near future.
- **Customized launch vehicles:** The propeller used in RLV can be customized accordingly, to launch a satellite in lower orbit.
    - Only 1 propeller in single stage to orbit RLV will be used.
    - For higher orbit, 2 stage to orbit RLV will be used.
- **Technology used in this launch vehicle can be used in other spacecrafts** either it is man mission to Moon or Mars. It will help to economize time and monetary cost.
- **Less space debris:** it reduces the growing space debris. Thus, it can see as preferred clean space technology at international level which can further boost India's space commerce industry.

3.4. SOUNDING ROCKET

- A **sounding rocket**, sometimes called a **research rocket**, is **an instrument-carrying rocket designed to take measurements and perform scientific experiments during its sub-orbital flight**.
- Sounding rockets are **one or two stage solid propellant rockets.**

SIGNIFICANCE

- **These are used for probing the upper atmospheric regions and for space research**.
- They also serve as **easily affordable platforms to test or prove prototypes of new components or subsystems** intended for use in launch vehicles and satellites.
- The sounding rocket programme was the bedrock on which the edifice of launch vehicle technology in ISRO could be built.
- It is possible to conduct coordinated campaigns by simultaneously launching sounding rockets from different locations. It is also possible to launch several sounding rockets in a single day.

SOUNDING ROCKETS IN INDIA

- ISRO started launching indigenously made sounding rockets from 1965 and experience gained was of immense value in the mastering of solid propellant technology.
- In 1975, all sounding rocket activities were consolidated under the Rohini Sounding Rocket (RSR) Programme.

4. ENGINES

4.1. CRYOGENIC ENGINE

A **cryogenic rocket engine** is a rocket engine that **uses a cryogenic fuel or oxidizer**, that is, its fuel or oxidizer (or both) are gases liquefied and stored at very low temperatures.

- A Cryogenic rocket stage is **more efficient** and provides more thrust for every kilogram of propellant it burns compared to solid and earth-storable liquid propellant rocket stages.
- Specific impulse (a measure of the efficiency) achievable with **cryogenic propellants** (liquid Hydrogen and liquid Oxygen) is much higher compared to earth storable liquid and solid propellants, giving it a substantial payload advantage.
- However, cryogenic stage is **technically a very complex system** compared to solid or earth-storable liquid propellant stages due to its **use of propellants at extremely low temperatures** and the **associated thermal and structural problems**.
- Cryogenic fuels are also very clean as they give out only water while burning.
- Oxygen liquifies at -183 deg C and Hydrogen at -253 deg C.
- The propellants, at these low temperatures are to be pumped using turbo pumps running at around 40,000 rpm.
- It also entails **complex ground support systems** like propellant storage and filling systems, cryo engine and stage test facilities, transportation and handling of cryo fluids and related safety aspects.
- ISRO's Cryogenic Upper Stage Project (CUSP) envisaged the design and development of the indigenous Cryogenic Upper Stage to replace the stage procured from Russia and used in GSLV flights. The main engine and two smaller steering engines of CUS together develop a nominal thrust of 73.55 kN in vacuum. During the flight, CUS fires for a nominal duration of 720 seconds.
- **Liquid Oxygen** (LOX) and **Liquid Hydrogen** (LH2) from the respective tanks are fed by individual booster pumps to the main turbopump to ensure a high flow rate of propellants into the combustion chamber. Thrust control and mixture ratio control are achieved by two independent regulators. Two gimballed steering engines provide for control of the stage during its thrusting phase.

PROGRESS IN DEVELOPMENT

- Cryogenic technology was **denied to ISRO** by the United States in the early 1990s,
- USA also objected to the Russian sale, citing provisions of Missile Technology Control Regime **(MTCR)** that neither India nor Russia was a member of, thus forcing it **develop it on its own.**
- In December 2014 the **experimental flight** of third generation (Mk-III) GSLV containing an indigenous cryogenic was first successful test.
- After that, there have been three successful launches of second generation GSLV (Mk-II), including GSLV-F09 that launched the **South Asian satellite**.
- However, the launch of **GSAT-19 aboard GSLV Mk III** in 2017 marked India's **first fully functional rocket to be tested with a cryogenic engine** that uses liquid propellants and carrying a 3200 kg satellite.

ADVANTAGES

- Cryogenic fuel provides the **extra thrust** required by the rocket to carry heavier satellites deeper into space.
- It will **reduce the weight** of engines carrying conventional liquid or solid fuel, which will **increase its efficiency.**
- It will mark entry of ISRO in the **market of commercial launches** of heavier satellites which will bring it extra revenue.

DIFFERENCE BETWEEN CRYOGENIC STAGE AND OTHER STAGES

- The cryogenic stage is technically a very complex system, as compared to solid liquid propellant stages, due to its **use of propellants at extremely low temperature (cryo)** and the associated **thermal and structural challenges**.
- A cryogenic rocket stage is **more efficient and provides more thrust** for every kilogram of propellant it burns.

4.2. SCRAMJET ENGINE

ISRO successfully tested its own **scramjet engines** from Satish Dhawan Space Centre in Sriharikota(Andhra Pradesh).

- In this mission, the ISRO has successfully demonstrated its capabilities in critical technologies like **ignition of air breathing engines at supersonic speed**, **air intake mechanism** and **fuel injection systems**.
- **ISRO's Advanced Technology Vehicle (ATV)** was used to test the scramjet engine. It is a **sounding rocket**.
- With this, India became the **4th country (**after **USA, Russia and the European Space Agency) to demonstrate the flight testing of a scramjet engines**. This mission is a milestone for ISRO's future space transportation system.

SCRAMJET ENGINE

- A **Scramjet** (**Supersonic Combustion Ramjet**) is a variant of a **ramjet air-breathing jet engine** in which **combustion takes place in supersonic airflow**.
    - As in ramjets, a scramjet **relies on high vehicle speed to forcefully compress the incoming air before combustion** (hence ramjet).
    - The Conventional aircraft engines compresses air using fan before combustion.
- It is also called the **air breathing engine** as it uses **atmospheric oxygen** to burn the **hydrogen fuel.**
- **Difference between Ramjet and Scramjet**: A ramjet decelerates the air to subsonic velocities before combustion, while airflow in a scramjet is supersonic throughout the entire engine. This allows the scramjet to operate efficiently at extremely high speeds.
- Rockets usually carry both fuel and oxidiser for easy combustion. Scramjet engine **uses the oxygen from atmosphere to compress fuel**, thus **reducing the weight of rocket** and **increasing the efficiency**.
- The scramjet is composed of three basic components:
    1. **A converging inlet**, where incoming air is compressed;
    2. **A combustor**, where gaseous fuel is burned with atmospheric oxygen to produce heat; and
    3. **A diverging nozzle,** where the heated air is accelerated to produce thrust.

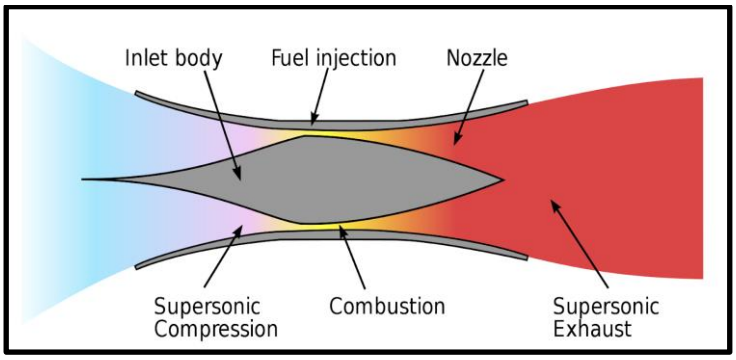


Figure: process inside a scramjet engine

ADVANTAGES OF SCRAMJET ENGINE

- These engines **have no moving parts**. Instead of the rotating compressor and turbine in a jet engine, **air is compressed and expanded** by complex systems of shockwaves under the front of the aircraft, inside the inlet and under the fuselage at the rear.
- Conventional rockets carry fuel and liquid oxygen, which make up ~3/4 of launch weight. A large proportion of that is liquid oxygen. If the engine can use atmosphere oxygen instead of carrying it then the **payload capacity of the vehicle would increase dramatically**.
- The scramjet engine **can liquefy the oxygen and store it on board**.
    - A scramjet engine uses oxygen present in the atmospheric air to burn the hydrogen fuel.
    - Scramjet engines **will help bringing down launch cost** by **reducing the amount of oxidiser to be carried along with the fuel**. It will reduce **cost-to payload ratio.**
- Scramjet-powered rockets also **have several times greater thrust** compared with rockets powered by liquid fuel or even cryogenic fuel.
- A rocket using a scramjet engine **would be significantly lighter and smaller and, therefore, cheaper**. Alternatively, rockets fired by scramjet engines **will be able to carry more payload**.
- Conventional rocket stages cannot be reused. **Scramjet can be designed to be 'Reusable', gliding or parachuting back to earth when expended**
    - In defence, the next generation of cruise missiles is likely to be powered by scramjets that reach hypersonic speeds.
    - However, civil aviation could commercialise air-breathing rocket engine technology even earlier than the space industry. It has a greater incentive and a bigger market.
    - Intercontinental flights can use scramjets to reach hypersonic speeds; would cut travel time.
- Since it relies on oxygen present in the atmosphere, the trajectories of scramjet engine-powered rockets are vastly different from conventional ones — **rockets with scramjet engines should remain in the atmosphere for a longer period than normal rockets.** Typically, scramjet rockets climb to a certain altitude and remain in the atmosphere for as long as possible to achieve the required velocity.

LIMITATIONS OF SCRAMJET ENGINE

- The scramjet engine is **used only during the atmospheric phase** of the rocket's flight.
- Scramjets are efficient only at **supersonic speed.**

Technical challenge:

- Due to the nature of their design, **scramjet operation is limited to near-hypersonic velocities**.
- **Oxygen is limited to the atmosphere** and is dense in the 10-20 km region. So scramjet can be used optimally at this height.
- As they lack mechanical compressors, **scramjets require the high kinetic energy of a hypersonic flow to compress the incoming air to operational conditions**. Thus, a scramjet-powered vehicle must be accelerated to the required velocity (usually about **Mach 4**) by some other means of propulsion, such as turbojet, railgun, or rocket engines.
- **Hypersonic flight within the atmosphere generates immense drag**, and **temperatures found on the aircraft and within the engine can be much greater than that of the surrounding air**.
- Maintaining combustion in the supersonic flow presents additional challenges, as the fuel must be injected, mixed, ignited, and burned within milliseconds.

5. REMOTE SENSING SATELLITE SYSTEM

- It is the **acquisition of information about an object/phenomenon without making physical contact with the object.**
- **Use of aerial sensor technologies to detect and classify objects on Earth** (both on surface, and in the atmosphere and oceans) **by means of propagated signals** (e.g. electromagnetic radiation).

TWO TYPES OF REMOTE SENSING

1. **Active remote sensing:** when a signal is first emitted from aircraft or satellites.
    - **Active collection emits energy to scan objects/areas after that a sensor detects+measures the reflected/backscattered radiation from the target.**
    - **RADAR and LiDAR are examples of active remote sensing where the time delay between emission and return is measured, establishing the location, speed and direction of an object.**

2. **Passive remote sensing:** (e.g. sunlight) when information is merely recorded.
    - **Passive sensors gather radiation that is emitted or reflected by the object or surrounding areas.**
    - **Reflected sunlight is the most common source of radiation measured by passive sensors.**
    - **Examples of passive remote sensors include film photography, infrared, charge-coupled devices, and radiometers.**

APPLICATIONS OF REMOTE SENSING

- **Geography and disaster management:**
    - Most Earth Science disciplines (for example, hydrology, ecology, oceanography, glaciology, geology);
    - **Monitor trends such as El Niño** and other natural long/short term phenomena.
    - Monitoring
        - deforestation in areas such as the Amazon Basin,
        - glacial features in Arctic and Antarctic regions, and
        - depth sounding of coastal and ocean depths.
    - ISRO Disaster Management Support Programme (ISRO-DMSP)
    - **Drought monitoring and assessment** based on vegetation condition.
    - **Flood risk zone mapping** and **flood damage assessment**.
    - Snowmelt runoff estimates for planning water use in downstream projects
    - **Coastal management:** Integrated Mission for Sustainable Development (initiated in 1992) for generating locale-specific prescriptions for integrated land and water resources development in 174 districts.
    - Helping the fisherman.
- **National Security:**
    - Military, intelligence, commercial, economic, planning, and humanitarian applications.
    - Collect data of dangerous or inaccessible areas, dangerous border areas.
- **Resource Management:**
    - Natural resource management, **Mineral Prospecting**
    - land usage and conservation,
    - Biodiversity Characterization at landscape level-

- **Policy making:**
  - Space Based Inputs for Decentralized Planning (SIS-DP)
  - National Urban Information System (NUIS)
  - Urban planning, **Forest survey, Wetland mapping**
  - **Environmental impact analysis,**
- **Agriculture:**
  - **Preharvest crop area** and **production estimation of major crops**.
  - Hydro-geomorphological maps for **locating underground water resources** for drilling well.
  - Irrigation command area status monitoring
  - Land use and land cover mappin

6. APPLICATION OF SPACE TECHNOLOGY

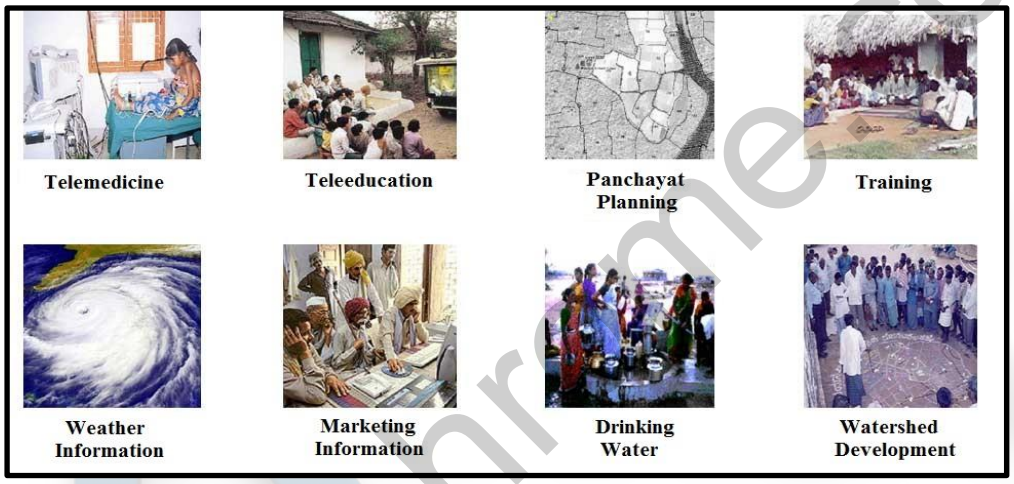


Figure: applications of remote sensing satellite.

a. **e-Governance services:** The services include information and guidance to local people on village-oriented government schemes on agriculture, poverty alleviation, rural employment, social safety nets and other basic entitlements, animal husbandry and livestock related, micro-finance related, etc.

b. **Weather Services:** Short, medium and long-term weather forecasts, at local level; and agrometeorology advisory services are being enabled.

c. **Agriculture**

- Remote sensing satellites provide key data **for monitoring soil, snow cover, drought and crop development**.
- **Rainfall assessments from satellites helps the farmers plan the timing and amount of irrigation** they will need for their crops.
- Accurate information and analysis
  - It can help **predict a region's agricultural output well in advance** and
  - It can be critical in anticipating and mitigating the effects of food shortages and famines.
- **Acreage and production estimates for the principal crops** such as wheat, rice, sorghum, cotton, mustard, and groundnut using **Forecasting Agriculture Output** using Space Agrometeorology and land-based observations (FASAL).
- **Precision farming using IRNSS**.

- **Identification of diseases of crops** through hyper spectral method.
- **Wasteland mapping,** watershed development and monitoring as well as help in fisheries sector for augmentation of income.
- Agro Meteorological (AGROMET) Towers to **measure soil temperature,** soil moisture, soil heat and net radiation, wind speed, wind direction, pressure and humidity; Flux Tower for multi-level micrometeorological observation as well as subsurface observations on soil temperature and moisture over the vegetative surfaces.
- A number of academic and research institutions as well as industries participate in the Indian space Programme. Several Indian industries have the expertise to undertake sophisticated jobs required for space systems.

d. **Land and Water Resources Management**

- Information on land and water resources extracted from satellite images is organised in Geographical Information System (GIS), and provided to the villagers through the VRC. The local farmers, availing the support of the skilled/ trained personnel managing VRCs, utilise this information for better management of their land resources.

e. **Interactive Advisory Services**

- VRCs facilitate interactions between the local people and experts at knowledge centers - Agricultural Universities, Technical Institutions, etc- on a wide range of subjects such as alternative cropping systems, optimisation of agricultural inputs-like seeds, water, fertilizer, insecticides, pesticides, producer-oriented marketing opportunities, crop insurance, etc.

f. **Economic growth and Investment**

- Space science always puts high demands on technology and these technologies could be an important investment for sophisticating future application missions to bring increased benefits to society.
- The successful conduct of planetary missions like Chandrayaan and Mangalyaan puts India in an exclusive club and this in turn gives the right credentials for international collaboration and cooperation on an equal partnership basis. **This will develop both scientific and space manufacturing industry in India**
- Commercialization of space launching technologies by ANTRIX has resulted into economic gain.
- The data is used for several applications covering agriculture, water resources, urban development, mineral prospecting, environment, forestry, drought and flood forecasting, ocean resources and disaster management.

g. **Disaster management**

- It plays a vital role in **delivering cyclone warnings** and is **used in search and rescue operations.**
- Use of INSAT for e-governance and developmental communication applications is also fast expanding.
- Doppler Weather Radar (DWR) to monitor severe weather events such as cyclone and heavy rainfall.

f. Satellite Communication

- Satellite Communication utilisation has become wide spread and ubiquitous throughout the country for such diverse applications like **Television, DTH Broadcasting, DSNG and VSAT** to exploit the unique capabilities in terms of coverage and outreach.
- Important initiatives pursued by ISRO towards societal development include Tele-education, Telemedicine, Village Resource Centre (VRC) and Disaster Management System (DMS) Programmes.
- Another application of satellite communication is Satellite Aided Search and Rescue (SAS&R), as a part of India's commitment to the International COSPAS- SARSAT programme for providing alerts and position location services for aircraft and ships in distress.

g. Telecommunication

- INSAT satellites have been traditionally supporting telecommunication applications for **providing voice and data communications**.
- Satellite links are the primary means of connectivity to remote and far-flung regions of the country and they are the backup links for large number of terrestrial connectivity in the mainland.

h. Scientific Temper:

- ISRO through its achievements
  - **It can attract millions of young minds towards science**
  - It can ignite these young minds through collaborations with various colleges, schools and universities like NASA.
- **Finding prospective groundwater zones** to provide drinking water in villages, providing land and water resources development plans at watershed level using IRS.

i. Tele-fishery: VRCs located at coastal tracts are being provided with **near real time information on satellite derived Potential Fishing Zones (PFZ)**. Information pertaining to inland fisheries, aquaculture, etc. is also provided through VRCs as relevant.

j. Telemedicine: Introducing telemedicine via satellite for making speciality treatment accessible to people in remote areas of India. Places around Bangalore, Kolkata and Tripura are networked with a hub using VSAT terminals.

k. Biodiversity information system: Use of space technological tools for characterization of biodiversity at a landscape level.

Village Resource Centre Programme

- ISRO/ DOS has launched the Village Resource Centres (VRCs) programme in association with NGOs/ Trusts and state/ central agencies
- To provide the space-based services directly to the rural areas
- VRCs essentially have:
  - Digital connectivity (for videoconferencing and information transfer) with knowledge centers and specialty healthcare providers enabled via INSAT;

- Spatial information on natural resources generated using IRS data;
- A host of information pertaining to management of natural resources and socio-economic relevance; and
- Facilities for primary healthcare services and distance education.

- Significance of VRCs: **It will catalyse rural entrepreneurship**; and **facilitate e-Governance and other services of social relevance**.
- Performance:
  - At present, there are 461 VRCs set up in 22 States/Union Territories.
  - Over 6500 programmes have been conducted by the VRCs so far addressing the areas like, Agriculture/horticulture development; Fisheries development; Livestock development; Water resources; Tele health care; Awareness programmes; Women empowerment; Supplementary education; Computer literacy; Micro credit; Micro finance; Skill development / vocational training for livelihood support etc. So far, over five Lakh people have used VRC services.

7. DRAFT SPACE ACTIVITIES BILL 2017

It is a proposed Bill **to promote and regulate the space activities** in India. The Bill encourages the **participation of non-governmental/private sector** agencies in space activities in India under the guidance and authorisation of the government through the Department of Space.

Need:

Private sector including few startup companies (e.g. Team Indus) in India have shown **keen interest** in space systems activities. However, there is **no legislation** to deal with space-related activities. Hence the bill envisages to create a legal environment for orderly performance and growth of space sector with private participation.

Provisions of the draft bill

- A non-transferable **licence** shall be provided by the Central Government to any person carrying out **commercial space activity**.
- The **Central Government** will formulate the **appropriate mechanism for licencing, eligibility criteria, and fees for licence.**
- The government will maintain a **register of all space objects** and. It will also provide professional and technical **support for commercial space activity** and regulate the procedures.
- If any person undertakes any commercial space activity **without authorisation,** they shall **be punished** with imprisonment up to 3 years or fined more than Rs 1 crore or both.

8. INDIAN SPACE ACHEIVEMENTS

A. THE MARS ORBITER MISSION (MOM)

- The Mars Orbiter Mission (MOM), also called Mangalyaan is **a space probe orbiting Mars** since 24 September 2014.
- It was launched by the Indian Space Research Organisation (ISRO).

ACHIEVEMENTS

- It is **India's first interplanetary mission**

- It made ISRO the 4th space agency to reach Mars, after ROSCOMOS, NASA, and the European Space Agency.
- It is the first Asian nation to reach Mars orbit, and the first nation in the world to do so in its first attempt.

It carries five instruments that will help advance knowledge about Mars to achieve its secondary, scientific objective.

MISSION OBJECTIVES

a) **Primary objective:**

- The mission is **a "technology demonstrator" project** to **develop the technologies for designing, planning, management, and operations of an interplanetary mission** comprising the following major tasks:
- Orbit manoeuvres to transfer the spacecraft from Earth-centred orbit to heliocentric trajectory and finally, capture into Martian orbit
- Development of force models and algorithms for orbit and attitude (orientation) computations and analysis
- Navigation in all phases
- Maintain the spacecraft in all phases of the mission
- Meeting power, communications, thermal and payload operation requirements
- Incorporate autonomous features to handle contingency situations

b) Secondary objective

- To **explore Mars' surface features, morphology, mineralogy and Martian atmosphere** using indigenous scientific instruments.

c) Scientific objectives

- **Exploration of Mars surface features** by studying the morphology, topography and mineralogy.
- **Study the constituents of Martian atmosphere** including methane and CO_2 using remote sensing techniques.
- **Study the dynamics of the upper atmosphere of Mars**, effects of solar wind and radiation and the escape of volatiles to outer space.
- The mission would also provide multiple opportunities to observe the Martian moon Phobos and also offer an opportunity to identify and re-estimate the orbits of asteroids seen during the Martian Transfer Trajectory.

MARS ORBITER MISSION PROFILE

1. **Geocentric Phase:** The spacecraft is injected into an Elliptic Parking Orbit by the launcher.
    - **It is gradually maneuvered into a departure hyperbolic trajectory with which it escapes from the Earth's Sphere of Influence (SOI) with Earth's orbital velocity with some acceleration.**
2. **Heliocentric Phase:** The spacecraft leaves Earth in a direction tangential to Earth's orbit and encounters Mars tangentially to its orbit. Eventually it will intersect the orbit of Mars at the exact moment when Mars is there too.
3. **Martian Phase:** The **spacecraft arrives at the Mars Sphere of Influence** in a hyperbolic trajectory.

- **At the time the spacecraft reaches the closest approach to Mars (Periapsis), it is captured into planned orbit around mars by imparting the Mars Orbit Insertion (MOI) manoeuvre.**

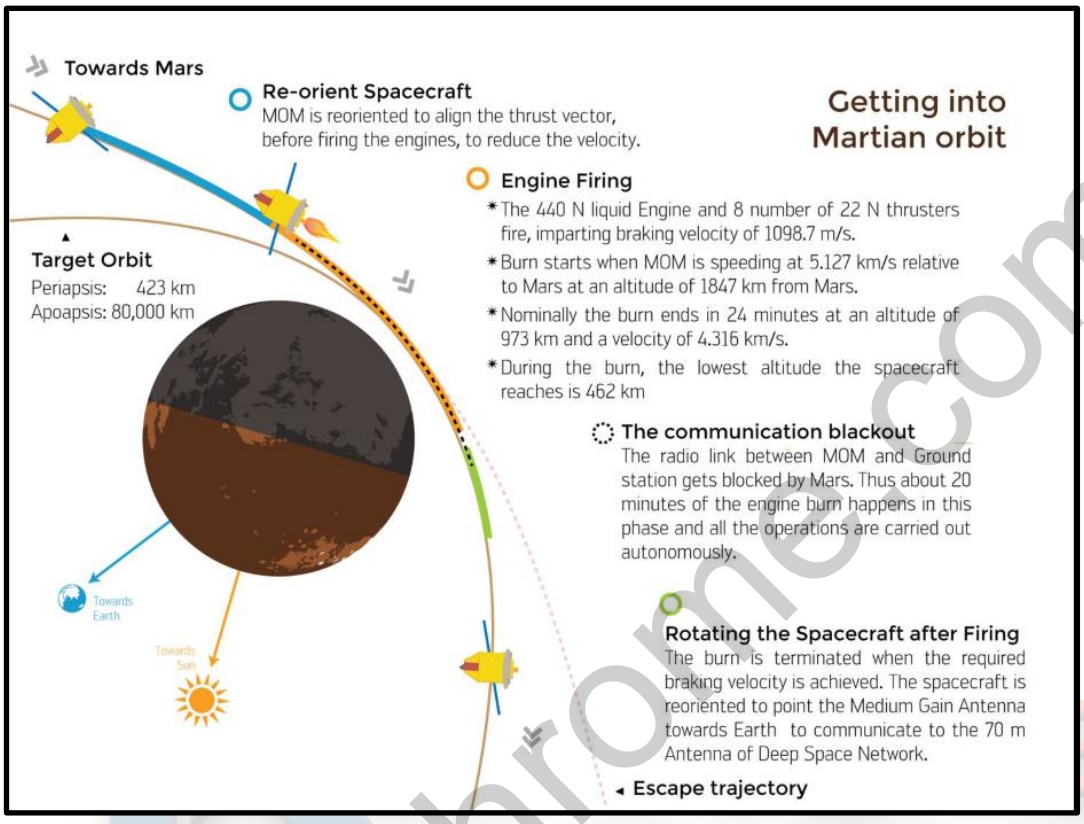


Figure: orbital path of MOM to mars

Payloads: MoM carries **5 scientific payloads** to observe Martian surface, atmosphere and exosphere extending up to 80000 km for a detailed understanding of evolution of planet and various processes associated with the mar's planet.

- **Atmospheric studies:**
  - **Lyman-Alpha Photometer (LAP):** A photometer that **measures the relative abundance of deuterium and hydrogen** in the upper atmosphere of Mars.
    - Why: To estimate the amount of water loss to outer space.
  - **Methane Sensor for Mars (MSM): to measure methane in the atmosphere of Mars**, if any, and **map its sources**.
    - It acquires data over illuminated scene as the sensor measures reflected solar radiation.
- **Particle environment studies:**
  - **Mars Exospheric Neutral Composition Analyser (MENCA)** – Analyses Neutral composition in Martian upper atmosphere.
    - Measure relative abundances of neutral constituents.
- **Surface imaging studies:**
  - **Thermal Infrared Imaging Spectrometer (TIS)** – TIS **measures the thermal emission** and **can be operated during both day and night**. It **would map surface composition and mineralogy of Mars** and also **monitor atmospheric CO2 and turbidity**.

- **Mars Colour Camera (MCC)** – This tricolour camera **gives images and information about the surface features and composition of Martian surface**.
  - It is useful to **monitor the dynamic events and weather of Mars like dust storms/atmospheric turbidity**.
  - MCC will also be used for **probing the two satellites of Mars, Phobos and Deimos**.

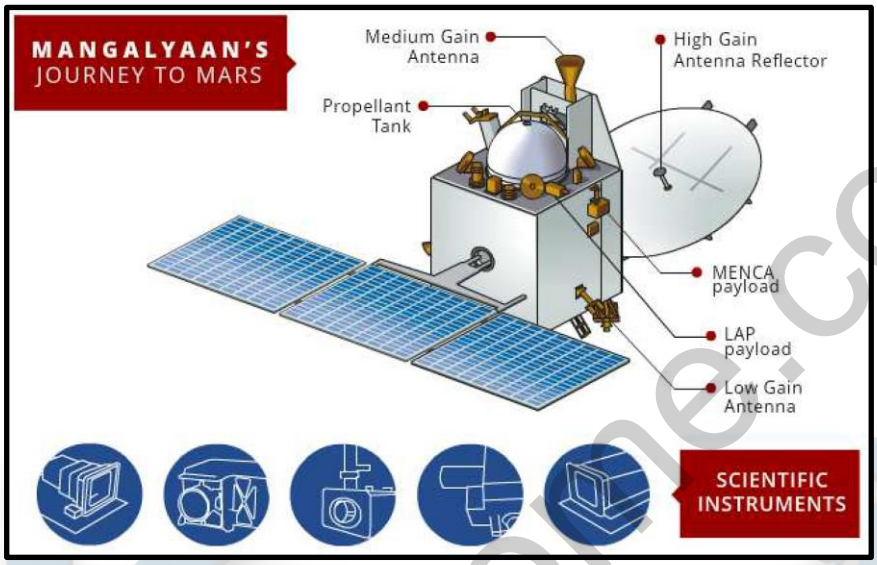


Figure: MOM payload

FOLLOW-UP MISSION

- ISRO plans to develop and launch a follow-up mission called **Mars Orbiter Mission 2 (MOM-2 or *Mangalyaan-2*)** with a greater scientific payload to Mars in 2022-2023.
- The orbiter will use aerobraking to reduce apoapsis of its initial orbit and reach an altitude more suitable for scientific observation.

B. INDIAN REGIONAL NAVIGATION SATELLITE SYSTEM (IRNSS)

It is India's own **regional** satellite system comprising **7 satellites** to provide accurate position information service to users in India as well as the region extending **up to 1500 km** from its **boundary,** which is its primary service area.

- **Three** of the 3 satellites are located in **geostationary orbit** of approximately 36,000 km above earth surface while remaining **4** satellites are in inclined **geosynchronous** orbit.

SIGNIFICANCE

- IRNSS is designed to provide two types of services, namely, **Standard Positioning Service (SPS)** which is provided to all the users and **Restricted Service (RS)**, which is an encrypted service provided only to the authorised users.
- The IRNSS System is expected to provide a position **accuracy of 10-20 m** in the primary service area and upto **0.1 m in restricted service area**.
- Its major **applications** are:
  - Terrestrial, Aerial and Marine **Navigation**
  - Disaster Management
  - Integration with mobile phones for **better location and tracking**

- **Mapping** and Geodetic data capture
- Terrestrial navigation aid for hikers and travellers
- **Visual and voice navigation for drivers**

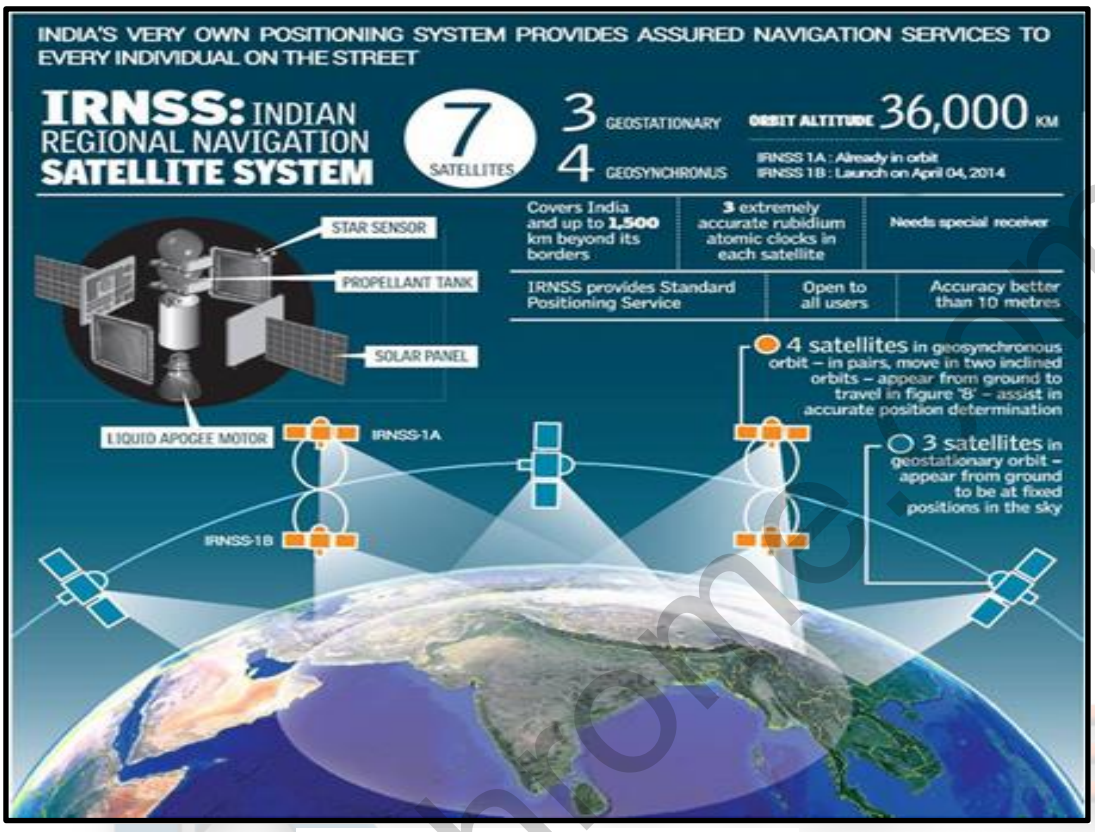


Figure: IRNSS (NAVIC) navigation system

IRNSS-1I

It is the most recent and the last in the series of the satellite constellation. It was launched in April 2018 by **PSLV C41**.

- The satellite is intended to replace the **failed IRNSS-1A**, and complete the constellation of geosynchronous navigation satellites after **IRNSS-1H failed to do so**.
- IRNSS-1I, like its predecessors, has two types of payloads; **navigation payload and the ranging payload.**
- The navigation payload **transmits navigation service signals** to the users. This payload is operating in L5 band and S band. A highly accurate **Rubidium atomic clock** is part of the navigation payload of the satellite.
- Failure of these Rubidium atomic clocks was the reason for IRNSS-1A to be deemed unfit.
- The ranging payload consists of a C-band **transponder**.

C. AIR BREATHING PROPULSION SYSTEM

ABPS refers to the arrangement which allows launch vehicles to use oxygen from the earth atmosphere itself for firing the fuel instead of carrying oxidizer with the vehicle.

IMPORTANCE

Generally, launch vehicles use a combination of propellants consisting of **oxidiser and fuel** for energy. Out of the total launch vehicle mass, **86% is propellant mass** out of which, **70% is oxidiser**. On the other hand,

ABPS is an arrangement that allows rockets to use natural oxygen present in the atmosphere up to 50 km from the earth's surface to burn the fuel stored in the rocket.

ADVANTAGES OF ABPS

- **Lesser fuel weight** to be carried on-board the vehicle
- **Reduced costs** in launching satellites
- Important step towards developing **reusable launch vehicles** which inherently require lesser weight
- **More payload** can be carried with available launch capacities
- ISRO in 2016 successfully tested the technology demonstration of air-breathing Scramjet engine (which itself uses Hydrogen as fuel).

D. GAGANYAAN MISSION

It is an indigenous mission that would take **Indian astronauts to space** by 2022. Gaganyaan will be an Indian crewed orbital spacecraft that is intended to send **3 astronauts** to space and **safely return** to the Earth after a mission duration for a minimum of **seven days**. It will be launched by 2022, as part of the **Indian Human Spaceflight Programme**.

- ISRO's Geosynchronous Satellite Launch Vehicle **GSLV Mk III**, the three-stage heavy-lift launch vehicle, will be used to launch Gaganyaan as it has the necessary payload capability.
- The spacecraft which is being developed by the Indian Space Research Organisation (ISRO), will be placed in a **low earth orbit of 300-400 km**. It will consist of a **service module** and a **crew module**, collectively known as the **Orbital Module**.
- **French space agency** CNES will assist ISRO in terms of expertise various fields including space medicine, astronaut health monitoring, radiation protection and life support.

Progress made

ISRO has already developed some critical technologies like **reentry mission capability**, **crew escape system, crew module configuration, thermal protection system, deceleration and flotation system, sub-systems of life support system** etc. required for Mission Gaganyaan.

E. ADITYA L1

It is a proposed **solar mission** spacecraft of **ISRO** weighing 1400 kg, slated to be launched aboard **PSLV-XL** in **2021**. Its main objective is **to observe the solar corona**, the outer layers of the Sun, above the disc (photosphere).

- It will carry a total of seven payloads which inter alia includes **Visible Emission Line Coronagraph (VELC)**, Solar Ultraviolet Imaging Telescope (SUIT), **Solar Low Energy X-ray Spectrometer (SoLEXS)**, High Energy L1 Orbiting X-ray Spectrometer (HEL1OS).
- The Aditya-L1 mission will be inserted in a halo orbit around the L1(Lagrangian point), which is about 1.5 million km from the Earth.
- **Lagrangian point** is a point where the attraction by the Sun and the Earth becomes equal. The point **doesn't experience gravitational force**. If a satellite is put there, it won't get deflected, yet the captured data will be accurate.

SIGNIFICANCE

The **Corona** has a **temperature** of more than a million-degree Kelvin which is **much higher than the solar disc (the lower layer)** temperature of around 6000K. How the corona gets heated to such high temperatures is what it seeks to analyse.

F. CARTOSAT SERIES SATELLITES

These are **Earth Observation satellites** indigenously developed and launched by ISRO. They form the most crucial part of **Indian Remote Sensing Programme**.

- These are used for **Earth Mapping, Resource management** and monitoring, urban planning etc.
- Till now, **8 Cartosat series satellites** have been launched, the most recent one being Cartosat 2f, launched aboard PSLV C40 in January 2018.
- They are placed in **Geocentric Sun synchronous orbit** generally in a low earth orbit (LEO) of around 500 km, for better mapping.

Cartosat 2F

8th of the Cartosat series satellites, it was launched along with 30 co-passenger satellites by the PSLV C40. The satellite weighed 710 kg and is placed in a sun synchronous orbit. It will act as another eye for land observation in India.

G. HYPERSPECTRAL IMAGING SATELLITE (HYSIS)

Indian Space Research Organisation's reliable workhorse PSLV rocket (PSLV C43) launched India's first hyperspectral imaging satellite (HysIS), an advanced earth observation satellite.

HySIS (Hyperspectral Imaging Satellite)

- It is an Earth observation satellite which **will provide hyperspectral imaging services to India for a range of applications in agriculture, forestry and in the assessment of geography such as coastal zones and inland waterways.**
- The data will also be accessible to India's defence forces.
- Before HySIS, other Indian hyperspectral imaging payloads were HySI (Hyperspectral Imager) on IMS-1 and Chandrayaan-1 and LiVHySI (Limb Viewing Hyperspectral Imager) on YouthSat.

HYPERSPECTRAL IMAGING

- **Hyperspectral imaging**, like other spectral imaging, **collects and processes information from across the electromagnetic spectrum**.
- Goal of hyperspectral imaging: **To obtain the spectrum for each pixel in the image of a scene**, with the purpose of **finding objects, identifying materials, or detecting processes**.\

Working:

- Whereas the human eye sees color of visible light in mostly three bands (long wavelengths - perceived as red, medium wavelengths - perceived as green, and short wavelengths - perceived as blue), spectral imaging **divides the spectrum into many more bands**.
- This technique of dividing images into bands can be extended beyond the visible.
- In hyperspectral imaging, **the recorded spectra have fine wavelength resolution and cover a wide range of wavelengths**.
- Hyperspectral imaging **measures continuous spectral bands**, as opposed to multispectral imaging which measures spaced spectral bands.

Applications: Hyperspectral remote sensing is used in a wide array of applications.

- Although **originally developed for mining and geology** (the ability of hyperspectral imaging to identify various minerals makes it ideal for the mining and oil industries, where it can be used to look

for ore and oil), it has now spread into fields as widespread as **ecology and surveillance**, as well as **historical manuscript research, such as the imaging of the Archimedes Palimpsest**.

- On a smaller scale, NIR hyperspectral imaging can be used to **rapidly monitor the application of pesticides to individual seeds for quality control of the optimum dose and homogeneous coverage**.
- Applications in astronomy, agriculture, molecular biology, biomedical imaging, geosciences, physics, and surveillance.
- Hyperspectral sensors look at objects using a vast portion of the electromagnetic spectrum. Certain objects leave unique 'fingerprints' in the electromagnetic spectrum. Known as spectral signatures, these 'fingerprints' **enable identification of the materials that make up a scanned object**. For example, **a spectral signature for oil helps geologists find new oil field.**

Advantages

- Because an entire spectrum is acquired at each point, **the operator needs no prior knowledge of the sample, and postprocessing allows all available information from the dataset to be mined**.
- Hyperspectral imaging can also take advantage of the **spatial relationships among the different spectra in a neighbourhood, allowing more elaborate spectral-spatial models for a more accurate segmentation and classification of the image**.

Disadvantages

- Cost and complexity.
- **Fast computers, sensitive detectors, and large data storage capacities are needed** for analyzing hyperspectral data.
- **Significant data storage capacity is necessary** since hyperspectral cubes are large, multidimensional datasets, potentially exceeding hundreds of megabytes.
- All of these factors **greatly increase the cost of acquiring and processing hyperspectral data**.
- Also, one of the hurdles researchers have had to face is **finding ways to program hyperspectral satellites to sort through data on their own and transmit only the most important images, as both transmission and storage of that much data could prove difficult and costly**.

As a relatively new analytical technique, the full potential of hyperspectral imaging has not yet been realized

H. SARASWATI SUPERCLUSTERS

It is a large **group of smaller galaxy clusters** or galaxy groups and among the **largest-known** structures of the cosmos. It was **discovered by a group of Indian scientists** in 2017.

- It has 42 cluster groups of galaxies and is **600 million light years across**. In comparison, the Milky Way is 150,000 light years across.
- The supercluster Saraswati lies in the **Stripe 82** of the **Sloan Digital Sky Survey**. SDSS stands for the Sloan Digital Sky Survey. This is an ambitious plan to make a digital **3D map of the universe.**

Significance

It is about **4000 million light years** away from the solar system and hence that much old. According to present theories, it is difficult for such a huge galaxy to have **formed so early (4 billion years ago)** in the universe's lifetime and hence this **discovery challenges such theories.**

9. OTHER SPACE AGENCIES ACHIEVEMENTS.

INITIATIVES	INDIA AND USA **NISAR MISSION: NASA - ISRO SYNTHETIC APERTURE RADAR** • **NISAR** mission is **a joint project between NASA and ISRO** to **co-develop and launch a dual frequency synthetic aperture radar on an Earth observation satellite**. **Significance/Application:** • The satellite will be the **first radar imaging satellite to use dual frequency** • It is planned **to be used for remote sensing to observe and understand natural processes on Earth** and **focusing on Antarctic cryosphere** with its right-facing instruments. • The NASA-ISRO Synthetic Aperture Radar, or NISAR satellite, **will provide an unprecedented detailed view of Earth by using advanced radar imaging**. • It is designed to observe and take measurements of some of the planet's most complex processes, including ecosystem disturbances, ice-sheet collapse, and natural hazards such as earthquakes, tsunamis, volcanoes and landslides. • Data collected from NISAR **will reveal information about the evolution and state of crust**, help scientists better **understand our planet's processes and changing climate**, and **aid future resource and hazard management**. **Status:** • The satellite will be launched from India aboard a Geosynchronous Satellite Launch Vehicle. • The satellite will be 3-axis stabilised and is planned to be launched into a Sun-synchronous dawn to dusk orbit with a mission life of 3 years. • The project has passed the first stage of the design validation phase and has been reviewed and approved by NASA. **ESA and NASA** **ASTEROID IMPACT AND DEFLECTION ASSESSMENT MISSION** AIDA is a **joint mission** of European Space Agency **(ESA) and NASA** proposed to study and demonstrate the kinetic effects of **crashing an impactor spacecraft into an asteroid moon**. (moon of Asteroid **Didymos**). The mission is intended to test whether a spacecraft could successfully **deflect an asteroid on a collision course with Earth** and hence to **save Earth from future asteroid collision** impact. It has two components: 1. An asteroid impactor; **Double Asteroid Redirection Test (DART)** mission by NASA which will crash straight into the asteroid moon at about 6 km/s. (Scheduled to be launched by 2022) 2. An asteroid rendezvous spacecraft - Asteroid **Impact Mission (AIM)** by the ESA. It will observe closely as DART hits Didymoon. In the aftermath, it will perform detailed before-and-after comparisons on the structure of the body itself, as well as its orbit, to characterise DART's kinetic impact and the consequences (To be launched in 2020).

	A close-Earth encounter of the binary asteroid Didymos (asteroid and its moon) in October 2022 provides the optimal target for such a mission. **NASA AND JAXA** **GEOTAIL** • The Geotail mission was a joint project of Japan's Institute of Space and Astronautical Science (ISAS) and later, from 2003, the Japan Aerospace Exploration Agency (JAXA) and NASA. The mission was part of the International Solar Terrestrial Physics (ISTP) project, which also included the Wind, Polar, SOHO, and Cluster missions. • Geotail provides information about the way the magnetic envelope surrounding Earth, called the magnetosphere, responds to incoming material and energy from the Sun. • Geotail's goal was to study the structure and dynamics of the long tail region of Earth's magnetosphere, which is created on the nightside of Earth by the solar wind. During active periods, the tail couples with the near-Earth magnetosphere, and often releases energy that is stored in the tail, activating auroras in the polar ionosphere.
	HAYABUSA-2 • It is a **Japanese asteroid-sampling spacecraft** that launched in December 2014. It successfully **landed on asteroid Ryugu** in October **2018**. • The probe will poke, prod and impact the asteroid, deploying a small lander and three rovers. It will then **blast an artificial crater** to analyze material below the asteroid's surface. • The probe will head back to Earth, arriving by the end of 2020 with **samples**. • The mission is a follow-up of Hayabusa, which returned samples of asteroid Itokawa to Earth in 2010.
NASA	**CASSINI MISSION** • Launched in **1997**, it was a joint collaboration of **NASA, ESA** (the European Space Agency) and the **Italian space agency** (ASI) to send a Cassini, a sophisticated robotic spacecraft to **study Saturn** and its complex system of **rings and moons**. • Cassini carried a probe called **Huygens** to the Saturn system. The probe, which was built by ESA, parachuted to the surface of Saturn's largest moon, **Titan,** in January 2005. • Key discoveries during its 13 years at Saturn included a **global ocean** with strong indications of **hydrothermal activity** within Enceladus (one of the moons of Saturn), and **liquid methane** season Titan. • The mission **ended in September 2018**. It returned spectacular images and other scientific results during the mission which will continue to yield new discoveries for decades. **GOLD and ICON** News: Global-scale Observations of the Limb (GOLD) and Disk and the Ionospheric Connection Explorer (ICON) are complimentary missions of **NASA** launched in 2018.

ICON

- It is placed in **low-Earth orbit** (LEO) located at 560 km above the Earth which is the **dynamic zone** high in our atmosphere where terrestrial weather from below meets space weather above.
- This is the area through which **radio communications and GPS signals travel**. Variations there can result in distortions or even complete disruption of signals. In order **to understand this complicated region** of near-Earth space, called the ionosphere, NASA has developed the ICON mission.

GOLD

- It is placed in a **geostationary orbit** over Western Hemisphere, about 35,398 km above earth. It will help in **full-disk view of ionosphere and upper atmosphere** beneath it every half hour. GOLD will **investigate the dynamic intermingling of space and Earth's uppermost atmosphere.**
- At the boundary between Earth's atmosphere and space, the charged particles making up the ionosphere co-exist with the upper reaches of the neutral atmosphere, called the **Thermosphere.**
- The two co-mingle and influence one another constantly. This interplay and the role **terrestrial weather, space weather and Earth's own magnetic field** each have in it, is the focus of GOLD's mission.

INSIGHT MISSION

- InSight, short for Interior Exploration using Seismic Investigations, Geodesy and Heat Transport, is a **Mars lander**, launched by **NASA** in May 2018 which successfully landed on Mars in November 2018.
- The **lander** uses cutting edge instruments, to delve **deep beneath the surface** and seek the fingerprints of the **processes that formed the terrestrial planets**.
- It is the **first** outer space robotic explorer **to study in-depth the inner space** of Mars: its crust, mantle, and core. InSight also measures **tectonic activity** and meteorite impacts on Mars.
- It seeks answers to key **questions about the early formation of rocky planets** in our inner solar system - Mercury, Venus, Earth, and Mars - more than 4 billion years ago, as well as rocky exoplanets.

PARKER SOLAR PROBE

- It is NASA's most ambitious solar probe launched in August 2018 and will be the **first-ever mission to 'touch' the Sun Corona**, if successful.
- The spacecraft, about the size of a small car, will travel directly into the **Sun's atmosphere** about 4 million miles from the surface, facing brutal heat of upto 1400 degree Celsius and ultimately providing humanity with the **closest-ever observations** of a star.
- It will provide a statistical survey of the **outer corona** and watch the solar wind speed up from subsonic to supersonic speeds. The primary science goals for the mission are:
    - To trace the **flow of energy** that heats and accelerates the solar corona and solar wind.

- Determine the structure and dynamics of the plasma and **magnetic fields** at the sources of the solar wind.
- Explore mechanisms that accelerate and transport **energetic particles**.

JUNO MISSION

It was launched by NASA in 2011 to probe Solar system's largest planet, **Jupiter**. It reached the orbit of Jupiter in 2016. It aims to improve our understanding of the **solar system's beginnings** by revealing the origin and evolution of Jupiter.

- It will determine how much **water is in Jupiter's atmosphere**, which helps determine which planet formation theory is correct (or if new theories are needed)
- Look deep into Jupiter's atmosphere to measure **composition, temperature, cloud motions** and other properties and map Jupiter's magnetic and gravity fields, revealing the planet's **deep structure**.

OSIRIS REx SPACECRAFT

- The **O**rigins, **S**pectral **I**nterpretation, **R**esource **I**dentification, **S**ecurity-**R**egolith **Ex**plorer mission of NASA was launched in 2016 to travel to a **carbonaceous near-Earth asteroid**, called **Bennu** and bring at least a 60 grams **sample back to Earth** for study.
- It landed on the asteroid in December 2018 and started collecting and analysing samples.
- The mission will help scientists investigate **how planets formed and how life began**, as well as improve our understanding of asteroids that could impact Earth.

VISIONS-2 Mission

- The VISIONS-2 mission, short for **Visualizing Ion Outflow via Neutral Atom Sensing-2**
- Will be launched by NASA

Significance:

- To get a closer look at the **how the Earth's atmosphere is slowly leaking into space**.
- Understanding atmospheric escape on Earth **has applications all over the Universe – from predicting which far off planets might be habitable, to piecing together how Mars became the desolate, exposed landscape it is today.**
- It is the first of 9 sounding rockets launching over the next 14 months as part of the **Grand Challenge Initiative - cusp**, an international collaboration to explore the unusual portal between Earth and space.

How the Earth's atmosphere is slowly leaking into space?

- The aurora play are fundamental drivers in the process of atmospheric escape, whereby planets, including Earth, gradually leak their atmosphere into space.

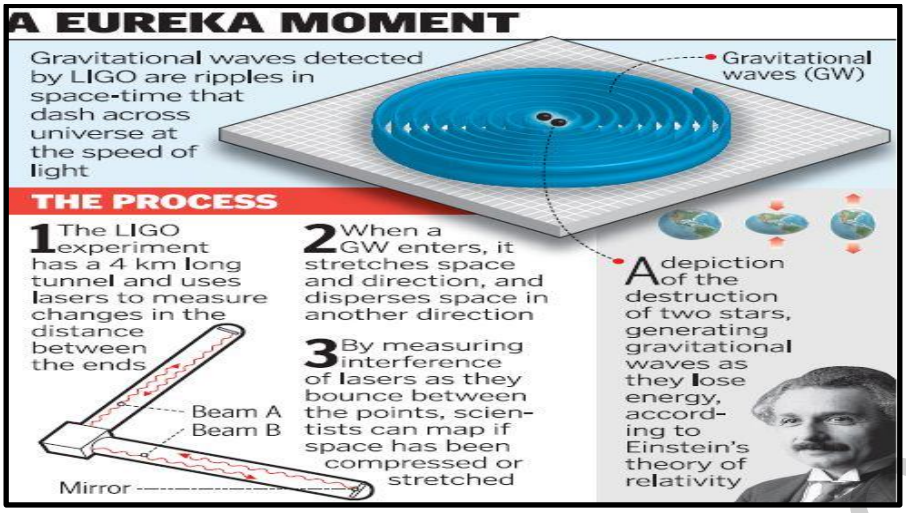
	• The aurora are **formed when energetic electrons, accelerated in the electric and magnetic fields in near-Earth space, crash into and excite atmospheric gases, which emit bright hues of red, green, and yellow as they relax back to a lower energy state**.
	  ○ The lights are seen **above the magnetic poles of the northern and southern** hemispheres.
	  ○ They are known as 'Aurora borealis' in the north and '**Aurora Australis**' in the south.
	• These unruly electrons also **create a cascade of havoc in the process, including driving electric currents that heat the upper atmosphere in splotchy patches**.
	• **In some cases, that heating is sufficient to give stray oxygen atoms enough energy to escape**.
	• VISIONS-1, the current mission's precursor, launched in 2013, where they **studied oxygen outflow from aurora that form on Earth's night side**, the part of the planet that is temporarily pointed away from the Sun.

	CHANG'E 4 MISSION
	• It is a **Chinese lunar exploration** mission, part of second phase of China's lunar program, which includes orbiting, landing and returning to Earth.
	• It successfully achieved soft **landing on the far side of the Moon** in January 2019, which is **first ever** landing on Moon's far side.
	• The mission is composed of two distinct elements: the lander and the rover.
	  ○ The **lander** is equipped with a Radioisotope Thermoelectric Generator (RTG) to power the lunar operations during the three-month mission. The energy will be used to power the scientific payload of seven instruments and cameras.
	  ○ The **lunar rover** will explore the lunar surface after departing the lander and is equipped with a solar panel to power the vehicle during the lunar day on a three-month mission.

10. AWARENESS IN THE FIELD OF SPACE

A. GRAVITATIONAL WAVES (GW)

- Albert Einstein predicted GW exactly 100 years ago
- After decades of search, scientists working with the gigantic optical instruments in the U.S. called LIGO [Laser Interferometer Gravitational-wave Observatory], **have detected signals of gravitational waves emanating from two merging black holes 1.3 billion light years away** arriving at their instruments on the Earth.



Gravitational waves

- Gravitational waves are small ripples in space-time
    - **caused by collisions of heavy and compact objects like black holes and neutron stars**
    - they are believed to travel across the universe at the speed of light.
- They are like tiny waves on a lake — from far away, the lake's surface looks glassy smooth; only up very close can the details of the surface be seen. They were predicted to exist by Albert Einstein in 1916 as a consequence of his General Theory of Relativity.
- Albert Einstein predicted the existence of gravitational waves in 1916 in his **General theory** of relativity.
- The effect is very weak; **only the biggest masses, moving under the greatest accelerations, are expected to warp their surroundings to any appreciable degree**. Put in this category the **explosion of giant stars, the collision of ultra-dense dead ones, and the coming together of black holes**. All these events should radiate gravitational energy **at the speed of light**.
- Gravitational waves have never been detected before, though indirect evidence of these waves have been found and resulted in a Nobel Prize in 1993.

Significance of the detection of Gravitational Waves

- All the current knowledge about the universe comes from **electromagnetic waves** like radio waves, visible light, infrared light, X-rays and gamma rays.
    - These electromagnetic waves get scattered as they traverse the cosmos, thus lot of information remains hidden.
- As **these gravitational waves don't get scattered as they traverse the cosmos**, making them potential source of information regarding what the universe was like in its infancy.
- This landmark discovery **provides new way to observe the cosmos and unlock secrets about the early universe and mysterious objects like black holes and neutron stars**.
- Now We will be able to:
    - For the first time **receive cosmic signals** that were previously entirely hidden from us.
    - **Track supernovas** hours before they're visible to any telescope because the waves arrive at Earth long before any light does, giving astronomers time to point telescopes like Hubble in that direction.
    - **Measure the frequency of major cosmic phenomena such as supernovas or merger of black holes** — events that shape star systems and galaxies

- **Hear the noises produced by gravitation of celestial bodies** on the fabric of space-time. Since the star or black hole **does not stop these waves**, which **move at the speed of light**, they come right to us and we can therefore make models... to distinguish and detect their signatures.

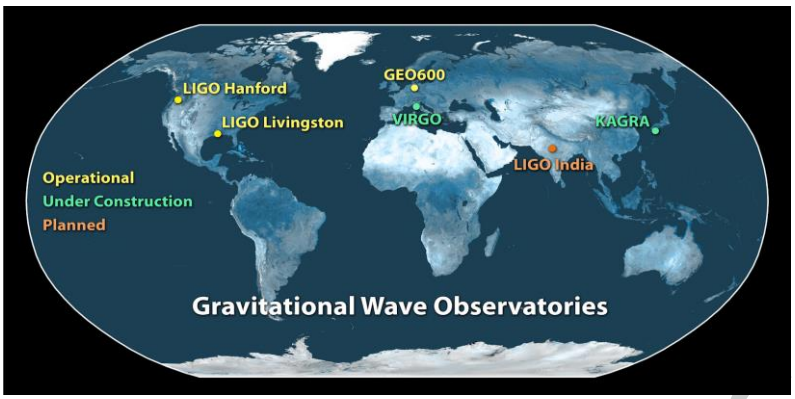


Figure: worldwide GWOs

LIGO [Laser Interferometer Gravitational-wave Observatory]

- The LIGO is the most precise instrument that has ever been built.
- It **consists of two identical L-shaped laser interferometer systems**, one at Hanford in Washington and one at Livingston in Louisiana.
- **Why are there two systems?** = To ensure that detection at both the instruments that are about 3000 km apart with the calculated time delay ensures that the detected signal is not due to any spurious seismic signal or any other local vibration.

Contribution of Indian in detection of the Gravitational Waves

- **India is a partner in the LIGO project** and the announcement was simultaneously made at the Inter-University Centre for Astronomy and Astrophysics (IUCAA) in Pune.
- Groups at IUCAA and the Raman Research Institute (RRI), Bangalore, have made significant **contribution in the analysis of the LIGO data**, which has **enabled it to be pinned down to a coalescence of two black holes consistent with Einstein's theory**.
- As many as 34 Indian scientists are contributing authors in the landmark paper about the discovery that has been published online in the journal Physical Review Letters.

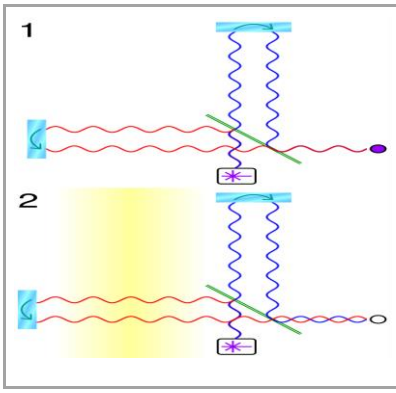
Functioning

- Each of the arms of the L is a 4 km tunnel in which **laser beams bounce back and forth between two highly sensitive suspended mirrors**.
- The laser beams are tuned to be perfectly in opposite phase so that there is total interference when the beams arrive at the intersection of the arms and no light passes through the beam splitter at the intersection into the photo-detector behind.
- But **when a gravitational wave passes through the detector, the space-time gets distorted much like a squeezed ball, oscillating between the two states compressed in one direction and elongated in the other**.
- So, the effect of this oscillatory compression of one arm and elongation of the other is that there is no total cancellation of the interfering laser beams and a net signal gets through to the photodetector.

Gravitational wave detector in India: India-LIGO project: INDIGO

- It will be a replica of the two LIGO detectors,
- It would be stationed at a perpendicular direction to the detectors in USA.

- It is **piloted by Department of Atomic Energy (DAE) and Department of Science and Technology (DST)**.
- It will be jointly coordinated and executed by three Indian research institutions:
    1. the Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune and



Simplified operation of a gravitational wave observatory

- Figure 1: A beamsplitter (green line) splits coherent light (from the white box) into two beams which reflect off the mirrors (cyan oblongs); only one outgoing and reflected beam in each arm is shown, and separated for clarity. **The reflected beams recombine and an interference pattern is detected (purple circle).**
- Figure 2: A gravitational wave passing over the left arm (yellow) changes its length and thus the interference pattern.

Department of Atomic Energy organizations:

1. **Institute for Plasma Research (IPR)**, Gandhinagar and
2. the Raja Ramanna Centre for Advanced Technology (RRCAT), Indore.

- It will enrich technological areas like **precision metrology, photonics** and control systems.
- it **will inspire coming generations of young Indians** to engage in international scientific research within the country.

Challenges:

- Project cost at least Rs. 1,200 crores.
- Such a project is at least eight years away.
- INO has been stalled for over a year due to protests by activist groups, concerned over its environmental impact.

B. HUBBLE SPACE TELESCOPE

- It was launched into low Earth orbit in 1990, and remains in operation.
- With a 2.4-meter (7.9 ft) mirror, Hubble's **four main instruments observe in the near ultraviolet, visible, and near infrared spectra**. The telescope is named after the astronomer Edwin Hubble.
- Hubble's orbit outside the distortion of Earth's atmosphere **allows it to take extremely high-resolution images with negligible background light.**
- Although not the first space telescope, Hubble is one of the largest and most versatile, and is well known as both a vital research tool and a public relations boon for astronomy.
- The HST was built by the United States space agency NASA, with contributions from the European Space Agency, and is operated by the Space Telescope Science Institute.
- The telescope is still operating as of 2016 and may last until 2030–2040.

Achievements:

- Hubble has recorded some of the most detailed visible-light images ever, allowing a deep view into space and time. Many Hubble observations have led to breakthroughs in astrophysics, such as accurately determining the rate of expansion of the universe.

- Recently, The Hubble Space Telescope has captured the image of the first-ever predicted supernova explosion that offers a unique opportunity for astronomers to test how mass — especially that of mysterious dark matter — is distributed within a galaxy cluster.
- Many stars end their lives with a bang, but only a few of these stellar explosions have been caught in the act.
- When they are, spotting them successfully has been down to pure luck — until now.
- Recently, astronomers not only imaged a supernova in action, but saw it when and where they had predicted it would be.

C. THE POLAR CUSP

- At almost any location near the surface of the magnetopause, the Earth's magnetic field provides a natural barrier to the solar wind particles.
- However, there are two regions, located above each pole, **where solar wind particles have a direct access to the Earth's ionosphere**. These regions are known as the polar cusp.
- is a region **in which the magnetosheath plasma has direct access to the ionosphere**?
- It exists whether the interplanetary magnetic field is northward or southward.
- In a non-reconnecting magnetosphere, the location of the cusp depends on the shape of the magnetopause but when the magnetosphere reconnects with either southward or northward interplanetary magnetic field the location of the cusp is altered.

D. INTERNATIONAL SPACE STATION (ISS)

- It is a space station, or a **habitable artificial satellite,** in **low Earth orbit**.
- It is a **multi-nation construction project** that is the largest single structure humans ever put into space.
- Its main construction was completed between 1998 and 2011, although the station continually evolves to include new missions and experiments.
- The Station is expected to operate till **2030**.
- It is the **largest human-made body** in low Earth orbit and can often be seen with the **naked eye** from Earth.
- **Significance:**
    - It serves as a **microgravity and space environment research laboratory**.
    - Astronaut time and research time on the space station is allocated to space agencies according to how much money or resources (such as modules or robotics) that they contribute.
- The ISS includes contributions from 15 nations.

E. SOLAR CYCLE

- The **solar cycle** or **solar magnetic activity cycle** is the **nearly periodic 11-year change in the Sun's activity (including changes in the levels of solar radiation and ejection of solar material) and appearance (changes in the number and size of sunspots, flares, and other manifestations)**.
- They have been observed (by changes in the Sun's appearance and by changes seen on Earth, such as auroras) for centuries.
- While it is the dominant variable in solar activity, aperiodic fluctuations also occur.
- **Significance:**
    - The changes on the Sun cause effects in space, in the atmosphere, and on Earth's surface.

- Because the solar cycle reflects magnetic activity, various magnetically driven solar phenomena follow the **solar cycle**, including **sunspots** and **coronal mass ejections**.

F. SUNSPOT

A team of researchers from IISER Kolkata have **developed a way of predicting the intensity of activity in the next solar cycle (approximately from 2020 to 2031) using data spread over the last 100 years**.

- Astronomers have observed sunspots on the surface of the sun for nearly 400 years.
- It is known that sunspots follow a cyclic pattern of growing in number and disappearing in approximately 11 years, known as the sunspot cycle or the sun's activity cycle.
- We are currently in the 24th sunspot cycle since the observation began in 1755.

Sunspots

- These are temporary phenomena on the **photosphere** of the Sun that **appear as dark spots** compared with surrounding regions.
- They are **areas of reduced surface temperature caused by concentrations of magnetic field flux that inhibit convection**.
- Sunspots usually **appear in pairs of opposite magnetic polarity**.
- Their number varies according to the approximately 11-year solar cycle.
- Individual sunspots **may endure anywhere from a few days to a few months**, but eventually **decay**.
- **Sunspots expand and contract** as they move across the surface of the Sun with sizes ranging from 16 kilometers (10 mi) to 160,000 kilometers (100,000 mi) in diameter.
- The **larger variety are visible from Earth without the aid of a telescope**.
- They may **travel at relative speeds**, or proper motions of a **few hundred meters per second** when they first emerge.
- Indicating intense magnetic activity, sunspots accompany secondary phenomena such as **coronal loops (prominences)** and **reconnection events**.
- Most solar flares and coronal mass ejections originate **in magnetically active regions** around visible sunspot groupings.
- Similar phenomena indirectly observed on stars other than the sun are commonly called starspots and both light and dark spots have been measured.

Reason to understand sunspots?

- **They affect space weather**.
  - **Space Weather**: This refers to the **effect of radiation, particle flux and magnetic flux in the region around the Sun**.
  - During extreme events, **space weather can affect electronics-driven satellite controls**, communications systems, air traffic over polar routes and even power grids.
- The belief that they are correlated with climate on earth.
  - A lot of the research in this area focuses on predicting the way the next sunspot cycle will shape up – whether the sun will be extremely active and produce many sunspots or not.

G. INTERSTELLAR SPACE

- **Interstellar space** is **the physical space within a galaxy beyond the influence of each star on the plasma.**

- The contents(matter) of interstellar space are called the **interstellar medium**. This matter includes gas in ionic, atomic, and molecular form, as well as dust and cosmic rays. It fills **interstellar space** and blends smoothly into the surrounding intergalactic **space**.

H. DARK ENERGY

- Dark energy is **an unknown form of energy** which is hypothesized to **permeate all of space, tending to accelerate the expansion of the universe**.
- Dark energy is the most accepted hypothesis to explain the observations since the 1990s indicating that the universe is expanding at an accelerating rate.
- dark energy contributes 68.3% of the total energy in the present-day observable universe.
    - dark matter = 26.8%
    - ordinary (baryonic) matter = 4.9%
    - Other components such as neutrinos and photons contribute a very small amount.

I. DARK MATTER

- It is a hypothetical type of matter.
- It **does not emit or interact with electromagnetic radiation**, such as light, and is **thus invisible to the entire electromagnetic spectrum**.
- Although dark matter has not been directly observed, its existence and properties are inferred from
    - Its gravitational effects such as the motions of visible matter, gravitational lensing,
    - Its influence on the universe's large-scale structure, and
    - Its effects in the cosmic microwave background.
- Dark matter is transparent to electromagnetic radiation and/or is so dense and small that it fails to absorb or emit enough radiation to be detectable with current imaging technology.
- It is **composed of weakly interacting massive particles** (WIMPs) **that interact only through gravity and the weak force**.

J. CORONAL MASS EJECTION (CME)

- It is **a significant release of plasma and accompanying magnetic field from the solar corona**.
- They often **follow solar flares** and are **normally present during a solar prominence eruption**.
- The plasma is released into the solar wind, and can be observed in coronagraph imagery.
- CMEs most often originate from active regions on the Sun's surface, such as groupings of sunspots associated with frequent flares.
- Coronal mass ejections **release large quantities of matter and electromagnetic radiation** into space above the Sun's surface, either near the corona (sometimes called a solar prominence), or farther into the planetary system, or beyond (interplanetary CME).
- The ejected material is **a magnetized plasma consisting primarily of electrons and protons**.
- While solar flares are very fast (being electromagnetic radiation), **CMEs are relatively slow**.
- Coronal mass ejections are associated with enormous changes and disturbances in the coronal magnetic field. They are usually observed with a white-light coronagraph.

Impact on Earth

- When the ejection is directed towards Earth and reaches it as an interplanetary CME (ICME), the shock wave of traveling mass **causes a geomagnetic storm that may disrupt Earth's magnetosphere**, **compressing it on the day side** and **extending the night-side magnetic tail**. When the

magnetosphere reconnects on the nightside, it releases power on the order of terawatt scale, which is directed back toward Earth's upper atmosphere.

- Solar energetic particles **can cause particularly strong aurorae** in large regions around Earth's magnetic poles.
    - These are also known as the *Northern Lights* (aurora borealis) in the northern hemisphere, and the *Southern Lights* (aurora australis) in the southern hemisphere.
- Coronal mass ejections, along with solar flares of other origin, **can disrupt radio transmissions** and **cause damage to satellites and electrical transmission line facilities**, resulting in **potentially massive and long-lasting power outages**.
- Energetic protons released by a CME **can cause an increase in the number of free electrons in the ionosphere**, especially in the high-latitude polar regions. The increase in free electrons **can enhance radio wave absorption**, especially within the D-region of the ionosphere, **leading to Polar Cap Absorption (PCA) events**.
    - **Humans at high altitudes, as in airplanes or space stations, risk exposure to relatively intense solar particle events**.

K. ELECTRIC PROPULSION SYSTEM

- An electrically powered spacecraft propulsion system
- will help in space station keeping and orbital maneuver of satellites.
- uses electrical energy to change the velocity of a spacecraft.
- Most of these kinds of spacecraft propulsion systems work by electrically expelling propellant (reaction mass) at high speed, but **electrodynamic tethers** work by interacting with a planet's magnetic field.
- Electric thrusters typically use much less propellant than chemical rockets because they have a higher exhaust speed (operate at a higher specific impulse) than chemical rockets. Due to limited electric power the thrust is much weaker compared to chemical rockets, but electric propulsion can provide a small thrust for a long time. Electric propulsion can achieve high speeds over long periods and thus can work better than chemical rockets for some deep space missions
- ABS–3A,
    - the world's first all-electric propulsion satellite.
    - makes use of a xenon-ion propulsion system to achieve thrust.

2. BIOTECHNOLOGY

1. WHAT IS BIOTECHNOLOGY.

- Biotechnology is any technological application that makes **use of biological systems, living organisms and its components to create products and other technological systems** with the aim of **advancing the human condition**.
- This advancement may come in the form of
    - Increased food production,
    - Medicinal breakthroughs or
    - Health improvement as result of new knowledge and products.
- Examples of biotechnology:
    - In vitro fertilization leading to a 'test-tube' baby,
    - Synthesizing a gene and using it,
    - Developing a DNA vaccine or correcting a defective gene
- Critical research areas of biotechnology are:
    - Providing the best catalyst in the form of improved organism usually a microbe or pure enzyme.
    - Creating optimal conditions through engineering for a catalyst to act, and
    - Downstream processing technologies to purify the protein/organic compound.

2. BRANCHES OF BIOTECHNOLOGY

- **Green Biotechnology** – This branch is concerned with agricultural processes such as **creating new plant or crop varieties with bigger yields** and **with resistance to pests** or specific weather conditions.
- **Blue Biotechnology** – This branch is concerned with **marine and aquatic applications**.
- **Red Biotechnology** – This branch is concerned with **medical and health processes** such as **production of antibiotics** and **engineering of genetic cures** through genetic manipulation.
- **White Biotechnology** – Also known as industrial biotechnology, here biotechnology is applied to **designing or having organisms produce specific chemicals that can be used for industrial purposes** such as environmentally safe cleaning agents or those that can break down and **neutralize hazardous chemicals and pollutants**.
- **Bioinformatics** – This branch is concerned with **addressing biological problems through computational techniques**, making rapid organization of large quantities of biological data and

producing analysis for the data. It is about conceptualizing biology in terms of molecules and then trying to understand and organize the information on a large scale.

3. IMPORTANCE OF BIOTECHNOLOGY TO INDIA.

- Biotechnology can deliver the next wave of technological change that can be as radical and even more pervasive than that brought about by IT.
- Employment generation, intellectual wealth creation, expanding entrepreneurial opportunities, augmenting industrial growth are a few of the compelling factors that warrant a focused approach for this sector.
- Biotechnology as a business segment for India **has the potential of generating revenues to the tune of US$ 5 Billion** and **creating one million jobs through products and services**.
- Biopharmaceuticals alone have the potential to be a US$ 2 billion market opportunity largely driven by vaccines and **bio-generics**.
    - Clinical development services can generate in excess of US$1.5 billion whilst bio-services or outsourced research services can garner a market of US$1 billion over this time scale.
    - The balance US$500 million is attributable to agricultural and industrial biotechnology.
- Indian agriculture faces the formidable **challenge of having to produce more farm commodities for our growing human and livestock population from diminishing per capita arable land and water resources**. Biotechnology has the potential to overcome this challenge to ensure the livelihood security of 110 million farming families in our country.

Biogenerics:

- Biogenerics are biological products manufactured after expiry of the patent of innovator biopharmaceuticals. Biogenerics, also known as Biosimilars (in Europe), Follow-on-biologics (in the US), and subsequent entry biologicals (in Japan) are effective treatment for a number of serious and life-threatening illness because of their high specificity and activity.
- India is growing in the arena of developing and marketing bio-generic products. In 2008, the Indian market was estimated to be $200 million for biogenerics, which is likely to increase to approximately $600 million by 2012

3.1. INDIA'S POTENTIAL IN THE FIELD OF BIOTECHNOLOGY

- India has many assets in its **strong pool of scientist and engineers, vast institutional network** and **cost-effective manufacturing**.
- There are over a hundred National Research Laboratories employing thousands of scientists.
- There are **more than 300 college level educational and training institutes** across the country offering degrees and diplomas in biotechnology, bio-informatics and the biological sciences, producing nearly 500,000 students on an annual basis.
- More than 100 medical colleges add ~17,000 medical practitioners per year.
- About 300,000 postgraduates and 1500 PhDs qualify in biosciences and engineering each year.
- India is reorganized as **a mega biodiversity country** and **biotechnology offers opportunities to convert our biological resources into economic wealth and employment opportunities**.
- Innovative products and services that draw on renewable resources bring greater efficiency into industrial processes, check environmental degradation and deliver a more bio-based economy.

Challenges faced by biotechnology in India

- research and development,
- creation of investment capital,
- technology transfer and technology absorption,
- patentability and intellectual property,
- affordability in pricing,
- regulatory issues and public confidence.

4. PRINCIPLES OF BIOTECHNOLOGY:

Two core techniques that enabled birth of modern biotechnology are

4.1. Genetic engineering: Techniques to **alter the chemistry of genetic material (DNA and RNA)**, to introduce these into host organisms and thus change the phenotype of the host organism.

There are three basic steps in genetically modifying an organism —

- **Identification of DNA with desirable genes;**
- **Introduction of the identified DNA into the host;**
- **Maintenance of introduced DNA in the host and transfer of the DNA to its progeny.**

Process of Genetically Engineering

- **Asexual reproduction preserves the genetic information, while sexual reproduction permits variation.**
- **Traditional hybridisation procedures used in plant and animal breeding, very often lead to inclusion and multiplication of undesirable genes along with the desired genes.**
- **The techniques of genetic engineering which include creation of recombinant DNA, use of gene cloning and gene transfer, overcome this limitation and allows us to isolate and introduce only one or a set of desirable genes without introducing undesirable genes into the target organism.**

4.2. Maintenance of sterile (microbial contamination-free) ambience in chemical engineering processes to enable growth of only the desired microbe/eukaryotic cell in large quantities for the manufacture of biotechnological products like antibiotics, vaccines, enzymes, etc.

FIRST GENE-EDITED HUMANS IN CHINA

In October 2018, a Chinese scientist claimed to have made the **world's first genetically edited babies**; twin girls born whose DNA was altered with gene-editing technology known as **CRISPR-Cas9**.

- The scientist **disabled a gene** called CCR5 that forms a protein doorway that allows HIV, the virus that causes AIDS, to enter a cell, hence bestowing an **ability to resist possible future infection with HIV.**

CRISPR Cas9

- CRISPR is a family of DNA sequences in bacteria and archaea. The sequences contain snippets of DNA from viruses that have attacked the prokaryote. These snippets are used by the prokaryote to detect and destroy DNA from similar viruses during subsequent attacks.
- It harnesses the natural defense mechanisms of bacteria to alter an organism's genetic code.

- It's likened to a pair of molecular scissors, a cut-and-paste technology, that can snip the two DNA strands at a specific location and modify gene function.
- The cutting is done by enzymes like Cas9, guided by pre-designed RNA sequences, which ensure that the targeted section of the genome is edited out.

Issues involved

- DNA changes **can pass to future generations** and it risks harming other genes.
- It's **too unsafe and premature** to try as an experiment on human beings as any error may spell disasters for the to-be-born.
- It is **not morally or ethically defensible** and may lead to humans opting for **designer babies,** thus **killing evolution and diversity of human race**.
- However, gene editing for **curing possible diseases,** which are a major and growing public health concern, can be step towards creating a world free from diseases.

Global status

Editing sperm, eggs or embryos of humans is almost entirely **prohibited across the world**. In the U.S., it's not allowed except for lab research. China outlaw's human cloning but not specifically gene editing. In the UK also, it is **illegal to create genetically modified babies**. Globally, among the scientists, there is a broad consensus that it would be deeply unethical to try.

5. BIOTECHNOLOGY AND ITS APPLICATIONS

The applications of biotechnology include **therapeutics, diagnostics, genetically modified crops for agriculture, processed food, bioremediation, waste treatment, and energy production**.

5.1. Applications in field of Agriculture

- Plants/bacteria/fungi/animals **whose genes have been altered** by manipulation are called **Genetically Modified Organisms (GMO)**. Genetic modification has:
  - Made crops more tolerant to abiotic stresses like cold, drought, salt, heat etc.
  - Reduced reliance on chemical pesticides leads to pest-resistant crops.
  - Helped to reduce post-harvest losses.
  - **Increased efficiency of mineral usage** by plants.
  - **Prevents early exhaustion of fertility of soil**.
  - enhanced nutritional value of food. Eg Vitamin 'A' enriched rice.
- GM has been used to **create tailor-made plants** to supply alternative resources to industries, in the form of starches, fuels and pharmaceuticals.
- **Bt toxin** is produced by a bacterium called **Bacillus thuringiensis** (Bt).
  - Some strains of Bacillus thuringiensis produce proteins that kill certain insects such as tobacco budworm, armyworm, beetles and dipterans flies, mosquitoes.
  - **Why does this toxin not kill the Bacillus?** Actually, the Bt toxin protein exist as inactive proteins but once an insect ingests the inactive toxin, it is converted into an active form of toxin due to the alkaline pH of the gut which solubilise the crystals.
  - Bt toxin gene has been cloned from the bacteria and been expressed in plants to provide resistance to insects without the need for insecticides; in effect created a bio-pesticide.
  - Examples are Bt cotton, Bt corn, rice, tomato, potato and soyabean etc.

5.2. Applications in field of Medicine

- **Genetically Engineered Insulin**
    - Insulin used for diabetes was earlier extracted from pancreas of slaughtered cattle and pigs.
        - Insulin from an animal source, though caused some patients to develop allergy or other types of reactions to the foreign protein.
        - Insulin consists of two short polypeptide chains: chain A and chain B, that are linked together by **disulphide**
        - In mammals, including humans, insulin is synthesised as a **prohormone** (like a pro-enzyme, the pro-hormone also needs to be processed before it becomes a fully mature and functional hormone) which contains an extra stretch called the C peptide. This C peptide is not present in the mature insulin and is removed during maturation into insulin. The main challenge for **production of insulin using rDNA techniques** was getting insulin assembled into a mature form.
    - In 1983, Eli Lilly an American company prepared two DNA sequences corresponding to A and B, chains of human insulin and introduced them in plasmids of E. coli to produce insulin chains. Chains A and B were produced separately, extracted and combined by creating disulfide bonds to form human insulin.

- **Gene Therapy**
    - Gene therapy is a technique for **correcting defective genes responsible for disease development**.
    - Gene therapy is a collection of methods that **allows correction of a gene defect that has been diagnosed in a child/embryo**.
    - Here genes are inserted into a person's cells and tissues to treat a disease. Correction of a genetic defect involves delivery of a normal gene into the individual or embryo to take over the function of and compensate for the non-functional gene.
- **Biopharmaceutics:** It is the field of study concerning biopharmaceuticals, medical drugs produced using biotechnology.
- **Pharmacogenomics:** Pharmacogenomics is the study of how genes affect a person's response to drugs.
- **Molecular Diagnosis**
    - **Recombinant DNA technology**, **Polymerase Chain Reaction (PCR)** and **Enzyme Linked Immunosorbent Assay (ELISA)** are some of the techniques that serve the purpose of early diagnosis of disease.
    - Presence of a pathogen (bacteria, viruses, etc.) is normally suspected only when the pathogen has produced a disease symptom. By this time the concentration of pathogen is already very high in the body.
    - However, very low concentration of a bacteria or virus (at a time when the symptoms of the disease are not yet visible) can be detected by amplification of their nucleic acid by PCR.
    - PCR is now routinely used to **detect HIV** in suspected AIDS patients. It is being used to detect mutations in genes in suspected **cancer** patients too. It is a powerful technique to identify many other genetic disorders.
    - ELISA is based on the principle of **antigen-antibody interaction**. Infection by pathogen can be detected by the presence of antigens (proteins, glycoproteins, etc.) or by detecting the antibodies synthesised against the pathogen.

- **Stem Cell Therapy:** It is an intervention strategy that **introduces new adult stem cells into damaged tissue** in order **to treat disease or injury**.
    - It has proven to be effective for organs and tissues restoration, and for fight against the incurable and obstinate diseases.
- **Genetic testing:** It is a type of medical test that identifies changes in chromosomes, genes, or proteins.
    - The results of a genetic test can confirm or rule out a suspected genetic condition or help determine a person's chance of developing or passing on a genetic disorder.
- **Assisted Reproductive Technologies (ART):** ART includes all fertility treatments in which both eggs and sperm are handled.
    - In general, ART procedures involve surgically removing eggs from a woman's ovaries, combining them with sperm in the laboratory, and returning them to the woman's body or donating them to another woman.

5.3. Applications of Biotechnology in Industry and Healthcare:

- Improvement in Fermentation Products
- Microbial Production of Synthetic Fuels
- Microbial Mining or Bioleaching
- Microbial Biomass and Single Cell Pro-tein Production
- Production of Enzymes and Human Proteins
- Production of Secondary Metabolites from Cultured Plant Cell
- Molecular Farming for Healthcare Pro-ducts

5.4. Applications of Biotechnology in Environment

- **Waste Treatment:** The aerobic waste treatment requires a large population of actively metabolizing microorgan-isms such as Pseudomonas, Alcaligenes, Achromobacter and Brevibacterium, able to degrade both colloidal and soluble organics with high rate of conversion of CO_2 and water.
    - The nitrogenous waste materials are treated both aerobically and anaerobically alternatively.
    - The degradation of nitrogenous compounds gives ammonia, which is then converted to nitrate by **nitrifying bacteria**. Then by the action of **denitrifying bacteria** in anaerobic environment releases N_2 gas in the atmosphere.
- **Biodegradation:** It is the process by which materials such as oil spill, herbicides, pes-ticides, etc. are degraded by the action of micro-bial system.
    - Organic compounds which are naturally occurring (biogenic) are biodegradable while man-made (xenobiotic) compounds may be biodegradable, persistent or recalcitrant.
    - Genes coding for some enzymes essential for the biodegradation of a number of organic compounds are plasmid borne and organisms have been constructed to degrade difficult waste.
    - A strain of Pseudomonas putida is constructed to contain plasmids coding for the breakdown of octane, xylene, metaxylene and camphor. This organism is claimed to be useful for **cleansing of oil spills**.
- **Microorganisms in Pollution Control:**
    - Microbial strains can be isolated in order to **con-trol various forms of chemical pollution such as biocides, detergents, plastic materials and hydro-carbons**.

- The bacteria belonging to the genus Pseudomonas have oxidoreduction or hydroxylation enzymes **capable of degrading a large number of hydrocarbon molecules or aromatic compounds** that are often highly toxic.

- **Biomass Energy Production:**
  - Ethanol is formed from various sources, such as cassava, cereals, potato, sugarcane, pineapple, sugar beet, etc.
  - Methane fermentation.
  - Production of biogas in rural areas.

6. DEVELOPMENTS IN THE FIELD OF BIOTECHNOLOGY

6.1. Proton therapy

- Proton beam therapy
- It is a medical procedure, **a type of particle therapy**
- **It uses a beam of protons to irradiate diseased tissue**, most often in the treatment of cancer.
- Proton therapy chief advantage over other types of external beam radiotherapy is that as a charged particle, the dose is deposited over a narrow range and there is minimal exit dose.
- a type of **external beam radiotherapy** that **uses ionizing radiation**.
- In proton therapy, medical personnel **use a particle accelerator to target a tumor with a beam of protons. These charged particles damage the DNA of cells, ultimately killing them or stopping their reproduction**. Cancerous cells are particularly vulnerable to attacks on DNA because of **their high rate of division** and **their reduced abilities to repair DNA damage**.
- **Due to their relatively large mass, protons have little lateral side scatter in the tissue; the beam does not broaden much, stays focused on the tumor shape and delivers only low-dose side-effects to surrounding tissue. All protons of a given energy have a certain range; very few protons penetrate beyond that distance**. Furthermore, the dose delivered to tissue is maximum just over the last few millimeters of the particle's range; this maximum is called the **Bragg peak.**

6.2. STEM CELL

- Our body is made up of many different types of cell. **Most cells are specialised to perform particular functions**, such as red blood cells that carry oxygen around our bodies in the blood, but **they are unable to divide**.
- A stem cell is a cell with the unique **ability to develop into specialised cell types** in the body.
- They remain inactive (inert, inoperative) as undifferentiated cells within tissues or organs as long as tissue homeostasis does not require generation of new cells. Here, they can renew themselves or differentiate**(transform) into some or all major specialized cell types** that make up the tissue or organ.
- Stem cells **provide new cells for the body as it grows**, and **replace specialised cells that are damaged or lost**. They have two unique properties that enable them to do this:
  - **They can divide over and over again** to produce new cells.
  - As they divide, **they can change into the other types of cell** that make up the body.
- When a stem cell divides, each new cell has the potential either to remain a stem cell or become another type of cell with a more specialized function, such as a muscle cell, a red blood cell, or a brain cell.
- In the future they may be **used to replace cells and tissues that have been damaged or lost due to disease**.

Types of stem cell: There are three main types of stem cell:

- Embryonic stem cells
- Adult stem cells
- Induced pluripotent stem cells

Embryonic stem cells

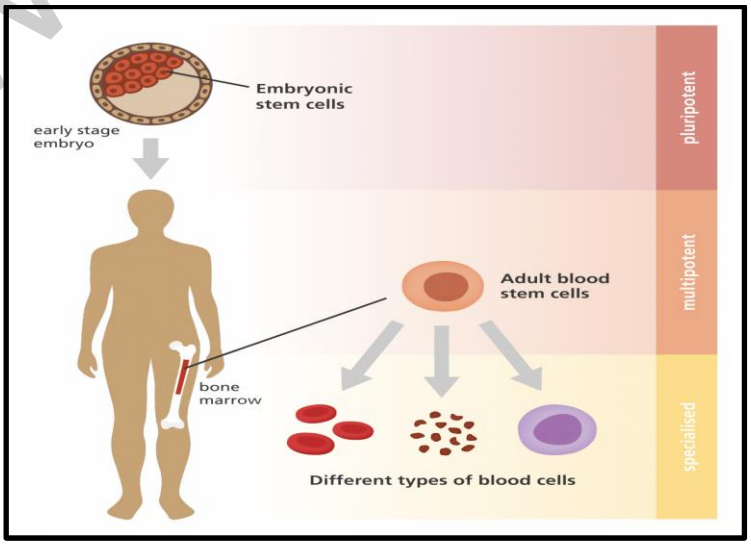
- **Present in adult human body**.
- They form part of some tissues like the epidermis of the skin, the lining of the small intestine and the bone marrow which undergoes continuous cellular change.
- their production does not require the destruction of an embryo.
- Embryonic stem cells **supply new cells for an embryo** as it grows and develops into a baby.
- These stem cells are said to be **pluripotent**, which means **they can change into any cell in the body**.
- when adult stem cells are obtained from the intended recipient (an autograft) there is no risk of immune rejection.
- Uses: Adult stem cell used to treat leukemia and related bone/blood cancers through bone marrow transplants.

Adult stem cells (i.e. somatic stem cells)

- Adult stem cells **supply new cells as an organism grows** and **to replace cells that get damaged**.
- Adult stem cells are said to be **multipotent**, which means **they can only change into some cells in the body, not any cell**. for example:
    - Blood (or 'haematopoietic') stem cells can only replace the various types of cells in the blood.
    - Skin (or 'epithelial') stem cells provide the different types of cells that make up our skin and hair.

Induced pluripotent stem cells

- Induced pluripotent stem cells, or 'iPS cells', are **stem cells that scientists make in the laboratory**.
- 'Induced' means that they are made in the lab **by taking normal adult cells, like skin or blood cells**, and **reprogramming them to become stem cells**.
- Just like embryonic stem cells, they are **pluripotent** so they can develop into any cell type.
- Tissues derived from iPSCs will be a nearly identical match to the cell donor and thus probably avoid rejection by the immune system.



Significance of stem cells: Stem cells have several uses including:

- **Research** – to help us understand the basic biology of how living things work and what happens in different types of cell during disease.
- **Therapy** – to replace lost or damaged cells that our bodies can't replace naturally.

Stem Cell Research

- Research is looking **to better understand the properties of stem cells** so that we can:
  - **understand how our bodies grow and develop**
  - **find ways of using stem cells to replace cells or tissues that have been damaged or lost**.
- We can use stem cells to **study how cells become specialised for specific functions in the body,** and **what happens when this process goes wrong in disease**.
- If we understand stem cell development, **we may be able to replicate this process to create new cells, tissues and organs**.
- We can grow tissue and organ structures from stem cells, which **can then be studied to find out how they function** and **how they are affected by different drugs**.

Stem Cell Therapy

- Cells, tissues and organs **can sometimes be permanently damaged or lost by disease**, injury and genetic conditions.
- Stem cells may be one **way of generating new cells** that can then be **transplanted into the body to replace those that are damaged/lost**.
- Adult stem cells are currently used to treat some conditions, for example:
  - **Blood stem cells are used to provide a source of healthy blood cells for people with some blood conditions**, such as thalassaemia, and cancer patients who have lost their own blood stem cells during treatment.
  - **Skin stem cells can be used to generate new skin for people with severe burns**.
- Stem cells could be used to **generate new organs for use in transplants:**
  - Currently, damaged organs can be replaced by obtaining healthy organs from a donor, however donated organs may be 'rejected' by the body as the immune system sees it as something that is foreign.
  - **Induced pluripotent stem cells** generated from the patient themselves could be used to **grow new organs that would have a lower risk of being rejected**.
- Stem cells are used in early clinical trials in Parkinson's diseases (foetal stem cells)
- Now in UK, researches have explored possibility of treating foetuses by stem cell therapy to remove genital defects.
- Stem cell therapy is also considered ideal for human cloning.

How to generate induced pluripotent stem cells?

- Signals in the body **tell a cell what type of specialised cell it should be** by switching some genes on and some genes off.
- To generate induced pluripotent stem cells, scientists **re-introduce the signals that normally tell stem cells to stay as stem cells in the early embryo**. These **switch off any genes that tell the cell to be specialised**, and **switch on genes that tell the cell to be a stem cell**.

Question from UPSC Main Exam:
Stem cell therapy is gaining popularity in India to treat a wide variety of medical conditions including leukaemia, Thalassemia, damaged cornea and several burns. Describe briefly what stem cell therapy is and what advantages it has over other treatments? (UPSC Mains 2017)

6.3. DNA PROFILING

What is DNA?

- DNA (Deoxyribonucleic acid) is the **hereditary material in humans and almost all other organisms**.
- Nearly every cell in a person's body has the same DNA.
- Most DNA is **located in the cell nucleus** (where it is called **nuclear DNA**), but a small amount of DNA can also be found in the mitochondria (where it is called **mitochondrial DNA** or mtDNA).
    - Mitochondria = Structures within cells that **convert the energy from food into a form that cells can use**.
- The information in DNA is stored as a code made up of four chemical bases: adenine (A), guanine (G), cytosine (C), and thymine (T).
- Human DNA consists of about 3 billion bases, and more than 99% of those bases are the same in all people. The **order, or sequence, of these bases** determines the information available for building and maintaining an organism.

Formation:

- DNA bases pair up with each other, A with T and C with G, to form units called base pairs.
- Each base is also attached to a sugar molecule and a phosphate molecule.
- Together, a base, sugar, and phosphate are called a **nucleotide**.
- Nucleotides are **arranged in two long strands** that **form a spiral called a double helix**.

Features:

- DNA can replicate, or make copies of itself.
- **Each strand of DNA in the double helix can serve as a pattern** for duplicating the sequence of bases.
- Even a small part of this information **can be used to uniquely identify a human being**, except in the case of identical twins who have almost the same DNA sequence.
- DNA **can be extracted from any part of the body,** blood, bones or even a strand of hair, or clothing.
- DNA in an individual's chromosomes **controls an array of visible characteristics (including race, colouring and sex)** as well as **invisible characteristics (such as blood groups and susceptibility to inherited diseases)**.

DNA Profiling

- It is also called DNA fingerprinting, DNA typing, genetic fingerprinting, genotyping, or identity testing.
- The process where **a specific DNA pattern, called a profile, is obtained from a person or sample of bodily tissue.**
- Method of **isolating and identifying** variable elements within the base-pair sequence of DNA.
- It involves collection of a few skin cells, muscle tissues, a hair root or a tiny amount of blood or saliva etc body fluids. Then, DNA strands are extracted from the sample.

- Human DNA profiles can be used to identify the origin of a DNA sample at a crime scene or test for parentage.

Use of DNA Profiling:

- DNA profiling is the best method to identify a person.
- **Identify the probable origin of a body fluid sample** associated with a crime or crime scene
- **Reveal family relationships:** An individual gets 50% of one's DNA from each of one's parents, which can be used to identify parents, siblings and relatives of an individual.
- **Identify disaster victims**, for example, ESR scientists travelled to Thailand to help identify victims of the 2004 Boxing Day tsunami.
- Identifying dead bodies, missing persons etc.
- Can help to trace people who are suspected of committing a crime.

Limitations of DNA technology

1. **Privacy issues:**
    - **DNA samples can reveal not just physical features of individual, but also more intrusive information like their allergies, or susceptibility to diseases.**
    - **Consequently, there is a greater risk of information from DNA analysis getting misused.**
    - **The misuse of information can cause serious harm to individuals and the society as a whole.**
2. **Not reliable data:** Sometimes, DNA data recovered from a crime scene may not be enough to produce a correct match for the algorithms.
3. **DNA profiling:** DNA profiling can be mismatched while generating a match. It will be difficult to resort if wrongly matched is taken as evidence.
    a) Data storage issues are also involved.
    b) DNA technology is very expensive

Why DNA Profiling Law is needed?

- At present, **DNA testing labs are unregulated and lack uniform testing protocols and procedures**. In the absence of a legal framework, a database can't be prepared and maintained.
- It **depends on the government as to what kind of information it wants included in the database** such as information on only convicted persons, suspects or all those jailed.
- If the database is to include all those in custody, then the DNA profile of acquitted individuals will have to be deleted, as done in some countries.

Various reports related to DNA:

1. **The A. P. Shah Committee Report:**
    - The report suggested safeguards to prevent illegal collection and use of DNA data.
    - Also provides safeguards to prevent the proposed body from misusing the same.
2. **Law commission report:**
    - The Law Commission of India, in its 271st report, prepared the draft Bill named The DNA Based Technology (Use and Regulation) Bill, 2017 after examining various judicial pronouncements and constitutional provisions.
    - It however had also flagged that privacy concerns and the ethics involved in this scientific collection of data were very high.

- The Commission highlighted that the procedure for DNA profiling, if given statutory recognition, should be done legitimately as per constitutional provisions.

3. **Malimath Committee Report:** It recommended amendment of Cr.P.C conferring all criminal courts at all levels with the inherent power to pass appropriate orders.
    - Maintenance of strict confidentiality with regard to keeping of records of DNA profiles and their use.
    - The violators of the provisions would be liable for punishment of imprisonment, which may extend up to three years and also fine which may extend up to Rs.2 lakhs.

The DNA Technology (Use and Application) Regulation Bill, 2018

- **Use of DNA Data:** The Bill **regulates the use of DNA technology** for establishing the identity of persons in respect of matters listed in a Schedule. These include
    - **Criminal matters** such as offences under the Indian Penal Code, 1860, and
    - **Civil matters** such as parentage disputes, emigration or immigration, and transplantation of human organs.
- **Consent for collecting bodily substances**
    - In case of a person arrested for an offence which carries punishment upto 7 years, the authorities are required to **obtain his written consent before collecting his bodily substances**.
        - If consent is not given, the authorities may approach a Magistrate who may order the taking of bodily substances from the individual, if he is satisfied that DNA will confirm or disprove the individual's involvement in the alleged offence.
        - If the offence carries a punishment of more than 7 years of imprisonment or death, **consent is not required**.
- **Accreditation of DNA Laboratories**
    - Any laboratory that **conducts DNA testing and analysis** to establish the identity of an individual, is required to **obtain accreditation from the DNA Regulatory Board**.
    - Every DNA laboratory is required to follow standards of quality assurance in collection, storing, testing, and analysis of DNA samples.
- **DNA Data Bank**
    - The central government will establish a **National DNA Data Bank** and **Regional DNA Data Banks** for each state (or two or more states).
    - Every DNA Data Bank is required to maintain the following indices based on DNA testing conducted by a DNA laboratory: (i) crime scene index, (ii) suspects' or undertrials' index, (iii) offenders' index, (iv) missing persons' index, and (v) unknown deceased persons' index.
- **Sharing of DNA data with Data Banks: All DNA laboratories will share DNA data prepared by them with the National and Regional DNA Data Banks**.
- **Removal of DNA profiles**
    - DNA profiles in the crime scene index or missing persons' index **will be removed from the DNA Data Banks on the basis of a written request by the individual**.
    - The DNA profile of a suspect will be removed after the filing of a police report or as per a court order.
    - In the case of an undertrial, the DNA profile will be removed on the basis of a court order.

- **DNA Regulatory Board**
  - The Bill provides for a DNA Regulatory Board, which **will supervise DNA Data Banks and DNA laboratories**.
  - The **Secretary in the Department of Biotechnology** is the ex-officio Chairperson of the Board.
  - The Board will comprise an additional 12 members including:
    i. experts in the field of biological sciences.
    ii. Director General of the National Investigation Agency.
    iii. Directors of the Central Bureau of Investigation, Centre for DNA Fingerprinting and Diagnostics, Central Forensic Science Laboratory.
    iv. member of the National Human Rights Commission.
  - The functions of the Board include:
    - supervising DNA laboratories and DNA Data Banks, including quality control,
    - granting accreditation to DNA laboratories, and
    - developing modules for training manpower to deal with DNA related matters.
    - the Board **will make recommendations to the central government on privacy protection in relation to the use and analysis of DNA samples**.
  - The Board is required to ensure that **all information relating to DNA profiles with Data Banks, DNA laboratories, and other persons are kept confidential**. DNA data may only be used for the identification of persons.
- **Offences and penalties:** The penalty for various offences such as:
  - unauthorised disclosure of information from the Data Bank,
  - obtaining information from the Data Bank without authorisation, or
  - using DNA sample without authorisation, is imprisonment up to three years and fine of up to one lakh rupees. Further, the penalty for intentional tampering or destruction of biological evidence is imprisonment up to five years as well as fine of up to two lakh rupees.

Issues with the Bill:

- The Bill requires consent of the individual when DNA profiling is used in criminal investigations and identifying missing persons. However, **consent requirements have not been specified in case of DNA profiling for civil matters**.
- The Schedule lists civil matters where DNA profiling can be used. This includes "issues relating to establishment of individual identity." DNA testing carried out in medical or research laboratories can be used to identify an individual. **It is unclear if the Bill intends to regulate such laboratories**.
- DNA laboratories are required to share DNA data with the Data Banks.
  - It is **unclear whether DNA profiles for civil matters will also be stored in the Data Banks**.
  - Storage of these profiles in the Data Banks **may violate the right to privacy**.
- DNA laboratories prepare DNA profiles and then share them with DNA Data Banks. The Bill specifies the process by which DNA profiles may be removed from the Data Banks. However, the Bill **does not require DNA laboratories to remove DNA profiles**.

7. NATIONAL BIOTECHNOLOGY DEVELOPMENT STRATEGY 2015-2020

- **The Strategy aims**
  - To establish India as a world-class bio-manufacturing hub.

    - To launch a major mission, backed with significant investments, for the creation of new biotech products, create a strong infrastructure for R&D and commercialization, and
    - To empower India's human resources scientifically and technologically.
- **The envisaged mission is:**
    - Provide impetus to utilising the knowledge and tools to the advantage of Humanity
    - Launch a major well directed mission backed with significant investment for generation of new Biotech Products
    - Empower scientifically and technologically India's incomparable Human Resource
    - Create a strong Infrastructure for R&D and Commercialisation
    - Establish India as a world class Bio-manufacturing Hub
- **The Key elements of the Strategy are:**
    - Building a Skilled Workforce and Leadership
    - Revitalizing the knowledge environment at par with the growing bio-economy
    - Enhance Research opportunities in basic, disciplinary and interdisciplinary sciences
    - Encourage use-inspired discovery research
    - Focus on biotechnology tools for inclusive development
    - Nurturing innovation, translational capacity and entrepreneurship
    - Ensuring a transparent, efficient and globally best Regulatory system and communication strategy
    - Biotechnology cooperation- Fostering global and national alliances
    - Strengthen Institutional Capacity with redesigned governance models
    - Create a matrix of measurement of processes as well as outcome
- **The key elements would be implemented in collaboration and partnership with Other Ministries, Departments, State Governments and international agencies towards achieving:**
    - Making India ready to meet the challenge of achieving US$100bn by 2025
    - Launching Four Major Missions – Healthcare, Food and Nutrition, Clean Energy and Education
    - Creating a Technology Development and Translation network across the country with global partnership-5 new clusters, 40 Biotech incubators, 150 TTOs, 20 Bio-connect centres
    - Strategic and focussed investment in building the Human Capital by creating a Life Sciences and Biotechnology Education Council
- Major initiatives of the National Biotechnology Development Strategy 2015-2020:
    - Launch **four major missions** in healthcare, food and nutrition, clean energy and education
    - Create a **technology development and translation network** across India with global partnership, including 5 new clusters, 40 biotech incubators, 150 TTOs, and 20 bio-connect centres
    - Ensure strategic and focused investment in building the human capital by setting up a **Life Sciences and Biotechnology Education Council**

8. NATIONAL BIOPHARMA MISSION

- It was launched in 2017 as the f**irst ever Industry-Academia mission** to accelerate biopharmaceutical development in India. Its legal arrangement with the **World Bank** was signed in 2018.
- The program named ***Innovate in India* (i3)** will witness an investment of USD 250 million with USD 125 million as a loan from World Bank.

- It aspires **to create an enabling ecosystem** to promote entrepreneurship and indigenous manufacturing in the sector.

Need for the scheme

- I**ndian biopharmaceutical industry** is still **10-15 years behind their counterparts** in the developed countries and faces stiff competition from China, Korea and others. The lacuna primarily exists due to **disconnected centers of excellence**, less focus on translational research and **staggered funding**.

Benefits

- India has only **2.8% share** in the global biopharmaceutical market, the program would elevate this to **5%** resulting in an additional **business opportunity of 16 Billion USD.**
- It has potential to make India a **hub for design and development** of novel, affordable and effective biopharmaceutical products and solutions.

Achievement of Indian in the field of Biotechnology: Nobel Laureate Har Gobind Khorana

- His contributions to biology are of contemporary relevance for some of the most exciting areas such as **synthetic biology and gene editing**.

What were his contributions to biology?

- After James Watson and Francis Crick found that DNA (Deoxyribonucleic acid) had a double-helix structure, Khorana was among those who significantly built on that knowledge and **explained how this sequence of nucleic acids (better known as the genetic code) goes about making proteins, which is critical to the functioning of cells.**
- **Synthetic genes: Har Gobind Khorana is credited with making the first synthetic genes by cutting and pasting DNA bits.**
- This is considered a forerunner to the method called Polymerase Chain Reaction that is among the methods used to commercially read the unique genetic structures of organisms today.
- **Founding father of biotechnology:** He further placed the lab-made gene in a living bacterium and was, in that sense, a founding father of biotechnology.
- **CRISPR/Cas9 system references Hargobind Khorana's work:** The CRISPR/Cas9 system, which is the glitziest new toy in genetics and is used alter the functioning of certain genes, references the work of Khorana as a key influence.'

Nobel Prize to HarGobind Khorana:

- The Nobel Prize in Physiology or Medicine for 1968 was awarded jointly to Robert W. Holley, HarGobind Khorana and Marshall W. Nirenberg "for their interpretation of the genetic code and its function in protein synthesis."
- Khorana was able to **create nucleic acids in the lab** and did so **by figuring out the order in which nucleotides needed to be to make a suite of amino acids**, which are the basic units of proteins.

His connection with India?

- Khorana was born in 1922 in Raipur, a village in Punjab now part of Pakistan
- He was the youngest of six siblings and his father was a 'patwari', a village agricultural taxation clerk in the British Indian system of government

- He lived in India until 1945, when the award of a Government of India Fellowship made it possible for him to go to England for a PhD at the University of Liverpool
- Khorana became a naturalised U.S. citizen in 1966.

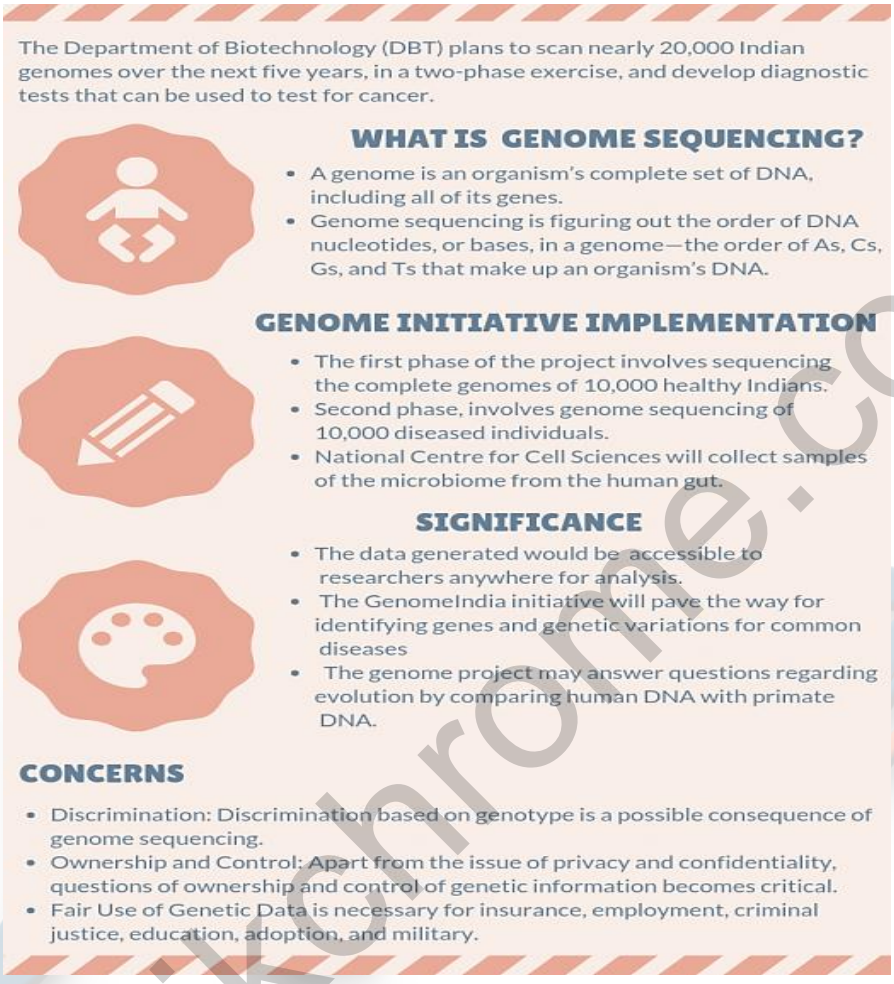


Figure: human genome initiative

9. MISCELLANEOUS

A. SOHUM HEARING AID

- Sohum is a low cost and unique portable device which uses brainstem auditory evoked response, the gold standard in auditory testing **to check for hearing response in a newborn**.
- It is indigenously developed by School of International Biodesign (SIB) startup M/s Sohum Innovation Labs India Pvt. Ltd. under **Department of Biotechnology** (DBT).

Significance

- Nearly **1,00,000 babies** are in India are born with **hearing impairment every year**.
- One of the most common birth disorders – congenital hearing loss when it is discovered at 4+ years, it's **too late to reverse** the damage. Thats where Sohum comes into picture.
- Currently, this technology is prohibitively expensive and inaccessible to many. Sohum has made the technology appropriate for the resource constrained settings and aims to cater to nearly **26 million babies** born every year in India.

- The **battery-operated** device is **non-invasive**, which means babies do not need to be sedated, which is a risky process in practice currently.

B. MONKEY FEVER IN KARNATAKA

Recently, **Shivamogga and Uttara Kannada district** have witnessed spiralling cases of **Kyasanur Forest Disease or monkey fever.** With the two districts reporting 110 positive KFD cases and nine deaths, it has caused **panic** among locals and tourists.

KFD

- It is caused by Kyasanur Forest Disease virus or KFD virus, a member of **Flaviviridae family**, which also causes **yellow fever and dengue.**
- It was first detected in **1957** in Kyasanur village, Shimoga and is endemic to Southern India.
- It is called as Monkey fever because it primarily **attacks black-faced langurs and red-faced bonnet monkeys**, resulting in their death.

Main concern

- Even after the death of the monkey, the KFD **virus is transmitted through the ticks** thriving on the monkeys.
- These ticks are carriers of the KFD and they thrive in **Western Ghats**, transmitting the disease to humans.

C. JEEVAN BINDI

- It is a **medically enhanced vermillion** (bindi) which contains **iodine** along with an adhesive base and has been developed by Singapore-based agency and a Maharashtra-based NGO.
- It will deliver daily requirement of 100-150 adsorption through the skin if it is worn 8 hours a day.

Significance

Over 70 million Indians suffer from various **iodine-deficiency related disorder including Goitre**. The most severe impact of this is seen in **pregnant women** which are the main target group for this initiative.

D. THREE-PARENT BABY

News: In February 2018, **UK** became the **first country** to officially **approve procedures for giving birth to three-parent baby.**

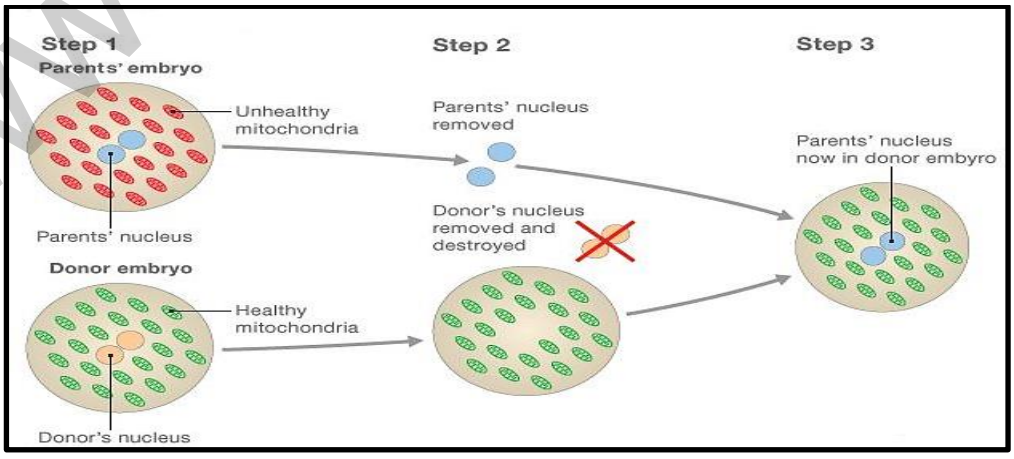


Figure: three parent mitochondrial therapy

Three parent babies

- This process is adapted **to replace the mother's faulty mitochondrial DNA** through Mitochondrial Replacement Therapy.
- The three-person baby procedure involves the **donation of healthy mitochondria** from a third person. But mitochondria have their own DNA, which is why resulting children have DNA from three people.
- However, everything that defines **physical and personality traits still comes from parents** as mitochondrial DNA accounts for negligible amount of overall DNA count.

Issues

It manipulates with natural human eggs which may have long-term **evolutionary implications** and unintended **hereditary consequences**. Also, parents may misuse this technique to go for **designer babies**. It may have a **psychological impact on the child** born. Also, the **identities of the donor** women involved in the cases have to be been withheld.

E. EMBRYO TRANSFER TECHNOLOGY

- **Department of Animal husbandry**, Dairying and Fisheries in 2017 launched **Embryo Transfer programme** under the scheme of **National Mission on Bovine Productivity**.
- Under this technology, **embryos of higher genetic merit** indigenous bovines such as Sahiwal, Gir, Red Sindhi, Ongole, Deoni and Vechur are **transferred in to surrogate cows.**

What is Embryo Transfer Technology?

- Embryo transfer is a specialized technique of breeding.
- A sexually mature female referred to as the donor is injected with exogenous hormones to produce.
- More ova, which are fertilized inside her either by natural or artificial service. These are then removed prior to their implantation and transfer to the reproductive tracts of synchronized surrogate mothers of the same species referred to as the recipients.
- The fertilized ova, thus are developed in the recipient body and resulting offspring derive their genes from the donor and from the male to which donor was bred.

Benefits

- A farmer can get a **5-6-fold increase in number of offsprings**.
- The **calves so born will be of high genetic merit** and
- The **offsprings born will be free from diseases**.

F. OXYTOCIN

Oxytocin is a hormone that is **released naturally** by the pituitary glands of mammals **during sex, childbirth, lactation or social bonding,** and is sometimes called "love hormone". It can **contract the uterus and induce delivery, control bleeding, and promote the release of breast milk.**

Misuse and effects

- **Indiscriminate use** of oxytocin in dairy animals, like buffaloes, to increase milk production make **cattle infertile** and **reduced their lifespans**. However, there is little evidence to fully support this view.
- Administering the injection by untrained farmers and also its high doses can **hurt animals**.
- It is also been used in the **flesh trade** to stimulate early puberty in young girls.

- In addition, it claimed that **drinking milk** from oxytocin-treated cattle led to male **impotence, early puberty among women and cancers**.

Government response

- In 2016, Himachal Pradesh High Court passed an order listing the **grave dangers** oxytocin posed to humans.
- Drugs Technical Advisory Board **recommended against a ban**, advocating better surveillance instead. A ban might lead to scarcity and high drug prices.
- However, from September 2018, Government has **restricted the manufacture** of Oxytocin formulations for domestic use to **public sector only**. It has also **banned the import** of Oxytocin and its formulations, in addition to **ban on the retail sale**.

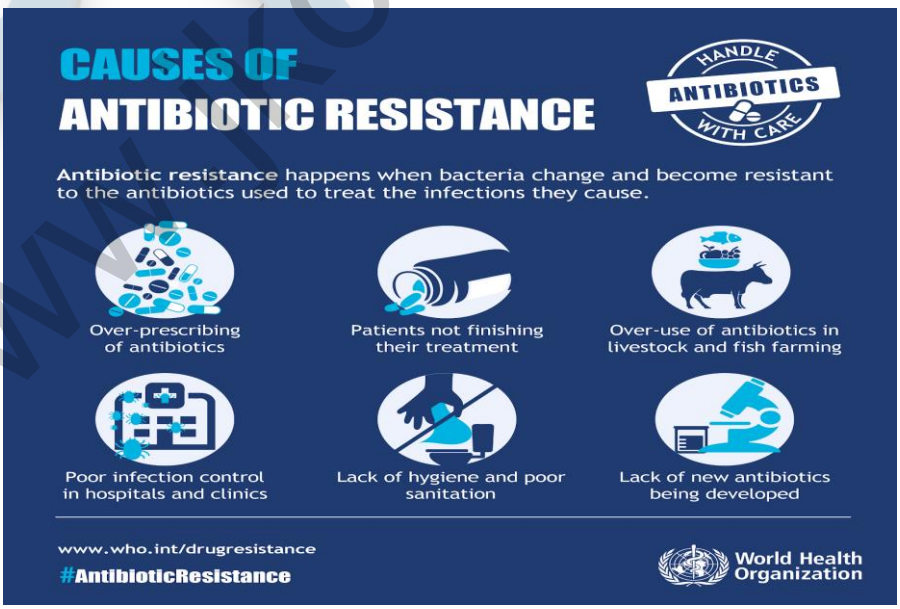
Current Status

The Delhi High Court had, on December 15, quashed the government order of restricting the manufacturing and sale of Oxytocin to only one public sector outfit — Karnataka Antibiotics and Pharmaceuticals (KAPL) — which continues the bulk production of the hormone. Continuing its battle to restrain the production of life-saving hormone Oxytocin, the Centre plans to move the Supreme Court, appealing for a ban on private manufacturing and sale of the crucial drug, said sources close to the development.

G. ANTIMICROBIAL RESISTANCE IN INDIA

Antimicrobial resistance occurs when **microorganisms** like bacteria, viruses etc. **undergo mutation or changes that renders the medications** used to cure the diseases to be **ineffective**.

- **India** is the **highest consumer of antibiotics** (though per capita consumption is less) as per a **2017 report of Ministry of Science and Technology**.
- Also is has one of the **highest resistances to carbapenem class of antibiotics**, which is the last-resort antibiotic to treat serious bacterial diseases.



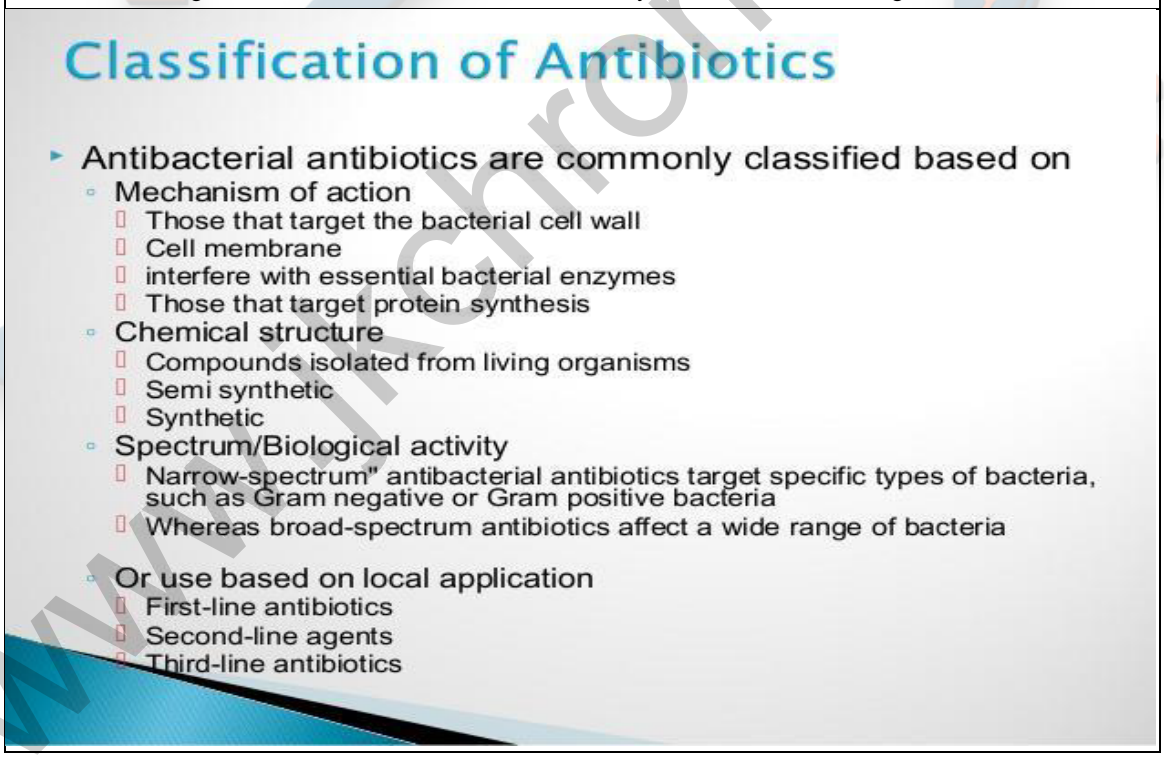
Government Initiatives

- In 2013, The Drugs and Cosmetics Rule was amended to incorporate a new **Schedule H1** class of drugs for having strict control over their sales.

- **FSSAI** has issued **guidelines** to limit their use in food products like fish.
- In 2016, **Red line campaign** on antibiotics by which **all antibiotics packets will carry a red line,** was launched, to create awareness.
- **National Action Plan on Antimicrobial Resistance 2017:** It envisages coordinated tasks of various Government agencies involving health, education, livestock and environment to change prescription practices and patients behaviour and increase surveillance.

WHO has been leading multiple initiatives to address antimicrobial resistance:

- **World Antibiotic Awareness Week**
  Held every November since 2015 with the theme "Antibiotics: Handle with care", the global, multi-year campaign has increasing volume of activities during the week of the campaign.
- **The Global Antimicrobial Resistance Surveillance System (GLASS)**
  The WHO-supported system supports a standardized approach to the collection, analysis and sharing of data related to antimicrobial resistance at a global level to inform decision-making, drive local, national and regional action.
- **Global Antibiotic Research and Development Partnership (GARDP)**
  A joint initiative of WHO and Drugs for Neglected Diseases initiative (DNDi), GARDP encourages research and development through public-private partnerships. By 2023, the partnership aims to develop and deliver up to four new treatments, through improvement of existing antibiotics and acceleration of the entry of new antibiotic drugs.



H. ZOONOTIC DISEASE: NIPAH VIRUS

- Zoonotic diseases are those diseases that can s**pread between humans and animals** and can be caused by bacteria, viruses, fungi and parasites. Important zoonotic diseases are rabies, avian influenza, plague, KFD, Nipah etc.
- **Kerala** in 2018 reported several deaths due to the outbreak of Nipah virus, third such outbreak in India after **2001(West Bengal)** and 2007.

Nipah virus

- It was first detected in **Nipah, Malaysia in 1998**. The major host of the virus are **fruit bats** while pigs and other domesticated animals can also be their host.
- The virus is present in **bat urine, faeces or other body fluids** from where they are transmitted to humans. It can be transmitted from **one person to other as well.**
- It is known to affect humans in Malaysia and Singapore after coming in direct contact with the **excretions or secretions of infected pigs.**
- Reports from outbreaks in Bangladesh suggest transmission from bats in the **process of drinking raw palm sap contaminated with bat excrement or climbing trees coated in the same.**
- Typically, the human infection presents as an **encephalitic syndrome** marked by fever, headache, drowsiness, disorientation, mental confusion, coma, and potentially death.

Cause of outbreaks

The rising number of zoonotic disease outbreak is due to increase in population, migration, habitat destruction etc.

I. TB ELIMINATION: STATUS IN INDIA

News: The WHO released **World Global TB report 2018** in which **India** is the **leading country** in terms of TB burden, accounting for 26 % of all new TB cases in 2017.

Tuberculosis

These are infectious communicable diseases caused by Mycobacterium tuberculosis and usually affects lungs. Globally, **1.7 million people die** of TB and over 10 million fall ill annually, thus making it second biggest killer disease.

Status in India

- India leads in the number of annual TB cases (**2.7 million out of 10 million**) as well as in cases of **Multidrug Resistant TB** (1.47 lakh out of 6 lakh cases)

Recent Initiatives by the Government

- National Strategic Plan for TB Elimination (**NSP 2017-25**): It envisages deploying **improved rapid diagnostics** to the field level, **improving communication**, outreach and **social mobilization** and utilizing **ICT tools** for strengthening TB surveillance, among others. It aims to make India **TB-free by 2025**, against global target of 2030.
- **NIKSHAY portal:** Launched in 2018, it is a web-based solution for **monitoring** of TB patients under the Revised National Tuberculosis Programme (RNTCP). **SMS services** are to be used for **communication with patients**. It helps the grassroot level healthcare providers to **track every TB patient**.
- The **Delhi End TB Summit 2018**: India hosted the summit where TB Free India Campaign was launched.
- **Bedaquiline drug** was introduced in India in 2016 under conditional access programme for selective group of the Multi drug resistant TB patients.
- To identify the drug resistance at early stage, all TB patient are being screened for detection of resistance under **Universal Drug Susceptibility Testing** since 2017.

WHO End TB Strategy 2016 - 2035

In 2014 the World Health Assembly adopted the World Health Organisation (WHO)'s "Global strategy and targets for tuberculosis prevention, care and control after 2015". This twenty-year strategy aims to end the global TB epidemic and is unsurprisingly called the End TB Strategy. Ending TB is defined as an incidence rate of less than 10 people per 100,000 population per year. The incidence rate is the number of new cases of active TB disease in a population in a particular time period.

The main targets in the End TB Strategy are:

- To reduce TB deaths by 95%
- To cut new cases of TB by 90% between 2015 and 2035
- To ensure that no family is burdened with catastrophic expenses due to TB.

Global Plan Targets (90-90-90)

At its core the Global Plan is about improving the reach and quality of medical treatment for TB. There is enormous scope for this to be done. Three targets have been set and it is estimated that if these targets are achieved by 2025 at the latest, then the goal to end TB will be met. The Global Plan therefore recommends that the targets should be achieved as soon as possible, ideally by 2020, and at the latest, by 2025.

Figure: WHO 90-90-90 target for TB

J. WOLBACHIA BACTERIA

Wolbachia

It is a **microorganism(bacteria)** which is present in almost 60% of all species of insects and mosquitoes, **except Aedes aegypti mosquito**. The 'Aedes aegypti mosquito' is primarily responsible for spreading diseases like chikungunya, dengue and zika.

- **If introduced** in mosquitoes, it **can prevent these viruses from growing and spreading.**

News:

- In 2018, **Australian researchers** successfully protected around 1.87 lakh population of Queensland's Townville from the mosquito-borne disease by using mosquitoes which carry Wolbachia.

- **Small numbers of Wolbachia-carrying mosquitoes are released** in target areas. They then **breed** with wild mosquitoes and over time the percentage of mosquitoes carrying Wolbachia grows **eliminating the need for regular introduction**.

Significance:
It is a **self-sustaining** method and offers a **safe, effective and long-term solution** to reduce the burden of dengue and other similar viruses.
India reported **1.9 lakh dengue cases and 325 deaths** across several states in the country in 2017.

Initiatives in India:
The **Andhra Pradesh government** in 2018 launched an experimental project to control the spread of dengue fever by infecting Aedes aegypti mosquito with Wolbachia. Similar research was already launched in **Maharashtra, and by the ICMR**.

3. IT AND COMPUTER SCIENCE

Computer is an electronic device which is used for processing information and performing various calculations by following different sets of programs to perform sequences of mathematical and logical operations, whereas, information is the study or use of systems (such as computers and telecommunications devices) for storing, retrieving, and sending data.
Information technology is the study, design, development, implementation, support or management of computer-based information systems—particularly software applications and computer hardware.

1. CYBER-PHYSICAL SYSTEMS (CPS)

- CPS are **integrations of computation, networking, and physical processes**.
- Embedded computers and networks **monitor and control the physical processes**, with **feedback loops** where physical processes affect computations and vice versa.
- The technology builds on the embedded systems, computers and software embedded in devices whose principle mission is not computation, such as cars, toys, medical devices, and scientific instruments.
- CPS **integrates the dynamics of the physical processes with those of the software and networking, providing abstractions and modeling, design, and analysis techniques for the integrated whole**.
- Technologies associated with CPS: Artificial Intelligence (Al), Internet of Things (loT), Machine Learning (ML), Deep Learning (DP), Big Data Analytics, Robotics, Quantum Computing, Quantum Communication, Quantum encryption (Quantum Key Distribution), Data Science & Predictive analytics, Cyber Security for physical infrastructure and other infrastructure.
- **Significance of CPS for Governments:**
    - It has become imperative for government and industries to be prepared to adopt these emerging and disruptive technologies in order to remain competitive, drive societal progress, generate employment, foster economic growth and to improve the overall quality of life and sustainability of the environment.

1.1. National Mission on Interdisciplinary Cyber-Physical Systems

- **Context:** The Union Cabinet chaired by the Prime Minister approved the launching of **National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS)** to be implemented by Department of Science & Technology at a total outlay of Rs. 3660 crore for a period of five years.

- The NM-ICPS is a comprehensive Mission which would address technology development, application development, human resource development & skill enhancement, entrepreneurship and start-up development in CPS and associated technologies.

1.2. Why the mission: The mission implementation would develop and bring:

- Cyber Physical Systems (CPS) and associated technologies within reach in the country.
- Adoption of CPS technologies to address India specific National / Regional issues.
- Produce Next Generation skilled manpower in CPS.
- Catalyse Translational Research.
- Accelerate entrepreneurship and start-up ecosystem development in CPS.
- Give impetus to advanced research in CPS, Technology development and higher education in Science, Technology and Engineering disciplines.
- Place India at par with other advanced countries and derive several direct and indirect benefits.

1.3. States/districts covered:

- NM-ICPS is a Pan India Mission and covers entire gamut of India that includes Central Ministries, State Governments, Industry and Academia.

1.4. Implementation strategy:

- The Mission aims at establishment of 15 Technology Innovation Hubs (TIH), 6 Application Innovation Hubs (AIH) and 4 Technology Translation Research Parks (TTRP).
- These Hubs & TTRPs will connect to Academics, Industry, Central Ministries and State Government in developing solutions at reputed academic, R&D and other organizations across the country in a hub and spoke model.

1.5. Focus areas: The Hubs & TTRPs have 4 focused areas along which the Mission implementation would proceed, namely

- Technology Development;
- HRD & Skill Development;
- Innovation, Entrepreneurship & Startups Ecosystem Development;
- International Collaborations.

1.6. Impact of the mission:

- CPS technologies provide a cutting edge to a Nation's scientific, engineering, and technologically innovative capabilities; support other missions of the government, provide industrial and economic competitiveness and have truly became a Strategic Resource. Volume, scale and complexity of emerging applications demand continued evolution of new technologies for the foreseeable future.
- The proposed Mission **would act as an engine of growth that would benefit national initiatives in health, education, energy, environment, agriculture, strategic cum security, and industrial sectors, Industry 4.0, SMART Cities, Sustainable Development Goals (SDGs) etc**.
- CPS **will bring a paradigm shift in entire skill sets requirement.**
    - The job opportunities will be enhanced through the Mission by imparting advanced skills and generating skilled manpower as per the requirement of the industry/ society.
    - As Innovation, Entrepreneurship and Start-up Ecosystem is an integral part of the proposed NM-ICPS, the **start-ups will also create a number of technologies driven job**

opportunities in CPS and allied areas. Accordingly, it is estimated that, about 40,000 jobs will be created in the short term and about 2,00,000 in long term.

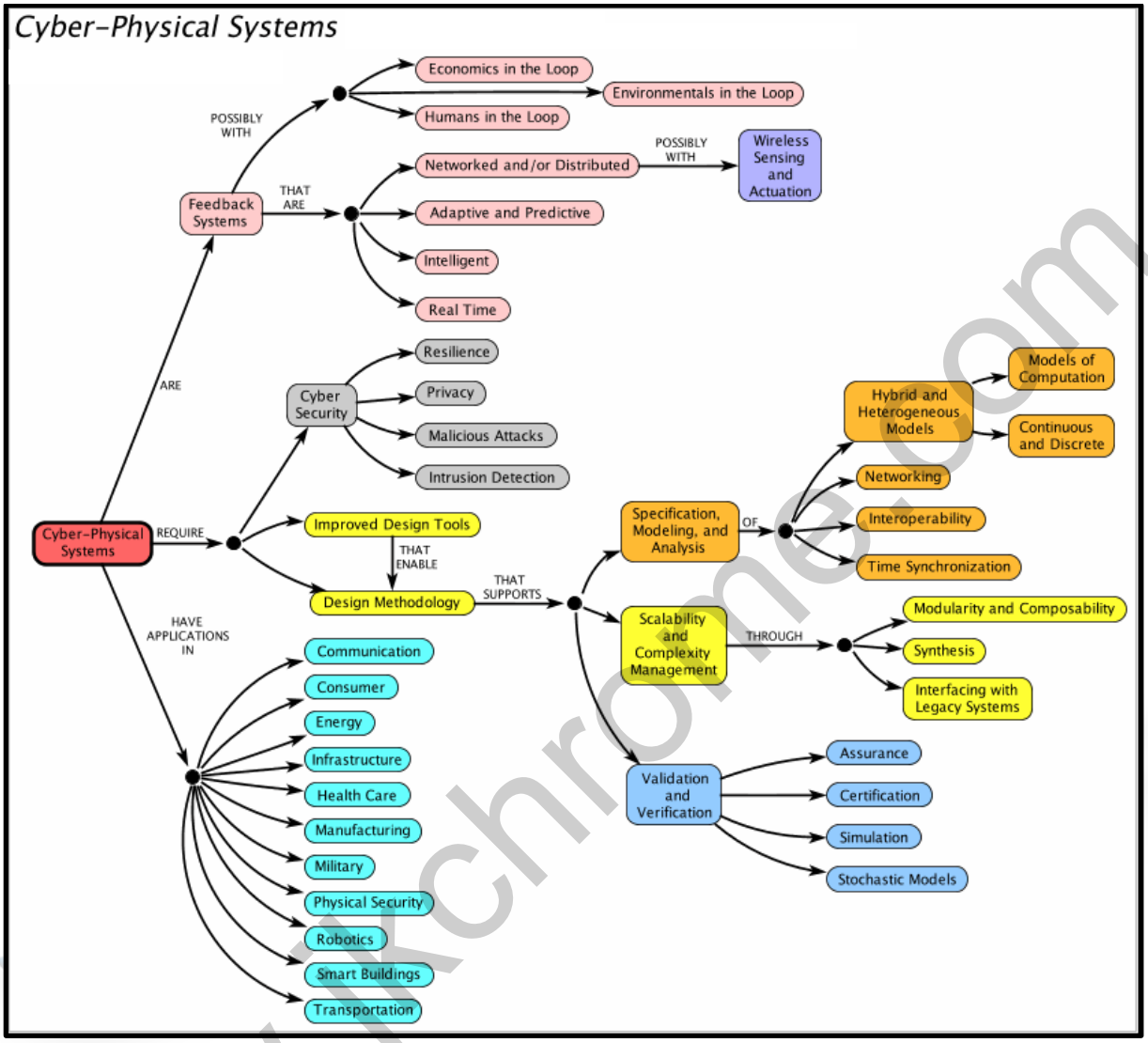


Figure: schematic representation of CPS

2. INTERNET OF THINGS (IoT)

- More accurately **the 'Internet of Devices'**.
- IoT is the **network of devices** such as vehicles, and home appliances **that contain electronics, software, sensors, actuators, and connectivity which allows these things to connect, interact and exchange data**.
- The IoT involves **extending Internet connectivity beyond standard devices**, such as desktops, laptops, smartphones and tablets, **to any range of traditionally dumb or non-internet-enabled physical devices and everyday objects**. Embedded with technology, these devices can communicate and interact over the Internet, and they can be remotely monitored and controlled.

2.1. Examples:

a. **Wristwatches with sensors** - track the wearers' heartbeat - Send the data to our smartphones(via bluetooth, not internet) - The smartphone store the data offline/online(on cloud) = This data can be

accessed at any point of time to view a report card of how your heart has been behaving for over a period of a week or a month.

b. **Driverless cars**
    - The car has **multiple devices/sensors which track the movement of objects, captures the images surrounding it** and **processes the information**.
    - It **can change the speed and direction of movement depending on the feedback it gets from the external environment**.
    - The data is then backed-up on a cloud from which it can receive instructions and behave accordingly, right from throttle accelerator to applying brakes.

2.2. Features:

- **IoT can be said to involve three distinct stages:**
    1. **Sensors** are used to collect data. Example: cameras are used to monitor places or people. This application can be seen in schools/universities/malls.
    2. **Applications:** collection and analysis of this data for further consolidation
    3. **Transmission of data to the decision-making server**.
- This allows huge amounts of data to be collected and transferred, which can then be used for multiple practical purposes.
- Internet of Things doesn't necessarily have to be connected to the internet; **it can also be a network of things**.

2.3. Concerns

- **Privacy:** IoT devices collect and share personal data in real-time, thus raising concerns on protecting personal information.
- **Government surveillance:** There is growing concern about the potential for increased government surveillance and a resulting encroachment of civil rights to suppress dissent or marginalize communities.
- **Huge cost:** the annual cost of cybercrime is over $1 trillion.
- **Cybercrime:** the IOT is capable of processing the tremendous amount of real-time data, it is possible for hackers and miscreants from accessing and manipulating those data.

However, there is a debate around how best to communicate and receive consent for personal data collected. Thus, IoT manufacturers will have to build and sustain consumer trust in their devices.

2.4. Status of IoT in India:

- The Department of Electronics & Information Technology targets to create an IoT industry in India of $15 billion by 2020.
- **Events related to IoT:**
    - IoT Startup Awards
    - IoT India Congress held in Bangalore
- **Applications:**
    - A team of researchers from IIT Hyderabad has been working to use the **IoT** to accurately diagnose **kidney** and **liver disorders** with the help of **ultrasound scanning devices**.
    - The technology can identify kidney stones and cysts and also grade a "fatty liver" classification. Even it can differentiate between cysts and stones in the kidney images.
- **Prospects of IoT In India:** IoTs solutions can be used to address the following challenges:

- **Smart Agriculture:** Using IoT to monitor soil moisture, earth density and pests and create an online update mechanism for farmers to enable precision farming operations.
- **Creation of smart cities** characterised by intelligent systems = Using IoT in Smart traffic management systems, smart grids, waste management systems, transport systems et al.
- **Smart Water:** Setting up tools to
  - detect the quality of water
  - provide real time information on leakages
  - monitor water level variation in rivers and dams for more proactive disaster management
- **Smart Environment:** Setting up tools, using IoT for monitoring CO2 emissions by factories and vehicles.
- **Smart Waste Management:** Using IoT to assist the Swachh Bharat Mission such as **systems which inform the municipal workers when trash containers are full**.
- **Smart Safety:** Use of IoT in wearable device for women, child and old people to ensure safety in public.

3. OPEN SOURCE SOFTWARE

- Under the overarching vision of **Digital India**, GoI aims
  - to **make Government services digitally accessible to citizens in their localities** and
  - to ensure efficiency, transparency and reliability of such services at affordable costs.
- To meet this objective, there is a **need to set up a commensurate hardware and software infrastructure**, which may require significant resources.
- Organizations worldwide have adopted **innovative alternative solutions in order to optimise costs by exploring avenues of "Open Source Software**".
- GoI has also been promoting the use of open source technologies in the e-Governance domain within the country in order to leverage economic and strategic benefits.
- Further, the **National Policy on Information Technology, 2012** has mentioned, as one of its objectives, **to "Adopt open standards and promote open source and open technologies**".
- In view of the above, several policies have been formulated for the Government Organizations to adopt Open Source Software.

3.1. POLICY ON ADOPTION OF OPEN SOURCE SOFTWARE FOR GOVERNMENT OF INDIA

Policy statement

- Government of India shall **endeavour to adopt Open Source Software in all e-Governance systems** implemented by various Government organizations, as a preferred option in comparison to Closed Source Software (CSS).
- The Open Source Software shall have the following characteristics:
  - The source code shall be available for the community / adopter/ end-user to study and modify the software and to redistribute copies of either the original or modified software.
  - Source code shall be free from any royalty.

Objectives

- To provide a policy framework for rapid and effective adoption of OSS
- To ensure strategic control in e-Governance applications and systems from a long-term perspective.
- To reduce the Total Cost of Ownership (TCO) of projects.

Applicability

- The policy shall be **applicable to all Government Organisations under the Central Governments** and **those State Governments that choose to adopt this policy** for the following categories of e-Governance systems:
    - All new e-Governance applications and systems being considered for implementation.
    - New versions of the legacy and existing systems.

OPEN SOURCE

- The term "open source" refers to **something people can modify and share because its design is publicly accessible**.
- The term originated in the context of software development to designate a specific approach to creating computer programs.

OPEN SOURCE SOFTWARE

- Open source software is **software with source code that anyone can inspect, modify, and enhance**.
- "**SOURCE CODE**" is the part of software that most computer users don't ever see; **it's the code computer programmers can manipulate to change how a piece of software—a "program" or "application"—works**.
- Programmers who have access to a computer program's source code can improve that program by adding features to it or fixing parts that don't always work correctly.
- Open source software programmers **can charge money for the open source software they create or to which they contribute**.

3.2. DIFFERENCE BETWEEN OPEN SOURCE SOFTWARE AND OTHER SOFTWARE

- "**Proprietary" or "closed source" software** : These software has source code that **only the person, team, or organization who created it—and maintains exclusive control over it—can modify**.
    - And in order to use proprietary software, computer users must agree (usually by signing a license displayed the first time they run this software) that they will not do anything with the software that the software's authors have not expressly permitted.
    - Microsoft Office and Adobe Photoshop are examples of proprietary software.
- **Open source software: Its authors make its source code available to others who would like to view that code, copy it, learn from it, alter it, or share it**.
    - LibreOffice and the GNU Image Manipulation Program are examples of open source software.

4. SUPERCOMPUTER

Supercomputer

- It is a computer with **a high level of performance** compared to a general-purpose computer.
- The performance of a supercomputer is **commonly measured in floating-point operations per second (FLOPS)** instead of million instructions per second (MIPS).
- **Prospects:** Additional research is being conducted in China, the United States, the European Union, Taiwan and Japan to build even faster, more powerful and more technologically superior exascale supercomputers.

4.1. APPLICATIONS:

- Supercomputers play an important role in the field of computational science.
- Used for a wide range of computationally intensive tasks in various fields, including **quantum mechanics, weather forecasting, climate research, oil and gas exploration, molecular modeling** (computing the structures and properties of chemical compounds, biological macromolecules, polymers, and crystals), and physical simulations (such as simulations of the early moments of the universe, airplane and spacecraft aerodynamics, the detonation of nuclear weapons, and nuclear fusion).
- Throughout their history, they have been essential in the field of cryptanalysis.

In news:

After a delay of more than 3 years, India awarded French technology firm Atos a ₹4,500-crore **contract to build 70 supercomputers** under the National Supercomputing Mission.

- **Significance:** The contract could see as many as **73 supercomputers manufactured and designed in India**, and **will boost India's supercomputing capabilities**.
- However, in terms of the speed, even the upcoming supercomputers will greatly lag those built by China, the world's largest supercomputer powerhouse.

4.2. NATIONAL SUPERCOMPUTING MISSION (NSM): Building Capacity and Capability

- **Why the mission:** Currently, in the top Supercomputing machines in the world, a major share is taken from advanced countries such as the US, Japan, China and the European Union (EU). The mission envisages India
  - To be in the select league of such nations.
  - To enable India to leapfrog to the league of world class computing power nations.
- The Mission would be implemented and **steered jointly by the Department of Science and Technology (DST) and Department of Electronics and Information Technology (DeitY)** at an estimated cost of Rs.4500 crore over a period of seven years.
- The Mission envisages **empowering our national academic and R&D institutions** spread over the country **by installing a vast supercomputing grid comprising of more than 70 high-performance computing facilities**.
  - These supercomputers will also be networked on the National Supercomputing grid over the National Knowledge Network (NKN).
- The Mission also includes **development of highly professional High-Performance Computing (HPC) aware human resource** for meeting challenges of development of these applications.

Significance of the NSM: The Mission implementation

- would **bring supercomputing within the reach of the large Scientific & Technology community** in the country;
- **will provide significant qualitative and quantitative improvement in R&D and higher education** in the disciplines of Science & Technology; and
- enable the country with a capacity of solving multi-disciplinary grand challenge problems.
- To provide continuity in maintaining a lead in supercomputing, the Mission also includes advanced R&D. This **will create requisite expertise to build state-of-the-art next generation supercomputing**.
- The Mission **supports the government's vision of "Digital India" and "Make in India" initiatives**.

4.3. EXAMPLES OF SUPERCOMPUTERS: PRATYUSH, MIHIR AND BULLSQUANA

a. **Pratyush and Mihir**

- These are **India's fastest supercomputers** with a maximum speed of 4 peta flops and 2.8 petaflops, respectively i.e. combined speed of **6.8 Petaflops**.
- These were installed at Indian Institute of Tropical Meteorology (IITM), **Pune** and NCMRWF, **Noida** respectively in 2018. And will be used in the fields of **weather forecasting and climate monitoring** in India.
- **Significance:**
  - India is now placed at the **4th position** after Japan, UK and USA for dedicated HPC resources for weather/climate community.
  - The supercomputers will help India to make **better forecasts** in terms of Monsoon, fishing, air quality, **extreme events** like Tsunami, cyclones, earthquakes, lightning and other **natural calamities** such as floods, droughts etc.

b. **Bull Sequana**

- These are high-performance supercomputers which India will procure **from France** after a deal worth Rs 4500 crore was signed recently.
- **Significance**
  - These are aimed at strengthening the **academic and research institutions** across India. These supercomputers are expected to create a network of over 70 high-performance supercomputing facilities for various academic and research institutions across India.

5. ARTIFICIAL INTELLIGENCE

It is the ability of machines, computers and softwares to **perform cognitive functions** e.g. learning, thinking, perceiving, decision making etc which are generally associated with humans only. It includes various sub-fields like **neural networks, machine learning, robotics** etc.

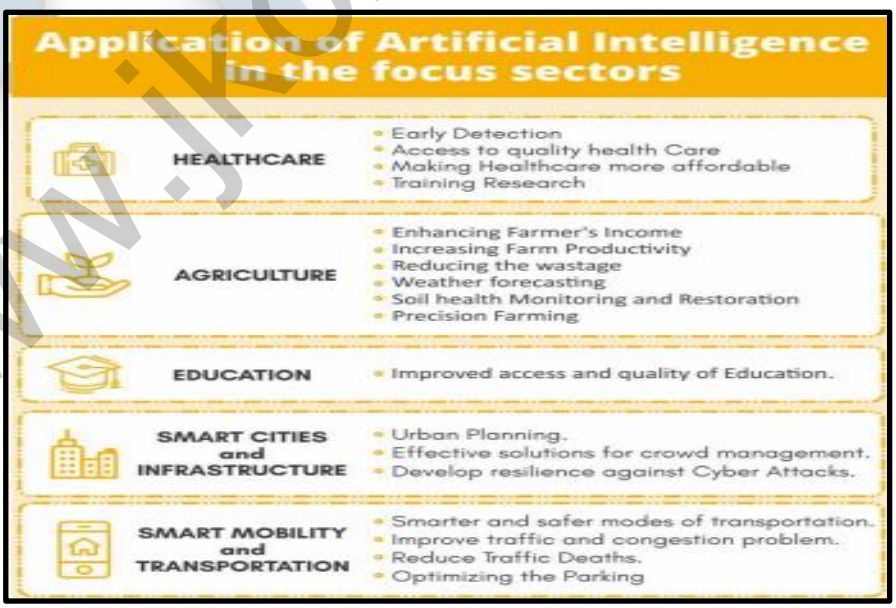


Figure: application of AI

5.1. Significance of AI

- AI will be most useful in getting computers and robots to do stuff that's possibly too **dangerous for humans** e.g. Disaster response, fire accident, mineral exploration etc.

- It can be used for **Precision manufacturing**, design creation, optimization of products and sales etc
- It can help in predicting weather, analysing soil and integrating all these with market dynamics to guide the farmers in raising appropriate crops in an appropriate manner : this is called as **precision agriculture**.
- In healthcare, it can help **diagnose and operate** on the diseases in an almost error freeway. A nationwide uniform and **centralised data-deposition system** of patients and diseases can be created which will help in generating the best possible treatment.
- In transportation, it can help in **traffic management** and in guiding commuters to the best available route. **Air traffic** can also be optimized using AI to avoid any possibility of errors.

5.2. Challenges to adoption

- **Absence of enabling Data ecosystem**: Lack of infrastructure and formal framework for Data collection
- **Data security**, protection and privacy concerns
- **Absence of collaboration** between researchers, industry and government.
- **Lack of trained professionals** and prospect of huge **job losses**.

5.3. Recent initiatives

- Government constituted a **Task Force on AI** under DIPP which submitted its report in 2018.
    - It identified **10 domains** for incorporation of AI e.g. education, environment, public utility services, healthcare etc.
    - It held that AI in all likelihood **will create more jobs** than it will destroy.
    - It suggested launching **an Inter-Ministerial National AI Mission** to act as a nodal agency for coordinating AI related activities in India and setting up **digital data banks.**
- **NITI Aayog** in June 2018, released '**National Strategy for Artificial Intelligence**', calling for '**#AIforAll**' and suggested various ways of adapting it several fields.
    - It has identified **five focus sectors** for application of AI: **Healthcare, Agriculture, Education, SMart cities & Infrastructure and Smart mobility & transportation**.

6. CLOUD COMPUTING

It is the **delivery of computing services**—servers, storage, databases, networking, software, analytics, intelligence and more—**over the Internet ("the cloud")** to offer faster innovation, flexible resources and economies of scale.

6.1. Types of cloud computing

There are three different ways to deploy cloud services: on a public cloud, private cloud or hybrid cloud.

- **Public cloud:** Public clouds are **owned and operated by a third-party cloud service providers**, which **deliver their computing resources like servers and storage over the Internet**.
    - Microsoft Azure is an example of a public cloud.
    - With a public cloud, **all hardware, software and other supporting infrastructure is owned and managed by the cloud provider**.
    - You access these services and manage your account using a web browser.
- **Private cloud:** A private cloud refers to **cloud computing resources used exclusively by a single business or organisation**.
    - A private cloud **can be physically located on the company's on-site datacenter**.

- Some companies also pay third-party service providers to host their private cloud.
- A private cloud is one in which the services and infrastructure are maintained on a private network.

- **Hybrid cloud:** Hybrid clouds **combine public and private clouds, bound together by technology that allows data and applications to be shared between them**.
  - By allowing data and applications to move between private and public clouds, a hybrid cloud gives your business greater flexibility, more deployment options and helps optimise your existing infrastructure, security and compliance.

6.2. Uses of cloud computing

- If you use an online service to send email, edit documents, watch movies or TV, listen to music, play games or store pictures and other files, it is likely that cloud computing is making it all possible behind the scenes.
- **Create new apps and services: Quickly build, deploy and scale applications**—web, mobile and API—on any platform. Access the resources you need to help meet performance, security and compliance requirements.
- **Test and build applications: Reduce application development cost and time** by using cloud infrastructures that **can easily be scaled up or down**.
- **Store, back up and recover data: Protect your data** more cost-efficiently—and **at massive scale—by transferring your data over the Internet to an offsite cloud storage system** that is accessible from any location and any device.
- **Analyse data: Unify your data across teams, divisions and locations** in the cloud. Then use cloud services, such as machine learning and artificial intelligence, to uncover insights for more informed decisions.
- **Stream audio and video:** Connect with your audience anywhere/anytime/on any device with high-definition video and audio with global distribution.
- **Embed intelligence:** Use intelligent models to help engage customers and provide valuable insights from the data captured.
- **Deliver software on demand:** Also known as software as a service (SaaS), on-demand software lets you offer the latest software versions and updates around to customers—anytime they need, anywhere they are.

6.3. Challenges for adoption of cloud computing in India.

- **Lack of dependable infrastructure for data centres**. For Cloud computing to be successful in India, the basic data centre grade **physical infrastructure i.e. Connectivity, Power and Cooling should be consistent.**
- **Energy resource management:** It has been estimated that the cost of powering and cooling accounts for 53 percent of the total operational expenditure of data centres. The goal is not only to cut down energy cost in data centres, but also to meet government regulations and environmental standards.
- **Server consolidation:** Achieving server consolidation (using the remote servers to maximum level to minimize energy usage) without compromising application performance is a vital major challenge.
- **Platform management:** This includes delivering middleware capabilities for building, deploying, integrating and managing applications in a multi-tenant, elastic and scalable environments.

6.4. Benefits of cloud computing

- **Cost:** Cloud computing **eliminates the capital expense of buying hardware and software and setting up and running on-site datacenters**—the racks of servers, the round-the-clock electricity for power and cooling, the IT experts for managing the infrastructure. **It adds up fast**.
- **Speed:** Most cloud computing services are **provided self service and on demand, so even vast amounts of computing resources can be provisioned in minutes, giving businesses a lot of flexibility and taking the pressure off capacity planning**.
- **Global scale: The ability to scale elastically**. That means **delivering the right amount of IT resources—for example, more or less computing power, storage, bandwidth—right when it is needed and from the right geographic location**.
- **Productivity:** On-site data centers typically require a lot of "racking and stacking"—hardware set up, software patching and other time-consuming IT management chores. Cloud computing **removes the need for many of these tasks**, so IT teams can spend time on achieving more important business goals.
- **Performance:** The biggest cloud computing services **run on a worldwide network of secure data centers, which are regularly upgraded to the latest generation of fast and efficient computing hardware**. This offers several benefits over a single corporate datacenter, including reduced network latency for applications and greater economies of scale.
- **Security:** Many cloud providers offer a broad set of policies, technologies and controls that strengthen your security posture overall, helping protect your data, apps and infrastructure from potential threats.

6.5. GOVERNMENT INITIATIVES IN CLOUD COMPUTING SECTOR

- **Infrastructure sector:**
  - **Smart Cities Mission** of the Union Government enables local development by harnessing technology for creating smart outcomes.
  - **Digital India,** integrates smart devices and infrastructure and processes data from the large amount of scattered sources in real time.
- **e-Governance:** All e-governance platforms including State Wide Area Networks (SWANs, Data Centres, etc) across the country could be migrated into cloud architecture in near future with an option of a public and private cloud.
- **Banking sector:**
  - The RBI has been incorporating Cloud based solutions particularly for Cooperative banks to extend the banking services across the country through core banking solutions.
  - **Indian Banking Community Cloud (IBCC)** is the first Community Cloud initiative for banking industry in the country.
- **Manufacturing sector:** With **Make in Indi**a initiative in full swing, adoption of this technology became even more relevant for the Indian manufacturing sector. It enhances manufacturing effectiveness are in data warehousing, information security, green IT, Human machine interface (HMI) applications and many others.
- **Telecom sector:** Deploying Operation Support System (OSS) and Business Support System (BSS) solutions over cloud platforms is a highly effective method of addressing several business and technical challenges faced by this sector.

- **Indian Railways:**
  - Railways are utilizing the mobile technology in a big way for freight management and passenger reservation system.
  - Strategies have been rolled out to use cloud for GIS management in railways, for e-ticket bookings and for automated surveillances of railway premises.
- **Education Sector: Megh-Sikshak** is a cloud-based learning management system, which is evolved from the objective of converting the traditional model of e-Learning system (eSikshak) to a SaaS model.
- **Health Sector:** Cloud Computing Innovation council of India has proposed a layout for systematic adoption of cloud services in Indian health sector, known as e-Health vision.
  - e-Health vision aims to incorporate Health Information Exchange (HIE) mechanisms to successful deployment of cloud.
  - An electronic health information exchange (HIE) allows stakeholders associated with health data to appropriately access and securely share a patient's vital medical information electronically.
- **Right to Information:** Government initiative to digitize its database and make more and more information available to the public domain.
- **Meghraj:** Department of Electronics and IT (DeitY) of the Union Government has initiated an extensive project termed as '**GI Cloud**'.
  - The 'GI Cloud' Meghraj is the Government of India's cloud computing environment that will be used by government departments and agencies at the centre and states following a set of common protocols, guidelines and standards.
- **National eGov App Store:** The eGov App Store will include the setting up of a common platform to host and run applications at National Cloud, which are easily customisable and configurable for reuse by various government agencies or departments at the central and state levels without investing effort in the development of such applications.

7. LONG-TERM EVOLUTION (LTE)

- **LTE** is **a standard for wireless broadband communication** for mobile devices and data terminals, **based on the GSM/EDGE and UMTS/HSPA technologies**.

7.1. FEATURES

- Peak **download rates up to 299.6 Mbit/s** and **upload rates up to 75.4 Mbit/s** depending on the user equipment category.
- **Low data transfer latencies**, **lower latencies for handover** and connection setup time than with previous radio access technologies.
- **Improved support for mobility**
- Increased spectrum flexibility: 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz and 20 MHz wide cells are standardized.
- Simplified architecture
- Support for inter-operation and co-existence with legacy standards (e.g., GSM/EDGE, UMTS and CDMA2000).
  - Users can start a call or transfer of data in an area using an LTE standard, and, should coverage be unavailable, continue the operation without any action on their part using GSM/GPRS or W-CDMA-based UMTS.
- Packet-switched radio interface.

7.2. Significance of LTE:

- It **increases the capacity and speed** using a **different radio interface** together with core network improvements.
- LTE is the **upgrade path for carriers with both GSM/UMTS networks** and CDMA2000 networks.

- LTE is commonly marketed as **4G LTE & Advance 4G**, but **it does not meet the technical criteria of a 4G wireless service.**
- The LTE standard **supports only packet switching with its all-IP network**.
- Voice calls in GSM, UMTS and CDMA2000 are circuit switched, so with the adoption of LTE, carriers will have to re-engineer their voice call network.

7.3. Voice over LTE

- **Voice over Long-Term Evolution (VoLTE)** is **a standard for high-speed wireless communication for mobile phones and data terminals - including IoT devices and wearables**.
- It is **based on the IP Multimedia Subsystem (IMS) network**, with **specific profiles for control and media planes of voice service on LTE**.
- **Significance:**
  - This approach results in the **voice service (control and media planes) being delivered as data flows within the LTE data bearer**.
  - This means that **there is no dependency on (or ultimately, requirement for) the legacy circuit-switched voice network to be maintained**.
  - In case of LTE, if you make a voice call and you also keep your data connection on, the quality of voice will reduce. But in case of VoLTE, the voice quality will not reduce even if your data connection is on. With VoLTE it is very easy to transmit telephone conversation over the data network.
  - VoLTE has up to **three times more voice and data capacity than 3G UMTS** and up to six times more than 2G GSM.
  - It **frees up bandwidth because VoLTE's packets headers are smaller than those of unoptimized VoIP/LTE**.

Mem-Computers

- A type computer that **works by mimicking the human brain**.
- In conventional computers, Processors and Memory are separate components. The transfer of data between processor and memory consumes time and energy, thus, limits computation power.
- Memcomputers are made up of "**mem-processors**" which **processes and store data at the same place**.
- This setup mimics the neurons that make up the human brain, with **each neuron serving as both processor and memory**.
- Quantum computers can operate at extremely low temperatures.
- **Memcomputers can operate at room temperature also**.
- This new brain-inspired computer device could help neuroscientists better understand the workings of human brains.
- Though this idea was mooted as early as 1970's, this is the first prototype machine of this architecture.

Quantum Computer

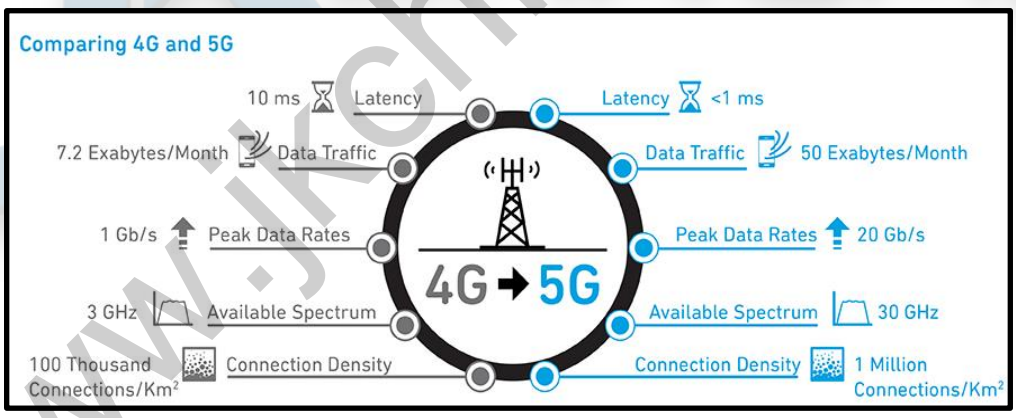
- It is **a computer design** which **uses principles of quantum physics** to increase computational power beyond what is attainable by a traditional computer.
- Computers function by storing data in a binary number format - in a series of 1s & 0s.
- A quantum computer store information as either **a 1, 0** or **a quantum superposition of the two states**. Such a "**quantum bit**," called a **qubit**, allows for far greater flexibility than the binary system.

Benefits of cloud computing

- Resources can be purchased and consumed on a "**pay-as-you-go" basis,** and increased or decreased as needed for optimal utilization.
- Capital expenses can be converted into operating expenses.
- Cloud customers can focus on rapid innovation without the expense and complexities of hardware procurement and infrastructure management.
- End-user productivity is likely enhanced because no software is installed, configured, or upgraded on personal devices, and services can be accessed from anywhere.
- Infrastructure functionality, performance, reliability, and security are likely to improve because customers can benefit from "vertically integrated" stacks that are customized at every level — which would be out of reach for on-premises deployments built from off-the-shelf components.

5G TECHNOLOGY

It is the next generation wireless communication technology after 4G LTE networks, which uses radio frequency to transmit and receive data. It entails a peak data speed of **20 Gbps or higher** and can support **1 million connections per km square.**



Government had constituted a **Steering Committee** in 2017 for identifying the 5G deployment roadmap for India, which submitted its report titled '**Making India 5G Ready**' in August 2018.

Main recommendations of the Committee

- The committee has marked three priority areas for 5G
  - **Deployment**: rolling out early, efficient and pervasive 5G networks
  - **Technology**: building India's industrial and R&D capacity in 5G
  - **Manufacturing**: expanding the manufacturing base in 5G for both semiconductor fabrication as well as assembly & test plants
- It calls for **technology demonstration** and major **trials** involving Telecom Service Providers (TSP), academia and industry.

Significance

- 5G technologies will help in increasing GDP by **one trillion USD by 2035**, in addition to creating employment and **digitizing the economy.**
- It will help in incorporating **Artificial Intelligence** in our lives and will also enable smart devices to exchange data seamlessly providing the ecosystem for **Internet of Things (IoT)**.
- It can provide more effective **tele-medicine delivery** and also the use of **robotics for precision manufacturing**.

8. BIG DATA

- By definition, **Big Data**, is **data whose scale, diversity, and complexity require new architecture, techniques, algorithms, and analytics to manage it and extract value and hidden knowledge from it**.
- Big data is characterised by volume, variety (structured and unstructured data) velocity (high rate of changing) and veracity (uncertainty and incompleteness).

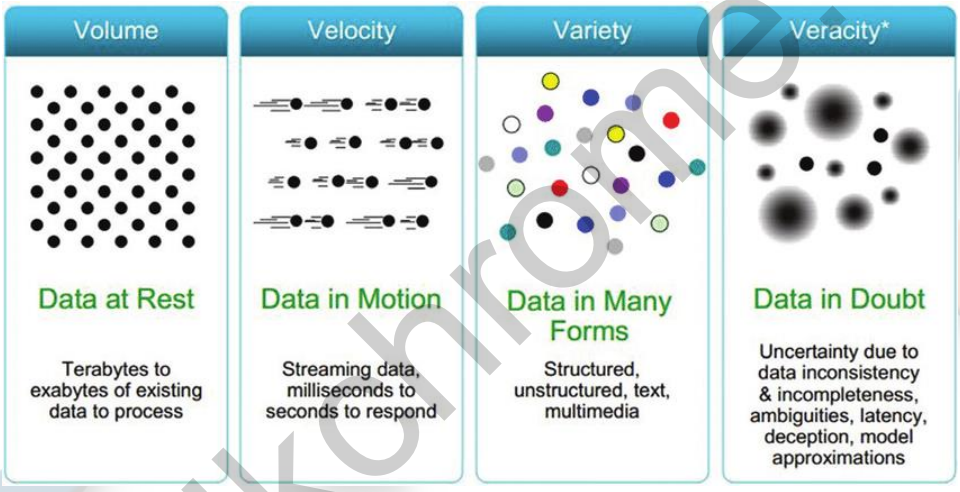


Figure: 4Vs in big data

8.1. Applications of Big Data

- **Companies** use big data
  - to better understand and **target customers**.
  - understanding customer shopping behaviour, his likes/preference/requirement => help in developing/projecting products customized to those customers.
  - to optimize their processes by **tracking and analyzing their supply chain delivery routes** and combine that data this with live traffic updates. Others use machine data to optimize the service cycles of their equipment and predict potential faults.
- **Government:**
  - Big data can be analysed for targeted delivery of schemes, maintain record of beneficiaries, analyse the response of the electorate to policies, predict future trends and demands of population.
  - **Massive data with UIDAI can be used to ensure DBT to prospective beneficiaries** => improving governance.
  - Data on agriculture collected through satellite can be used for insurance purposes, studying agriculture patterns etc. which can be used as inputs to make agricultural decisions

- **National Security:** Analysis of fund transfer/emails/web accounts can enhance our preparedness to tackle emergent situations such as rioting and terrorism.
- **In healthcare**
    - to optimize treatment;
    - even **predict diseases** before any physical symptoms appear.
    - It can map a person's genetic profile and it helps doctors and scientists to predict a patient's health condition.
- **To analyze and improve the performance of individuals (at sports, at home or work)** where data from sensors in equipment and wearable devices can be combined with video analytics to get insights.
- Security agencies use big data to prevent cyber-attacks, detect credit card fraud, **foil terrorism** and even predict criminal activity.
- To improve our homes, cities and countries by e.g. optimizing the heating or lighting in our homes, the traffic flow in our cities, or the energy grit across the country.

8.2. Big Data: Challenges

- Some of the S&T challenges we facing are related to data deluge pertaining to Astrophysics, Materials Science, Earth & atmospheric observations, Energy, Fundamental Science, Computational Biology, Bioinformatics & Medicine, Engineering & Technology, GIS and Remote Sensing, Cognitive science and Statistical data.
- The overall constraints that community facing are
    1. **The IT Challenge:** Storage and computational power
    2. **The computer science:** Algorithm design, visualization, scalability (Machine Learning, network & Graph analysis, streaming of data and text mining), distributed data, architectures, data dimension reduction and implementation
    3. **The mathematical science:** Statistics, Optimisation, uncertainty quantification, model development (statistical, Ab Initio, simulation) analysis and systems theory

Data mining:
Data mining is a process used by companies to turn raw data into useful information. By using software to look for patterns in large batches of data, businesses can learn more about their customers to develop more effective marketing strategies, increase sales and decrease costs. Data mining depends on effective data collection, warehousing, and computer processing.

Example of Data Mining:
Many supermarkets offer free loyalty cards to customers that give them access to reduced prices not available to non-members. The cards make it easy for stores to track who is buying what, when they are buying it and at what price. After analysing the data, stores can then use this data to offer customers coupons targeted to their buying habits and decide when to put items on sale or when to sell them at full price.

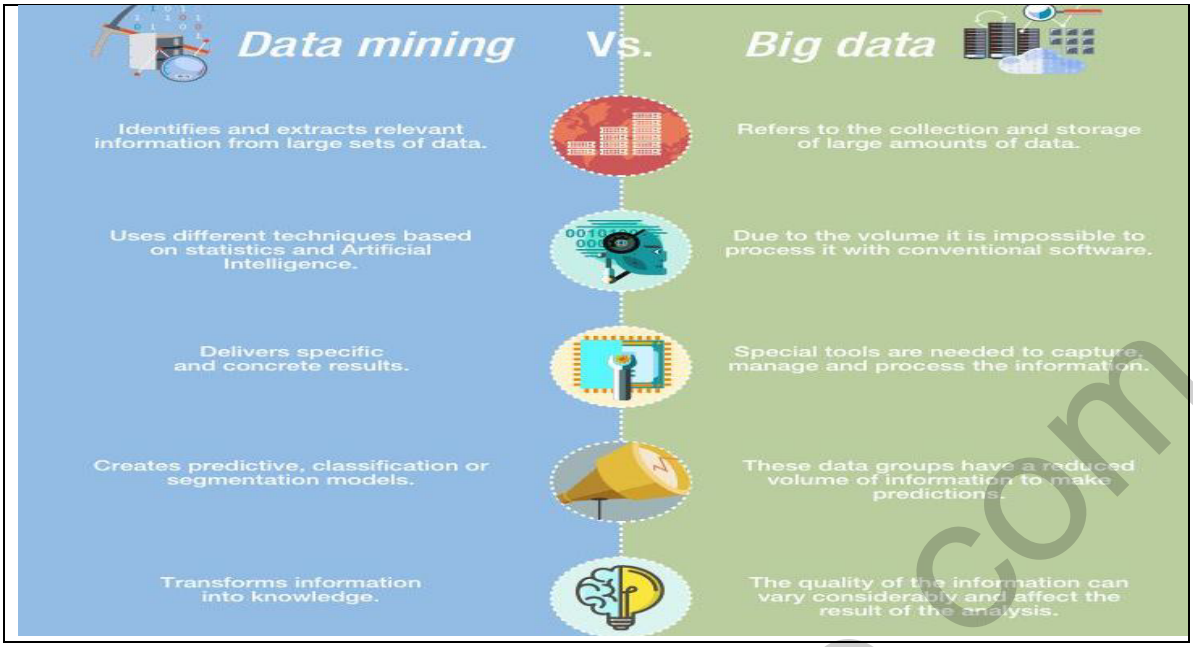


Figure: data mining vs big data

8.3. Big data analytics and India

To tap the analytics momentum, India now needs to build a sustainable analytics eco-system that brings in a strong partnership across the industry players, government, and academia. Some of the key actions for analytics ecosystem in India would be around.

1. **Talent Pool** -
    - **Create industry academia partnership to groom the talent pool in universities**
    - **develop strong internal training curriculum to advance analytical depth.**
2. **Collaborate** - Form analytics forum across organization boundaries to discuss the pain-points of the practitioner community and share best practices to scale analytics organizations.
3. **Capability Development** - Invest in long term skills and capabilities that forms the basis for differentiation and value creation. There needs to be an innovation culture that will facilitate IP creation and asset development.
4. **Value Creation** - Building rigor to measure the impact of analytics deployment is very critical to earn legitimacy within the organization.

8.4. Big Data in Policy Making

- The Aadhaar programme, with its hundreds of millions of data points that can be mined for policy formulation and implementation.
- Geo-tagging of Mahatma Gandhi National Rural Employment Guarantee Scheme assets.
- **Websites like Mygov.in, makeinindia.com, ebiz.com etc.** helps government to **connect with citizens, incorporate their feedback/suggestions** in course correction of present projects or designing of future projects and scheme.
- **Online searches can be trawled for data that helps predict disease outbreaks**.
- Cell Phone data can help direct relief efforts in the aftermath of a natural disaster.
- Power-usage data can be analysed **to optimize energy grids and plant power generation;** discoms in India are already using data from last-mile sensors to implement measures for cutting down aggregated technical and commercial losses.
- Using healthcare data to revamp the public health system.

- Massive amounts of **data generated by cities, from traffic signals to public transport usage, can be used to improve infrastructure and transport systems** as Singapore has done.
- Vast number of surveys, **national census, socio-economic census, UIDAI etc** can provide government with vast data that they can use.
- Big Data processing can also help in combating terrorist activity by **real-time communication monitoring.**
- Also, data from various private companies etc. can help government track the **changing behavior of citizen.**
- It can help in **assessment of its own work and working of government.**

8.5. Challenges in using big data in Policy Making

- **Volume and Veracity of data: Infrastructure in India for efficient data collection and management is lacking**; this must be strengthened.
    - The comptroller and auditor general's Big Data management policy and its establishment of the Centre for Data Management and Analytics are positive signs in this context.
- Volume and veracity also **necessitate sharing of data across ministries and departments**—indeed, **with the public at large—to allow private-sector solutions that can in turn be utilized in government policymaking**.
    - The government's Open Government Data portal is a significant step, with thousands of data sets available regarding everything from health to agriculture.
    - However, **the reliability of the data, the tendency to work in silos, the reluctance to share data and lack of standard formats** are all concerns.
- **Data velocity:** Large amounts of data are collected swiftly today; this also means that **much of it loses relevance after some time**.
    - Using Big Data effectively for policy formulation will thus mean **changing policymaking structures and processes—continuously re-evaluating and rejigging policies based on the feedback generated by new data**, from on the ground results to public opinion scraped from social media.
    - **Incorporating this flexibility in hierarchical bureaucratic structures will not be easy**.

8.6. Status in India

- Government is collecting Data through its initiative like **Aadhaar, DigiLocker and Digital India mission** for better and targeted delivery of services.
- Big data was exercised in the **2017 Economic Survey** and Annual Budget, shedding new perspectives on the flow of goods, and migration in the country
- NITI Aayog in 2017 batted for **Evidence-based policing** guided by Big Data in India.
- **CAG** launched the **Big Data Management Policy** in 2016 making the way for creating Data Analytics Centre.
- India being the **second-largest Internet market** in the world, has immense potential to use Big Data for improving standard of living. NASSCOM predicts that India's big data market will be a **$16-billion industry by 2025**, with a 32% share of the global market.
- Thus, Government must **establish data centres and back-end infrastructure** in addition to strengthening **cyber security** arrangement, to tap vast opportunities provided by Big Data analytics.

BIG DATA INITIATIVE (BDI) PROGRAMME

- Initiated by Dept of Sci and Technology
- **To promote and foster Big Data Science**, Technology and Applications in the country and to develop core generic technologies, tools and algorithms for wider applications in Govt.
- To understand the present status of the industry in terms of market size, different players providing services across sectors/ functions, opportunities, SWOT of industry, policy framework (if any), present skill levels available etc.
- To carry out market landscape survey to assess the future opportunities and demand for skill levels in next 10 years
- To carry out gap analysis in terms of skills levels and policy framework.
- To evolve a strategic Road Map and micro level action plan clearly defining of roles of various stakeholders – Govt., Industry, Academia, Industry Associations and others with clear timelines and outcome for the next 10 years.

9. BLOCKCHAIN TECHNOLOGY

Blockchain is the digital, distributed, and decentralized ledger underlying most virtual currencies that's responsible for **logging all transactions** without the need for a financial intermediary, such as a bank. In other words, it's a new means of transmitting funds and/or **logging information**.

- At its essence, the blockchain is a distributed ledger—or list—of all transactions across a peer-to-peer network.
- Blockchain can be considered as a data structure containing transactions that is shared and synced among nodes in a network (but in fact it gets much more complicated than that).
- Each node has a copy of the entire ledger and works with others to maintain its consistency.
- Changes to the ledger are made through consensus among the participants. When someone wants to add a new record to the blockchain ledger, it has to be verified by the participants in the network, all of whom have a copy of the ledger.
- If a majority of the nodes agree that the transaction looks valid, it will be approved and will be inserted in a new "block" which will be appended to the ledger at all the locations where it is stored.
- Each new block can store one or more transactions and is tied to previous ones through digital signatures or hashes.
- Transactions are indefinitely stored and can't be modified after they've been validated and committed to the ledger.
- It enables companies, entities and individuals to make and verify transactions instantaneously without relying on a central authority.

9.1. Uses:

- Healthcare and pharmaceuticals: blockchain can be used to **store sensitive clinical data** which requires a secure and reliable system (e.g. **saving Aadhaar data**)
- It can be used to **eliminate fraudulent claims** in insurance schemes, pension schemes agricultural subsidy claims etc. (e.g. in **MGNREGS, PMFBY** schemes)
- It can create a repository of passouts and **job records** of people to enable swift verification by the employers.
- Blockchain-powered **smart contracts** can be used to record every information in a traceable and irreversible manner which can improve credibility, accuracy and efficiency of contracts and reduce frauds.

- By removing paper-based trails, businesses should be able to **pinpoint inefficiencies** within their **supply chains** quickly, as well as locate items in real time.
- Blockchain offers the ability to **vote digitally**. It combines the ease of digital voting with the immutability of blockchain (e.g. recent **EVM debacle in India**).

10. CRYPTOCURRENCY

Cryptocurrency is a digital or **virtual currency** that uses cryptography to secure, control and verify financial transactions. The control of each cryptocurrency works through the **distributed ledger technology called blockchain.**

10.1. Status in India:

Government has largely **ignored cryptocurrencies** and held them **illegal** means of exchange. **RBI in 2018** has directed all financial institutions **to stop dealing** with individuals and businesses involved in transaction in cryptocurrencies.

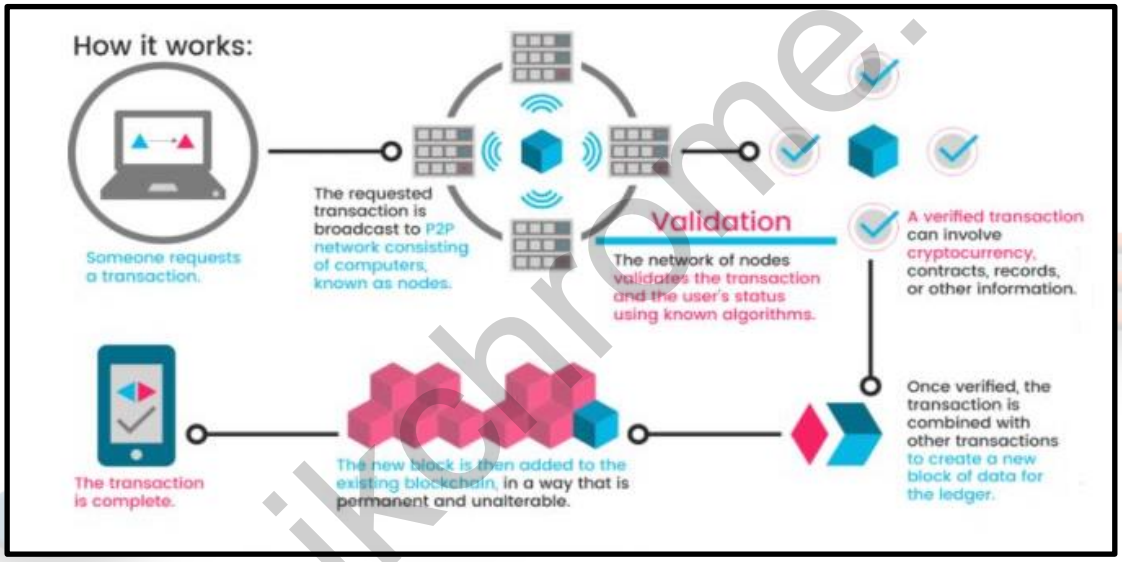


Figure: process under cryptocurrency

10.2. Advantages

- These are **decentralized** medium of transaction i.e. there is no single entity like a Central Bank that can control and affect cryptocurrencies (unlike tangible currencies).
- Digital currencies are stored in digital wallets and transferred digitally to someone else's digital wallet. Hence **no physical asset** is involved. This eliminates cost of managing currencies. Also, it is **impossible to be counterfeited.**
- The **identity** of the coin holder is stored in the **encrypted** address they control – not attached to a person's identity.
- There is **no transaction fees** for cryptocurrency exchange as the miners are compensated by the network.
- It gives ordinary people **options to choose from multiple currencies** in the market and help people gather funds for various cause.

Figure: list of important Cryptocurrency.

10.3. Challenges

- They can endanger **financial stability** as they are highly **volatile** in nature.
- As they do not have a central repository, the digital balance can be wiped out by a **computer crash** if backup does not exist.
- These are prone to **security risks** such as malware attacks, password theft, hacking etc.
- Also, these may be used for **money laundering, tax evasion** etc and can also be used to **finance illegal activities** e.g. drug dealing.

10.4. Way forward

As the world enters into **digital age**, it is only a matter of time when cryptocurrencies will become normal, hence **ban shall not be the solution**. Governments shall **upgrade technological platforms** and **create security** oversight to **gradually integrate** the cryptocurrencies into financial system with requisite regulations.

11. RANSOMWARE

- **Ransomware** is a type of **malicious software** that **threatens to publish the victim's data** or **perpetually block access to it (by encrypting the victim's files) unless a ransom is paid**.

11.1. How does it work?

- Ransomware attacks are typically **carried out using a Trojan** that is **disguised as a legitimate file** that the user is tricked into downloading or opening when it arrives as an email attachment.
- However, one high-profile example, the "WannaCry worm", traveled automatically between computers without user interaction.

11.2. Types of ransomware: Three main types of ransomware

a) **Scareware**
   - It includes **rogue security software and tech support scams**.
   - You might receive a pop-up message claiming that malware was discovered and the only way to get rid of it is to pay up. If you do nothing, you'll likely continue to be bombarded with pop-ups, but your files are essentially safe.

b) **Screen lockers**
   - You're frozen out of your PC entirely.
   - Upon starting up your computer, a full-size window will appear saying illegal activity has been detected on your computer and you must pay a fine.

c) **Encrypting ransomware**
   - They encrypt the files, demanding payment in order to decrypt and redeliver.
   - no security software or system restore can return them to you.
   - And even if you do pay up, there's no guarantee the cybercriminals will give you those files back.

11.3. Ransomware examples

- **CryptoLocker**, a 2013 attack that launched the modern ransomware age and infected up to 500,000 machines at its height
- **TeslaCrypt**, which targeted gaming files and saw constant improvement during its reign of terror
- **SimpleLocker**, the first widespread ransomware attack that focused on mobile devices
- **Not Petya**, which also used EternalBlue and may have been part of a Russian-directed cyberattack against Ukraine
- **Wannacry Ransomware**
  - It is also known as Wanna Decryptor
  - is a program that is used by the attackers to lock the documents and data in the targeted systems leaving the user with only two files:
    i. What to do next to get access to their data
    ii. the Wanna Decryptor program.
  - When users click on the software, it tells them that their files have been encrypted. It gives them a few days to pay a certain amount in bitcoins and if failed, their files will be deleted. It asks them to pay in bitcoins, gives them instruction on how to buy it and a Bitcoin address to send the payment to.
  - One of the messages received by a victim read: "Your files are encrypted. To get the key to decrypt files you have to pay 500 USD."
  - To infect a new computer, the WannaCry program contacts the web address. The WannaCry is programmed in such a way that it terminates itself if it manages to get through.
- **Petya Ransomware:**
  - It relies on the same NSA-leaked EternalBlue exploit that was used by WannaCry.
  - Petya **infects computers and locks down their hard drives**. It demands a ransom of $300 (Rs 19,000) in Bitcoins. The email associated with the ransomware has been blocked, so even if victims pay, they won't get their files back.
  - Once it infects a computer, Petya waits for 10-60 minutes, and then reboots the computer. It then encrypts the master file table and then overwrites the master boot record with a custom loader. It places a ransom note to explain what users must do to regain control.
- **How is Petya different from Wannacry?**
  - Unlike Wannacry, **Petya does not encrypt individual files**, but **overwrites the master boot record** and **encrypts the master file table, thus rendering the system inoperable until the ransom has been paid**.

- **Locky Ransomware**
    - Locky ransomware is being circulated through massive spam campaign in which spam emails with common subject lines target computers by locking them and demanding ransom for restoring access to users. It first had surfaced in 2016.
    - It encrypts files on victims' PCs and adds **a.locky file extension**. The attackers then demand ransom in Bitcoin payment to unlock the files. It is demanding ransom of half bitcoin, which at present rate is equivalent to over Rs 1.5 lakh. So far, it has extorted more than $7.8 million in payments, according to a recent study. However, its impact on Indian systems is not clear so far.

11.4. Risk India faces:

- Most of the ransomware attacks in India are **crypto-ransomware**, an attack where **all the data of connected devices are encrypted** so that user cannot use them until they pay up money as directed by the cyber attackers.
- The main targets
    - Indian government servers
    - entities based on Internet of Things
    - Android smartphones
    - banking institutions.
- **Several other businesses are still running Windows XP, even after the end of support.** These firms are at high risk of being hacked and injected with ransomware.
- Some **Bank ATMs** are still using Windows XP. They have not yet started upgrading despite the RBI urging them to upgrade at least to Windows 7. They say the cost would be too high.
- **E-governance and Aadhar has access to huge personal data which may be susceptible to cyber-crime.**

11.5. Impact is significantly low in India because:

- Cybercriminals typically seek return on investment (ROI) from their crimes. Hence, it makes more sense **to seek ransom from people in developed countries who have more money.**

11.6. Measures be protected from Ransomware: -

- Regularly backup data to a different location.
- Use a good anti-ransomware tool.
- A fully updated modern operating system.
- Ensure that all the installed software, especially security software & browser are updated to the latest version.
- Exercise caution while clicking on any web link or opening email attachments.

4. ARTIFICIAL INTELLIGENCE

1. Understanding a few key terms related to AI

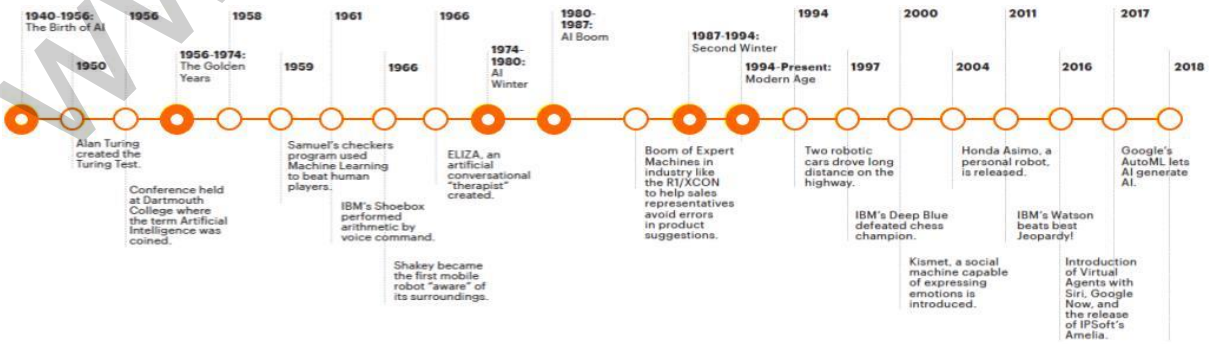
AI is a constellation of technology that enable machines to act with higher levels of intelligence and emulate the human capabilities of sense, comprehend and act. Thus, computer vision and audio processing can actively perceive the world around them by acquiring and processing images, sound and speech. In simple words, AI is the actions of the machines that mimics human mind.

- ❖ An AI system can also take action by using new technologies like expert system and inference engine or undertake actions in the physical world.
- ❖ Examples on AI- Google maps shown traffic status and suggests the best route possible; Facebook suggested friends list, Sofia-the humanoid can answer abstract questions, Amazon's query chatbot, google search algorithms; autonomous driving systems; predict the next words in messaging apps.

> ❖ An expert **system** is a computer system that emulates the decision-making ability of a human expert. Expert systems are designed to solve complex problems by reasoning through bodies of knowledge, represented mainly as if–then rules rather than through conventional procedural code
>
> ❖ **An inference engine** is a component of the system that applies logical rules to the knowledge base to deduce new information.

2. HISTORY OF AI

- AI is not a new phenomenon, rather developed over the past to year by scientists such as Alan Turing, Marvin Minsky and John McCarthy. **A confer**ence at Dartmouth college launched the field of AI in 1956.



3. KEY TECHNOLOGIES IN AI

Name	Use	Examples
Machine learning	To Improve performance w/o specific instruction	Big Data
Natural language processing	To Work with text as humans do	Chat bots
Speech processing	To Transcribe and generate speech with accuracy	Voice bots
Computer vision	Identify, objects, scenes activities from images	Facial recognition software
Robotics	Cognitive tech sensors, actuators	Internet of Things

INDIA and AI

In G-20 summit-2019, Osaka, Japan. The Indian PM underscore the significance of digital economy and AI. PM has also recognized India as one of the fastest growing economy and quick to adopt and utilize AI potential to transform the economy.

In 2018-19 budget government mandated NITI Aayog to establish the National Program on AI with a view to guiding R&D in new and emerging technologies. For this purpose, Govt has allocated funds of 7,000 crores INR.

The application of AI is immense and in few areas AI already set very high standard of economy and efficiency, and in few sectors AI has a huge potential. These are few sectors which hold great importance for India, in both social and economic growth: -

Accenture report: AI can boost India's annual growth rate by 1.3 % by 2035.
According to Global AI talent report 2019, India stood at 9th position in terms of number of experts working in Ai field. The USA, UK and China are at top 3 position. This report is published by the **Element AI**.

NITI Aayog's 3-pronged approach on AI.

1. Undertaking AI projects in various areas- health, Agriculture, education, etc.
2. Crafting the national strategy for building vibrant AI ecosystem.
3. Collaborating with various experts and stakeholders.

NITI Aayog established a cloud computing platform AIRAWAT (Artificial Intelligence Research, Analytics and Knowledge Assimilation Platform).

Ministry of Commerce & Industries has set up the task force to explore the use of AI, data technologies, etc.

4. APPLICATION OF AI

HEALTH

Major challenges in health sector:

a) **Shortage of qualified healthcare professionals:**

It is evident that 0.76 doctors and 2.09 nurses per 1,000 population (as compared to WHO recommendations of 1 doctor and 2.5 nurses per 1,000 population respectively)

b) **Non-uniform accessibility to healthcare:**

With most of the private facilities concentrated in and around metro/big cities, patients have to travel substantial distances for basic and advanced healthcare services. The problem is further accentuated by lack of consistent quality in healthcare across India, most of the services provided is individual driven rather than institution driven, and less than 2% of hospitals in India are accredited.

> E***xample:*** A Kolkata based medical centre has devised an AI-assisted model for automatically grading the aggressiveness of breast cancer. The solution relies on deep learning algorithms to identify high-risk and normal tumour types. In the process, it helps overcome human error

c) **Affordability:**

The private expenditure accounting for ~70% of healthcare expenses, of which ~62% is out-of-pocket expenditure, probably one of the highest in the world.

Implementation of AI in healthcare servives.

1. **Diagnosis:**
   - AI technology can help industry stakeholders collate the massive health data that is available. It is estimated that more than 80% of the health data is unstructured, making it invisible to current systems, Price Waterhouse Coopers (PWC) report.
   - A lot of pathological evaluations like microscopy for infections like malaria, differential counts, etc, depend on **image analysis**. AI can help by screening the image analysis to help the pathologist or the radiologist give a faster and more accurate diagnosis.
   - E.g. **Google's DeepMind** Health platform is working with clinics and health institutes across the world to implement Artificial Intelligence. IBM's popular AI, **Watson**, is using cognitive technology to process and analyse the vast data.

2. **Monitoring of Chronic Conditions:**
   Conditions like diabetes, cholesterol, fertility issues and cardiac heath are managed by regular monitoring and lifestyle changes. Connected POC devices help generate a lot of data about the user's body parameters. This can be combined with lifestyle information like food habits, exercise, etc, by an AI algorithm to help manage the conditions and adjust dosage of medication.

> **AI in Indian Healthcare**
> The adoption of AI in India is being propelled by the likes of Microsoft and a slew of health-tech startups.
> 1. Manipal Hospitals is using IBM Watson for Oncology, a cognitive-computing platform, to assist physicians discover personalised cancer care options, according to an Accenture report.
> 2. For cardiac care, Columbia Asia Hospitals in Bengaluru is leveraging start-up Cardiotrack's AI solutions to predict and diagnose cardiac diseases.

3. NExT, a Microsoft initiative which aims to accelerate healthcare innovation through AI and cloud computing.
4. Microsoft Intelligent Network for Eyecare (MINE) project where the company is working the government of Telangana for its Rastriya Bal Swasthya Karyakram. The state government has adopted the MINE an AI platform to reduce avoidable blindness Microsoft also has a partnership with Apollo Hospitals to use AI for early detection of cardiac diseases.
5. Health-I is a four-year-old Bengaluru-based digital health and wellness start-up. The company uses predictive analytics, personalisation algorithms and machine learning to deliver personalised health suggestions.

3. **AI assisted Robotic Surgery:**
   AI assisted robotics can guide the surgeon's instrument during a procedure, cutting down the time required to do the surgery and reducing complications.

4. **Using the fitness wearables**
   Fitbit, Xiaomi Mi Band to Apple Watch. These fitness devices are coupled with applications that provide a deeper insight on the individual's health on a daily basis. What AI can do is here is create an encrypted data and share it with the doctors or relevant people to help the individuals with better and personalised suggestions to help achieve their fitness goals

5. **Drug discovery**
   The AI has the potential to help researchers create drugs as well. E.g. Atom-wise, which uses deep learning process to reduce the time taken to discover new drugs.

6. **Other uses of AI**
   Early identification of potential pandemics and tracking disease incidence to contain spread, and image processing and diagnostics for radiology and pathology. Such assistive and augmentative applications of AI play a critical role in enhancing efficacy, particularly that of less experienced practitioners

AI make healthcare accessible to a wider stratum of the society. AI-powered intelligent technologies can boost the productivity and accessibility of the existing resources such that they can serve more patients with the dual benefits of improved outcomes and at lower expenses. Thus, AI in India is enhancing the productivity and availability of physicians.

AGRICULTURE

Agriculture and allied sectors like forestry and fisheries accounted for over 14% of India's GDP and over 50% of the workforce.

Thus, agriculture is one of the most important sectors from following viewpoints, such as food security, increasing population, low productivity, employment dependency, etc

The technologies include Artificial Intelligence, Big Data Analytics, Block chain Technology, Internet of Things etc. By use of the modern/advance technologies and Artificial Intelligence (AI) and giving accurate and timely information regarding crops, weather and insects etc. to the farmers may improve the crop productivity, reduce the risk and improve the income of the farmers.

Challenges in Indian agriculture

- Land degradation
- Reduction in soil fertility
- Increased dependence on chemicals
- Decreasing ground water table
- Lower crop yield
- Unprintable monsoon
- Non-existent functional end to end value chain

Govt uses Artificial Intelligence on pilot basis for Pradhan Mantri Fasal Bima Yojana due to following reasons.

1. To cutting down the cost of farming while increasing productivity.
2. To ensuring better prices for farmers.
3. AI may reduce the cost of production through precise application of agricultural inputs like fertilizer, chemicals, irrigation, etc.
4. AI may help Indian farmers to choose the right crop and minimise the risks.

Few Private Initiatives.

1. **Intello Labs:** Uses image – recognition software to monitor crops and predict farm yields.
2. **Aibono** :- Uses agri – data science and AI to provide solutions to stabilizes crop yields .
3. **Trithi Robotics:** Uses drone technology to allow farmers to monitor crops in real time.
4. **Sat sure India**: Uses ML to access images of farms and predict economic value of their future yields

Benefits of AI in agriculture:

1. Intelligent solutions: AI-powered intelligent solutions that enable smarter production, processing, storage, distribution and consumption of agricultural products.
2. Site-specific data: data related to crops facilitates the application of appropriate inputs on fertilisers and chemicals, crop health and disease, spreads, monitoring health of farm animals.
3. Farm mechanisation: intelligent farm mechanisation through autonomous machines such as harvesters, thus improving the yield per square unit of land.
4. Value chain: AI and ML systems can make commodity packaging and storage more effective with lower wastage and spoilage
5. Agri-services: Tata consultancy services, mkrishi initiative, provide advisory services in local language to farmers on their mobiles

AI practices in Indian agriculture

Irrigation	The irrigation system developed by Avani-Jal, monitors and control irrigation by combining user input and actual on-ground conditions and is helping farmers reap better yield on their investment.
Precision farming	NITI Aayog and IBM have partnered to develop a crop yield prediction model using AI to provide real time advisory to farmers. The project is being implemented in 10 Aspirational Districts across the States of Assam, Bihar, Jharkhand, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh
Soil-care	Berlin-based agricultural tech start-up PEAT has developed a deep learning application called Plantix that reportedly identifies potential defects and nutrient deficiencies in the soil.
Sowing	Microsoft in collaboration with ICRISAT, developed an AI Sowing App powered by Microsoft Cortana Intelligence Suite including Machine Learning and Power

	BI. The app sends sowing advisories to participating farmers on the optimal date to sow.
Herbicides	Blue River Technology has designed and integrated computer vision and machine learning technology that enables farmers to reduce the use of herbicides by spraying only where weeds are present, optimising the use of inputs in farming (a key objective of precision agriculture).
Price forecasting	The Government of Karnataka to develop a multi-variant agro-commodity price forecasting model using AI, ML on the cloud, satellite imaging and other advanced technologies.
Crop monitoring	By using technologies like IOT, drones, satellite imaging and autonomous robot's data can be collected reliably from the fields, monitored and analyzed by AI based application.
Cattle Health:	Teck labs developed an app, Betty that uses AI and N/L to convert the responses to a series of question on regional form and weather data by the farmers, to a list of most likely causes of disease in their cattle.

AI in practice

1. **Handloom:** Ruuh, an AI chat bot on social media, generates thousands of designs for handloom weavers to choose.
2. **Warehouse management:** Hitachi saw 8% boost in productivity when it connected a general – purpose AI to its warehouse management
3. An Indian start-up uses AI system in the form of a powerful camera which borrows the intelligence of machine learning to analyse driving patterns and can help determine the cause of an accident.

MANUFACTURING

Industry 4.0 digitisation—IoT-enabled supply chains, advanced analytics, AI and ML techniques—have been transforming the manufacturing sector by incorporating greater visibility, flexibility and operational efficiency in the supply chain

AI and robotics in manufacturing includes:

Challenges in manufacturing

- Inability to compete with other industries -heavy nations. E.g. China
- Poor infrastructure including logistics housing and ports.
- Non – availability of low – cost financing.
- Company and labor law reforms.
- Law level of automation.
- Issues of skill deficit and re-skilling.

India has shown a steady increase in robot units as per International Federation of Robotics (IFR), with the automobile sector contributing to more than 50% of the numbers. However, compared to Asian countries like China and Japan, the relative robot units in factories is considerably low for India—3 robot units per 10,000 employees as compared to 68 for China.

- **Demand forecasting:** Robust demand forecasting based on critical demand drivers; improved decision making through structured scenario analysis.

- **Heavy data processing**: ML can look at large volumes of data and extract actionable insights. The data may be in form of sensor readings (time-series), text entries, audio samples, images or video streams—ML can be used to extract valuable knowledge from it.
- **Inventory optimisation**: By using ML, it can help factories with inventory management to plan their supply and delivery cycles.
- **Prediction models**: By using data related to machine performance and downtime history. The technologies like neural networks and fuzzy logic work on several data sources like operation history, usage patterns and weather data to predict the demand.
- **Optimisation of manufacturing processes**: By enhanced monitoring and auto-correction of processes; identification of inefficient machines and processes and adjusting parameters to improve yields.
- **Quality inspections:** By quantifying implicit and explicit costs associated with poor quality of work in progress (WIP) and finished goods—for example, warranty pay-outs, cost of raw material scraps, quality inspection costs
- **Visual inspection:** As industrial cameras are getting cheaper; we could use these live video feeds to detect incidents like fire in the plant. We could use cameras and AI algorithms to inspect parts and improve quality.
- **Fail safe**: By using special types of sensors like acoustic and vibration probes we can monitor the vibration of equipment. We can use AI algorithms to identify signatures of failure much before the equipment actually fails—giving us enough time to inspect and fix.
- **Transportation**: Data on geo location, traffic and weather can be used for smart scheduling so as to overcome jams and allow for real-time route adjustments. Further, AI and ML come into play in enabling semiautonomous driver assistance, autonomous fleets for ride sharing, engine monitoring and predictive maintenance of vehicles.
- **Digital twins**: DTs are data-driven models specific to individual assets which keep learning from new data and update themselves. They can provide the latest and up-to-date status of your asset.

Ways to reduce dependencies in manufacturing sectors

The successful application of AI and robotics in the manufacturing and supply chain sector has the following dependencies, where government and private sector intervention may be required:

1. **Data management**: Standards for data transformation and exchange for the large volumes of data generated by IoT-enabled machine-to-machine (M2M) communication.

Figure: AI in manufacturing

2. **Real time monitoring**: High-bandwidth industrial communications networks that enable machines, robots, wearables, sensors and actuators to exchange data at high speed, allowing real-time monitoring and updates.

3. **Efficient workflow**: Faster and more streamlined workflow from ideation to approval for testing and deployment of novel technologies such as autonomous vehicles and collaborative robots.
4. **Training:** Provisions for vocational training to industrial workers on using smart machine tools and collaborating with robotic agents.
5. **Industry and academia-based education:** Introduction of domain-focused education in schools and universities covering applications of AI, ML and robotics in an industrial product focused scenario— for example, as course materials in core engineering steams like mechanical and electrical engineering, and industrials products management.

As per the National Artificial Intelligence strategy drafted by NITI Aayog—the manufacturing industry is expected to be one of the biggest beneficiaries of AI based solutions, thus enabling the 'Factory of the Future'.

EDUCATION

Challenges in education sectors:

a) **Poor teacher-pupil ratio in schools:** it is difficult to have separate classrooms and teachers for different grades or classes.

b) **Low retention rates:** Retention rate of 70.7% at elementary level indicates that one-third of enrolled children drop out before completing Class 8. Risk of dropout due to various factors, such as inadequate school infrastructure, poor teachers, poor school readiness, language barriers, large learning gaps with respect to grade level, family circumstances (e.g. migrant families), poor nutritional or health status, etc

c) **Poor learning outcomes***:* ASER survey says, in rural areas, only 47.8% of Class 5 children could read Class 2 level text and only 26% could do Class-5-level arithmetic.

c) **Lack of interactive and remedial classes:** Teaching-learning processes in most classrooms are highly rote-based and non-interactive. Remedial instruction, where conducted, typically lacks customisation to the child's learning level, abilities, and pace of learning.

d) **Large teacher vacancies due to uneven distribution across locations:**
Recent figures for Uttar Pradesh revealed 1.74 lakh teacher vacancies at elementary school level, but a simultaneous surplus of 0.66 lakh teachers across the state.

AI-led transformation in the education sector are:

a. Tie-ups with universities and professional course content creators to effectively distribute open online course materials, conduct examinations through standardised evaluation templates and arrange for clearance-based certifications in the areas of AI, ML and robotics.
b. **Coverage of foundational courses:** In the areas data science, statistics, ML, AI, robotics, communication technology, cyber security, big data and analytics at the undergraduate and postgraduate levels
c. **Pedagogical upgrades**: to include industry and public sector cases where AI techniques have been historically applied to leverage learnings about the implementation lifecycle and outcomes
d. Provision of educational opportunities that extend beyond the formative years into late adulthood catering to a working population with the objective of making learning and **re-skilling** an incremental exercise over one's career.
e. **Feedbacking**: ML techniques are also used to provide feedback to teachers themselves. For example, by identifying areas where students lack clarity, the platform can help teachers act on their knowledge delivery and rectify the gaps.

f. **Teaching assistance:** Robotic teaching assistants connected over the cloud may alleviate the inaccessibility of experienced knowledge practitioners in remote locations by emulating their teaching style, either on a standalone basis or in real-time collaboration with human teachers

Applications of AI in education	**Best practices of AI in education**
a) Adaptive and customised learning: AI has the potential to greatly assist teachers in efficiently and effectively managing people to teacher ratio, by judging learning levels of individual students, and allowing automated development of customised educational content adapted to each child's class and learning level. **b) Intelligent and interactive tutoring systems:** Intelligent Tutoring Systems can provide great benefit to students through delivery of learning materials adapted to the child's proficiency level, learning style, and pace of learning. e.g. Grade Guardian, uses predictive models and visualisations for student performance with an interactive dashboard showing anticipated effect of policy changes. **c) AI as Predictive tools:** Analysis of test results and attendance records using AI can be used to predict probable student activities and inform pre-emptive action. For instance, In Andhra Pradesh uses AI applications to process data with the objective of helping the government identify students likely to drop out. **d) Automated rationalisation of teachers:** AI tools can be used to develop automated teacher posting and transfer systems, using analytics based on demand – supply gaps across schools in the State, candidate's prior postings, candidate preferences, etc. **e) Customised professional courses:** Adaptive AI tools can be used to design automated, customised professional development training content for the teacher based on their performance, identification of their knowledge and skill gaps. This could then be continuously adapted as teacher's skills and concepts improve.	**Smart Content:** AI can be used to develop smart content. 1. Content Technologies Inc. using deep learning to absorb and analyse existing course materials, textbooks, and course curriculum, the technology creates custom learning materials, including textbooks, chapter summaries, and multiple-choice tests. 2. NITI Aayog's hackathon featured 'ReadEx', an android application that does real-time question generation using NLP, content recommendations, and flashcard creation. **Pearson's Write-To-Learn software:** Uses natural language processing technology to give students personalised feedback, hints, and tips to improve their writing skills. **K-12 feedback teaching – learning process.** the learning app is using feedback driven learning mechanism using machine learning. ML helps in identifying gaps in conceptual clarity of student and in turn guides the teachers to concentrate and strengthen those very specific gaps.

CONSUMER AND RETAIL

AI-powered products and services such as digital assistants, customer service bots, and recommendation engines for e-commerce and entertainment portals are just a few examples of AI making inroads into the lives of consumers.

Additional uses for AI applications include personalised design and production, deep learning for predicting customer demand and orders, and efficient inventory and delivery management. In the retail store setting, shopper-friendly robots can help assist shoppers by directing them towards the appropriate product stocked in particular section of the store

Fact findings

- As per a report published by market research firm Tractica, the retail industry is the third largest end market for the application of AI technology
- One of India's largest retail chains has launched a consumer and digital lab that will focus on new innovative technologies such as AI, IoT and robotics for solutions in the consumer space. The objective behind this is to enhance retail experiences in areas like payments, unique customer identification, personalised exchanges and supply chain automation.
- As per Gartner, AI bots will power 85% of customer service interactions by 2020. This may drive up to 33 trillion USD of annual economic growth.
- A specialist publication "Retail Week" and retail tech firm "Qubit" jointly came out with a survey of UK retailers in 2017 that revealed that around 38% of the businesses that appeared for the survey were already implementing AI, while 48% were using machine learning

AI-led transformation in the consumer and retail sector are:

Artificial Intelligence helps the retailers who want to provide satisfactory customer services.

- **Consumer protection**: Establishment of strong frameworks for consumer data protection and product safety as well as access to quick and effective means of recourse in case of violations.
- **Understand consumer behaviour**: Retailers are using AI effectively to analyse their customer behaviour, and use the customer data to provide personalized shopping experience to the customers. AI helps retailers analyse customer data and change how interactions happen with the shoppers.
- **Directing consumer engagement**: By using human-AI interfaces such as augmented and virtual reality so that developments in these areas drive inclusion (of differently abled citizens, children and elderly groups, etc.) and provide oversight against predatory and exploitative marketing tactics.
- **Inventory management**: AI is helpful in predicting demands of products so the stores can manage inventory efficiently and have the in-demand supplies available at all times.

AI IN RETAIL SECTOR

- To predict customers' purchasing patterns over the next 30 days, German-based ecommerce player Otto analyses about three billion past transactions and 200 variables, including sales, searches, and weather conditions. The AI system predicts customer purchases at 90% accuracy, thereby reducing product returns by over two million items a year.
- UK retailer Morrisons is working with Blue Yonder, a tech firm, on an AI deployment that analyses different data sets: such as sales, weather patterns or public holidays. This allows the company to predict demand down to the individual store level and then automates the product orders.

DIFFERENTLY ABLED- AID, ASSISTANCE AND ACCESSIBILITY

As per 2016 statistics India has more than 2.6 crore disabled persons representing 2.2% of the population (both physical & mental), whereas Old age-based disabilities are nearly 10% of the population.

AI-enabled assistive technology for differently abled individuals is an as yet untapped market in India. India is growing in terms of the quality of smart prosthetics, incorporating newer designs and technologies.

Challenges faced in case of any disability enabled technology

- **Quality** It lags behind more developed countries when it comes to quality and advancements.
- **Affordability**: is a barrier for those differently abled people who fall within the lower income groups

AI Practice

- **LIP Reading**: Oxford's AI lab has developed a Lip reader software powered by deep learning which would be useful for hearing and speech impaired to communicate.
- **Sign language interpretation**: Malaysia and New Zealand in collaboration developed a system known as Automatic sign language translator (ASLT) that uses machine language and convert it into text
- **Microsoft and Amity school:** developed an app called 'Practikality' assisting the hearing impaired with real-time captioning for conversations
- **Optical character recognition:** Leveraging AI capabilities for the blind and the low-vision community, the Microsoft app uses Optical character recognition (OCR) to read text, scans barcodes and recognises faces, emotions and objects to describe the world.
- **GnoSys** is a smartphone application explicitly developed for deaf and mute people.

Importance of AI in aiding differently abled

- AI in combination with other emerging technologies like 3D printing and IoT, has great potential for widespread availability, affordability and feasibility of innovations in smart prosthetics.
- Biometric attendance systems make it easier for people with dyslexia who find it difficult to remember passwords login easily.
- AI-embedded accessibility features for the differently abled is the automatic captioning employed by leading video streaming sites, aimed at catering to people with full or partial hearing impairment.
- AI holds high potential for easing the daily activities of people with visual, speech or mobility impairments and allowing them to operate at higher levels of productivity. For example, smartphone apps with built-in image processing capabilities can describe an object or scene or read the text of bills and documents to a visually impaired person.

ENVIRONMENT

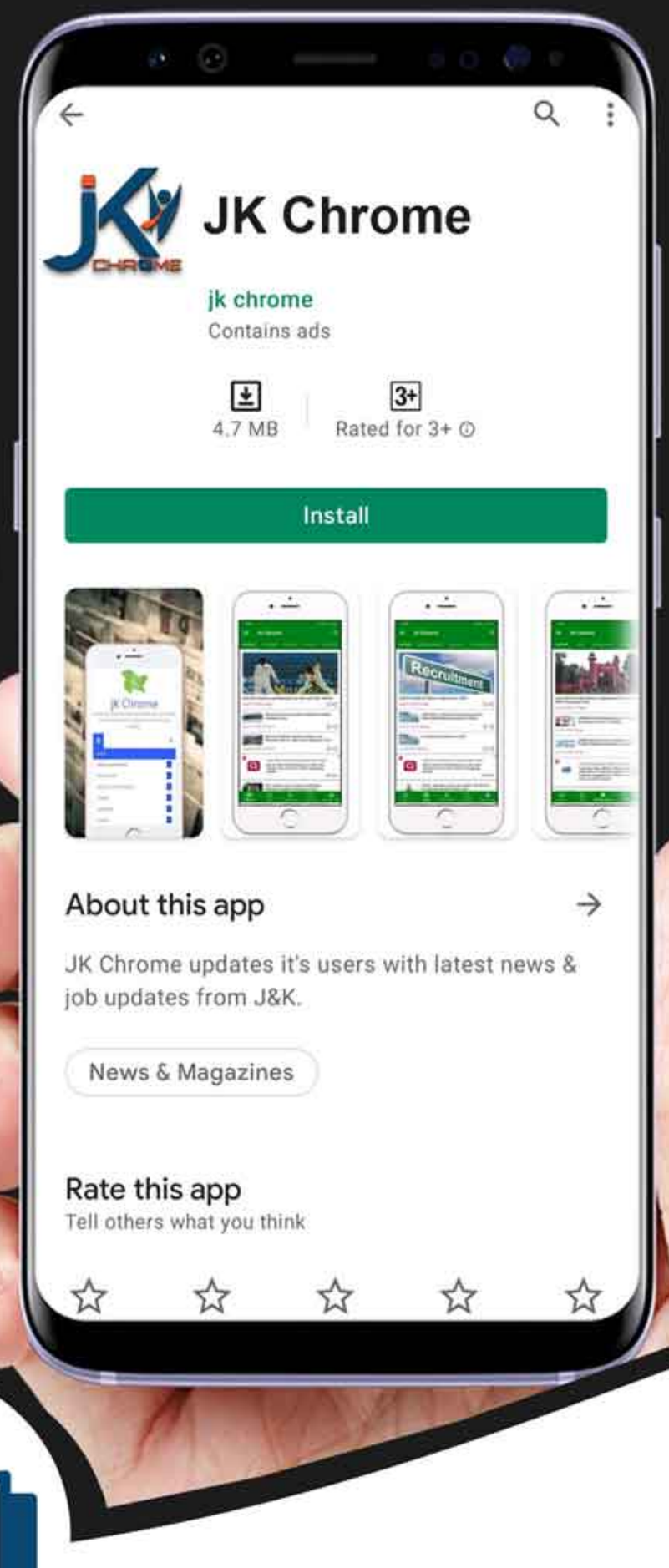
AI has been successfully applied in the environmental sciences globally. AI technologies for environmental sciences have not picked up significantly in India.

AI applications in environment al fields:

1. **AI optimised 'smart' energy grids for power generation**
    - AI optimised energy system modelling and forecasting decreases unpredictability and increases efficiency, power balancing, use, and storage of renewable energy through intelligent grids.
    - Neural networks for solar: Can improve the reliability and affordability of photovoltaic energy.
    - Smart lighting and heating systems: To utilise lighting and heating only when required.

JK Chrome

JK Chrome | Employment Portal



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AI in practice

1. **Project Sunroof:**
   an online tool based on Google Earth's 3D imagery that helps individual homeowners explore whether they should go solar by providing them with a viability report.
2. **Pollution prediction**
   China have tested an AI system that can predict the severity of pollution levels in different areas
3. **Helping tigers**
   Software developed with help from the Wildlife Conservation Society (WCS) is used to calculate tiger populations and investigate poaching activities in an area by matching their stripe patterns captured on camera, similar to the fingerprinting process.
4. **Sustainable forestry Initiatives**
   Researchers in brazil have used neural networks to develop more accurate measures of tree taper. It is a critical variable in estimating forest density and health

2. **Precision manufacturing for reduced waste and emissions.**
   - Precision strength: Robots minimising the need for larger less efficient machines.
   - Eliminating product waste: More efficient use of raw materials.
   - Industrial lifecycle tracking: Optimising maintenance, energy efficiency, recycling of machinery.
   - Reducing energy consumption and release of harmful gases and waste

3. **Smart homes and smart cities**
   - **Smart sensor system:** In offices and homes can increase safety by indicating and possibly taking remedial action against catastrophic risks such as fire, floods and earthquakes.
   - **Sustainable building design:** It can maximise energy and product efficiency in building design and improve energy efficiency by switching heating and air-conditioning ON/Off at the right times to exploit off peak rates.
   - **Energy monitoring:** It can learn electrical signatures in a smart office or home to generate insights and alerts on energy usage.

4. **Smart transportation systems**
   - **Autonomous vehicles (AVs)** AVs can improve the energy efficiency of road transport by identifying most energy-efficient routes and speeds.
   - **Managing traffic:** Big data, IoT and cloud-enabled vehicles communicate with transport infrastructure, which helps in managing vehicle flows, eco-driving and effective traffic control.
   - **AI-enabled autonomous drones and sensors:** If linked to IoT platforms can offer real-time traffic and logistics information for optimised routing.

5. **Monitoring of land usage and soil erosion**

AI-enabled automated land-use change monitoring will aid in detecting and monitoring deforestation. Transparency of real-time land use practices can be enabled by drones, advanced satellites, IoT sensors and the cloud, which will be a game changer for implementing smart land use practices and driving accountability in agriculture and forestry value chains.

6. **Disaster management and recovery**
   - **Prevent disasters** Software applications of ML can detect patterns leading to a natural disaster (e.g. rotation tracks of cyclones, tornadoes).

- **Early warning system:**Machine leaning models can estimate the range and severity of impact and trigger automated alerts and warnings with lead time for evacuation and risk control mitigation measures.
- **Damage control:** Autonomous robots and vehicles can find utility in highly hazardous and contaminated ecosystems in recovery and clean-up, such as a nuclear reactor meltdown.

In the event of a flood or earthquake, robots can be used to navigate tortuous locations, including small spaces, underwater areas and debris-ridden sites.

7. **Disease prevention and outbreak control.**
   - ML models have been used to predict location and severity of disease outbreaks and whether an outbreak should receive immediate attention.
   - Researchers had used satellite data to trace the relationship between temperatures in the equatorial part of the Indian Ocean, leading to conditions suitable for an increase in mosquitoes and the outbreak of malaria in Africa.
8. **Conservation of ecological habitats**
   - Capturing data on pollution levels generated by airborne particulates, water and solid waste and effluents using a network of sensors and communication devices

NATIONAL SECURITY

AI applications in the fields of defence and security as well.	**AI in practice**
• **Protect critical infrastructure:** Anomalous behaviour detection in individuals and infrastructure disruption prediction (natural/man-made causes) powered by the use of distributed sensors and pattern recognition are just a few examples of the potential use cases of AI in this sector. • **Perform unsafe jobs:** robots can perform tasks such as recovering explosives, detecting mines, space exploration, deep water probes, scouting for hostile territories and capturing video feed, to name a few. The usage of AI and robots in defence and military began with unmanned aerial vehicles (UAVs) and unmanned ground systems (UGS) guided bombs and missiles.	• The electrically powered remotely operated vehicle (ROV) Daksh can locate, handle and dismantle hazardous objects such as explosive devices. • In the US, the Hummingbird drone (DARPA) is a small unmanned machine used for capturing and sending video imagery. • USA's project Maven uses Ai to speed up analysis of full motion video data from tactical aerial drone platforms such as the scan Eagle and medium – altitude platforms such as the mQ-1C gray Eagle and the MQ-9 Reaper.

Set-up of network and platform to feed information from across a range of sources. e.g., security cameras and critical infrastructure, imagery and video surveillance from aircraft, radar and satellite feeds, human intelligence, signal intelligence—into AI platforms for real-time processing of information and recognition of patterns for threat detection.

Future applications of AI and robotics in unmanned systems are likely to include:

- Target identification and classification using image processing and interpretation
- Expert systems used to diagnose weapon systems like radars and missiles
- Precision targeting systems for ammunitions leading to improved accuracy
- Trajectory analysis, impact zone and kill zone evaluation using computerised simulations

AI in practice

- **Safe trading:** Recently few banks are working with technology giants in the AI and ML space to develop cognitive solutions that combine robotics and optical character recognition (OCR) to increase the safety and efficiency of trades.
- **Customer services:** An Indian robot manufactured in China, 'Mitra', is able to recognise the nationalities of and guide customers in a bank. It has been deployed at the Bengaluru branch of a prominent Indian bank.
- **Financial solutions:** A Bengaluru-based firm specialises in providing RPA solutions (among other technologies), having provided solutions in areas within insurance like claims registration, credit note refunds, policy cancellations, no claims discount verification and policy issuance.
- **Financial Risk management:** HSBC will be going to use data analytic and ML in the cloud. Having completed a set of proof of concepts (POCs) in partnership with google, HSBC has revealed pilot projects centering on areas including anti-money laundering and risk simulations.

FINANCE SECTOR

AI, ML and robotics have a wide range of use cases in financial services.

- The use of chatbots to facilitate automated conversational flows
- **Efficient customer service:** intelligent agents such as robo-advisors for personalised financial planning.
- **Anti-money laundering:** Advanced analytical techniques and ML algorithms with human expertise to facilitate fraud detection and prevention of money allow institutions to flag transactions as potentially fraudulent at the time of occurrence and hence contain the damage as early as possible.
- **Financial inclusion:** The advent of intelligent technologies is pushing towards financial inclusion across the Indian economy by introducing schemes like Jan Dhan Yojana and Cashless India.
- **Transparency, speed and efficiency:** The importance of AI systems for drawing insights from large volumes of data.
- **Prevent malpractices:** such as lapses in human judgement, and low visibility on financial exposure to certain counterparties and more. E.g. NPAs or lending segment which has recently come under the microscope with respect to the risk assessment techniques used.
- **Lean data learning techniques:** It could allow institutions to assess micro businesses and SMEs on limited historical data and in turn improve capital access to them.

Other AI applications in Finance sector

- **Transactions:** Creating new opportunities for paperless, cashless, and consent – based financial transaction.
- **NPAS/Lending:** It is driven by risk metric of a person's ability to payback and willingness to pay back.
- **Investment prediction:** AI is already being used for predicting investment opportunities with the right timing advice. E.g.- AI could manage risk related to investment decision particularly by new participant

- Automated handling of claims
- Making anonymised data available from past transactions from across different financial institutions.
- Establishing data access frameworks and guidelines for open application interfaces from financial institutions.
- Provision training for employees in banking and financial services on monitoring and calibrating AI and RPA (robotic process automation) systems to ensure compliance with regulatory policies and guidelines.

SMART CITIES AND INFRASTRUCTURE

India is currently in the midst of a surge of urbanisation. While the percentage of the population living in urban areas was estimated to be 31% in 2011, recent research on satellite data indicates that this figure is close to 45% today and predicted to rise to up-to 60 percent by 2050.

Smart cities attempt to address the challenges of urbanisation.

a) **Poor urban planning**: Challenges of inefficient land use, improper land use categorisation, area-based development and lack of open spaces such as parks, playgrounds, and recreational spaces in order to enhance the quality of life of citizens, reduce the urban heat effect, and generally promote improved ecological balance.

b) **Inefficient utility distribution**: Govt try to solve challenges such as leakages in electricity and water distribution, and improper disposal of waste.

c) **Poor grievance redressal**: In the domain of service delivery there is low accountability and transparency.

d) **Public safety**: Cities in India today are hotbeds for a range of crimes. Smart cities aim to address the issues of increase in crime and increased risk of urban emergencies through improved city design and surveillance analytics.

Some use cases of AI that can augment the features of a smart city are listed below.

a) **Smart Parks and public facilities**: Public facilities such as parks and other spaces contribute substantially to a city's liveability. Use of AI to monitor patronage and accordingly control associated systems such as pavement lighting, park maintenance and other operational conditions could lead to cost savings while also improving safety and accessibility.

b) **Smart Homes**: AI technologies being developed to optimise human effort in performing daily activities, such as smart metering, smart rooftops, water saving applications optimising domestic water utilisation for different human activities etc.

c) **AI driven service delivery**: Implementation of AI to leverage data on service delivery could see application such as predictive service delivery on the basis of citizen data, rationalisation of administrative personnel on the basis of predicted service demand and migration trend analysis, and AI based grievance redressal through chat-bots.

d) **Crowd management**: Use of AI in providing effective solutions in crowd management scale challenges such as managing mega footfall events, emergency and disasters.
   - the "Kumbha Mela Experiment" is aimed at predicting crowd behaviour and possibility of a stampede

e) **Intelligent safety systems**: AI technology could provide safety through smart command centres with sophisticated surveillance systems that could keep checks on people's movement, potential crime incidents, and general security of the residents.

- Social media intelligence platforms can provide aid to public safety by gathering information from social media and predicting potential activities that could disrupt public peace.
- In the city of Surat, the crime rate has declined by 27% after the implementation of AI powered safety systems.

SMART MOBILITY AND TRANSPORTATION

Following issues can be improve by AI in transportation

a) Congestion and road accidents:
Statistics from Government of India and a study conducted by IIT Madras suggest that in 2004-05 there were 60 vehicles registration per 1000 population. In 2015, its more 160 vehicles per 1000

b) High number of traffic deaths:
According to a PIB release by the Ministry of Road Transport and Highways (MORTH) in March 2017, the total number of road accidents in the country during 2015 was 501,423 which resulted to 146,133 fatalities.

c) Lack of public transportation infrastructure:
Public transport infrastructure development remains laggard in the overall discourse of transport policy design, either at national and regional levels, with focus directed towards promoting and improving private car and associated infrastructure

d) Assisted vehicle technologies:

1. AI can assist the driver by taking driving decisions which the system has a high degree of confidence in and alerting the driver in case it has a low degree of confidence in any decision.
2. AI is the advanced cruise control used in Tesla vehicles today. This can follow highway traffic and the curves in the road as well as

Major applications of AI on the mobility:

a) Autonomous trucking:
AI can help increase safety and hauling efficiency through intelligent platooning, wherein trucks form platoons giving drivers the liberty to rest while the platoon keeps moving. Such a method also ensures optimal road-space utilisation, helping improve road infrastructure capacity.

b) Intelligent Transportation Systems:

1. By using of an intelligent traffic management system including sensors, CCTV cameras, automatic number plate recognition cameras, speed detection cameras, signalised pedestrian crossings and stop line violation detection systems and the use of AI, real time dynamic decisions on traffic flows such as lane monitoring, access to exits, toll pricing, allocating right of way to public transport vehicles, enforcing traffic regulations through smart ticketing etc. can be made.
2. Accident heat maps could be generated using accident data and driver behaviour at specific locations on the road network
3. AI could help to design sophisticated urban traffic control systems that can optimise signal timings at the intersection, zonal and network level.

c) Travel route/flow optimisation:

1. AI can help make **smart predictions for public transport** journeys by optimising total journey time including access time, waiting time and travel time.
2. About private car usage, AI could utilise a range of traffic data sets and one's own preferences to make **human-like decisions** on route selection.
3. With information on dynamic tolls and traffic flows on links, the dependency on overhead **Variable Messaging Systems (VMS)** could be minimised, reducing substantial infrastructure costs

start and stop in response to traffic. **e) Need for sustainable transportation:** The existing issues in urban mobility related to congestion, efficient traffic flow, movement of goods etc. can indeed be solved using AI technology. **f) lack of greenfield infrastructure:** Autonomous-ready traffic will have significant impacts on greenfield road infrastructure. Lane size, lesser traffic congestion and reduced costs in upgradation of highway infrastructure are some of the externalities which will benefit the sector of assisted vehicle adoption.	**d) AI for Railways:** According to railways, more than 500 train accidents occurred between 2012- 2017, 53% of them due to derailment. 1. Fleet management and asset maintenance including that of rolling stock are pertinent AI use cases. 2. The Ministry of Railways, Govt. of India has decided to use AI to undertake remote condition monitoring using non-intrusive sensors for monitoring signals, track circuits, axle counters and their sub-systems of interlocking, power supply systems including the voltage and current levels, relays, timers. **e) Community Based Parking:** AI can help optimise parking, likely by minimising vehicle downtime and maximising driving time. 1. **Vehicle grid interactions**: With the advent of electric vehicles, AI will be needed to mediate the complex vehicle grid interactions (VGI) as well as for charging optimisation. 2. **Parking guidance systems** help drivers to find vacant parking spaces while they are using the road network and have approached close to their destination. 3. **Community based parking** using AI helps cars in traffic to collect data on vacant parking spaces, and allocates cars to spaces such that the demand is always met.

5. IMPACT OF AI ON SOCIETY AND BUSINESSES

PWC survey conducted to understand existing perceptions of the impact of AI and robotics on broad social and economic causes as well as AI-enabled service delivery.

Impact of AI on society	*Impact of AI on businesses and workplace*
The results showed an overwhelmingly optimistic view on the impact of AI, with over **71%** of the participants believing that AI will help humans solve complex problems and live more enriched lives. a) **Personalisation and interaction with humans:** • **61%** of participants indicated having used digital assistants with perceived benefits that range from saving time,	Business decision makers from across sectors and functions who were surveyed indicated the growing importance of AI-powered solutions for their businesses **AI boosting productivity** Close to **55%** of business decision makers believed that the benefits of AI for business through

managing calendar events and reminders, and helping get things done. ● **72%** of Indian business decision makers feel that AI can provide better one-to-one personalisation compared to humans. b) **AI-rendered services,** ▪ Nearly half (**49%**) of the participants indicated that they would be willing to pay extra for 'smarter customer services' run by AI, preferably with access to human agents when required. c) **Socioeconomic causes** ● **58–74%** of the participants indicated a positive outlook on the likelihood that AI will aid socioeconomic causes like economic growth, health and well-being, education, cyber security and privacy, and that the government would take steps towards their application for the same.	generating growth and boosting productivity will outweigh potential employ **Future workplace:** ● about **83%** of the business decision makers believe that an 'AI advisor' at work would be either more or at least equally rational and impartial in monitoring performance and giving promotions and raises as compared to humans. ● **Nearly 75%** of them felt that they would be comfortable with AI advisors (alone or potentially in collaboration with human advisors) taking decisions regarding their promotion. ● Over **75%** of business decision makers were convinced that AI managers would create newer, more collaborative opportunities for work; allow for a balanced workload; free up people from menial and repetitive tasks; and provide more freedom and flexibility at work.

6. HANDLING AI CHALLENGES

Challenges.

- High costs.
- Lack of technical ability.
- Lack of quality data.
- Privacy concerns
- Concerns of trust
- Too many unknowns

6.1. Integration of AI in business

To tackle the following challenges govt need find more holistic solutions, such as: -

- **Need investment:** AI Integration for businesses require time and investment.
- **Sharing AI insight:** Various governments and public-private collaboration, facilitated by a team of champions, would prove to crucial towards preventing confusion and foster new program.
- **AI as Commodity:** AI and ML solutions are being commoditized, the technical skill capital required for effectively capturing and analyzing data is slowly turning out to be prime assets for companies.
- **Need Skilled workers:** Data science professionals, statistician, robotics engineer and team leaders.

6.2. AI system must be accountable & Responsible

Few steps to make AI responsible

- **Audit bodies and ethics panels**: such bodies can do screen research, periodic reviews, etc.
- **Clear performance standard**: Documented plan of action for scenarios where AI systems operate in a manner deviated from their intended functioning.

In multi – cultural society, such as India, AI development and deployment affecting a wide section of the population, such as civil services – water, transportation, healthcare, these services must fall within the purview of the legally, culturally and ethically applications.

There are few types:

- **Responsible AI**: It ensures that its workings are aligned to ethical standards and social norms pertinent within its scope of operations. E.g.- in military and defence, the use of AI in combative equipment and robots must be aptly governed by laws of armed conflict and mandates each as International humanitarian laws.
- **Explainable AI**: It ensure that the inner working of an AI system is transparent and well understood by the system owner and administrators. EAI is important to establish publish trust in AI system
- **Robust AI**: AI must be robust against attempts of outcome manipulation through contamination of training data or algorithmic tampering. E.g. hacking-proof systems

6.3. Managing the impact of AI on employment

The Artificial Intelligence Task Force findings

- The AI industry in India to be worth **180 million USD**.
- **38%** of AI professionals are employed with large-sized companies and **33%** with start-ups.
- Bengaluru as a city alone accounts for around **37%** of AI-related jobs, followed by Delhi NCR and Mumbai, together accounting for **36%** of the jobs.

With the initiation of automation and implementation of AI in organisations, there have been concerns regarding job displacement.

While employment-related concerns cannot be dismissed altogether, there is likely to be a shift from traditional jobs to more evolved, high-involvement roles for humans in the future as efficiency, safety and standardised quality are expected to take precedence in certain services over the natural course of development.

In the debate of the potential impact of AI-powered automation on the workforce, following areas should be taken in cognizance:

1. It would be pragmatic to recognise 'lump of labour' or 'fixed-pie' fallacies.
2. The slow adoption of AI could pose a greater risk to economic growth and employment opportunities in the future as trade investments get channelled towards more advanced, efficient and cost-competitive economies.
3. AI is expected to create new areas of economic opportunity and wealth creation, which will be an ingredient in retaining key sectoral competitiveness and, in turn, jobs.

The '**Report of the Task Force on Artificial Intelligence'** (Dr. V. Kamakoti committee) has also highlighted a few noteworthy cases of new jobs that may be created by AI. They include:

- **Advisory solutions in human-AI collaboration:** opportunities to compress human expertise and knowledge via ML into computerised advisory solutions. These might be particularly beneficial for agriculture, rural healthcare and financial advice.
- **Greater levels of involvement of healthcare professionals** – AI may free up physicians, nurses and other care providers to apply themselves more intensively to the interactive, humane and empathetic side of care delivery and also to prioritise their time and expertise towards critical cases.
- **Creation of new roles within IT services** – AI-focused automation and the shift in IT service requirements may see a relative move away from jobs like research analysts, data entry operators, system engineers and test engineers towards newer roles such as AI research scientists, language processing specialists, RPA developers, and man-machine teaming managers.
- **ML schools** – where humans may apply their innate cognitive skills such as recognising images and faces and interpreting language and speech to generate data for training machines.

6.4. Re-skilling the workforce

The fast pace of innovation in AI and robotics has posed a challenge for academics and businesses, leading to the need for trained personnel to create, maintain and permeate AI and ML solutions.

The data science and programming competencies are invaluable skills for new-age tech (AI, ML and robotics), specific skill sets on algorithms—the base of these technologies—are emerging as game changers.

Challenges for India in re-skilling

1. **Late entry to AI:** India is a late entrant into the AI and robotics field and will be required to expedite the skilling of its talent base to match the current level of demand.
2. **Outdated curriculum:** India is home to a large number of engineers graduating from colleges every year (with a big proportion of them specialising in IT), their skill sets are centred more on traditional software and applications as opposed to R&D in the field of new age technology.
3. **Shortage of expertise:** the lack of talent in robotics, ML and advanced analytics is also creating challenges for entrepreneurs.
4. **Dependency on old technologies:** New-age technologies such as AI and robotics usually only have a minimal knowledge dependency on legacy technologies such as language, platform

Stake holders in re-skilling

Role of individuals

An individual will be required not only to adapt to organisational change but also to acquire new and upcoming skills and capabilities throughout his/her lifetime. This will help him/her in learning new tasks and even retraining himself/herself at the middle of his/her career.

Role of educational institutions

- **Skill development:** Academic institutions need to play a role in skill development by creating an interface for students to connect with industry professionals.
- **Inspire students:** Academic institutions can also encourage the students to work in the industry sector on different real-life challenges pertaining to current technologies and practices
- **Upgrade curriculum:** Academic institutions should upgrade their curriculum, workshops and laboratories with the current industry requirements.

or system, e.g. JAVA enabled phone are replaced by android and ios.	• **Advanced infrastructure:** new and emerging technologies should be installed in technical institutions. **Role of businesses** • **Innovation**: Fostering a culture of innovation: driven by rewards and recognition has become vital for organisations to identify solutions to their challenges and use technology to address them. • **Skill development of employees** -training will ensure smooth transition into new roles within a digitally transformed organisation. A unique way for tech companies to increase the number of jobs available to people could be by using technologies such as cognition and natural language processing.

6.5. Data privacy and security

Increasing volumes of data can be seen under threat because of increased Cyber-attacks, cyber criminals can misuse AI based applications.

- **AI – enabled cyber security**: Such systems rely on historical data of cyber-attacks and apply ML to predict and data similar threats
- **Risk detection**: Automated system can monitor are detecting risks helps the humans from the time-consuming task and categories their red flags based on their threat level.
- **AI based prediction**: For autonomous AI – self driving can and predictive profiling – we need to establish robust legal and ethical boundaries that could direct developers that could direct developers and AI firms so that their products are responsible and transparent.
- **Privacy breach**: for example, in health care, any govt policy may share the patient data without patient's consent.

GLOBAL DEVELOPMENTS IN ARTIFICIAL INTELLIGENCE

- Countries around the world are becoming increasingly aware of the potential economic and social benefits of developing and applying AI.
- Example:
  - **Role in GDP**: China and U.K. estimate that 26% and 10% of their GDPs respectively in 2030 will be sourced from AI-related activities and businesses.
  - **AI strategy paper**: the US published its AI report in 2016; France published the AI strategy in 2017; Japan released a document in 2017; China published the AI strategy in 2017; and U.K. released its industrial strategy in 2017.
  - **Creation of "data trusts":** rolling out of digital connectivity infrastructure such as 5G / full fiber networks, common supercomputing facilities, fiscal incentives and creation of open source software libraries are some of the focus areas of various governments as committed in their strategy papers.

- **Core research in AI and related technologies:**
  - Universities and research institutions from the US, China and Japan have led the publication volume on AI research topics between 2010 and 2016.
  - Universities in USA, primarily Carnegie Mellon University, Massachusetts Institute of Technology and Stanford, took an early lead in AI research by offering new courses, establishing research facilities and instituting industry partnerships.
  - Off late, Chinese universities, especially Peking and Tsinghua Universities have caught on to the race by utilising large scale public funding and extensive research partnerships with private companies.
- **Building the future workforce for AI:**
  - **These** countries are also significantly increasing the allocation of resources for Science, Technology, Engineering and Maths (STEM) talent development through investment in universities, mandating new courses (e.g., AI and law), and offering schemes to retrain people.
  - For instance, U.K. has planned to build over 1,000 government supported PhD researchers by 2025 and set up a Turing fellowship to support an initial cohort of AI fellows,
  - China has launched a five-year university program to train at least 500 teachers and 5,000 students working on AI technologies.
  - Many countries have instituted dedicated public offices such as Ministry of AI (UAE), and Office of AI and AI Council (U.K.) while China and Japan have allowed existing ministries to take up AI implementation in their sectoral areas.
- **Financing infrastructure and start-ups:**
  - National governments have significantly increased public funding for AI through commitments such as increasing the R&D spend, setting up industrial and investment funds in AI start-ups, investing in network and infrastructure and AI-related public procurements.
  - China, USA, France and Japan have committed significant public spending for AI technology development and adoption.
  - These countries are also leveraging different combinations of public-private-academia to develop and promote AI.
  - Development of technology parks, and connecting large corporations with start-ups and Discussion Paper

A Way forward

A study by EY and NASCCOM found that by 2022, around 46% of the workforce will be engaged in entirely new jobs that do not exist today, or will be deployed in jobs that have radically changed skillsets. If some countries decide to wait for a few years to establish an AI strategy and put in place the foundations for developing the AI ecosystem, it seems unlikely that they would be able to attain and match up to the current momentum in the rapidly changing socio-economic environment. Therefore, the need of the hour is to develop a policy framework that will help set up a vibrant AI ecosystem in India

5. DEFENCE

1. TYPES OF MISSILE SYSTEM IN INDIA

1.1. On the basis of Type:

A. Cruise Missile:

- Cruise missiles fly at a **low altitude**, mostly to avoid radar detection, and can be guided throughout its path. Unmanned, self-propelled (till the time of impact).
- They fly within the earth's atmosphere and use jet engine technology. These vehicles vary greatly in their speed and ability to penetrate defences.
- Guided vehicle, sustains the flight through aerodynamic lift for most of its flight path.
- Its primary mission is to **place an ordnance or special payload on a target**.
- Fly within the earth's atmosphere, use jet engine technology.
- These vehicles vary greatly in their speed and ability to penetrate defences.
- Cruise missiles can be categorized by size, speed (subsonic or supersonic), range and whether launched from land, air, surface ship or submarine.
- Example are Nirbhay and Brahmos.

Features of Nirbhay

- Nirbhay is a six-metre long two-stage missile that can strike a target from 1,000 km away.
- With a diameter of 0.52 metres and wing span of 2.7 metres, it weighs around 1,500 kg and can carry warheads up to 200-300 kg.
- Comparable with **America's Tomahawk missile** as far as the stealth capability, it can cruise at a speed of Mach 0.6-0.7.
- The Nirbhay is a land attack cruise missile designed to be launched from air, sea, and land.
- Nirbhay blasts off like a rocket and unlike a missile it turns into a vehicle akin an aircraft.
- While flying at **tree-top level** it can **deceive enemy radars,** making it difficult to be detected.
- Designed by **Aeronautical Development Establishment (ADE).**

Depending upon the speed cruise missiles are classified as:

- **Subsonic**: flies at a speed lesser than that of sound. It travels at a speed of around 0.8 Mach.
  - Examples: American Tomahawk cruise missile, Harpoon of USA, Exocet of France, Nirbhaya of India is a subsonic cruise missile.
- **Supersonic**: the speed in between 2-3 Mach, can be integrated with many platforms like warships, submarines, different types of aircraft, mobile autonomous launchers and silos.

- The combination of supersonic speed and warhead mass provides high kinetic energy ensuring tremendous lethal effect.
- **BRAHMOS** is the only known versatile supersonic cruise missile system which is in service.

- **Hypersonic cruise missile:** speed of more than 5 Mach.
  - Many countries are working to develop hypersonic cruise missiles.
  - BrahMos Aerospace is also in the process of developing a hypersonic cruise missile,
  - BRAHMOS-II, which would fly at a speed greater than 5 Mach.

B. Ballistic Missile:

- A missile that has **a ballistic trajectory** over most of its flight path, regardless of whether or not it is a weapon-delivery vehicle.
- Range is maximum distance measured along the surface of earth's ellipsoid from the point of launch to the point of impact of the last element of their payload.
- They carry a huge payload.
- They can be launched from ships and land-based facilities.
- Example: Prithvi I, II, Agni I, II, Dhanush ballistic missiles are currently operational in the Indian defence forces.

Interceptor missile

- It is **an anti- ballistic missile**
- **It is designed to counter the ballistic missile like intermediate range and intercontinental ballistic missiles launched from any country.**
- The trajectory of the interceptor missile is **programmed** to intercept the incoming missile in the mid-air.
- **Ballistic missile is used to deliver nuclear, chemical, biological or conventional warheads in a ballistic flight trajectory.**

1.2. On the basis of Launch Mode:

- **Surface-to-Surface Missile:** Guided; launched from a hand-held, vehicle mounted, trailer mounted or fixed installation.
  - **Often powered by a rocket motor or sometimes fired by an explosive charge since the launch platform is stationary. Eg. Agni missiles.**
- **Surface-to-Air Missile:**
  - **Designed for launch from the ground to destroy aerial targets like aircrafts, helicopters and even ballistic missiles.**
  - **These missiles are generally called air defence systems as they defend any aerial attacks by the enemy.**
  - **Example is Akash.**
- **Surface (Coast)-to-Sea Missile:** A surface (coast)-to-sea missile is designed to be launched from land to ship in the sea as targets. E.g. Brahmos.
- **Air-to-Air Missile:** An air-to-air missile is launched from an aircraft to destroy the enemy aircraft. The missile flies at a speed of around 4 Mach. E.g. Astra.
- **Air-to-Surface Missile:** An air-to-surface missile is designed for launch from military aircraft and strikes ground targets on land, at sea or both.
  - **The missiles are basically guided via laser guidance, infrared guidance and optical guidance or via GPS signals. The type of guidance depends on the type of target.**

- **Sea-to-Sea Missile:** A sea-to-sea missile is designed for launch from one ship to another ship.
- **Sea-to-Surface (Coast) Missile:** A sea-to-surface missile is designed for launch from ship to land based targets.
- **Anti-Tank Missile:** An anti-tank missile is a guided missile primarily designed to hit and destroy heavily-armoured tanks and other armoured fighting vehicles.
    - **Anti-tank missiles could be launched from aircraft, helicopters, tanks and also from shoulder mounted launcher.**
    - **Example is Nag missile.**

1.3. On the basis of Range:

This type of classification is based on maximum range achieved by the missiles. The basic classification is as follows:

- Short Range Missile. E.g. Prithvi
- Medium Range Missile. E.g. Agni 1
- Intermediate Range Ballistic Missile. E.g. Agni 4
- Intercontinental Ballistic Missile. E.g. Agni 5

Figure: Indian Missile Arsenal

1.4. On the basis of Guidance Systems:

- **Wire Guidance:** This system is broadly similar to radio command, but is less susceptible to electronic counter measures.
    - The command signals are passed along a wire (or wires) dispensed from the missile after launch.
- **Command Guidance:** Command guidance involves tracking the projectile from the launch site or platform and transmitting commands by radio, radar, or laser impulses or along thin wires or optical fibers.
    - Tracking might be accomplished by
        - radar or optical instruments from the launch site or
        - by radar or television imagery relayed from the missile.

- **Terrain Comparison Guidance:** Terrain Comparison (TERCOM) is used invariably by cruise missiles.
    - The system uses sensitive altimeters to measure the profile of the ground directly below and checks the result against stored information.
    - Used in BrahMos missile.
- **Terrestrial Guidance:** This system constantly measures star angles and compares them with the pre-programmed angles expected on the missile's intended trajectory.
    - The guidance system directs the control system whenever an alteration to trajectory is required.
- **Inertial Guidance:** This system is totally contained within the missile and is programmed prior to launch.
    - Three accelerometers, mounted on a platform space-stabilised by gyros, measure accelerations along three mutually perpendicular axes; these accelerations are then integrated twice, the first integration giving velocity and the second giving position. The system then directs the control system to preserve the pre-programmed trajectory. This system is used in the surface-to-surface missiles and in cruise missiles.
- **Beam Rider Guidance:** The beam rider concept relies on an external ground or ship-based radar station that transmits a beam of radar energy towards the target.
    - The surface radar tracks the target and also transmits a guidance beam that adjusts its angle as the target moves across the sky.
    - Mainly used in anti-aircraft missiles and air defence systems.
- **Laser Guidance:** In laser guidance, a laser beam is focused on the target and the laser beam reflects off the target and gets scattered.
    - The missile has a laser seeker that can detect even miniscule amount of radiation.
    - The seeker provides the direction of the laser scatters to the guidance system.
    - The missile is launched towards the target, the seeker looks out for the laser reflections and the guidance system steers the missile towards the source of laser reflections that is ultimately the target.

1.5. On the basis of Propulsion:

- **Solid Propulsion:** Solid fuel is used in solid propulsion. Generally, the fuel is aluminum powder.
    - Solid propulsion has the advantage of
        - being easily stored and
        - It can reach very high speeds quickly.
    - Its simplicity also makes it a good choice whenever large amount of thrust is needed.
    - Also used as Solid rocket booster in missiles and launch vehicles for static thrust at time of takeoff.
- **Liquid Propulsion:** The liquid propulsion technology uses liquid as fuel.
    - The fuels are hydrocarbons.
    - The storage of missile with liquid fuel is difficult and complex. In addition, preparation of missile takes considerable time.
    - In liquid propulsion, propulsion can be controlled easily by restricting the fuel flow by using valves and it can also be controlled even under emergency conditions.
    - Basically, liquid fuel gives high specific impulse as compared to solid fuel.
- **Hybrid Propulsion:** There are two stages in hybrid propulsion – Solid propulsion and Liquid propulsion.

- This kind of propulsion
  - compensates the disadvantages of both propulsion systems and
  - has the combined advantages of the two propulsion systems.

- **Ramjet:** A ramjet engine does not have any turbines unlike turbojet engines. It achieves compression of intake air just by the forward speed of the air vehicle. The fuel is injected and ignited. The expansion of hot gases after fuel injection and combustion accelerates the exhaust air to a velocity higher than that at the inlet and creates positive push. However, the air entering the engine should be at supersonic speeds. So, the aerial vehicle must be moving in supersonic speeds.
  - Ramjet engines cannot propel an aerial vehicle from zero to supersonic speeds.
  - Used in BrahMos missile.
  - **Scramjet:** Scramjet is an acronym for Supersonic Combustion Ramjet.
  - The difference between scramjet and ramjet is that the combustion takes place at supersonic air velocities through the engine.
  - It is mechanically simple, but vastly more complex aerodynamically than a jet engine.
  - Hydrogen is normally the fuel used.

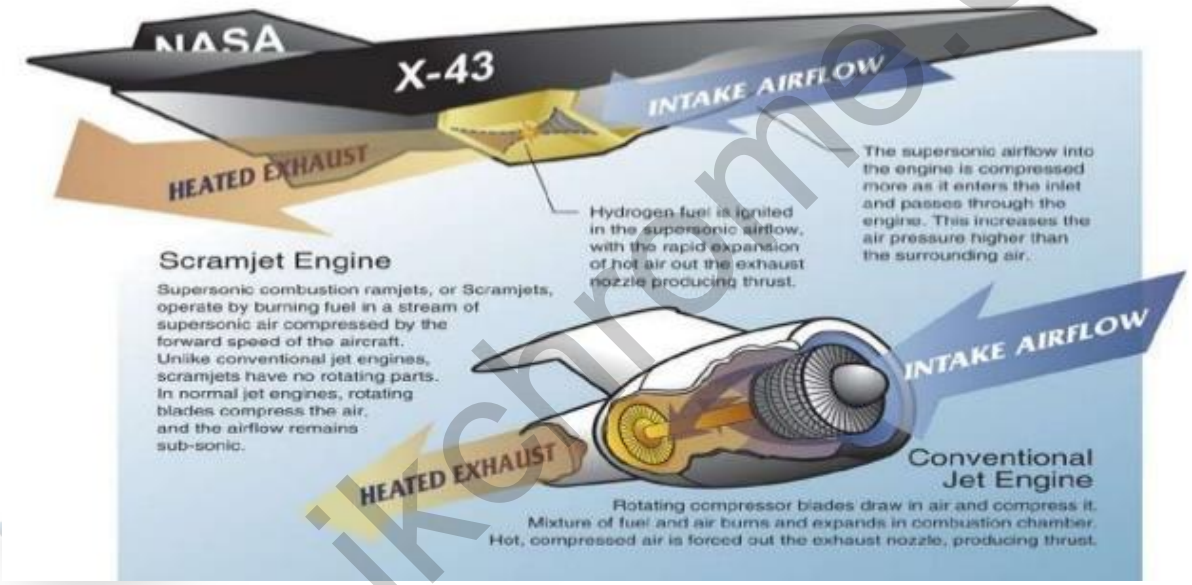


Figure: difference between Ramjet and Scramjet engines.

- **Cryogenic:** Cryogenic propellants are liquefied gases stored at very low temperatures, most frequently liquid hydrogen as the fuel and Liquid oxygen as the oxidizer.
  - Cryogenic propellants require special insulated containers and vents which allow gas to escape from the evaporating liquids.
    - The liquid fuel and oxidizer are pumped from the storage tanks to an expansion chamber and injected into the combustion chamber where they are mixed and ignited by a flame or spark.
    - The fuel expands as it burns and the hot exhaust gases are directed out of the nozzle to provide thrust.

1.6. On the basis of Warhead:

- **Conventional Warhead:** A conventional warhead contains high energy explosives.
    - It is filled with a chemical explosive and relies on the detonation of the explosive and the resulting metal casing fragmentation as kill mechanisms.
- **Strategic Warhead:** In a strategic warhead, Radioactive materials are present and when triggered they exhibit huge radio activity that can wipe out even cities.
    - They are generally designed for mass annihilation.
- **Biological warhead:** India don't have any biological warhead and there is no programme for development of Biological Warhead.

Biological weapon, also called **germ weapon**, any of a number of disease-producing agents—such as bacteria, viruses, fungi, toxins, or other biological agents—that may be utilized as weapons against humans, animals, or plants.

- Biological weapons, like chemical weapons, radiological weapons, and nuclear weapons, are commonly referred to as weapons of mass destruction, although the term is not truly appropriate in the case of biological armaments.
- Nevertheless, because of the indiscriminate nature of these weapons—as well as the potential for starting widespread pandemics, the difficulty of controlling disease effects, and the simple fear that they inspire—most countries have agreed to ban the entire class.
- In 2013 a total of 180 states had signed the Biological Weapons Convention (BWC) and 170 of those states had signed and ratified the treaty, which was opened for signature in 1972.

2. INTEGRATED GUIDED MISSILE DEFENCE PROGRAMME

Integrated Guided Missile Development Programme (IGMDP) was conceived by renowned scientist Dr. A.P.J Abdul Kalam in 1983 to enable India to attain self-sufficiency in the field of missile technology. Keeping in mind the requirements of various types of missiles by the defence forces, the team recommended development of five missiles.

1. Short range surface to surface ballistic missile **Prithvi.**
2. Intermediate range surface to surface ballistic missile **Agni.**
3. Short-range low-level surface to air missile **Trishul.**
4. Medium range surface to air missile **Akash.**
5. Third Generation anti-tank missile **Nag.**

The Agni, which was initially conceived to be a technology demonstrator projected in the form of a re-entry vehicle, was later upgraded to a ballistic missile with different ranges. After achieving the goal of making India self-reliant in missile technology, DRDO on January 8, 2008 formally announced successful completion of IGMDP.

Prithvi	• These tactical **surface-to-surface short-range ballistic missile** (SRBM) developed by DRDO. • The Prithvi missile project encompassed developing **three variants** for use by the Indian Army, Indian Air Force and the Indian Navy. • The Army version with the range of **150 km** and Air Force version with range of 350 km are already inducted while the Naval version also named **Dhanush** with a range of 350 km is undergoing trials.

Akash	• These are **medium-range mobile Surface-to-Air missile defense system.** • It can target aircraft up to a **distance of 30 km, at an altitude of up to 18 km.** • It has the capability to neutralise aerial targets like fighter jets, cruise missiles and air-to-surface missiles as well as ballistic missiles. • It is in **operational** service with the Indian Army and the Indian Air Force.
Trishul	• It is a **short-range surface-to-air missile**. • Trishul flies at **supersonic speed** and has range of **12 km.** • The system has been developed to **defend naval vessels** against missiles and also as a short-range missile for low level targets on land.
Nag	• It is a **third-generation anti-tank guided missile** which works on "fire and forget" principle. • It is designed mainly **to destroy modern main battle tanks** and other heavily armoured targets. • Nag can be launched from land and air-based platforms. The helicopter launched version is known as helicopter-launched NAG (**HELINA**). • The land-based version of the missile (**NAMICA**) can be launched through ATGM carrier. The operational range for Land version is 500m to 4km and for Air-launched version, it is 7-10 km.
Agni	• These are a series of **Medium-range ballistic missiles** (Agni-I, Agni-II), **Intermediate-range ballistic missiles** (Agni-III, Agni-IV) and **Intercontinental ballistic missiles** (Agni-V, Agni VI), initially developed under the IGMDP, but was **later delinked** with it after successfully developing Agni-I in 1989. • All the Agni missiles can carry **nuclear warheads** and has been developed as a deterrent to hostile neighbours viz. Pakistan and China. • Their ranges vary from **700-900 km for Agni-I to 5000-5500 km for Agni-V**. Agni-I, Agni-II and Agni-III are operational while Agni-IV and Agni-V are undergoing trials. Agni-VI, having a range of 8000-10000 km is under development.

3. INDIA'S BALLISTIC MISSILE DEFENCE PROGRAMME

It is a programme to develop **multi-layered defence shield** to counter and neutralise incoming ballistic missiles before it hits the target in India.

- A system that provides any missile defense against any missile type by any country.
- Can detect and then destroy a missile before it can cause any harm.
- India's air defence network has **two principal components** - the 'Air Defence Ground Environment System' (ADGES) and the 'Base Air Defence Zones' (BADZ).
- The ADGES network provides for wide area radar coverage and permits the detection and interception of most aerial incursions into Indian airspace.
- The BADZ system is far more concentrated with radars, interceptors, SAMs and AAA units working in conjunction to provide an intense and highly effective defensive barrier to attacks on vital targets.

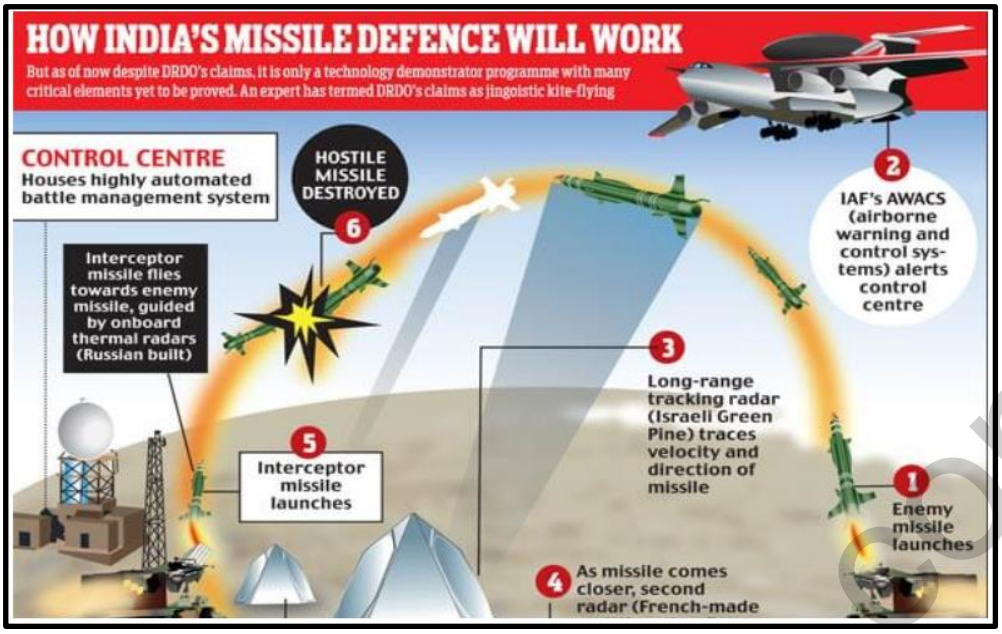


Figure: Missile Defence Program

The Ballistic Missile Defence Program:

- It is an initiative to develop and deploy a multi-layered ballistic missile defense system to protect India from ballistic missile attacks.
- based on an interceptor missile shooting down an enemy missile mid-air.
- It needs ground radars, command-and-control systems and data links.
- Besides the interceptors, a BMD consists of radars — satellite-, ground-, and sea-based — to detect and track a missile and its warhead, data communication links to pass on the information, and a command and control system.
- India's BMD does not yet have geostationary satellites.
- Introduced in light of the ballistic missile threat from Pakistan
- it is a double-tiered system consisting of two interceptor missiles, namely the Prithvi Air Defence (PAD) missile for high altitude interception, and the Advanced Air Defence (AAD) Missile for lower altitude interception.

Cruise missile defense:

- Defending against an attack by a cruise missile
- similar to tackling low-flying manned aircraft
- hence most methods of aircraft defence can be used for a cruise missile defence system.
- In order to ward off the threats of nuke-tipped cruise missile attack India has a new missile defence programme which will be focused solely on intercepting cruise missiles. The technological breakthrough has been created with an Advanced Air Defence missile (AAD).

- It is a **two-tiered** system consisting of two interceptor missiles, namely **Prithvi Air Defence** (PAD) missile for **high altitude** interception, and the **Advanced Air Defence** (AAD) missile for **lower altitude** interception. The shield will be able to intercept any incoming missile launched **even 2,000 km away**.

AAD

- AAD is a **single stage** solid rocket propelled guided missile designed to intercept incoming ballistic missiles in the **endo-atmosphere.**
- It can intercept and neutralise incoming ballistic missile at altitudes of up to **30 km**. The missile can be launched from an 8 x 8 **Tatra transporter-erector.**

PAD

- It is a **two-stage** missile defence system developed to intercept incoming ballistic missiles outside the atmosphere **(exo-atmospheric).**
- Also known as **Pradyumna**, PAD has a maximum interception altitude of **80km.** It can engage the ballistic missiles coming from 300 km-2,000km range at a speed of **Mach 5.**

Note: The missile defense battle space is divided between intercepts in the atmosphere, what is called endo-atmospheric, and out of the atmosphere, what is called Exo-atmospheric.

- Exo-atmospheric missiles are capable of completing missions outside of the earth's atmosphere. Exo-atmospheric missiles may be used to provide an orbital defense layer against hostile ballistic missiles.
- An endo-atmospheric missile is one that remains within the earth's atmosphere, i.e., at an altitude below 100 kilometers.

Need:

It was developed as a consequence of **threat from ballistic missile attacks from Pakistan and China**, especially after Pakistan's threat to use any weapon during the **Kargil Conflict** 1999.

Current status

After completion of successful tests by 2018, the shield is ready to be inducted.

4. SEEKER TECHNOLOGY DEVELOPED BY INDIA

Though a closely guarded secret, the technology **helps a missile to hit its target with pinpoint accuracy** at close ranges. Until now, it is not available with India and it was being sought from foreign countries.

4.1. Recent developments

- Since 2014, DRDO has been tasked to develop critical technologies, such as seekers, by 2022 to achieve **self-reliance and end imports.**
- Thus, in March 2018, Supersonic cruise missile **BrahMos** was successfully flight-tested for first time with **indigenously developed 'seeker'**.
- It will help the country **save at least Rs 15,000 to Rs 20,000 crore** in the near future, as the seeker equipment forms 35-40 percent of the total cost of missile.

5. INDIA'S NUCLEAR TRIAD

Nuclear triad refers to the capability of delivering nuclear weapons by aircraft, ballistic missiles from land and submarine launched missiles i.e. **from air, land and sea**.

5.1. Progress made

- India had the capabilities to launch **nuclear weapons from the Air**, mounted largely on its Mirage 2000 and Jaguar Aircraft, and by **land-based missiles**, ranging from its Agni 1 missile, with a range 700-900 km, to Agni 5 Missiles, with a range of 5500 km.

- Recent development: In 2016 Indian navy inducted the indigenously built strategic nuclear submarine **INS Arihant** into service. This was made **operationally ready in November 2018** with the integration of Sagarika missiles with a range of 750 km and the K-4 missiles, with a range of 3500 km. This completed India's Nuclear Triad.
- India will soon operationalise a **second nuclear submarine the 'INS Arighat'** and is expected to have a fleet of four such submarines by 2022.

5.2. Importance

- With Pakistan's India-aimed N-doctrine and China's ambiguity, India needs to boost its land, sea and air-based nuclear arsenal. The triad has thus been developed to have a **"credible nuclear deterrent",** with capabilities to deliver nuclear weapons from multiple locations on land, air and sea, to all strategic areas and centres.
- With this India joined a **elite group** of just 4 other countries viz. USA, Russia, China and France which have completed nuclear triad.
- The importance of nuclear triad specially to have the potential to launch from submarine lies in the fact that if all the nuclear facilities on the lands including aircrafts are destroyed, the submarines which are difficult to detect will have the final say in destroying enemies' nuclear arsenals.

6. OTHER DEFENCE INITIATIVES

6.1. S-400 TRIUMF

It is a modern **long-range surface-to-air missile** (MLR SAM) system i.e. a **defence shield**, developed by **Russia.** The missile system integrates a multifunction radar, autonomous detection and targeting systems, anti-aircraft missile systems, launchers, and command & control centre.

- It can provide a **layered defence** as it is capable of firing **four types of missiles** ranging from very long-range ones to short range ones.
- The S-400 Triumf can engage **all types of aerial targets** such as aircraft, ballistic and cruise missiles, unmanned aerial vehicles (UAV), which are within the range of **400 km**, at an altitude of up to 30 km.
- It can track 100 airborne targets, including super fighters such as the **American built F-35,** and engage six of them simultaneously. It can be deployed **within five minutes.**

Recent developments

- In October 2016 during the BRICS Summit, India and Russia signed an Inter-Governmental Agreement (IGA) for the **supply of five S-400** anti-aircraft missile systems.
- In **October 2018**, India and Russia signed a **US$5.43 billion deal** for five S-400 missile systems. The deliveries are expected to commence in 24 months, by the end of 2020.

Need for India

India needs to be well-equipped against neighboring threats. **Pakistan** has over 20 fighter squadrons, with upgraded F-16s, and inducting J-17 from China. **China** has 1,700 fighters, including 800 4-Gen fighters. However, **India has shortfall of fighter squadrons** and hence to **balance that gap** which will take some time to fill, India needs a missile defence shield.

6.2. HAL TEJAS

It is lightweight single-seat multi-role jet fighter, powered by single engine. It is pegged as **world's smallest and lightest supersonic fighter aircraft** in its class.

- It is designed, developed and manufactured indigenously by Hindustan Aeronautical Limited (**HAL**) and Aeronautical Development Agency (ADA) as part of LCA programme, which started in 1980s **to replace India's ageing MiG-21 fighters**.
- Features: The single-engine Tejas has endurance of an hour, with a radius of action of **350-400-km**. It has many features of **stealth fighter aircraft**. It can fire air-to-air missiles, carry bombs and precision guided ammunition.
- Current status: It was inducted in the Air Force in 2016 and **commenced its operation** by July 2018.

Mid-Air Refueling

It involves refueling of fighter jets in the air itself **without coming back to ground** which is time consuming and could be detrimental in war scenario. It increases the longevity of action of the fighter jets.

In September 2018, Indian Air Force successfully conducted **mid-air refueling of LCA Tejas** when 1,900 kg of fuel was transferred from the mid-air refuelling tanker of IAF to the Tejas aircraft.

6.3. PROJECT 75

It is a project of the Indian Navy to build **six Scorpene-class submarines** by Mazagon Docks Limited, Mumbai with technology transfer from **France's DCNS**. The submarines are **diesel electric attack submarines** of the Kalvari class. These are named as: INS Kalvari, INS Khanderi, INS Karanj, INS Vela, INS Vagir and INS Vagsheer.

Progress

- INS Kalvari was commissioned in the Navy in 2017.
- INS Khanderi and INS Karanj are undergoing sea trials. The other three submarines are under construction.

Importance

- These are **stealth submarine** difficult to be detected by the enemy and is designed to operate in all theatres including the tropics.
- It can undertake various operations including multifarious warfare, Anti-submarine warfare, Intelligence gathering, mine laying, area surveillance etc. It can launch attack on the enemy using **precision guided weapons** and attack **can be launched from underwater or on surface.**
- Their induction will be landmark milestone in India's bid to build its underwater warfare capabilities with an **eye on China and Pakistan**. They will boost up India's submarine fleet which at present is insufficient to deal with a **two front war scenario.**

6.4. ASTRA

- It is an indigenously developed **Beyond Visual Range Air-to-Air Missile** (BVRAAM).
- It can engage targets at varying range and altitudes allowing for engagement of both short-range targets at a distance of **20 km** and long-range targets up to a distance of **80 km.**
- It is the **first air-to-air missile** developed by India.

- DRDO has developed the missile and has **integrated the weapon on Su-30Mki** while integration with other air platforms like Dassault Mirage 2000 and MiG-29 will be done in the future.

6.5. BRAHMOS

- It is **medium range supersonic cruise missile** that can be used against ships and land targets. It is developed jointly by **India and Russia** and is named after rivers Brahmaputra (India) and Moskva (Russia).
- The missile is uniquely configured for installing in **ships, submarines & aircraft as well as on ground launch vehicles** and all these versions works on "fire and forget" principle of operation.
- It has a flight range of **290 km** which is now considered to be increased to over **600 km** after India joined **MTCR.**
- It is the **world's fastest cruise missile** in operation that can travels at speeds of **Mach 2.8 to 3.0**, which is being upgraded to Mach 5.0.

Current developments

- **Ship based and Land based** versions are already in **operation** while **Air based and submarine-based ones are undergoing trials.**
- Also, a hypersonic version of it i.e. **BrahMos-II** with a speed of Mach 7-8 in under development.

Triad Completion

The air-launched version of missile was test-fired in November, 2017 for first time from modified **Su-30MKI** aircraft, making it **world's fastest supersonic cruise missile to be fired from a combat jet** against a target. With this, Brahmos completes the **cruise missile triad**, which means it can be launched from l**and, sea and air.**

6.6. BARAK-8

- **It is medium range as well as long range surface-to-air missile d**eveloped jointly by **India and Israel.**
- The missile provides broad aerial and point defence against wide range of threats from the air, sea or land.
- It has maximum speed of **Mach 2** with maximum operational range of **70 km** (which has been increased to 100 km).
- It is designed to defend against variety of short-to-long-range airborne threats, including fixed-wing aircraft, helicopters, drones and projectiles.
- It can be launched from **mobile launchers** on land as well through **sea corvettes, destroyers**, and **aircraft carriers.**
- The system is **operational** Indian Air Force and Indian Navy and, will be operational in the near future with the Indian Army as well.

6.7. NAL SARAS

NAL Saras is India's first multi-purpose **civilian aircraft** in the light transport aircraft category as designed by the National Aerospace Laboratories (NAL), Bengaluru.

Saras Mk2 version

- The revises version will be a **19-seater aircraft** instead of a 14-seater proposed earlier.

- the aircraft could accelerate above 700 km/ph with full payload. The **military version** of the plane will also be produced.
- Its important features are considerable drag/weight reduction with unique features like **high cruise speed**, **lower fuel consumption**, short landing and take-off distance, **low acquisition and maintenance cost** etc

Progress

- The civilian aircraft was started in **2004-05**, during its trial run it struck a roadblock in 2009 where two pilots were killed in an accident
- The project was revived in 2016 was **successfully test flown twice** in January and February **2018**. The aircraft's production will start from **2022**.

Significance

- The aircraft's cost is around Rs 40-45 crore, **20-25% cheaper** than any imported aircraft in the same category. It will also **save India's forex reserves** used in buying such planes
- Saras Mk 2 will be ideal for commuter connectivity under the **UDAAN scheme** and other applications like aerial search/survey, executive transport, **disaster management and border patrol.** It will also **generate employment**.

7. DEFENCE DEALS

7.1. *Defence Deals with Russia*: Russia is the most important defence partner of India and India has signed the maximum number of defence deals with Russia. Russian manufactured defence systems form the backbone of Indian armed forces. So far India has signed 7 important defence deals with

7.1.1. **S-400 Triumf Missile System**: The S-400 Triumf is a modern long-range surface-to-air missile (MLR SAM) system developed by Russia. The missile system integrates a multi-function radar, autonomous detection and targeting systems, anti-aircraft missile systems, launchers, and command and control centre. India has signed $5.4 billion agreement with Russia during the visit of Russian President in October 2018 to acquire 5 units of S-400 Triumf units.

7.1.2. **BrahMos Missile**: The BrahMos is a medium-range ramjet supersonic cruise missile that can be launched from submarine, ships, aircraft, or land. It is the fastest cruise missile in the world. The missile travels at speeds of Mach 2.8 to 3.0, which is being upgraded to Mach 5.0.The BrahMos has been developed as a joint venture between the DRDO of India and the NPOM of Russia.

7.1.3. **Sukhoi-30MKI Fighter**: The $1.5 billion deal for SU-30 aircrafts was made between India and Russia in 1996. The Sukhoi Su-30MKI is a twinjet multirole air superiority developed by Russia's Sukhoi and built under licence by India's Hindustan Aeronautics Limited (HAL) for the Indian Air Force (IAF).

7.1.4. **MiG 29K Fighter Aircraft**: MiG-29K is an all-weather carrier-based multirole aircraft being produced by Russian Aircraft Corporation MiG (RAC MiG). India ordered 45 MiG-29K aircraft and equipment worth $2.2 billion in two separate orders — in 2004 and 2010 — from Russia. Since then India has gone on to procure about 89 MiG 29K from Russia.

7.1.5. **IL-76 Heavy Lift Transport Aircraft**: the 'Gajraj' in the air force, the IL 76 (Ilyushin 76) was ordered in 1983 from Russia and has been India's main heavy lift aircraft before the arrival of the Boeing C 17 aircraft in 2013.

7.1.6. **Mi-17 Transport Helicopter:** In 2012 India signed a $1.3 billion defence deal with Russia for delivery of 71 Mi-17 military helicopters. It is a medium twin-turbine transport helicopter.

7.2. Defence Deals with Israel

7.2.1. **Barak 8** MR-SAM Missile Barak 8 also known as LR-SAM or as MR-SAM is an Indian-Israeli surface-to-air missile (SAM), designed to defend against any type of airborne threat including aircraft, helicopters, anti-ship missiles, and UAVs as well as ballistic missiles, cruise missiles and combat jets. Barak 8 was jointly developed by Israel Aerospace Industries (IAI) and India's Defence Research & Development Organisation (DRDO).

7.2.2. **The Phalcon:** The Phalcon is an Israeli manufactured Airborne Early Warning, Command and Control (AEWC&C) system. It is one of the most powerful such systems in the world. In January 2004, India and Israel signed a $1.1 billion contract for 3 Phalcon AWACS aircraft.

7.3. Defence Deals with USA

7.3.1. **P-8I Poseidon:** The Boeing P-8I is a long-range anti-submarine warfare, anti-surface warfare, intelligence, surveillance and reconnaissance aircraft capable of broad-area, maritime and littoral operations.

7.3.2. **C-130J Super Hercules:** The Lockheed Martin C-130J Super Hercules is a four-engine turbo propulsion military transport aircraft. The Indian Air Force purchased six C-130J-30s in early 2008 at a cost of up to US$1.059 billion for its special operations forces in a package deal with the US government under its Foreign Military Sales (FMS) program.

7.3.3. **C-17 Globemaster III:** The Boeing C-17 Globemaster III is a large military transport aircraft. In 2009, the Indian Air Force (IAF) selected the C-17 for its Very Heavy Lift Transport Aircraft requirement to replace several types of transport aircraft.

7.3.4. **Apache AH-64 Attack Helicopters:** In July 2018 India signed a $930 million deal to acquire six AH-64E Apache attack helicopters from USA. The AH-64 Apache is the world's most advanced multi-role combat helicopter manufactured by Boeing.

7.3.5. **Chinook CH-47 Helicopters:** India signed a $2.5 billion deal with USA in 2018 to acquire 15 Chinook and 22 Apache for the Armed forces. The Boeing CH-47 Chinook helicopter transports troops, artillery, supplies and equipment. It is suited for mountain operations; the Chinook is highly maneuverable and can get in and out of tight valley.

FOUNDATIONAL AGREEMENT with USA

The four agreements —

- General Security of Military Information Agreement (GSOMIA), Logistics Exchange Memorandum of Agreement (LEMOA), Communications Interoperability and Security Memorandum of Agreement (CISMOA) and Basic Exchange and Cooperation Agreement for Geo-spatial Cooperation (BECA) are referred to as the foundational agreements which the U.S. signs with countries with which it has close military ties.

1) **General Security of Military Information Agreement (GSOMIA)**
   - It was signed in 2002 between India and USA.
   - GSOMIA paved the way for greater technology cooperation in the military sector.
   - It allows the sharing of classified information from the U.S. government and American companies with the Government of India and Defense Public Sector Undertakings (DPSU) but not with Indian private companies.

2) **Logistics Exchange Memorandum of Agreement (LEMOA)**
   - This is a logistics support agreement signed in 2016.
   - It gives both the nations access to each other's military facilities. But it does not make it automatic or obligatory.
   - It is a tweaked India-specific version of the Logistics Support Agreement (LSA) which the U.S. has with several countries it has close military to military cooperation.
   - The agreement will primarily cover four areas — port calls, joint exercises, training and Humanitarian Assistance and Disaster Relief. Any other requirement has to be agreed upon by both sides on a case-by-case basis.

3) **Communications Compatibility and Security Agreement (COMCASA)**
   - It is the most recent agreement signed in 2018.
   - COMCASA is an India-specific version of the Communication and Information on Security Memorandum of Agreement (CISMOA). It comes into force immediately and is valid for a period 10 years.
   - It would facilitate access to advanced defense systems and enable India to optimally utilize its existing U.S.-origin platforms. COMCASA allows India to procure transfer specialized equipment for encrypted communications for US origin military platforms like the C-17, C-130 and P-8Is.

4) **Basic Exchange and Cooperation Agreement (BECA):**
   - BECA is last of the four foundational agreements. It is yet to be signed between the two nations.
   - It facilitates exchange of geospatial information. It would set a framework through which the US could share sensitive data to aid targeting and navigation with India.
   - These agreements can bring military advantage to India though they have been politically contentious. Also, it is feared that they may undermine India's military autonomy.

7.4. Defence Deals with France

7.4.1. **Rafale Multirole Combat Fighter**: In 2016 India entered into a $9.04 billion (7.8 billion Euros) defence deal with France to acquire 36 Dassault Rafale fighters. The Rafale is a twin-jet combat aircraft capable of carrying out a wide range of short and long-range missions, including ground and sea attacks, reconnaissance, high-accuracy strikes and nuclear strike deterrence.

7.4.2. **Mirage 2000 Fighter Jet**: The Dassault Mirage 2000 is a French multirole, single-engine fourth-generation jet fighter manufactured by Dassault Aviation. The original Mirage 2000 entered service into the Indian Air Force way back in 1985. In 2011 the India government cleared a $2.4 billion deal with France for upgrading India's Mirage-2000 combat planes.

7.4.3. **Scorpene-class Submarine**: In 2005 India and France entered into a $3.75 billion defence agreement to build 6 Scorpene class submarines under transfer of technology agreement. The submarines are being built by Mazgaon Dock Limited (MDL) in Mumbai. Scorpene is a conventional powered submarine weighing 1,500 tonnes and can go up to depths of 300m. It is built by DCNS of France.

8. JOINT ARMED EXERCISES

Joint Exercises conducted by Army:

S. No.	Country	Exercise
1.	Australia	Ex AUSTRA HIND
2.	Bangladesh	Ex SAMPRITI
3.	China	Ex HAND IN HAND
4.	France	Ex SHAKTI
5.	Indonesia	Ex GARUDA SHAKTI
6.	Kazakhstan	Ex PRABAL DOSTYK
7.	Kyrgyzstan	Ex KHANJAR
8.	Maldives	Ex EKUVERIN
9.	Mongolia	Ex NOMADIC ELEPHANT
10.	Myanmar	IMBEX
11.	Nepal	Ex SURYA KIRAN
12.	Oman	AL NAGAH
13.	Russia	Ex INDRA
14.	Seychelles	Ex LAMITYE
15.	Sri Lanka	Ex MITRA SHAKTI
16.	Thailand	Ex MAITREE
17.	UK	Ex AJEYA WARRIOR
18.	USA	Ex YUDHABHAYAS
		Ex VAJRA PRAHAR
19.	Vietnam	VINBAX
20.	Multinational (ADMM Plus)	Ex FORCE 18

Joint Exercises conducted by Navy:

S. No.	Country	Exercise
1.	Australia	AUSINDEX
2.	Bangladesh	IN-BN CORPAT
3.	Brazil & South Africa	IBSAMAR
4.	France	VARUNA

5.	Indonesia	IND-INDO CORPAT
		IND-INDO BILAT
6.	Malaysia	IN-MN Table Top Ex
7.	Myanmar	IMCOR
		IN-MN BILAT
8.	Oman	Naseem-al-Bahr
9.	Russia	INDRA NAVY
10.	Sri Lanka	SLINEX
11	Singapore	SIMBEX
12.	Thailand	INDO-THAI CORPAT
13	UAE	In-UAE BILAT
14	UK	KONKAN
15.	USA	MALABAR
		RIMPAC (Multilateral)
16	Multilateral Exercise by Brunei	ADMM+ Exercise
17	Multilateral Exercise by Indonesia	Ex KOMODO
18	Multilateral Exercise by India	MILAN

Joint Exercises conducted by Air Force:

S. No.	**Country**	**Exercise**
1.	Bangladesh	Table Top Ex
2.	Israel	Ex Blue Flag-17
3.	Oman	Ex EASTERN BRIDGE-IV
4.	Russia	Ex INDRA-17
5.	Singapore	JOINT MILITARY TRAINING
6.	Thailand	Ex SIAM BHARAT
7.	UAE	DESERT EAGLE-II
8.	UK	INDRADHANUSH-IV
9.	USA	RED FLAG 16-1
10.	Multinational Air Exercise	Ex Samvedna with Bangladesh, Nepal, Sri Lanka, UAE

6. NUCLEAR TECHNOLOGY

1. INDIA'S THREE STAGE NUCLEAR PROGRAMME

India's 3-stage nuclear power programme was formulated by **Homi J. Bhabha** in the 1950s to secure the country's long-term energy independence, **through the use of uranium and thorium reserves** found in the **monazite sands of coastal regions of South India**.

Vision:

- The three-stage nuclear power programme aims to **multiply the domestically available fissile resource** through the use of natural uranium in Pressurised Heavy Water Reactors,
- The above will be followed by **use of plutonium obtained from the spent fuel** of Pressurised Heavy Water Reactors in Fast Breeder Reactors.
- Large scale **use of Thorium** will subsequently follow making use of the Uranium-233 that will be bred in **Fast Breeder Reactors**, when adequate capacity has been built in the country.

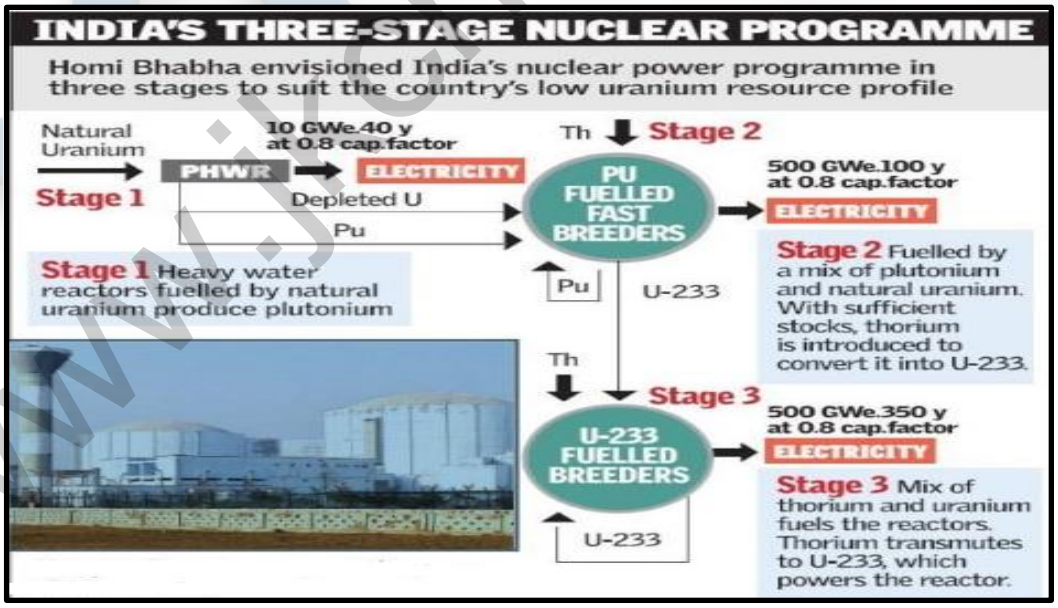


Figure: India's three stage nuclear programme

- **Ultimate focus** is on **enabling the thorium reserves of India to be utilised** in meeting the country's energy requirements.

Why Thorium:

- India has only around 1–2% of the global uranium reserves, but **about 25% of the world's known thorium reserves**.
- The Indian nuclear establishment estimates that the country could produce 500 GWe for at least four centuries using just the country's economically extractable thorium reserves.

- **Aim:** The first 2 stages, natural **Uranium-fueled heavy water reactors** and **Plutonium-fueled fast breeder reactors**, are intended to generate sufficient fissile material from India's limited uranium resources, so that all its vast thorium reserves can be fully utilized in the 3rd stage of thermal breeder reactors.
- **Challenges in using Thorium:**
  - Thorium is more difficult to use than uranium as a fuel because **it requires breeding**, and **global uranium prices remain low enough which makes breeding is unnecessary**.
  - **Thorium itself is not a fissile material, and thus cannot undergo fission to produce energy.** Instead, it must be **transmuted to uranium-233** in a reactor fueled by other fissile materials [Plutonium-239 or Uranium-235].
    - **Transmutation** is the conversion of an atom of one element to an atom of another through nuclear reactions.
    - Induced nuclear **transmutation** is a type of **transmutation** which is induced by scientists by striking the nuclei with high volume particles
- **Present status of the programme:**
  - India's first **Prototype Fast Breeder Reactor had been delayed.**
  - India continues to import thousands of tonnes of uranium from Russia, Kazakhstan, France, and Uzbekistan.

STAGE 1: PRESSURISED HEAVY WATER REACTOR (PHWR)

- In the 1st stage of the programme, **natural uranium fuelled PHWR produce electricity** while generating **Plutonium-239 as by-product**.
  - Natural uranium contains **0.7%** U-**235**, **99.3%** U-**238**, and a trace of U-234 by weight (0.0055%)
  - In PWHR, **enrichment of Uranium to improve concentration of U-235 is not required**. U-238 can be directly fed into the reactor core
  - U-238 → Plutonium-239 + Heat
- **Heavy water (Deuterium Oxide = D_2O) is used as moderator and coolant** in PHWR.
- **Why PHWRs for first stage?**
  - Because it had the most **efficient reactor design [uranium enrichment not required]** in terms of uranium utilisation.
  - India correctly calculated that it would be easier to create heavy water production facilities (required for PHWRs) than uranium enrichment facilities (required for light water reactors (LWRs)).
  - Almost the entire existing base of Indian nuclear power (4780 MW) is composed of first stage PHWRs, with the exception of the two Boiling Water Reactor (BWR) units at Tarapur.

Major Components of Nuclear Reactors

Name	Function	Desirable Characteristics	Materials
Nuclear Fuel	To undergo nuclear fission by neutrons	▪ Excellent nuclear characteristics ▪ High thermal conductivity ▪ Irradiation & chemical stability	UO_2, UO_2/PuO_2, U-Al, U-Mg, U-Zr
Moderator	To reduce neutron energy by scattering without significant capture	▪ Large scattering cross section ▪ Small absorption cross section ▪ Large energy loss per collision ▪ Low atomic number	H_2O, D_2O, Be, C(graphite)
Coolant	To remove fission heat from the primary heat source such as a reactor core or breeding blanket	▪ Excellent heat transfer ▪ Chemical stability ▪ Small pumping requirement ▪ Irradiation stability ▪ Abundance & low cost, etc.	H_2O, D_2O, CO_2, He Na(liq.), Pb-Bi(liq.)
Reactivity Control Material	To control neutron flux in the core by absorbing neutrons	▪ Control rods: B, B_4C, Cd, Ag-In- Id, Hf, Ag-Hf, Ag-In-Hf ▪ Burnable poison: Eu_2O_3, Er_2O_3, Gd_2O_3 ▪ Chemical shim: H_3BO_3	
Structural Material	To maintain geometry	▪ High strength & ductility ▪ Small absorption cross section ▪ Thermal & irradiation resistance ▪ Corrosion resistance, etc.	Zircaloy, S/S, C/S, A & its alloy, Mg & its alloy, Be, C, SiC, MgO, etc.

Figure: component in nuclear reactor

STAGE 2 : FAST BREEDER REACTOR

- In the second stage, **fast breeder reactors (FBRs) [moderators not required] would use a mixed oxide (MOX) fuel made from plutonium-239**[recovered by reprocessing spent fuel from lst stage] and **natural uranium**.
- In FBRs, **Plutonium-239 undergoes fission** to produce energy, while **Uranium-238 present in the mixed oxide fuel transmutes to additional Plutonium-239**.
    - Thus, the **Stage II FBRs are designed to "breed" more fuel than they consume**.
    - Once the inventory of plutonium-239 is built up thorium can be introduced as a blanket material in the reactor and transmuted to uranium-233 for use in the third stage.
    - The surplus plutonium bred in each fast reactor can be used to set up more such reactors, and might thus grow the Indian civil nuclear power capacity till the point where the third stage reactors using thorium as fuel can be brought online, which is forecasted as being possible once 50 GW of nuclear power capacity has been achieved.
- **Why should Uranium-238 be transmuted to Plutonium-239?**
    - Uranium-235 and Plutonium-239 can sustain a chain reaction. But Uranium-238 cannot sustain a chain reaction. So, it is required to be transmuted to Plutonium-239.
- **But Why U-238 and not U-235?**
    - Natural uranium contains **only 0.7% of the fissile isotope uranium-235**.
    - Most of the **remaining 99.3% is uranium-238** which is **not fissile** but can be converted in a reactor to the fissile isotope Plutonium-239.
- **Doubling time:** Doubling time refers to **the time required to extract as output, double the amount of fissile fuel, which was fed as input into the breeder reactors**.
    - This metric is critical for understanding the time durations that are unavoidable while transitioning from the second stage to the third stage of Bhabha's plan, because building up a sufficiently large fissile stock is essential to the large deployment of the third stage.

- **Current Status:** The design of the country's 1st fast breeder, called Prototype Fast Breeder Reactor (PFBR), was done by Indira Gandhi Centre for Atomic Research (IGCAR).
    - Bharatiya Nabhikiya Vidyut Nigam Ltd (Bhavini), a PSU under the Department of Atomic Energy (DAE), has been given the responsibility to build the fast breeder reactors in India.
    - The construction of this PFBR at Kalpakkam was due to be completed in 2012. It is not yet complete.

STAGE 3 : THORIUM BASED REACTORS:

- A Stage III reactor or an **Advanced nuclear power system involves a self-sustaining series of thorium-232-uranium-233 fuelled reactors**. This would be **a thermal breeder reactor**, which in principle **can be refueled – after its initial fuel charge – using only naturally occurring thorium**.
- **Current status:**
    - According to the three-stage programme, Indian nuclear energy could grow to about 10 GW through PHWRs fueled by domestic uranium, and the growth above that would have to come from FBRs till about 50GW.
    - The third stage is to be deployed only after this capacity has been achieved.
    - Full exploitation of India's domestic thorium reserves will likely not occur until after the year 2050.
- Three options under consideration are the Indian Accelerator Driven Systems (IADS), Advanced Heavy Water Reactor (AHWR) and Compact High Temperature Reactor.

Advanced Heavy Water Reactor (AHWR):

- The design for AHWR is ready for deployment.
- AHWR is a 300 MWe **vertical pressure tube type, boiling light water cooled and heavy water moderated reactor, using uranium 233–thorium MOX** and **plutonium–thorium MOX**.
- It is **expected to generate 65% of its power from thorium** and **can also be configured to accept other fuel types in full core including enriched uranium and uranium–plutonium MOX**.

Accelerator Driven System:

- An **accelerator-driven subcritical reactor** is a nuclear reactor design formed by coupling a substantially subcritical nuclear reactor core with a high-energy proton accelerator.
- Such reactors can use thorium as a fuel, which is more abundant than uranium
- India's Department of Atomic Energy and USA's Fermilab are designing unique first-of-its-kind accelerator driven systems.
- No country has yet built an Accelerator Driven System for power generation.

Indian Molten Salt Breeder Reactor (IMSBR)

- It is under development.
- In the newly published Thorium Energy Report (Thorium Energy Report) India reported that it has initiated studies on a conceptual design of the Indian Molten Salt Breeder Reactor (IMBSR).
- The design will build on the accumulated experience from the AHWR as well as India's previous research on Molten Salt Reactors. If India can learn to master the molten salt reactor technology as well, it could become the most efficient thorium reactor in India's portfolio and make the country's thorium resources last even longer.

PROTOTYPE FAST BREEDER REACTOR (PFBR) AT KALPAKKAM

- PFBR is a **500 MWe fast breeder nuclear reactor** presently being constructed at the Madras Atomic Power Station in Kalpakkam, India.
- The **Indira Gandhi Centre for Atomic Research (IGCAR)** is responsible for the design of this reactor.
- BHAVINI, a public sector undertaking of the Department of Atomic Energy, has already built the PFBR.
- The Kalpakkam PFBR is using **uranium-238 not thorium**, to breed new fissile material, in a sodium-cooled fast reactor design.
- The surplus plutonium or uranium-233 for thorium reactors [U-238 transmutates into plutonium] from each fast reactor can be used to set up more such reactors and grow the nuclear capacity in tune with India's needs for power.
- **Issues:**
    - The fact that **PFBR will be cooled by liquid sodium** creates additional safety requirements to isolate the coolant from the environment, since sodium explodes if it comes into contact with water and burns when in contact with air.
    - Another hazard associated with the use of sodium as a coolant is the absorption of neutrons to generate the radioactive isotope ^{24}Na.
- **Precaution:**
    - In the case of sodium fire in an open place, sodium bicarbonate — a dry chemical powder — would be used to douse the fire. If sodium caught fire in an enclosed place, nitrogen would be injected to extinguish it. Sodium fire is milder than oil catching fire.

What is the single greatest factor that prevents the large-scale deployment of thorium-fuelled reactors in India? Critical shortage of fissile material.

- **Fissile material** - one that can sustain a chain reaction upon bombardment by neutrons.
- Thorium is by itself fertile, which means it can transmute(change) into a fissile radioisotope but cannot itself keep a chain reaction going.
- In a thorium reactor, a fissile material like uranium or plutonium is blanketed by thorium. The fissile material (a driver in this case), drives the chain reaction to produce energy while simultaneously changing the fertile material into fissile material.

Why emphasis on thorium technology? Because Thorium reactors -

1. **Less waste generation:** Produce far less waste than present-day reactors. The minuscule waste that is generated is toxic for only 3 or 4 hundred years rather than thousands of years.
2. **High radioactivity:** Have the ability to burn up most of the highly radioactive and long-lasting minor actinides that makes nuclear waste from Light Water Reactors a nuisance to deal with.
3. **Low cost:** cheaper because they have higher burnup.
4. **Low proliferation:** thorium reactors are significantly more proliferation-resistant than present reactors. This is because the U-233 produced by transmuting thorium also contains U-232, a strong source of gamma radiation that makes it difficult to work with. Its daughter product, thallium-208, is equally difficult to handle and easy to detect.
    a) so offers an enormous advantage to proliferation-resistance as well as the environment.
    b) Admittedly, there still remains a proliferation risk, but these can be addressed by already existing safeguards.

5. For India, it offers the added benefit that **it can act as a guarantor for the lifetime supply of nuclear fuel for reactors if it chooses to enter the export market**, something it is unable to do for uranium-fueled reactors.

Current status:

- India has an installed nuclear power capacity of **6.8 GW**, all of which is driven by Uranium as a fuel, mostly imported from other countries. Hence India is **yet to achieve** the objective of the programme.
- India has at least **3,60,000 tonnes** of Thorium reserves which is the ultimate focus of the programme in meeting the country's energy requirements. However, **Thorium alone cannot be used as a fuel and it has to be converted into Uranium-233** in a reactor before it can be used as fuel.

Recent developments:

- Government, in June 2017, decided to build **ten India-designed 700 MW Pressurized Heavy Water Reactors.**
- At Kalpakkam, the **Prototype Fast Breeder Reactor** of 500 MW is in the process of commission.
- Bhabha Atomic Research Centre (BARC), has developed a design for **Advanced Heavy Water Reactor (AHWR), a Technology Demonstrator Reactor of 300 MW**, for utilisation of **Thorium**.
- **Apsara U:** It is a reactor developed by BARC which became operational in 2017. It uses low enriched Uranium fuel.

Types of Nuclear Reactors:

Nuclear reactors serve three general purposes.

- **Civilian reactors** are used to generate energy for electricity and sometimes also steam for district heating
- **Military reactors** create materials that can be used in nuclear weapons.

Research reactors are used to develop weapons or energy production technology, for training purposes, for nuclear physics experimentation, and for producing radio-isotopes for medicine and research.

The two tables below give information about civilian and military reactors.

	Light Water Reactor (LWR)		
Reactor Type	a. Boiling Water Reactor	b. Pressurized Water Reactor (PWR)	Heavy Water Reactor (HWR)
Purpose	electricity	electricity; nuclear powered ships (U.S.)	electricity; plutonium production
Coolant Type	water (H2O)	water	heavy water (deuterium oxide, D2O)
Moderator Type	water	water	heavy water
Fuel — Chemical Composition	uranium-dioxide (UO2)	uranium-dioxide	uranium-dioxide or metal
Fuel – Enrichment Level	low-enriched	low-enriched	natural uranium (not enriched)

Comments	steam generated inside the reactor goes directly to the turbine	steam is generated outside the reactor in a secondary heat transfer loop	used in Canada: called "CANDU" – "Canadian Deuterium Uranium;" Also used in Savannah River Site reactors (metal fuel at SRS)

	Graphite Moderated Reactor		Fast Breeder Reactor (FBR)
Reactor Type	a. Gas Cooled	b. Water Cooled	Liquid Metal (LMFBR) (most common type of breeder)
Purpose	electricity; plutonium production	electricity; plutonium production	electricity; plutonium production
Coolant Type	gas (carbon dioxide or helium)	water	molten, liquid sodium
Moderator Type	graphite	graphite	not required
Fuel-Chemical Composition	uranium dicarbide (UC2) or uranium metal	uranium dioxide (RBMK) or metal (N-reactor)	plutonium dioxide and uranium dioxide in various arrangements
Fuel Enrichment Level	slightly-enriched, natural uranium	slightly-enriched	various mixtures of plutonium-239 and uranium-235
Comments	used in Britain, and France (e.g.: AGR, MAGNOX)	used in former Soviet Union, e.g. Chernobyl (RBMK); N-reactor at Hanford.	breeder reactors are designed to produce more fissile material than they consume. Monju; Phenix

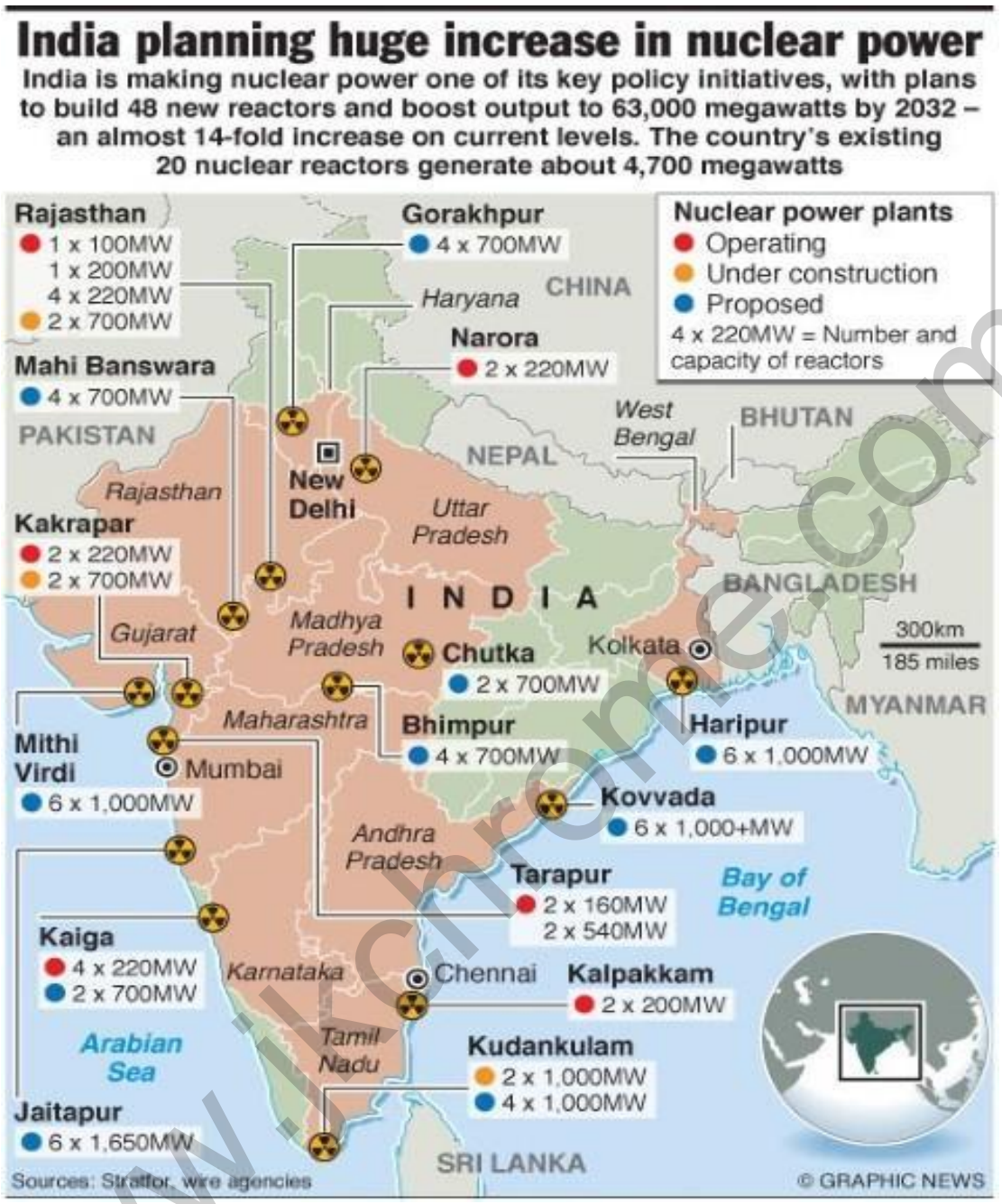


Figure: nuclear power plants in india

2. NUCLEAR COOPERATION

History of Nuclear cooperation:

- USA helped India to construct the two boiling water reactor (BWR) units of 210 MWe each at Tarapore Atomic Power Station (T.A.P.S.) is located in Tarapore, Maharashtra. However, The United States and Canada terminated their assistance after the detonation of India's first nuclear explosion in 1974.
- The Treaty on the Non-Proliferation of Nuclear Weapons (NPT) was came to prevent the spread of nuclear weapons and weapons technology and to promote cooperation in the peaceful uses of nuclear energy, and to further the goal of achieving nuclear disarmament. India refused to sign the treaty on ground of discriminatory treatment & unfair.

- After 1998 nuclear test in Pokhran, USA and allies further imposed sanctions on India. However, India continued to play its diplomacy with the west and adhered to non-proliferation guidelines voluntarily.

Nuclear agreement with nations

A. **Nuclear Agreement with France:**
   - France signed a civilian nuclear agreement with India in 2008.
   - French President, Nicholas Sarkozy, in agreements to setting-up third-generation EPR reactors of 1650 MW each at Jaitapur, Maharashtra by the French company Areva.

B. **Nuclear Agreement with USA:**
   - India and the USA have signed Agreement 123 for civil nuclear cooperation.
   - After NSG's waiver to India to commence civilian nuclear trade in 2008, US signed an agreement with India on civil nuclear cooperation and even convinced its allies to do so.
   - The Agreement would end technology denial regimes against India that have been in place for three decades and end India's nuclear isolation.
   - The 123 agreement will open new vistas for India to have civil nuclear cooperation as an equal partner with the USA and the rest of the world.
   - It will enable us to meet the two challenges of
     1) energy security and
     2) environmental sustainability.

   Recently, the USA and India has agreed to construct six nuclear reactors by US company Westinghouse in India. This will add significant capacity to India's nuclear installations.

C. **Nuclear Agreement with Russia:**
   - Russia has an ongoing agreement of 1988 vintage with India regarding establishing of two VVER 1000 MW reactors (water-cooled water-moderated light water power reactors) at Koodankulam in Tamil Nadu.
   - A 2008 agreement caters for provision of an additional four third generation. The water-water energetic reactor (VVER) 1200 reactors of capacity 1170 MW each.
   - Russia has also assisted in India's efforts to design a nuclear plant for its nuclear submarine. In 2009, the Russians stated that Russia would not agree to curbs on export of sensitive technology to India.
   - A new accord signed in 2009 with Russia gives India freedom to proceed with the closed fuel cycle, which includes mining, preparation of the fuel for use in reactors, and reprocessing of spent fuel.
   - In 2015, during Prime Minister's visit to Russia, a Joint Programme of Action for Localization of Manufacturing in India for Russian-designed Nuclear Power Plants was signed. A minimum of 12 reactor units will be built with Russian collaboration.

D. **Nuclear Agreement with other countries:**
   - **India and Mongolia** signed a crucial civil nuclear agreement in 2009 for supply of Uranium to India, making it the fifth nation in the world to seal a civil nuclear pact with India.

- **India and Canada** signed a civil nuclear cooperation agreement in 2010. Canada is one of the world's largest exporters of uranium and Canada's heavy water nuclear technology is marketed abroad with CANDU-type units operating in India, Pakistan, Argentina, South Korea, Romania and China.
- In 2014, India and Australia signed a civil nuclear agreement which allows the export of uranium to India. Australia is the third largest producer of uranium in the world.

E. India and Britain has signed a civil nuclear cooperation agreement. India also signed agreement on supply of nuclear fuel include Kazakhstan, while South Korea signed an agreement to help built the nuclear reactors in India.

The Civil Liability for Nuclear Damage Act, 2010

In most countries, nuclear plant operators are liable for any damage caused in the event of an accident, against which they take out liability insurance. India had been a notable exception, with reactor suppliers potentially liable for damages in the event of an accident. The 2010 legislation makes Indian operators primarily liable for any nuclear accident, but still keeps open the possibility of recourse to suppliers.

The Civil Liability for Nuclear Damage Act, 2010 seeks to create a mechanism for compensating victims of nuclear damage arising from a nuclear incident.

Key Features:

- It fixes liability for nuclear damage and specifies procedures for compensating victims.
- The Bill fixes no-fault liability on operators and gives them a right of recourse against certain persons. It caps the liability of the operator at Rs 500 crore.
- All operators (except the central government) need to take insurance or provide financial security to cover their liability.
- For facilities owned by the government, the entire liability up to 300 million SDR will be borne by the government.
- The Act specifies who can claim compensation and the authorities who will assess and award compensation for nuclear damage.

3. MULTILATERAL EXPORT CONTROL REGIMES DEFINED

These are groups of like-minded supplier countries which seek to contribute to the non-proliferation of weapons of mass destruction (WMD) and delivery systems through national implementation of Guidelines and control list for exports.

There are four such regimes in the world today:

A. **Nuclear Supplier Group:**
   - It was created after India's Smiling Buddha nuclear explosion in 1974.
   - Many developed countries feared that the technology transferred for peaceful purposes might be misused.
   - It has 48 participating governments. **China is a member of the NSG** but not of the Wassenaar Arrangement or the MTCR.
   - India is not the member of NSG.

B. **Wassenaar Arrangement:**
   - It was established in 1995 after replacing the earlier export control regime COCOM.

- It was formed to contribute to regional and international security and stability, by **promoting transparency and greater responsibility in transfers of conventional arms and dual use goods and technologies**.
- Dual-use refers to the ability of a good or technology to be used for multiple purposes - usually peaceful and military.
- It has 42 member states comprising mostly NATO and EU states. The participating nations have to ensure that transfer under the Wassenaar Arrangement do not lead to undermining of the goals of the regime.
- **India became a member of Wassenaar Arrangement in 2017**

Coordinating Committee for Multilateral Export Controls (COCOM):

- The Coordinating Committee for Multilateral Export Controls (COCOM) was created in 1949 for the purpose of preventing Western companies and countries from selling strategic goods and services to the Eastern bloc countries behind the "iron curtain."
- The founding members of COCOM were the United States, Belgium, France, Italy, the Netherlands, Luxembourg, and the United Kingdom. Countries joining COCOM at later dates were Spain, Canada, Australia, Denmark, Germany, Greece, Italy, Norway, Portugal, Japan, and Turkey.

C. **Australian Group:**

- The **Australia Group** is an informal group of countries established in 1985 to help member countries to identify those exports which need to be controlled so as not to contribute to the spread of chemical and biological weapons. It was established in the aftermath of the use of chemical weapons by Iraq in 1984.
- It has 42 members (including the European Commission). The members work on a consensus basis. The annual meeting is held in Paris, France.
- **It aims to ensure that exports do not contribute to the development of chemical or biological weapons.**
- **India became a member of Australian group in 2018.**

D. **Missile Technology Control Regime (MTCR)**

- MTCR seeks to limit the risks of proliferation of weapons of mass destruction (WMD) by controlling exports of goods and technologies that could make a contribution to delivery systems (other than manned aircraft) for such weapons.
- The Regime places particular focus on rockets and unmanned aerial vehicles capable of delivering a payload of at least 500 kg to a range of at least 300 km and on equipment, software, and technology for such systems.
- The members are thus prohibited from supplying such missile and UAV systems that are controlled by the MTCR to non-members. The decisions are taken by consensus of all the members
- **India joined MTCR in 2016.**

India and Nuclear Supplier Group:

Challenges for Indian Membership of NSG:

- Countries like China, Brazil, New Zealand, Austria, Ireland and Turkey are against Indian membership to NSG citing procedural problem relating to India's non-commitment to Non-proliferation regime.
- The NSG membership can only be acquired through a unanimous vote.

India's Stand on NSG Membership:

- Government has engaged with NSG members on the basis of its record on non-proliferation and disarmament, its commitment to follow the guidelines of the NSG, its ability to supply the items controlled by the NSG and its enforcement of a strict law-based export control system.
- It has highlighted India's fulfilment of all the criteria that were taken on record at the time of the September 2008 NSG decision on India. Government has underlined that India's participation in the NSG is in the larger global interest and would advance non-proliferation, energy security and facilitate combat against climate change.

Countries in support of Indian Membership of Nuclear Supplier Group:

- India has received support from a diverse and large number of members, including the United States, France, United Kingdom, the Russian Federation, Canada, Australia, Germany, Belgium, Republic of Korea, Spain, Netherlands, Sweden, Finland and Japan.

Impact of Nuclear Supplier Group membership on Indian Nuclear Programme:

India is pursuing civil nuclear cooperation with key partners such as Canada, France, Kazakhstan, Russia and the US. Membership of the NSG would place our existing cooperation on a predictable basis and facilitate the enhanced investments, industrial tie ups and technology access required to accelerate augmentation of nuclear power capacity in India.

Benefits of Indian Nuclear Supplier Group Membership for India:

- It will boost India's access to state-of-the-art technology from the members of the group.
- India will open new ways to access Uranium than it has at present post 2008 Nuclear deal with US.
- India can begin to commercially produce nuclear power equipment's which can even be sold to other countries.
- It can give a boost to Make in India programme of the Government of India.
- It will help India fulfil its Climate Change commitment goals by reducing dependence on Fossil fuels.
- India can use its membership to restrict membership of Pakistan.

4. SUPERCRITICAL CARBON DIOXIDE BRAYTON CYCLE

In 2018, Indian scientists at IISc in collaboration with US scientists have developed a **supercritical carbon dioxide Brayton test loop facility** which can help generate clean energy from future power plants by **replacing steam with CO2**.

Supercritical CO2

It refers to the state of carbon dioxide **above its critical temperature** of 31-degree Celsius and **critical pressure** of 73 atm. This makes it **twice as dense as steam**.

- **Critical Temperature:** The temperature above which, a substance cannot exist as a liquid, no matter how much pressure is applied.
- **Critical Pressure:** The pressure required to liquify a substance vapor at its critical temperature

Significance

- As conventional power plants use steam to turn turbine, the supercritical CO2 can help **generate more power** by improving its efficiency. It can also be used in **Heavy water nuclear reactors.**
- Such power plants using closed CO2 cycle, have the potential to replace steam-based **nuclear and thermal power plants**, which will also **reduce carbon footprints** significantly.

5. NEUTRINOS

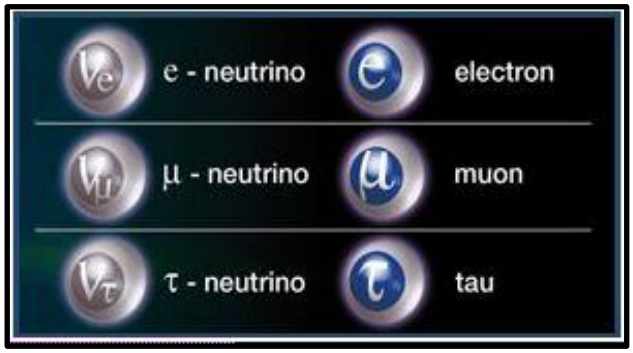
- Neutrinos are **fundamental particles belonging to the lepton family**.
- They come in **three flavours**, one associated with electrons and the others with their heavier cousins the muon and the Tau.
- According to **standard model of particle physics**, they are mass less. However recent experiments indicate that **these charge-neutral fundamental particles, have finite but small mass** which is unknown.
- Neutrinos can change from one flavor to another as they travel. This process is called **neutrino oscillation**
- They interact with matter **via the weak force**.
    - Weakness of this force gives neutrinos the property that **matter is almost transparent to them**.
    - Since they rarely interact, these neutrinos pass through the Sun, and even Earth, unhindered.
- The neutrino was postulated first by **Wolfgang Pauli** in 1930 to **explain how beta decay could conserve energy, momentum, and angular momentum** (spin).
- The neutrino density of the universe is 330 per cubic centimetre

Other Fundamental Particles:

Additional Information:
The **Standard Model of Particle Physics** suggests the material universe is assumed to be built by a small number of fundamental particles:
Quarks: They bind together through the strong interaction to make, for example, protons and neutrons.
Leptons: They do not take part in the strong interaction, and only interact via the electromagnetic and weak forces.
Electrically Charged Leptons:
the electron (e)
the muon (μ): It is 200 times heavier than an electron
the tauon (τ): It is 3500 times heavier than the electron.
Electrically neutral leptons (neutrinos (ν)): Associated to each charged lepton, there are three distinct kinds of neutrinos:
the electron neutrino (νe)
the muon neutrino (νμ)
the tauon neutrino (νε)

Sources of Neutrinos

- **Stars,** exploding stars (supernovae),
- relic neutrinos, **natural radioactivity**, and
- **cosmic ray interactions** in the atmosphere of the Earth.



Applications of Neutrino Science:

- **Information on the evolution of Universe:** Neutrinos hold the key to several important and fundamental questions on the origin of the Universe and the energy production in stars. As neutrinos can travel long distances and remain uninterrupted over time, they **can provide knowledge about the origin of the universe and the early stages of the infant universe, soon after the Big Bang**.
- **Composition of universe:** If the properties of neutrinos can be studied better, they **can be used in astronomy to discover what the universe is made up of**.
- **Data Transmission:** In future, Neutrinos can be used to send data seamlessly without any transmission loss.
- **Medical:** Neutrinos can be used in **detection of particle traversing human body** and **detection of abnormalities (cancer detection).** Neutrino science and INO laboratory greatly aid the development of detector technology and its varied applications. For example: in the areas of medical imaging.
- **Properties of the sun:** The visible light that reaches us from the sun is emitted from the surface of the sun. Solar neutrinos produced in the core of the sun **can give us information about the interior of the sun**.
- **Nuclear disaster:** Neutrinos can prevent pilferage of nuclear fuels by early detection.
- **Geological:** Neutrinos **can help in detection of oil and mineral deposits** (meeting energy security), unraveling tomography of early geological defects (early warning system from any seismic activity).

6. INDIA-BASED NEUTRINO OBSERVATORY

- The India-based Neutrino Observatory (INO) Project is a multi-institutional effort **aimed at building a world-class underground laboratory with a rock cover of approx.1200 m for non-accelerator based high energy and nuclear physics research in India**.
- The project includes
    1. **construction of an underground laboratory and associated surface facilities** in Bodi West hills of Tamil Nadu,
    2. **construction of an Iron Calorimeter (ICAL) detector** for studying neutrinos
    3. **setting up of National Centre for High Energy Physics** at Madurai, for the operation and maintenance of the underground laboratory, human resource development and detector R&D along with its applications.

Iron-Calorimeter Detector aims to probe the Earth matter effects on the propagation of atmospheric neutrinos and to determine neutrino oscillation parameters in the 2-3 oscillation sector.

- Currently ICAL is the only proposed magnetised detector which can resolve mass hierarchy via studying the survival of muon neutrinos and anti-neutrinos.

- The ICAL detector is designed to address some of these key open problems in a unique way. Over the years this underground facility is expected to develop into a full-fledged underground science laboratory for other studies in physics, biology, geology, hydrology etc.

The primary goals of the ICAL:

1. Unambiguous and precise determination of neutrino oscillation parameters using atmospheric neutrinos.
2. Study of matter effects through electric charge identification, that may lead to the determination of the unknown sign of one of the mass differences.
3. Study of charge-conjugation and charge parity (CP) violation in the leptonic sector as well as possible charge-conjugation, parity, time-reversal (CPT) violation studies.

- Jointly funded by the Department of Atomic Energy (DAE) and the Department of Science and Technology (DST).
- INO has no strategic or defence applications.
- Its operation involves no radioactivity release or toxic emissions.
- The initial goal of INO is to study neutrinos.

Significance of INO:

- Neutrinos occur in **three different types, – ve, vì, and vô**. These are **separated in terms of different masses**. From experiments so far, we know that **neutrinos have a tiny mass**, but the ordering of the **neutrino mass states is not known** and is one of the key questions that remain unanswered till today. This is a major challenge INO will set to resolve.
- The INO laboratory will host experiments to
    - Study neutrinos
    - Development of detector technology and its varied applications.
    - the neutrinoless double beta decay and the search for dark matter.
    - **Determination of neutrino masses and mixing parameters**
- The ICAL detector that will be installed in the INO laboratory will be the **world's most massive detector**.
- It is being developed completely indigenously.
- The laboratory itself **will greatly aid the development of detector technology** and its varied applications (which have so far been in the areas of medical imaging).

Concerns associated with INO:

- **Proximity to Dams:** There are 15 dams storing over 3 billion m^3 of water within radii of 5 to 70 km from the proposed site. Construction of underground observatory with deep tunnel in close proximity to dams **raises concerns over reservoir triggered seismicity, change in hydro-geology and possible floods.**
- **Blast-induced earthquakes:** A massif made up of hard and brittle charnockite rock will be blasted during the construction process which may lead to stress related problems like rock bursts. The potential damages to buildings and dams near the site of the project from rock bursts is a serious concern.
- **Aquifer impacts:** The impact on the aquifers and underground springs is a major concern.

- For example: the disruption of the aquifer during the tunnelling at the time of construction of Italy's Gran Sasso National Laboratories (LNGS) resulted in death of several workers and a massive flood in the plains.
- Further, the chronic impacts on the groundwater level were more massive and irreversible.

- **Impact on ecology and Wildlife:** Environmentalist have raised concerns over the **possible impact on ecology and wildlife due to INO's close proximity to Mathikettan Shola National Park in Kerala Western Ghats**.
- **Concerns over radioactive emissions:** Many have raised concerns about the **possibility of nuclear or radioactive emissions**. However, the government has said the concern is **not true** and INO has been involving in mass awareness exercises regarding the same.

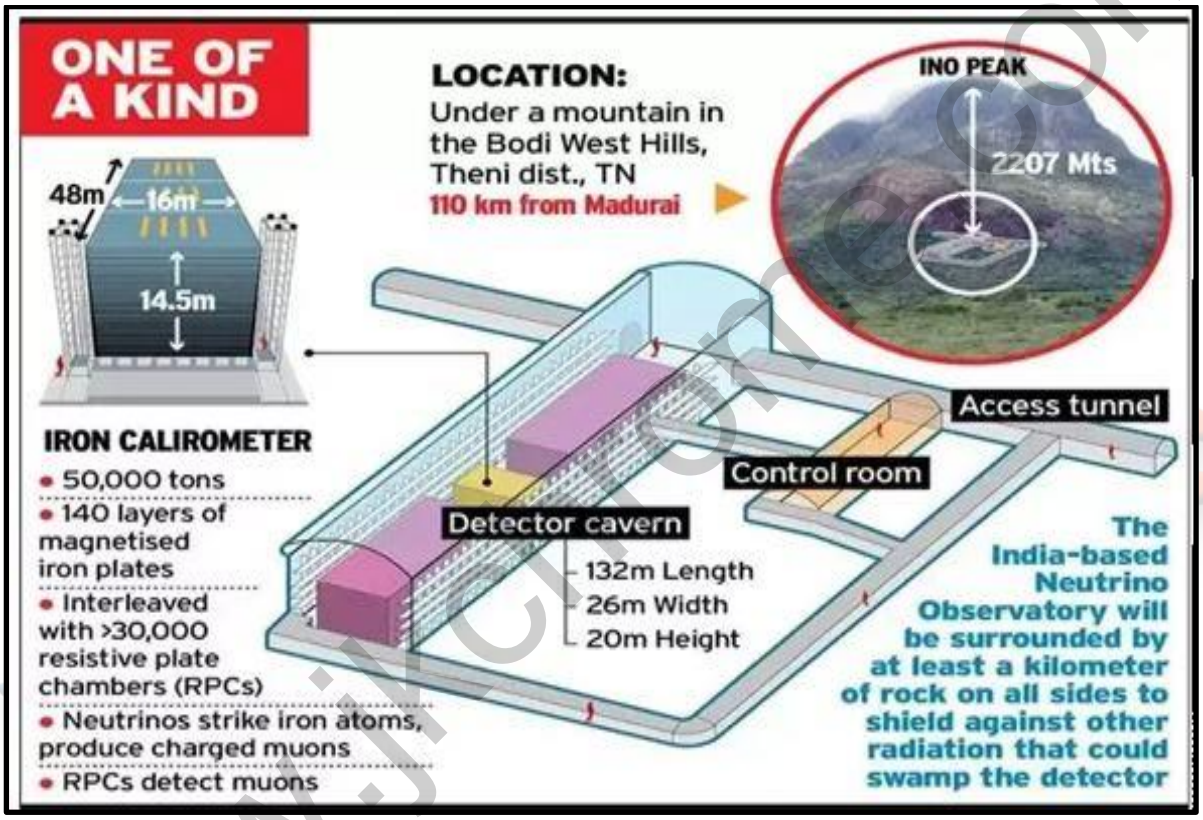


Figure: INO

7. NANOTECHNOLOGY & ROBOTICS

1. NANO TECHNOLOGIES

Nano technologies are the **design, characterization, production and application of structures, devices and systems by controlling shape and size on a nanometer scale**.

- At this scale, the **general physical, chemical, electrical, biological and optical properties of a material start behaving in a unique and peculiar way**. Nano technology opens up new vistas for enquiry and applications.

Scope: Research in nanotechnology spans across an array of fields such as health, environment, agriculture, food and beverages, product development, space technology, power generation, genetics, biotechnology, forensic science, electronics and communications.

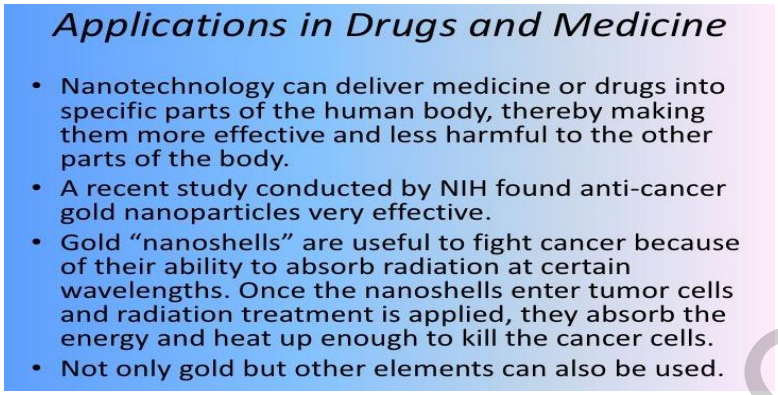
1.1. APPLICATIONS

Mainly in consumer products, electronics and healthcare.

- **In electronics:** Nanotechnology has **significantly scaled down the size of transistors and chips** used in the production of electronic goods.
- **In medicine:**
  - Several **nano- sized gadgets and materials** are being developed **to diagnose and treat diseases like cancer more effectively**.
  - **Nano-pharmacology** helps **to produce smart drugs that have negligible side effects**.

- In **consumer products:**
  - **Nano Silver:** It **provides an effective, broad-spectrum antimicrobial coating to the surface of various consumer products**. Silver nanotechnology is **being used in consumer products such as wound dressings, textiles, food storage containers, paints and personal care appliances**.
  - **Nanoscale thin films** on eyeglasses, computer/camera displays, windows etc **can make them water-repellent, anti-reflective, self-cleaning, resistant to ultraviolet/infrared light, anti-fog, antimicrobial, scratch-resistant, or electrically conductive**.

- **In Textiles:**
  - Scientists are using nanoparticles **to enhance clothing**.
  - Coating fabrics with a thin layer of **zinc oxide nanoparticles**, we can **create clothes that give better protection from UV radiation**.



1.2. MISSION ON NANO SCIENCE AND TECHNOLOGY (NANO MISSION)

- It is **an umbrella programme for capacity building.**
- It envisages the **overall development of this field of research in the country** and **to tap some of its applied potential for nation's development**.
- **Objectives of Nano Mission:**
  - **Basic Research Promotion – Funding of basic research** by individual scientists and/or groups of scientists and creation of centres of excellence for pursuing studies leading to fundamental understanding of matter that enables control and manipulation at the nanoscale.
  - **Infrastructure Development for Nano Science & Technology Research** – Investigations on the nano scale require expensive equipments like Optical Tweezer, Nano Indenter, Transmission Electron Microscope (TEM), Atomic Force Microscope (AFM), Scanning Tunneling Microscope (STM), Matrix Assisted Laser Desorption Time of Flight Mass Spectrometer (MALDI TOF MS), Microarray Spotter & Scanner etc. For optimal use of expensive and sophisticated facilities, it is proposed to **establish a chain of shared facilities across the country**.
  - **Nano Applications and Technology Development Programmes- To catalyze Applications and Technology Development Programmes leading to products and devices**, the Mission proposes **to promote application-oriented R&D Projects**, **establish Nano Applications and Technology Development Centres**, Nano-Technology Business Incubators etc.
    - Special effort will be made to involve the industrial sector into nanotechnology R&D directly or through Public Private Partnership (PPP) ventures.
  - **Human Resource Development** – The Mission shall focus on providing **effective education and training to researchers and professionals** in diversified fields so that **a genuine interdisciplinary culture for nanoscale science, engineering and technology can emerge**.
    - It is planned to launch M.Sc./M. Tech. programmes, create national and overseas postdoctoral fellowships, chairs in universities, etc.
  - **International Collaborations** – Apart from exploratory visits of scientists, organization of joint workshops and conferences and joint research projects, it is also planned to facilitate

access to sophisticated research facilities abroad, establish joint centres of excellence and forge academia-industry partnerships at the international level wherever required and desirable.

1.3. NANOTECHNOLOGY IN INDIA: CURRENT STATUS AND FUTURE PROSPECTS

- **Self-reliance in nanotechnology** can make good use of the natural and human resources India has and also help make India self-reliant in sectors like defence and anti-terrorism.
- Research from academic institutions has indicated how much impact nanotechnology can have on needs of Indian market.
    - A team from IIT Madras has used nanotechnology for arsenic decontamination of water.
    - A team from IIT Delhi has come up with a water based self-cleaning technology for use in textile industry.

- **Challenges**
    - The **amount India spends on nanotechnology research is still just a fraction of the research spending of countries like Japan, USA, France and China**.
    - The quality of research has **shown only a little improvement** from the NSTI phase (till 2006) to the nano mission phase (post 2007).
    - Though people look at nanoscience and technology very positively, the **number of students following undergraduate and graduate degrees in the area is low** and **career prospects still extremely limited**.
    - The number of PhDs awarded in nanoscience and technology is about 150 per year; a very small number compared to the target of producing 10,000 PhD students annually over the next decade articulated by the Ministry of Human Resource Development.
    - The **contribution of the private sector to nanotechnology research has been minimal.**

1.4. QUANTUM SPIN LIQUID

- **It is a new 'state of matter'.**
- causes electrons to break into pieces.
- was found in a two-dimensional material with a structure similar to graphene.

How a typical magnetic material behave?

- Each electrons behaves like a tiny bar magnets.
- **When a material is cooled to a low enough temperature, they will order themselves so that all the north magnetic poles point in the same direction**.
- But in a material containing a spin liquid state, even if cooled to absolute zero, **the bar magnets would not align** but form an entangled soup.
- 'spin' = intrinsic angular momentum in quantum mechanics.
- "Liquid" refers to the fact that **the quantum spins of electrons in the material suddenly start interacting to create a disordered state (much in the way liquid water is in a disordered state compared to crystalline ice).**
- It can be used in **quantum computers** - which would be exponentially faster than regular computers.

Experiment: Researchers used 'neutron scattering techniques' to look for evidence of fractionalisation in crystals of ruthenium chloride ($RuCl_3$) to measure the first signatures of fractional particles known as **Majorana fermions**.

- **Majorana fermions** is a fermion that is its own antiparticle
- **Fermion** is
    - any particle characterized by Fermi–Dirac statistics.
    - These particles obey the Pauli exclusion principle.
    - Fermions include **all quarks and leptons**, as well as any composite particle made of an odd number of these, such as **all baryons** and many atoms and nuclei.
    - Fermions differ from bosons, which obey Bose–Einstein statistics.
    - A fermion can be an elementary particle, such as the electron, or it can be a composite particle, such as the proton. According to the spin-statistics theorem in any reasonable relativistic quantum field theory, particles with integer spin are bosons, while particles with half-integer spin are fermions.
    - Besides this spin characteristic, fermions have another specific property: they possess conserved baryon or lepton quantum numbers. Therefore, what is usually referred as the spin statistics relation is in fact a spin statistics-quantum number relation.
    - As a consequence of the Pauli exclusion principle, only one fermion can occupy a particular quantum state at any given time. If multiple fermions have the same spatial probability distribution, then at least one property of each fermion, such as its spin, must be different.
- The researchers tested the magnetic properties of the $RuCl_3$ crystals by illuminating them with neutrons, and observing the pattern of ripples that the neutrons produced on a screen.
- A regular magnet would create distinct sharp spots, but the patterns made by Majorana fermions in a spin liquid were yet to be understood.

- **Way forward**
    - Nano technology holds great potential for India and a multi-pronged approach will ensure that this is fully leveraged.
    - **Funding should be increased** and long-term funding which can accommodate coherent research programs with high-impact outcome is needed.
    - **Various research centers throughout India must work together** so that the collective efforts can lead to better results.
    - A highly equipped central facility should plan and initiate research activities.
    - The **administrative aspects of new projects should be streamlined**.
    - Most importantly, **remuneration for people trained in the field should increase, to attract high calibre work force to join these research facilities**.

2. ROBOTICS

- In the initial stages of development of Robotics, it was defined as "**a multipurpose machine incorporating a memory and a mechanism intended to execute various functions automatically, thereby substituting for human manpower**."
- A **robot** is a machine—especially one programmable by a computer— capable of carrying out a complex series of actions automatically.

Basic structure:

- Almost all robots are comprised of a movable body, wheels operated by motors, and parts which can be moved made of plastic or metal.
- The sections are coupled together with joints.

- Solenoids and electric motors are used as actuators to operate the robots, while hydraulic and pneumatic systems are also utilized for this purpose.
- A combination of all these systems is also used.

Control: Robots can be guided by an external control device or the control may be embedded within.

Types:

- Robots can be **autonomous or semi-autonomous** and range from **humanoids** such as Honda's *Advanced Step in Innovative Mobility* (ASIMO) and TOSY's *TOSY Ping Pong Playing Robot* (TOPIO) to **industrial robots, medical operating robots, patient assist robots, dog therapy robots**, collectively programmed *swarm* robots, UAV drones such as General Atomics MQ-1 Predator, and even microscopic nano robots.
- By mimicking a lifelike appearance or automating movements, a robot may convey a sense of intelligence or thought of its own.
- Autonomous things are expected to proliferate in the coming decade, with home robotics and the autonomous car as some of the main drivers.

2.1. APPLICATIONS OF ROBOTICS

- They are also **being used in operation theatres and rehabilitation centres** to enhance the quality of life.
- Automotive, atomic energy, defence, space, metals, textiles and manufacturing use Robotic technologies very effusively.
- Robots are required everywhere to improve productivity.
- **Industrial Applications:**
    - Industrial robots are used in automobile and manufacturing industries.
    - Robots **cut and shape fabricated parts, assemble machinery and inspect manufactured parts**.
    - Robots perform task of load bricks, die cast, drill, fasten, forge, make glass, grind, heat treat, load/unload machines, machine parts, handle parts, measure, monitor radiation, run nuts, sort parts, clean parts, profile objects, perform quality control, rivet, sand blast, change tools and weld.

- **Application of Robots in Medicine:**
    - Robots are used **where extreme precision and delicacy is essential**, and **the margin for error is very low**.
    - Main areas of applications = Surgery. Because
        - robots are **able to perform major operations** while **only making small incisions**
        - Patients receive many benefits: lessened trauma, fewer infections, decreased healing time, and a faster discharge from the hospital.
    - Robots are used to **perform heart surgery without opening patient's chests**.
    - In Prosthetics, Mechanical **replacements for missing limbs and organs** that can interact with the human organic system are a long-standing goal of the robotics community.
    - Robotic devices can **provide help to people with severe restrictions on movement.**

- Rehabilitation Robots can provide exercise platforms to help restore limb function and can monitor the condition of patients undergoing rehabilitation from the effects of injuries, stroke or other brain or nerve damage.

- **Application of Robotics in education:**
  - Robots are currently used to test medical students.
  - Pregnant humanoid robots, for instance, prepare students for various birth complications.
- **Application of robotics in defence:**
  - Drones are used in surveillance purposes.
  - Robotics can used for IED detection and in bomb disposals.

2.2. ADVANTAGES

- Robots have **replaced humans in performing repetitive and dangerous tasks** which humans prefer not to do, or are unable to do because of size limitations, or which take place in extreme environments such as outer space or the bottom of the sea.
- Robotics can free human from monotonous and repetitive tasks.

2.3. CONCERNS

- There are concerns about the **increasing use of robots and their role in society**.
- Robots are blamed for **rising technological unemployment** as **they replace workers in increasing numbers of functions**.
- The use of robots in military combat raises ethical concerns.
- The possibilities of robot autonomy and potential repercussions have been addressed in fiction and may be a realistic concern in the future.

Challenges of robotics in India:

- High cost of adoption
- Inadequate availability of skilled talent
- **Cost and procurement of the required hardware and other electronic components** to build a robot.
- Due to the **extensive paperwork involved in importing hardware components into the country**, not many commercial applications are ready to enter the market.
- Additionally, acquiring and retaining quality talent is one of the biggest challenges, as robotics is a multidisciplinary field.

2.4. OPPORTUNITIES

- Robotic technologies are extensively used across a range of sectors such as **atomic energy, space, metals, textiles, automotive, and manufacturing industries**.
- Health sector in India has also initiated the **use of robotic technology widely in operation theatres and even in rehabilitation centers to augment the quality of life**.
- Robotics is **best suited for industrial automation** which includes **manufacturing, packaging, and assembling**.
- Robotics and automation have the **potential to revolutionize the industrial scenario by promising to bring the same result as computer systems have brought in services and other sectors**.

- Robotics in automation sector has proved to improve productivity, safety as well as the quality of the end product while allowing the human operators to take up more value-added roles.

2.5. CURRENT STATE OF INDUSTRIAL ROBOTICS IN INDIA

- USA, UK, Japan, Germany, Korea and China are way ahead of India in robotic automation. However, India is expected to grow very fast.
- **Tata motors uses industrial robotics and automation for production.**
    - Reports reveal that the production force in Tata Motors came down by 20%. At the same time its turnover increased by 250%. In a single plant in Pune, Tata is said to have installed 100 robots.
- **Many Indian subsidiaries of Multinational Companies like Samsung, LG, Philips, Honda, Renault, Suzuki, Hyundai and Ford also use industrial robots**.
- The "Make in India" campaign is a shot in the arm for Indian manufacturing and startups. So, **as more industries come up in the country, industrial robotics is likely to flourish**.
- Korean Japanese and American firms have chosen India to be the center for manufacturing industrial robots. Many indigenous companies and startups have also made a foray in the field of production of industrial robots. Some of these companies are Team Indus, GreyOrange, NavStik Autonomous Systems etc.

Future prospects:

- Robotics is mainly capturing industries like manufacturing, pharmaceutical, packaging, FMCG, and inspection.
- The other promising sectors include education and defense.
- Robotics technologies are all set to change the way things are done in the industries in which they are being implemented.
- Like other technologies, adoption of robotics technology would is usually slow.

8. INTELLECTUAL PROPERTY RIGHTS

1. INTELLECTUAL PROPERTY

- Intellectual property refers to **creations of the mind**:
  - inventions;
  - literary and artistic works; and
  - symbols, names and images used in commerce.
- It is divided into two categories:
  - **Industrial Property:** It includes **patents for inventions, trademarks, industrial designs** and **geographical indications**.
  - **Copyright:** It covers **literary works** (such as novels, poems and plays), films, music, artistic works (e.g., drawings, paintings, photographs and sculptures) and architectural design.
- **Whose Intellectual Property?**
  - Rights related to copyright include **those of performing artists** in their performances, **producers** of phonograms in their recordings, and **broadcasters** in their radio and television programs.

2. INTELLECTUAL PROPERTY RIGHTS

- These are like any other property right.
- A right that is **had by a person or by a company to have exclusive rights to use its own plans, ideas, or other intangible assets without the worry of competition**, at least for a specific period of time.
- They **allow creators, or owners, of patents, trademarks or copyrighted works** to **benefit from their own work or investment in a creation**.
- These rights may be enforced by a court via a lawsuit.

3. TYPES OF INTELLECTUAL PROPERTIES

- **Copyright** covers literary works (such as novels, poems and plays), films, music, artistic works (e.g., drawings, paintings, photographs and sculptures) and architectural design.

    - Rights related to copyright include those of performing artists in their performances, producers of phonograms in their recordings, and broadcasters in their radio and television programs.
- **Industrial Property** includes patents for inventions, trademarks, industrial designs and geographical indications.
- **Patents:** Patents are exclusive rights granted by the Government to a company/individual for an invention.
    - Patents are time bound. For ex: In India patents are granted for a period of 20 years from the date of filing of the patent application.
    - It is also to be noted that the patents are valid only within the territory where they have been granted.
    - Once a patent expires, protection ends and the invention enters the public domain
- **Trademark:** Trademark is a word, or symbol, or phrase, or design, or any combination of these, which identifies and distinguishes the source or origin of a product or service.
    - Other forms of identifying features which have come to be recognised as trademarks include particular colour combinations, smells and sounds (for example, an advertisement jingle), textures, packaging, shapes, etc.
    - The period of protection varies, but a trademark can be renewed indefinitely upon payment of the corresponding fees.
- **Design:** Design refers to the features of shape, configuration, pattern, ornamentation or composition of lines or colours applied to any article, in two or three dimensional (or both) forms.
    - It may be applied by any industrial process or means (manual, mechanical or chemical) separately or by a combined process, which in the finished article appeals to and is judged solely by the eye.
    - Term of protection granted is generally five years, with the possibility of further renewal, in most cases for a period of up to 15 years.
- **Geographical Indication**: A geographical indication is a sign used on goods that have a specific geographical origin and possess qualities or a reputation due to that place of origin.
    - Most commonly, a geographical indication consists of the name of the place of origin of the goods.

4. LEGAL AND CONSTITUTIONAL FRAMEWORK FOR IPR

- The importance of IP was first recognized in the Paris Convention for the Protection of Industrial Property (1883) and the Berne Convention for the Protection of Literary and Artistic Works (1886).
    - Both administered by the World Intellectual Property Organization.
- IPRs are outlined in Article 27 of the Universal Declaration of Human Rights.
    - It provides for the right to benefit from the protection of moral and material interests resulting from authorship of scientific, literary or artistic productions.
- Patent act in India is more than 150 years old. The first Act was in 1856, which was based on the British patent system and it has provided the patent term of 14 years followed by numerous acts and amendment.

WTO TRIPS

The WTO's **Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS)**, negotiated during the 1986-94 Uruguay Round, introduced intellectual property rules into the multilateral trading system for the first time.

Under the TRIPS Agreement, WTO members have considerable scope to tailor their approaches to IP protection and enforcement in order to suit their needs and achieve public policy goals. The Agreement provides ample room for members to strike a balance between the long-term benefits of incentivising innovation and the possible short-term costs of limiting access to creations of the mind. Members can reduce short term costs through various mechanisms allowed under TRIPS provisions, such as exclusions or exceptions to intellectual property rights.

The TRIPS Agreement covers five broad areas:

- How general provisions and basic principles of the multilateral trading system apply to international intellectual property
- What the minimum standards of protection are for intellectual property rights that members should provide
- Which procedures members should provide for the enforcement of those rights in their own territories.
- How to settle disputes on intellectual property between members of the WTO
- Special transitional arrangements for the implementation of TRIPS provisions.

5. INSTITUTIONAL FRAMEWORK IN INDIA

- Department of Industrial Policy & Promotion (DIPP), Ministry of Commerce, Government of India, has been appointed as the nodal department to coordinate, guide and oversee the implementation and future development of IPRs in India.
- The 'Cell for IPR Promotion & Management (CIPAM)', setup under a professional body under the aegis of DIPP, is to be the single point of reference for implementation of the objectives of the National IPR Policy.

Fact: IPR in India.

- In particular, 2240 Patent agents and 702 Trademark agents have been registered under the relevant provisions of the Patents Act, 1970 and Trade Marks Act, 1999 respectively by the Controller General of Patents, Designs and Trademarks.
- Further, an advocate registered under the Advocates Act can directly work as Trademarks Attorney for filing/processing of trademarks applications.
- Despite being actively engaged in research and new innovations, over 35% people are not aware of intellectual property rights (IPR), a latest study revealed.

6. INDIA'S INITIATIVES FOR IPR PROTECTION

India has been a member of the World Trade Organisation (WTO) since 1995. This requires member nations to establish intellectual property (IP) laws whose effect is in line with minimum standards.

- **Copyright:** India is a signatory to the Berne Convention on copyright. Copyrights Act and Information Technology Act, 2000 (for copyright in electronics and digital field) govern the laws for copyright in India.
- **Patents:** India's **Patents Act of 1970** and **2003 Patent Rules** govern the law concerning patents. The regulatory authority for patents is the Patent Registrar within the department of the Controller

General of Patents, Designs and Trademarks, which is part of India's Ministry of Commerce and Industry.

- **Designs:** law on industrial designs are governed by Designs Act, 2000 under DIPP, Ministry of Commerce and industry.
- **Geographical Indications:** The GIs are governed under Geographical Indications of Goods Act, 1999 under DIPP, Ministry of Commerce and industry.
- **Traditional Knowledge:** A Traditional Knowledge Digital Library has been created to safeguard and bring together traditional knowledge at one platform through collaboration – between the CSIR and the Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy (Dept. of AYUSH), Ministry of Health & Family Welfare, Government of India.

GI status: it is an indication that identifies goods as **produced from a particular area**, which has special quality or reputation attributable to its geographical origin.

- GI-branded goods possess a recall value amongst consumers who essentially attribute these characteristics, qualities or reputation to such geographical origin.

Importance of GI Tag:

- GI tag protects the **producers to differentiate their products** from competing products in the market
- **To build a reputation and goodwill around their products**, which often fetch a premium price.
- To help producers in export earning, promotion of tourism, cultural heritage and national identity. GIs have great potential to play a major role in trade between countries.
- To protect **livelihoods** and encourage **employment**
- Benefit to the **rural economy by improving the incomes of farmers or nonfarmers.**
- GI allows genuine producers to capture the market and creates entry barriers for fakes.

Under Paris Convention for the Protection of Industrial Property, **GIs are covered as an element of IPRs.**

- GI is governed by WTO's Agreement on TRIPS.
- In India, GI tag is governed by Geographical Indications of Goods (Registration and Protection Act), 1999.
- This Act is administered by Controller General of Patents, Designs and Trade Marks, who is also Registrar of Geographical Indications.

7. NATIONAL INTELLECTUAL PROPERTY RIGHTS POLICY (NIPRP)

- The policy shall lay the future roadmap for IPRs in India.
- The plan **will be reviewed every 5 years** in consultation with stakeholders.
- **Mission Statement:** Stimulate a **dynamic/vibrant/balanced intellectual property rights system** in India to:
    - Foster creativity and innovation and thereby, promote entrepreneurship and enhance socio-economic and cultural development, and
    - Focus on enhancing access to healthcare, food security and environmental protection, among other sectors of vital social, economic and technological importance.
- **Objectives:** The Policy lays down the following seven objectives:
    - IPR Awareness: Outreach and Promotion - To **create public awareness about the economic, social and cultural benefits of IPRs among all sections of society**.
    - Generation of IPRs - To stimulate the generation of IPRs.

    - Legal and Legislative Framework - To **have strong and effective IPR laws**, which **balance the interests of rights owners with larger public interest**.
    - Administration and Management - To modernize and strengthen service-oriented IPR administration.
    - Commercialization of IPRs - Get value for IPRs through commercialization.
    - Enforcement and Adjudication - To **strengthen the enforcement and adjudicatory mechanisms for combating IPR infringements**.
    - Human Capital Development - To strengthen and expand human resources, institutions and capacities for teaching, training, research and skill building in IPRs.
- The Policy **recognises**
    - **The abundance of creative and innovative energies that flow in India**, and
    - The **need to tap into and channelize these energies towards a better and brighter future for all**.
- The National IPR Policy will endeavour for a "Creative India; Innovative India: रचनात्मक भारत; अभिनव भारत".
- **Aims to**
    - **Create and exploit synergies between all forms of intellectual property (IP), concerned statutes and agencies**.
    - Incorporate and adapt global best practices to the Indian scenario.
- It **sets in place an institutional mechanism for implementation, monitoring and review**.
- It **suggests making the department of industrial policy and promotion (DIPP) the nodal agency** for all IPR issues. Copyrights related issues will also come under DIPP's ambit from that of the Human Resource Development (HRD) Ministry.
- Films, music, industrial drawings will be all covered by copyright.
- Proposal to create an effective loan guarantee scheme to encourage start-ups.
- India will engage constructively in the **negotiation of international treaties and agreements in consultation with stakeholders.** The government **will examine accession to some multilateral treaties which are in India's interest**, and **become a signatory to those treaties which India has de facto implemented to enable it to participate in their decision-making process.**
- It also says "**India will continue to utilise the legislative space and flexibilities available in international treaties and the TRIPS Agreement**." These flexibilities include the **sovereign right of countries to ensure the availability of essential and life-saving drugs at affordable prices**.
- The IPR policy favoured the government considering financial support for a limited period on sale and export of products based on IPRs generated from public-funded research.
- This policy shall weave in the strengths of the Government, research and development organizations, educational institutions, corporate entities including MSMEs, start-ups and other stakeholders in the creation of an innovation-conducive environment, which stimulates creativity and innovation across sectors, as also facilitates a stable, transparent and service-oriented IPR administration in the country.
- The Policy **recognizes that**
    - **India has a well-established TRIPS-compliant legislative, administrative and judicial framework to safeguard IPRs**, which meets its international obligations while utilizing the flexibilities provided in the international regime to address its developmental concerns.
    - **There is a need to increase awareness on IPRs in India**, be it **regarding the IPRs owned by oneself or respect for others' IPRs**.

    - The importance of IPRs as a marketable financial asset and economic tool also needs to be recognised. For this, **domestic IP filings, as also commercialization of patents granted, need to increase**.
    - Innovation and sub-optimal spending on R&D too are issues to be addressed.
- It **reiterates India's commitment to the Doha Development Agenda and the TRIPS agreement.**

Implementation: These objectives are sought to be achieved through detailed action points. The action by different Ministries/ Departments shall be monitored by DIPP which shall be the nodal department to coordinate, guide and oversee implementation and future development of IPRs in India.

Criticism of National IPR Policy: Policy has some drawbacks in striking a balance between innovation and interests of under privileged because:

- The policy equates IPR generation as Innovation.
- Emphasizing on the commercialization of IPRs will act as a deterrent for start-ups and even increase the cost of the products.
- The policy doesn't mention mechanisms to protect the traditional knowledge and heritages of tribal area which are being exploited by outsiders.

Issues in India's IPR:

- **The Indian Patent Act 1970 (as amended in 2005)** does not allow patent to be granted to inventions involving new forms of a known substance unless it differs significantly in properties with regard to efficacy.
- **Compulsory licencing (CL):** CL is problematic for foreign investments who bring technology as they are concerned about the misuse of CL to replicate their products. It has been affecting India-EU-FTA ties.
- **Data Exclusivity:** Foreign investors allege that Indian laws does not protect against unfair commercial use of test data or other data submitted to the government during the application for market approval of pharmaceutical or agro-chemical products. For this they demand a Data Exclusivity law.
- **Enforcement of the Copyright act is weak,** and piracy of copyrighted materials is high.

Way Forward:

- India needs a clear and tough stance on intellectual property both in domestic policy and at the multilateral level.
- Support for innovation has to be accompanied with instruments that guard local companies against the misuse of market power, coercive bargaining and aggressive acquisition strategies.
- India needs to spread awareness on IPR in public and for its traditional industries to enable fair monetisation of IP Rights.
- It needs to safeguard its patents, copyrights and traditional knowledge by ensuring easy IPR rules.
- Just like the NITI Aayog has formed the Atal Innovation Mission, **a cohesive national strategy for innovation must be articulated**
- The government in partnership with industry and academics should seek to identify areas of focus—areas where India seeks to innovate with appropriate technologies and create solutions for India and the world.
- **Clear incentives should be provided to firms to invest in research and development**.

- Effective regulatory regimes should be encouraged to support intellectual property and the longer-term investments of firms.

NATIONAL IPR POLICY: PERFORMANCE

The National Intellectual Property Rights (IPR) Policy 2016 was adopted in 2016 as a vision document to guide future development of IPRs in the country. This has led to the following achievements: -

1. **Strengthening of Institutional Mechanism:**
    - The **administration of Copyright Act, 1957 and Semiconductor Integrated Circuits Layout-Design Act, 2000 has been transferred to Department of Industrial Policy and Promotion**.
    - This has enabled **an integrated approach and synergy between different IP offices and Acts**.
    - The **Copyright Board has also been merged with the Intellectual Property Appellate Board.**
2. **Clearing Backlog/ Reducing Pendency:** Steps undertaken by the Government:
    - Augmentation of technical manpower have resulted in drastic reduction in pendency in IP applications.
    - Automatic issuance of electronically generated patent and trademark certificates has been introduced.
3. **Increase in Filings:**
    - **Patent filings have increased by nearly 7%** in the first 8 months of 2018-19 vis-à-vis the corresponding period of 2017-18.
    - **Trademark filings have increased** by nearly 28% in this duration.
4. **IP Process Re-engineering**
    - **Patent Rules, 2003 has been amended** to streamline processes and make them more user friendly.
    - **Expedited Examination of patents is now permitted** on certain grounds.
        - In fact, the shortest time taken to grant a patent recently has been just 81 days from the filing of the request for examination.
    - Totally revamped Trade Marks Rules, 2017 have been notified on 6th March, 2017.
    - **India has acceded to the WIPO Copyright Treaty (WCT) and WIPO Performances and Phonograms Treaty (WPPT)**, which extend coverage of copyright to the internet and digital environment.
5. **Creating IPR Awareness**
    - IPR Awareness programs have been conducted in over 200 academic institutions, including rural schools through satellite communication, and for industry, police, customs and judiciary.
6. **IPRs in School Syllabus:** Content on IPRs has been included in the NCERT curriculum of Commerce stream.
7. **Technology and Innovation Support Centres (TISCs):** In conjunction with WIPO, 6 TISCs have been established in various institutions across different states.
8. **Global Innovation Index (GII):** India's rank in the GII Report issued by WIPO has improved from 81st in 2015 to 57th place in 2018.
9. **IPR Enforcement Toolkit for Police:** An IPR Enforcement Toolkit have been prepared to assist police officials in dealing with IP crimes, in particular, Trademark counterfeiting and Copyright piracy.

- While there is no specific scheme to establish IP Centres in all universities in India, State Governments have been approached to establish IPR Cells in various academic institutions;
- **IPR Cells have been established in 41 universities** across different States.
- **'Institution Innovation Councils' (IICs) have been set up** in more than 1000 Higher Education Institutions (HEIs) through the Innovation Cell at AICTE under the Ministry of HRD.

8. PROMOTION AND PROTECTION OF INTELLECTUAL PROPERTY

- To **encourage innovation without the fear that a competitor will steal the idea and/or take the credit for it**.
- The **progress and well-being of humanity** rest on **its capacity to create and invent new works** in the areas of technology and culture.
- The legal protection of new creations **encourages the commitment of additional resources for further innovation**.
- IP system **helps strike a balance between the interests of innovators and the public interest, providing an environment in which creativity and invention can flourish**, for the benefit of all.
- The promotion and protection of intellectual property **spurs economic growth, creates new jobs and industries, and enhances the quality and enjoyment of life**.
- An efficient and equitable IP system = Help all countries to realize intellectual property's potential as a catalyst for economic development and social and cultural well-being.

9. STRENGTHS OF THE INDIAN IPR REGIME

- The IPR framework in India is **stable and well established from a legal, judicial and administrative point of view** and is **fully compliant with the Agreement on Trade-Related Aspects of Intellectual Property Rights**.
- India is committed to a number of international treaties and conventions relating to Intellectual Property Rights.
- A number of **awareness programs enumerating the types of intellectual property and its protection through IPR** are being conducted by the Government, targeting audience from industry, universities, and schools.
- During the last few years, **Indian IP offices have undergone major improvements in terms of upgradation of IP legislation, infrastructure facilities, human resources, processing of IP applications, computerization of the IP offices, IP databases, quality services to stakeholders, transparency in functioning and free access to IP-data through a dynamic website**.
- **State of the art, integrated and IT- enabled office buildings** have been setup in the last few years in Delhi, Kolkata, Chennai, Mumbai and Ahmedabad, housing offices of Patents, Designs, Trademarks and Geographical Indications.
    - The Patent Office is headquartered in Kolkata with branches in Delhi, Chennai, and Mumbai. The Trade Marks Registry, headquartered at Mumbai has branches in Ahmedabad, Chennai, Delhi, and Kolkata.
    - The Design Office is located in Kolkata and the GI Registry is in Chennai.

- Separate facilities house the International Searching Authority (ISA) / International Preliminary Examining Authority (IPEA) in Delhi; an Intellectual Property Office Archives center has been setup at Ahmedabad.

- The procedure for filing and processing of IP applications has been simplified, E-filing facilities and incentives for Small and Medium Enterprises (SMEs) and Startups are some of the other initiatives in the area of promoting intellectual property rights in India.

10. COMPULSORY LICENSING

- As per WTO, **Compulsory licensing** is **when a government authorizes a party other than the patent owner to produce the patented product or process, without the patent owner's consent**.
- **When can compulsory license be granted or laws governing Compulsory Licenses?**
  - Under **Indian Patent Act, 1970**, the provision with regard to compulsory licensing is specifically given under **Chapter XVI**.
  - The conditions which need to be fulfilled in order for a compulsory license to be granted are also laid down under Sections 84 and 92 of the Act.
  - Under Section 84 (1) of the **Indian Patent Act**, any person may request a compulsory license (CL) if,
    - After three years from the date of the grant of a patent, the needs of the public to be covered by the invention have not been satisfied;
    - the invention is not available to the public at an affordable price;
    - the patented invention is not "worked in," or manufactured in the country, to the fullest extent possible
  - India's National Manufacturing Policy (NMP) also supports the application of CL across different manufacturing sectors, more specifically to ensure access to the latest green technologies that are patented.
  - The NMP provides the "option" to entities such as the Technology Acquisition and Development Fund "to approach the government for issue of a CL for the technology which is not being provided by the patent holder at reasonable rates or is not being 'worked in India' to meet the domestic demand in a satisfactory manner."

Case Study: Nexavar Case

- India has invoked this provision once only in a case involving Bayer, a German multinational pharmaceutical company, against Natco Pharma Ltd, an Indian generic company.
- **Excessively priced**: Natco had petitioned the patent office arguing that Bayer's price for its patented anti-cancer drug, Nexavar, was exorbitant at Rs2.8 lakh and unaffordable to a large segment of the patient population and that it was willing to supply the drug at less than 1/30th of the patented price, i.e. at Rs 8800. The patent office ruled in favour of Natco, holding in pertinent part that Bayer's price was excessive.

9. AWARENESS OF TECHNOLOGY IN AGRICULTURE, ENVIRONMENT AND DISASTER MANAGEMENT

1. AGRICULTURE

1.1. FORMALIN

- Formalin is a chemical derived from formaldehyde which is a known **cancer-causing** agent. It is **used to preserve bodies** in mortuaries. It can also **increase shelf life of fresh food.**
- In July 2018, **Kerala** followed by several other states found **unacceptable levels of formalin in the fisheries** stocks, prompting the ban of import of such fish by other states.

Reason for use

- **Use by sellers:** Fish is a highly perishable commodity. If it isn't maintained at the proper temperature of 5 degrees Celsius, it gets spoilt. To avoid that and **increase its shelf life**, the sellers now use chemicals such as formalin and ammonia.
- **Use by fishermen:** A fishing boat that spends nearly 20 days in the sea requires around 10 tonnes of **ice** to conserve the catch till the boat reaches the shore. But to reduce the spend on ice which is **costly**, many boat operators prefer to keep chemicals such as formalin, ammonia etc.

Impact

- While formalin can cause nausea, coughing and burning sensation in eyes, nose and throat in the short term, it can cause cancer if consumed over a long period of time.

Government response

- The use of this chemical is **banned** in fresh foods, like fish, by the Food Safety and Standards Authority of India.
- Kerala's Food safety department has launched '**Operation Sagar Rani**' to check adulteration of fish.
- In 2018, ICAR-CIFT has developed two **rapid detection kits** for checking adulteration of fresh fish with formaldehyde and ammonia.

1.2. ZERO BUDGET NATURAL FARMING

- It is an **eco-friendly** farming practice that believes in **natural growth** of crops **without adding any fertilizers and pesticides** or any other foreign elements. The word Zero Budget refers to **zero net cost of production** of all crops.
- Farmers use earthworms, cow dung, urine, plants, human excreta and such **biological fertilizers** which are **available locally** free of cost.

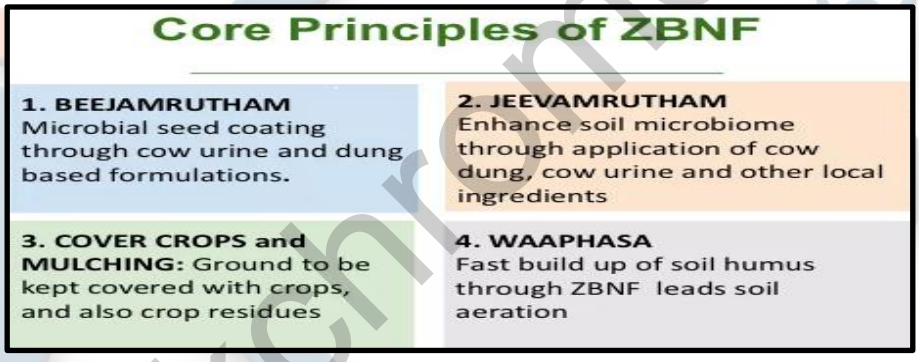


Figure: principles of ZBNF

Recent initiatives

- **Andhra Pradesh** in June 2018, launched a scale-out plan to transition 6 million farms/farmers cultivating 8 million hectares of land **from conventional synthetic chemical agriculture to Zero-Budget Natural Farming (ZBNF) by 2024,** making Andhra Pradesh **India's first 100 percent natural farming state**.
- It is led by **Rythu Sadhikara Samstha (RySS)** – a not-for-profit established by the Government to implement the ZBNF programme in partnership between **UN Environment**,
- The governments of **Karnataka and Himachal Pradesh** are implementing the practice in their states as well.

1.3. GM FOOD LABELLING NORMS

- In May 2018, FSSAI came up with **Draft guidelines** for labelling genetically modified packaged food.
- All packaged food with **at least 5% content** from genetically engineered sources needs to be labelled so.
- The draft also **defines the safe levels** of fat, sugar and salt in processed food.

- Moreover, foods that exceed norms of sugar and fat should carry **'red' and 'green' labels** specifying the extent to which they do so.

Current status

- Current laws **prohibit** any GM food unless cleared by the **Genetic Engineering Appraisal Committee** from being sold in the country.
- GEAC comes under Environment Protection Act, 1986.
- Through a **2007 notification**, the Ministry **exempted processed foods** from this requirement, but this has been **stayed by the courts**.
- There was also **dispute between the FSSAI and the Environment Ministry** on who checks if a particular food had a GE provenance.

1.4. DMH-11 MUSTARD

It is genetically modified variety of **Herbicide Tolerant mustard**. It was created by using "**barnase/barstar" technology** for genetic modification by adding genes from soil bacterium that makes mustard **self-pollinating plant**. It was developed by a team of scientists from **Delhi University**.

Recent Developments

- In May 2017, GEAC had given **final clearance** for GM mustard. But it was mired with confusion and also received **widespread ire** of the experts and stakeholders prompting the Environment Ministry to refer it back to GEAC.
- In May 2018, the Ministry **turned down nod to commercial release** of GM Mustard on grounds that more field trials are needed to ascertain its **impact on honey bees, soil microbial diversity and honey**.

Importance

- The indigenous technology is **cost-effective** and traits like **pest resistance** can easily be integrated into it.
- Also, it has expected to **improve yield** of mustard which will increase farm income.
- India heavy dependence on **edible oil imports** can be significantly reduced, thus saving crucial forex.

Concerns

GM-Mustard's **impact on health** of the people and **environment** is not known yet. Also, the possibility of the **crop becoming weed resistant** has also been flagged off.

1.5. 'AEROBIC' RICE CULTIVATION

- An approach to **grow rice like an upland crop, such as wheat, on non-flooded aerobic soils.**
- Aerobic rice cultivation means **growing rice plant as irrigated crop** like cultivating maize and wheat **in aerobic condition, where oxygen is plenty in soil =>**
    - **Eliminates continuous seepage and percolation**
    - **Greatly reduces evaporation**.

Geographical conditions required for aerobic rice cultivation:

- **Irrigated lowlands where rainfall is insufficient to sustain rice production**
- **Delta regions** where there is delay in water release from reservoir
- Irrigated system of rice cultivation, where pumping from deep bore well has become so expensive and favourable upland system has access to supplementary irrigation.

- Aerobic rice cultivation needs **suitable rice varieties having the characteristics of both upland and high yielding lowland varieties** to get good yield under the new unconventional system of cultivation.
- The ecology for this type of rice is intermediate between upland and favourable shallow low lands.
- This type of cultivation practice can be adopted in target areas like, tank irrigate area, deep bore well / well irrigated area and the places where presumed to receive delayed channel / river water i.e. in delta region during *kharif* (June – July) and summer (February).
- **Preferred Areas:** Tamil Nadu, Jharkhand, Chhattisgarh, parts of Bihar, Odisha, Karnataka, and eastern Uttar Pradesh are the projected area where there is uneven distribution and frequent occurrence of soil moisture limitation

Why do we need it?

- Conventional method of rice cultivation utilises 5,000 litres of water for producing one kg of rice than its actual requirement of 3,000 litres.
- **About 2,000 litres is lost due to flooding and seepage losses**.
- Due to decline in water table we need improved water-use efficiency and water productivity in rice cultivation.

Advantages

- **Profuse rooting and High tilling**, Less lodging and high grain and fodder yield.
- Retention of soil structure and quality
- Throughout the growing season, aerobic rice field is **kept under unsaturated condition** and **field is irrigated by surface or sprinkler system to keep soil wet**. => **Water productivity is reported to be higher in aerobic rice by 64-88%** (calculated as grams of grain produced per kg of water input) and utilises 3,000 to 3,500 litres of water to produce 1 kg of rice compared to rice raised under transplanted flooded system.
- Nursery and transplanting is not required, rather direct seed sowing
- Aerobic rice cultivation system **involves mechanised way of sowing with no puddling, transplanting and not need of frequent irrigation**, which **reduce labour usage more than 50%**, compared to irrigated rice.
- Saving of seeds up to 80% + Efficient fertilizer utilization
- Less pest / disease incidence
- Early-maturing varieties are with **good seedling vigour, responsive to high input and tolerate flooding**.
- In environmental point of view, **emission of methane is lowered substantially in aerobic rice**.

Disadvantages:

- **Increased weed growth, poor crop stands, crop lodging, high percentage of panicle sterility** and **root-knot nematode infestation**.
- High weed infestation is the major constraint for aerobic rice and **cost involved in weed control is higher**.
- Due to **high infiltration rate of water** and **imbalanced availability of nitrogen** makes the aerobic soil **further ailing for micronutrients (iron and zinc)** and **rise in nematode population**.

Prospects:

- Therefore, efficient nutrient management techniques along with integrated weed management are researchable areas for successful aerobic rice cultivation.
- The **yield of aerobic rice is comparable with transplanted rice.** Thus, **it is an alternative option to reduce labour drudgery** and **to increase water productivity**.

1.6. AERIAL SEEDING

- Aerial seeding is **a technique of sowing seeds by spraying them through aerial mechanical** means such as a drone, plane or helicopter.
- It is considered **a broadcast method of seeding**.
- **Suitable geographical areas:**
    - It is often used to spread different grasses and legumes **to large areas of land that are in need of vegetative cover after fires**.
    - Areas where terrain is **extremely rocky** or **at high elevations** or **otherwise inaccessible**.

Advantages of aerial seeding:

- Efficient coverage of a large area in the least amount of time.
- It facilitates **seeding in areas that otherwise would be impossible to seed with traditional methods**, such as land that is too hard to reach by non-aircraft or ground conditions being far too wet.

1.7. CLOUD SEEDING

- Clouds are made up of tiny water droplets or ice crystals that form when water vapor in the atmosphere cools and condenses around a particle of dust or salt. Without these particles, known as condensation nuclei, raindrops or snowflakes cannot form and precipitation will not occur.
- Cloud seeding is a weather modification technique that improves a cloud's ability to produce rain or snow by artificially adding condensation nuclei to the atmosphere, providing a base for for snowflakes or raindrops to form. After cloud seeding takes place, precipitation falls from the clouds back to the surface of the Earth.
- **Chemicals used:**
    1. Silver iodide, potassium iodide and dry ice (solid CO2) and Liquid propane
    2. Hygroscopic materials like table salt are being increasingly used.
- Cloud seeding is done by 2 process:
    1. Hygroscopic Seeding: To get rainfall in a particular area
    2. Glaciogenic Seeding: To get snowfall or hail.

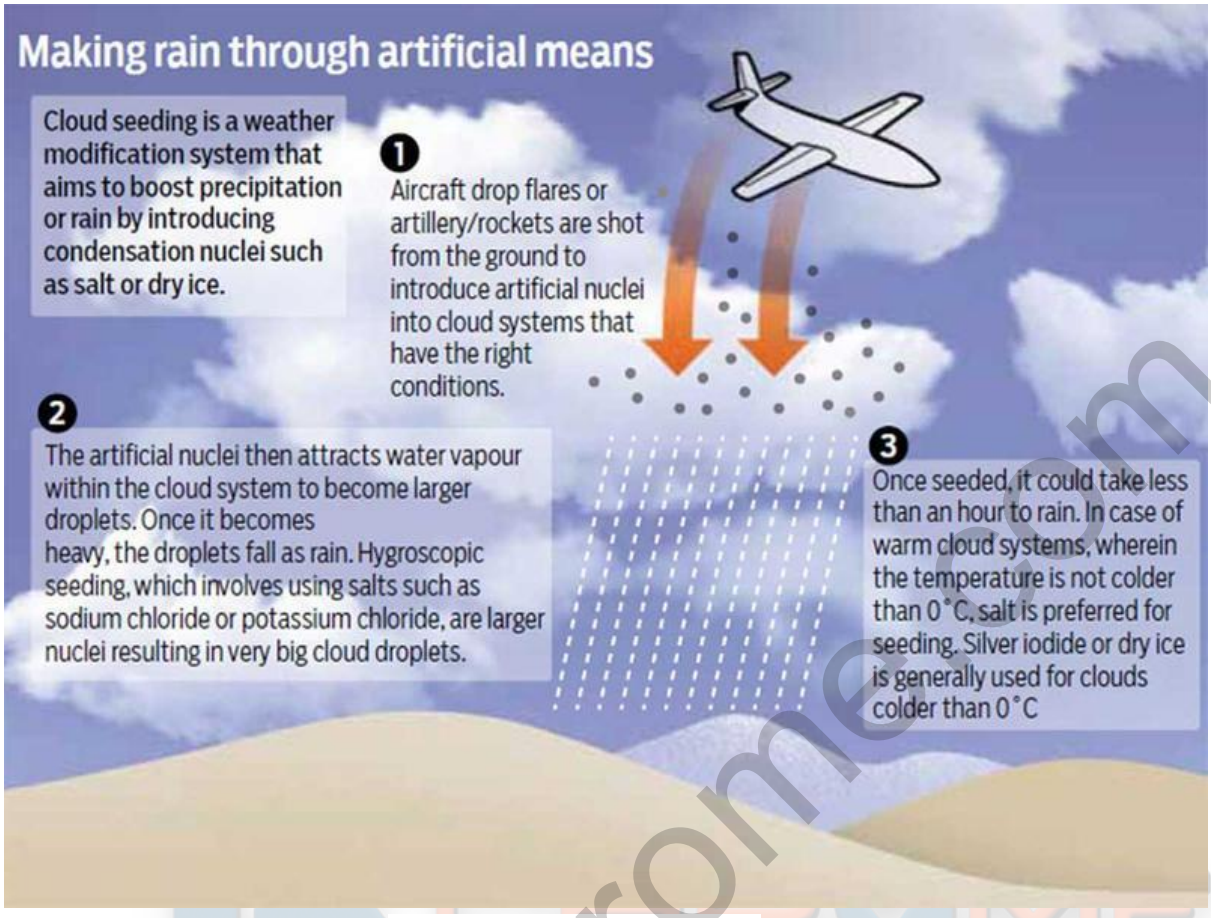


Figure: process of cloud seeding

Applications world over:

- The technology has been used by more than 50 countries for different reasons.
- China using cloud seeding in an effort to fight pollution before the 2008 Summer Olympics opening ceremony.
    - China frequently uses weather modification system to create rainfall during droughts.
    - China is set on seeding more clouds as it grapples with the problem of pollution and inadequate rainfall.
- Water managers are also seeing cloud seeding as one way of increasing winter snowfall.
- United Arab Emirates trying to meet an increasing demand for water
- In United States, cloud seeding is occasionally used by ski resorts to induce snowfall.
- During London Olympics: Seeding cloud before they reach stadium = can prevent washing of events by rainfall.
- In Agriculture:
    - Inducing cloud **to precipitate and break dry spell** = helps manage sowing and prevent crop wilting.
    - Glaciogenic techniques can be used to **reduce size of hailstones** and **check crop loss**.
- Disaster Management:
    - Getting rainfall at places with adequate water harvesting and storage capacities can prevent both droughts and floods.
- Glaciogenic techniques = can help restore the mass of depleting glaciers.

Potential use in India:

- Indian Monsoon = highly erratic causing agrarian and economic crises. => Cloud seeding can manage this uncertainty of rainfall.
- **Crop loss in Vidarbha due to hail storms can be mitigated**.
- Restoring the mass of Gangotri glacier =>
    - It can augment Namami Ganga program.
    - Floods and drought can be mitigated.

Can it work in Delhi?

- According to experts, **Delhi's dry weather is not suitable for cloud-seeding**.
- First, **some clouds are needed to carry out the seeding process**.
- Second, **the humidity in the air is too less for it to succeed in Delhi**.
- But considering the severity of air pollution and the threat it poses to people in Delhi-NCR, this method could be worth a try.

2. ENVIRONMENT

2.1. BIO JET FUEL FLIGHT

News: In August 2018, A blend of oil from **jatropha seeds** and aviation turbine fuel propelled the country's **first ever bio-jet fuel powered flight** operated by SpiceJet.

Importance

- It has potential to **reduce fuel costs by 15-20%** in the future, thus saving forex reserves as India **imports over 80% of its oil**.
- The bio-jet fuel is **more energy dense** as compared to Aviation Turbine Fuel (ATF) and is, therefore, **more efficient.**
- A **lower sulphur content** also means that it causes less wear and tear.
- Also, bio jet fuel can be produced from **animal fat, used cooking oil, waste dairy fat, sewage sludge,** etc. which India have in plenty.
- In future, it has the potential to reduce the cost of travel through airways and thus can give a huge boost to '**UDAN' Scheme**.

Challenges

- Inedible oil seeds like jatropha have **low per acre productivity** and there is a need to use biotechnology to enhance yields.
- **Technological challenges:** The oil needs to have a freezing point below -47 degrees so it doesn't freeze at **altitudes at which planes fly,** should not catch fire on ground when being transferred into a plane, must have the same density as ATF, have a certain calorific value and should not choke the filters.

2.2. NATIONAL POLICY ON BIOFUELS 2018

BIO FUELS

Any hydrocarbon fuel that is **produced from organic matter in a short period of time** through process of **biological carbon fixation**. **Between generations**, the **structure of the biofuel itself does not change, but the source** from which the fuel is derived changes.

It can be characterized **on basis of their source biomass**.

- **1st Generation Biofuels:**
    - **Directly using food crops** like wheat and sugar for making ethanol and oil seeds for biodiesel.
    - **Manufactured by conventional method of fermentation**.
    - **Concerns:**
        - Emitted more greenhouse gases.
        - **High volume of food grains was directed away from food market** and used in the energy market, causing damages to the food security aims.
- **2nd Generation Biofuels:**
    - Used **non-food crops and feedstock** instead of food crops.
    - Produced **from marginal croplands** unsuitable for food production or non-food crops.
    - Example: Jatropha.
    - Raw material: Wood, grass, seed crops, organic waste.
    - Advantage: **Resolves food vs fuel debate** in 1st generation biofuel.
- **3rd Generation Biofuels:**
    - **Based on improvements on production of biomass** by taking advantage of specially engineered energy crops such as algae as its energy source.
    - Use **specially engineered Algae** whose biomass is used to convert into biofuels.
    - **Advantages:**
        - Greenhouse gas emission will be low in comparison to others.
        - Have potential to produce **more energy per acre** than conventional crops.
        - Algae based biofuels can be used for a wide range of fuels such as diesel, petrol and jet fuel.
    - **Advantages of using Algae:**
        - Act as a low-cost alternative.
        - It gives high-energy and entirely renewable feedstock.
        - **Algae can be grown using land and water which are unsuitable for food production** as well as reducing the strain on already depleted water sources.
    - **Concerns:**
        - However, Algae, even when grown in wastewater, requires large amounts of water, nitrogen and phosphorus to grow. Also, it requires large amount of fertilizers increasing GHG emissions and hence will be much costlier.

Class of Biofuels: Bioethanol, biodiesel and biogas.

1. **Bio ethanol**:
    - **Produced from fermentation of carbohydrate and cellulosic material** of crops and other plants and grasses.
    - **Generally used as an additive,** to increase octane number of fuel.
2. **Biodiesel**:
    - It is **a methyl or methyl ester of fatty acids produced by transesterification of oils and fats** obtained from plants & animals.
    - Can be **directly used as fuel**.

3. **Bio gas:**
    - Biogas is **methane** produced **by anaerobic digestion of organic material** by anaerobes.
    - Can be produced
        - from biodegradable waste materials
        - by the use of energy crops fed into anaerobic digesters to supplement gas yields.

Significance of Biofuels:

- It forms an essential element of energy security of India.
- **Environment friendly fuel:** Addresses the climate change imperatives.
- **Use of Agricultural Waste:** We can use 170 million tonnes (out of the 800 million tonnes generated) of agricultural waste to be used for ethanol production.
    - This could easily be ramped up to 250 million tonnes per year, to produce between 31-47 billion litres of ethanol by 2020.
    - 31-47 billion litres is a radical increase from the current production of 2 billion litres.
- **Solution to stubble burning:**
    - **Use of Agricultural Waste in biofuel manufacturing**: an economic incentive available to farmers to remove and give the crop waste to biofuel plants. Hence, **a huge reduction in stubble burning**.
- **Sewage treatment plants (STPs):** India generates around 70 billion litres of waste water every day.
    - By building biogas generation and upgrading facilities at the STP sites, the output can potentially substitute 350 million litres of diesel, 2.3 gigawatt hours of natural gas fired power and over 8 million LPG cylinders of 14.2kg each.
- **Job creation:** The increase in ethanol production alone has **the potential to create over 700,000 jobs when targeting only the base potential**.
    - States with a combination of high agricultural activity and large fuel consumption like Maharashtra, Punjab and UP would be the best positioned to exploit this opportunity.
    - However, the economic viability of placing more orders and scaling up such pilot projects would only happen if a rational tax policy is implemented.

The Policy approved in May 2018, is aimed at **promoting use of biofuels** in the country. The policy is in sync with the objectives of the Government to **double farmers' income, promote clean energy and reduce import of fuels**.

Main features of the Policy

- The policy **categorises** biofuels, to enable extension of appropriate financial and fiscal incentives under each category, as follows:
    - **Basic Biofuels**: First Generation (1G) bioethanol and biodiesel
    - **Advanced Biofuels**: Second Generation (2G) ethanol, Municipal Solid Waste (MSW) to drop-in fuels, Third Generation (3G) biofuels, bio-CNG etc.
- The Policy **expands the scope of raw material for ethanol production** by allowing use of products that are unfit for human consumption for ethanol production Sugarcane Juice, **damaged food grains** like wheat, broken rice, rotten Potatoes etc.
- It also provides for the establishment **national biofuel authority**.
- It allows use of **surplus food grains** for production of ethanol for blending with petrol with the approval of National Biofuel Coordination Committee.

- It also provides for a **viability gap funding** scheme of Rs 5000 crore in six years **for second generation** (more advanced) ethanol bio-refineries in addition to tax incentives and a higher purchase price as compared to first generation biofuels.

Benefits out of this Policy:

- **Reduce Import Dependency:** One crore lit of E10 (10% ethanol and 90% petrol) saves Rs.28 crore of forex at current rates.
- **Cleaner Environment:** There will be lesser emissions of CO2 to the tune of 30 lakh ton. By reducing crop burning & conversion of agricultural residues/wastes to biofuels there will be further reduction in Greenhouse Gas emissions.
- **Health benefits:** Prolonged reuse of Cooking Oil for preparing food, particularly in deep-frying is a potential health hazard and can lead to many diseases. Used Cooking Oil is a potential feedstock for biodiesel and its use for making biodiesel will prevent diversion of used cooking oil in the food industry.
- **MSW Management:** It is estimated that, annually 62 MMT of Municipal Solid Waste gets generated in India. There are technologies available which can convert waste/plastic, MSW to drop in fuels. One ton of such waste has the potential to provide around 20% of drop in fuels.
- **Infrastructural Investment in Rural Areas:** It is estimated that, one 100klpd bio refinery will require around Rs.800 crore capital investment. Further addition of 2G bio refineries across the Country will spur infrastructural investment in the rural areas.
- **Employment Generation:** One 100klpd 2G bio refinery can contribute 1200 jobs in Plant Operations, Village Level Entrepreneurs and Supply Chain Management.
- **Reduction in oil import target 10% by 2022.**
- **Additional Income to Farmers:** By adopting 2G technologies, agricultural residues/waste which otherwise are burnt by the farmers can be converted to ethanol and can fetch a price for these wastes if a market is developed for the same. Also, farmers are at a risk of not getting appropriate price for their produce during the surplus production phase. Thus, conversion of surplus grains and agricultural biomass can help in price stabilization.

2.3. NATIONAL CLEAN AIR PROGRAMME

News: In January 2019, Government launched a **pan-India initiative**, NCAP, t**o combat rising levels of air pollution** in the country in a comprehensive and time-bound manner.

- According to a **Lancet Planetary Health report**, one in every eight deaths in India is attributable to air pollution which now contributes to more disease burden than smoking.

The programme

- **Collaborative and participatory approach** involving relevant Central Ministries, State Governments, local bodies and other Stakeholders with focus on all sources of pollution, forms the crux of the Programme.
- Pollution monitoring networks will be enhanced (to install **300 more real-time ambient air quality monitoring systems** across the country by 2024) and activities will be put in place to improve **awareness.**
- The programme aims to reduce the concentration of **PM2.5 and PM10** by **20-30 per cent** over the 2017 annual average levels by **2024. 102 cities** have been chosen for this intervention.

2.4. WATER HYACINTH TO CLEAN WATER

- In 2017, a group of **scientists from India and Ethiopia** developed a new method for **removing chromium**, a highly toxic heavy metal, **from wastewater**.
- In 2018, **a plant** found in the Amazon basin successfully **removed toxic metal pollution** from a Swansea river (Brazil). The water hyacinths **extracted 100% of cadmium, cobalt and manganese and 80% of zinc.**

Importance

- **Heavy metal poisoning** is a growing concern in many parts of the country. In addition to **cleaning up our rivers**, this technique can help to provide **safe drinking water** and also in dealing with certain implications of **climate change**.
- Use of water hyacinth as an adsorbent is a **low-cost and very effective** way of removing an extremely hazardous element from **industrial waste** before it becomes dangerous to humans.
- The hyacinth plant could be used as **fuel, compost** and the **metals could also be recovered.**

Challenges

- The water hyacinth is classed as an **invasive species** and is considered a **weed** in some parts of the world, so it would need to be used in purpose-built lagoons.

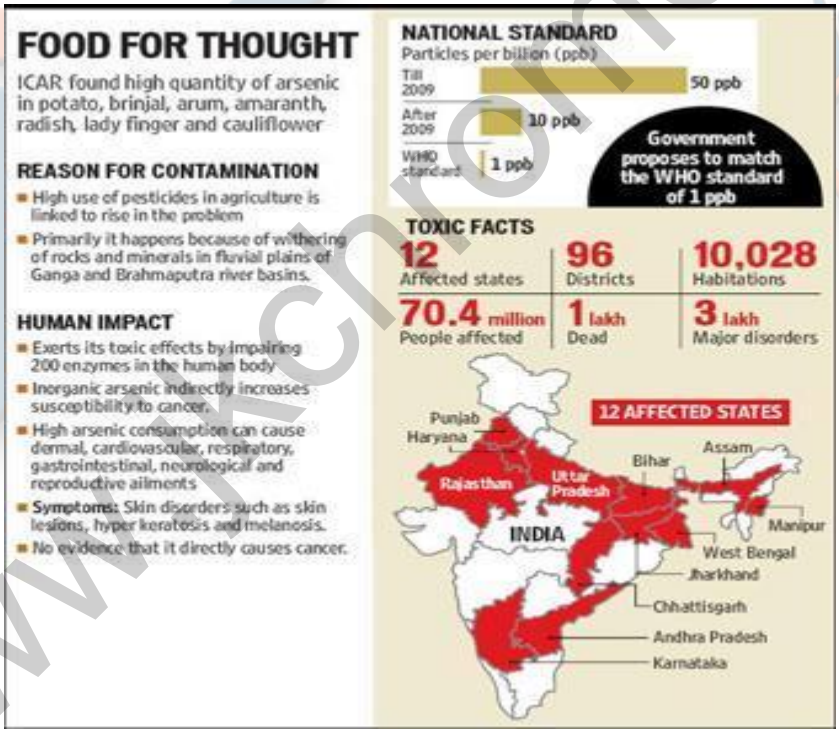


Figure: heavy water contamination.

2.5. M-STrIPES

- It stands for **Monitoring system for Tigers – Intensive Protection and Ecological Status**. It is **software-based** monitoring system launched in 2010 across Indian tiger reserves by the National Tiger Conservation Authority **(NTCA).**
- The android based software was developed by **Wildlife Institute of India**. The system consists of **two components** a) field-based protocols for patrolling, law enforcement, recording wildlife crimes and ecological monitoring, and b) a customized software for storage, retrieval, analysis and reporting.

- It was used for the **2018 all-India tiger estimation** and is expected to **eliminate human error** in counting with **end-to-end digitization** of data.

2.6. HYDROGEN-CNG POWERED TRANSPORT

News

- The Delhi government and the Indian Oil Corporation (IOC) aimed to sign an agreement in 2018 for setting up a gas compact reformer, which **partially reforms natural gas to directly produce hydrogen-CNG mixture** in the desired proportion.
- If smoothly executed, **Delhi will become the first Indian city** where trials to use clean fuel in public buses will be conducted.
- **Hydrogen enriched CNG** is a blend of about 18 to 20 percent of hydrogen with compressed natural gas (CNG).

Advantages

- H-CNG releases up to **70% less carbon monoxide**, and up to **15% less hydrocarbons**, such as benzene, as against neat CNG.
- As hydrogen fuel cell technology, which uses hydrogen as fuel, and electric vehicles continue to be cost prohibitive, H-CNG can aid a **quicker transition to cleaner fuels** and help **fight air pollution** and hence **global warming** in a better way.

2.7. ELECTRIC VEHICLES IN INDIA

Transportation accounts for about **11 percent of India's carbon emissions**. As many as **14 of the world's top 20 most-polluted cities** are in India, according to a 2018 World Health Organization (WHO) report. Thus, with a view to **reduce its carbon footprints, combat air pollution** and also to **reduce oil imports**, Government of India in 2016 announced its proposal to make India a **100 percent electric vehicle nation by 2030.**

Measures taken

- **National Electric Mobility Mission Plan (NEMMP) 2020**: Launched in 2013, it aims to achieve national fuel security by promoting hybrid and electric vehicles in the country. There is an ambitious target to achieve 6-7 million sales of hybrid and electric vehicles year on year from 2020 onwards.
- **FAME India scheme 2015**: Faster Adoption and Manufacturing of Electric vehicles (FAME) initiative under the NEMMP, is intended to provide subsidies on electric and hybrid cars apart from creating demand and market and also develop charging infrastructure.
- **Karnataka** approved Electric Vehicle and Energy Storage Policy 2017, thus becoming the first state to do so.

Issues and Challenges

- **Over reliance on coal:** More than 70% of electricity is generated from dirty sources such as coal. To seamlessly charge the batteries for electric vehicles, more thermal power itself will be needed which defeats the whole purpose of having electric car.
- With an existing **vehicular population of more than 210 million** and swelling, reaching an all-electric vehicle fleet in about a decade is almost impossible.
- **Infrastructure bottlenecks**: Government will have **to limit EV use to within the radius of charging stations**, generally urban areas, which would hardly be acceptable to most buyers as they need to travel beyond as well.

- **Low investment:** Manufacturers who have already pumped in money to **meet the BS-VI deadline** and hence have **little incentive to invest on EVs** which in turn have **no assured demand and market**.
- Existing standard lithium-ion batteries use expensive materials such as **lithium & cobalt**. India is almost **entirely dependent on their imports**. Thus, pushing EVs would also mean more imports and worse off Balance of Payment.

2.8. ARTIFICIAL REEF TO SAVE SINKING ISLAND

Artificial Reef

- An artificial reef is a manmade structure that may mimic some of the characteristics of a natural reef.
- **Submerged shipwrecks** are the most common form of artificial reef. Oil and gas platforms, bridges, lighthouses, and other offshore structures often function as artificial reefs. **Long-lasting** artificial reefs are typically constructed of **limestone, steel, and concrete**.

Tamil Nadu Government is deploying artificial reefs near vulnerable islands to save them from sinking, after a **successful pilot project** which has been found to save the sinking **Vaan Island** in the Gulf of Mannar.

Significance

- With **sea level rise** due to climate change posing additional t**hreat to coastal islands,** the reefs can provide a solution to save such islands.
- It **enhances marine habitats** for higher fish & other marine production and protection of marine diversity.
- **Natural corals** get attached to artificial reefs over time and **start regeneration.**

2.9. CARBON CAPTURE AND STORAGE

It is the process of **capturing used carbon dioxide** from large sources, such as fossil fuel power plants, **transporting it to a storage site** (normally an underground geological formation), depositing it and possibly converting it to rocks, so that it will **not enter the atmosphere again.**

- **CarbFix project of Iceland**: Iceland in 2017 became the **first country** to have a negative emission power plant which performs Carbon Capture and Storage.
- The facility pumps CO2 into the volcanic rock under Iceland and speeds up a natural process where the basalts react with the gas to form **carbonate minerals**, which make up limestone.

Benefits

It is a potential **answer to Global warming and climate change** as the Carbon dioxide gas is permanently removed from the atmosphere.

Challenges

- There are concerns about **costs and potential leakages.**
- The technique requires **large amounts of water**: 25 tonnes of water for each tonne of CO2 buried, which may not be available everywhere.

2.10. IMPACT OF AEROSOLS ON MONSOON

- Researchers from Indian Institute of Tropical Meteorology, Pune, in a report in 2017, found that **aerosols may be weakening the monsoon** and may be a far more important factor than GHGs.
- A good monsoon is produced by the **difference in temperature between land and sea**.

- But, the dust clouds, containing aerosols from vehicular exhaust, half-burnt crop residue, dust, chemical effluents etc. **shield the earth from the sun's rays**, which means lower average temperature on earth (thus **combating global warming**).
- However, in depressing land and sea temperatures and **reducing the variation between the two**, it also ends up suppressing the monsoon.

2.11. ARTIFICIAL LEAF DEVELOPED BY IISc

In 2018, researchers at the **Indian Institute of Science** (IISc) developed an artificial leaf that **absorbs carbon dioxide from the atmosphere to generate fuel and release oxygen in the process**, simulating the process of photosynthesis.

Advantages

- The developed leaf is **100 times more efficient** than a natural leaf in absorbing carbon dioxide.
- It can convert about **20 percent** of the incident solar energy into chemical energy in the form of fuel and oxygen.
- It is composed of completely **biocompatible, earth abundant and inexpensive elements.**

Significance

- It provides an ideal opportunity to use this artificial leaf as a **source of renewable energy** on a large scale.
- It significantly **reduces the carbon footprint** from the atmosphere, releasing more oxygen in the process.
- It enhances the Carbon sequestration, which is the process of capturing and storing atmospheric carbon dioxide. It is one method of reducing the amount of carbon dioxide in the atmosphere with the goal of reducing global climate change

2.12. ISRO'S LITHIUM ION TECHNOLOGY

- The Lithium-ion cell technology has been **developed by ISRO's** Vikram Sarabhai Space Centre. It has been successfully used in indigenous lithium-ion batteries in various missions of ISRO since 2011.
- ISRO will now **transfer the technology** to the industries for **commercial use**: to establish production facilities for producing lithium-ion cells. It will charge a nominal one-time fee of Rs 1 Crore.
- The battery so developed will be having **high voltage, high energy density, long life cycle and high storage characteristics.**

Significance

- The battery technology will act as a big boost for the production of **electric vehicles (EV),** one of the most prevalent uses of li-ion batteries in today's world.
- It will **bring down the production cost** of a li-ion battery and will also reduce the cost of importing such technology from foreign countries.

Lithium-ion battery manufacturing:

The proposed capacity target for lithium-ion battery-manufacturing base has been raised to 50GW from 40GW. The government is in the process of opening to tenders to set up a 50GW battery manufacturing base at around US$50 billion investment.

- The government is offering financial incentives in the form of subsidies and duty cuts, which could include a reduction in minimum alternate tax to half and import and export duty waivers or cuts for eight years. The successful bidder companies will have to set up production facilities by 2022 and can apply incentives until 2030.
- NITI Aayog (National Institute for Transforming India), the premier policy think-tank of the government of India is working to seek proposals from states to identify locations for plants and to provide duty waivers and exemptions to selected manufacturers.
- India can move on to manufacturer cells after batteries. The country currently imports batteries and cells from China and the US.
- The government announced it would increase the basic import duty on lithium-ion cells to 10 per cent from April 2021, from the current 5 per cent. Lithium-ion cells are used in the manufacturing of lithium-ion accumulator for EVs. Import duty on battery packs will also increase from 5 per cent currently to 15 per cent from April 2021.

Difference between Lithium ion battery and Lead based battery

Parameters	Lead Based Battery	Lithium-ion Battery
WEIGHT	Heavy (Three times the weight of Lithium battery)	Light
EFFICIENCY	Highly inefficient for both charge and discharge	Efficient in both charge and discharge
DISCHARGE	Never discharges more than 80%.	Achieves almost a 100% discharge.
CYCLE LIFE	300 lifetime cycles	500-700 lifetime cycles.
VOLTAGE	Constant drop of voltage during discharge.	Constant voltage levels.
COST	Cheapest to produce.	Cost is lower when performance and longevity is considered.
ENVIRONMENTAL IMPACT	High	Low

2.13. ROADKILLS APP

- 'Roadkills', an easy-to-use android app. is developed by the Wildlife Conservation Trust **to help citizens to report wildlife deaths.**
- It accesses **location information** from phones and permits users to **upload photographs** and other details of a dead wild animal on a road or railway line.

Significance

This can be used to **identify crucial road or rail stretches** that urgently require mitigation measures to save wildlife and prevent animal-human conflict.

2.14. TECHNOLOGIES TO CONTROL AIR POLLUTION

Various air pollution control technologies and strategies are available to reduce air pollution.

A. DUST COLLECTOR

- A **dust collector** is a system used **to enhance the quality of air released from industrial and commercial processes by collecting dust and other impurities from air or gas**.
- Designed to handle high-volume dust loads, a dust collector system consists of a blower, dust filter, a filter-cleaning system, and a dust receptacle or dust removal system.
- It is distinguished from air purifiers, which use disposable filters to remove dust.
- **Uses**
    - Dust collectors are used in many processes to either recover valuable granular solid or powder from process streams, or to remove granular solid pollutants from exhaust gases prior to venting to the atmosphere.
    - Dust collection is an online process for collecting any process-generated dust from the source point on a continuous basis.
    - Dust collectors may be of single unit construction, or a collection of devices used to separate particulate matter from the process air.
    - They are often used as an air pollution control device to maintain or improve air quality.

B. MIST COLLECTORS

- Remove particulate matter in the form of fine liquid droplets from the air.
- They are often used for the collection of metal working fluids, and coolant or oil mists.
- Mist collectors are often used to improve or maintain the quality of air in the workplace environment.

C. FUME AND SMOKE COLLECTORS

- They are used to remove sub-micrometer-size particulates from the air.
- They effectively reduce or eliminate particulate matter and gas streams from many industrial processes such as welding, rubber and plastic processing, high speed machining with coolants, tempering, and quenching.

Types of dust collectors: Five main types of industrial dust collectors are:

1. Inertial separators
2. Fabric filters
3. Wet scrubbers
4. Unit collectors
5. Electrostatic precipitators

ELECTROSTATIC PRECIPITATOR (ESP)

- It is a filtration device that **removes fine particles, like dust and smoke,** from a flowing gas using the force of an induced electrostatic charge minimally impeding the flow of gases through the unit.
- In contrast to wet scrubbers which apply energy directly to the flowing fluid medium, an ESP **applies energy only to the particulate matter being collected** and therefore is **very efficient in its consumption of energy (in the form of electricity)**.

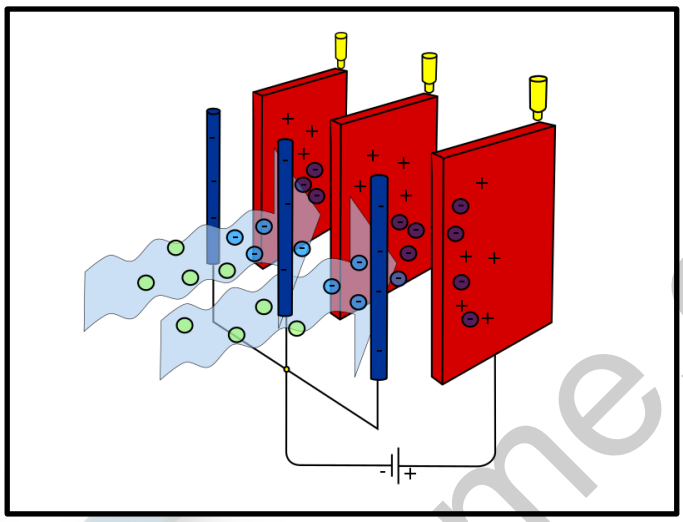


Figure: Conceptual diagram of an electrostatic precipitator

- **Wet electrostatic precipitator**
  - A wet electrostatic precipitator (WESP or wet ESP) **operates with water vapor saturated air streams** (100% relative humidity).
  - WESPs are commonly used to remove liquid droplets such as sulfuric acid mist from industrial process gas streams.
  - The WESP is also commonly used where the gases are high in moisture content, contain combustible particulate, or have particles that are sticky in nature.
  - The preferred and most modern type of WESP is a downflow tubular design.
    - This design allows the collected moisture and particulate to form a moving slurry that helps to keep the collection surfaces clean.
- Relative advantages and disadvantages of wet scrubbers compared to other control devices

Advantages	*Disadvantages*
• **Small space requirements:** Scrubbers reduce the temperature and volume of the unsaturated exhaust stream. Therefore, vessel sizes, including fans and ducts downstream, are smaller than those of other control devices. Smaller sizes result in lower capital costs and more flexibility in site location of the scrubber. • **No secondary dust sources:** Once particulate matter is collected; it cannot escape from hoppers or during transport. • **Handles high-temperature, high-humidity gas streams:** No temperature limits or condensation problems can occur as in baghouses or ESPs. • **Minimal fire and explosion hazards:** Various dry dusts are flammable. Using water eliminates the possibility of explosions. • Ability to collect both gases and particulate matter.	• **Corrosion problems:** Water and dissolved pollutants can form highly corrosive acid solutions. Proper construction materials are very important. Also, wet-dry interface areas can result in corrosion. • **High power requirements:** High collection efficiencies for particulate matter are attainable only at high pressure drops, resulting in high operating costs. • **Water pollution problems:** Settling ponds or sludge clarifiers may be needed to meet wastewater regulations. • **Difficult product recovery:** Dewatering and drying of scrubber sludge make recovery of any dust for reuse very expensive and difficult.

CATALYTIC CONVERTOR

- **An exhaust emission control device**
- **It can convert toxic gases and pollutants in exhaust gas from an internal combustion engine into less-toxic pollutants** by **catalyzing a redox reaction** (an oxidation and a reduction reaction).
- Uses:
    - Catalytic converters are usually used with internal combustion engines fueled by either gasoline or diesel—including lean-burn engines as well as kerosene heaters and stoves.
    - they are also used on electrical generators, forklifts, mining equipment, trucks, buses, locomotives, and motorcycles.
    - They are also used on some wood stoves to control emissions. The catalytic converter uses non-lead fuel.

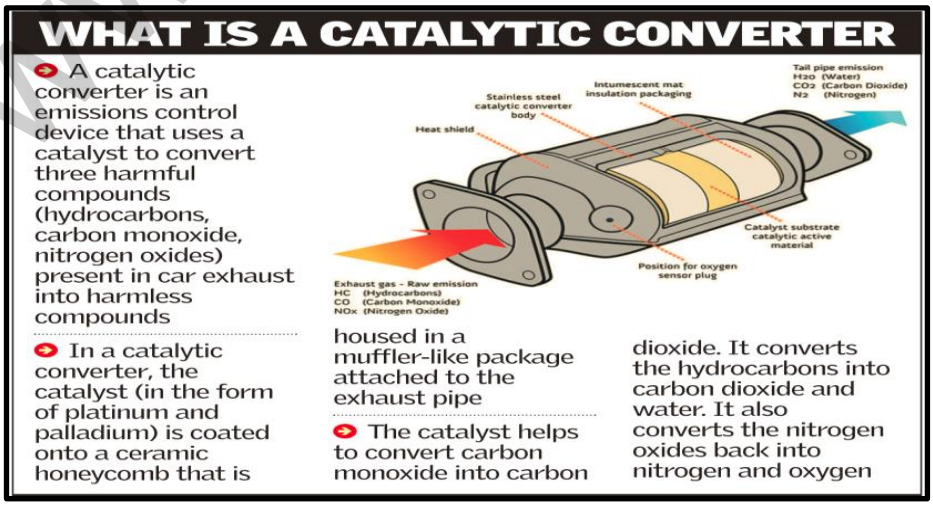


Figure: Catalytic converter

BIOFILTRATION

- a pollution control technique using a bioreactor containing living material to capture and biologically degrade pollutants.
- Common uses include
    - processing wastewater,
    - capturing harmful chemicals or silt from surface runoff, and
    - microbiotic oxidation of contaminants in air.

SCRUBBER SYSTEMS

- Examples: chemical scrubbers, gas scrubbers
- These are a diverse group of air pollution control devices that can be **used to remove some particulates and/or gases from industrial exhaust streams**.
- Scrubbers are one of the primary devices that control gaseous emissions, especially acid gases.
- Scrubbers can also be used for heat recovery from hot gases by flue-gas condensation.
- They are also used for the high flows in solar, PV, or LED processes.

DRY SCRUBBING

- A dry or semi-dry scrubbing system, unlike the wet scrubber, **does not saturate the flue gas stream that is being treated with moisture**.
- In some cases no moisture is added, while in others only the amount of moisture that can be evaporated in the flue gas without condensing is added. Therefore, dry scrubbers **generally do not have a stack steam plume or wastewater handling/disposal requirements**.
- Dry scrubbing systems are **used to remove acid gases (such as SO2 and HCl) primarily from combustion sources**.
- Dry scrubbing systems can be categorized as
    - dry sorbent injectors (DSIs) or
    - spray dryer absorbers (SDAs).
    - Spray dryer absorbers are also called semi-dry scrubbers or spray dryers.
- Dry scrubbing systems are often used for the removal of odorous and corrosive gases from wastewater treatment plant operations

3. DISASTER MANAGEMENT

3.1. SAGAR VANI

It is a **software platform** where various dissemination modes will be **integrated** on a single central server. The 'Sagar Vani' includes various services like **multilingual** SMS, voice call / audio advisory, social media advisory etc and comes with a dedicated **mobile app**.

- It has been developed by ESSO-INCOIS in order to **effectively and timely disseminate** the advisories, directly from the lab to the end user.
- The system also has facility to provide **access to various stakeholders** e.g. NGOs, State Fishery Departments etc., so that they too will be able to further disseminate these ocean information and alerts to the user community.
- It will serve the coastal community, especially the **fishermen community** with the **advisories and alerts** towards their livelihood as well as their safety at Sea.

3.2. CYCLONE WARNING SYSTEM: KERALA AND ODISHA

The India Meteorological Department is responsible for tracking tropical cyclones within the North Indian Ocean. The IMD issues warnings in **four stages** for the Indian coast depending on the time in advancement of the cyclone.

Current status

- At present, IMD has cyclone warning centres only at Chennai, Visakhapatnam, Bhubaneswar, Kolkata, Ahmedabad and Mumbai.

Proposal

- With several incidents of tropical cyclones and severe weather events striking over Kerala and Karnataka coasts, the recent one being August 2018 cyclone and flood, the Government has proposed to set up a **Cyclone Warning Centre in Thiruvananthapuram** to cater to the needs of Kerala and Karnataka.
- **Doppler Radar**: The Ministry is also planning to set up another C-Band Doppler Weather Radar at **Mangalore** by end of 2019, which will cover the northern parts of Kerala.
    - At present, there are two Doppler Weather Radars in the state, at Kochi and Thiruvananthapuram.
    - With these 3 radars, the entire state will be covered **for monitoring of rainfall and severe weather events**, and adequately warn the people well in advance.

Odisha's cyclone early warning system:

In October 2018, **Odisha** Government launched its own **Early Warning Dissemination System,** the first of its kind technology in India, to simultaneously **warn coastal community and fisherfolk** about impending cyclone and tsunami through **siren towers**.

- Sirens will go off from **122 towers installed** along the 480-km-long coast of the State if a button is pressed in the State emergency centre in Bhubaneswar.
- **Fishermen fishing in deep sea** can also be reached via mass SMS on their mobile phones through EWDS.

3.3. ENSEMBLE PREDICTION SYSTEMS (EPS)

It was launched by **IMD** in June 2018 **to provide probabilistic weather forecasts up to the next 10 days**. The new ensemble will tell the probability of rainfall according to its intensity and volume, which will be **colour coded** for ease of interpretation. It will help **disaster management** authorities in making better emergency response decisions. It has been developed under **National Monsoon Mission.**

National Monsoon Mission

- It was launched in 2015 by the Ministry of Earth Science.
- **IMD collaborates with weather research organisations** nationally as well as internationally to improve monsoon forecast for the country. The mission's focus is on **developing a dynamic model for monsoon prediction.**
- It was envisaged after **IMD's repeated inefficiencies:** e.g. while IMD had predicted deficient rainfall in the country in 2009, it was drastically below their estimations. IMD had also failed to predict the droughts of 2002 and 2004.

ITCOOCEAN

In December 2017, Government signed an **agreement with UNESCO** to establish International Training Centre for Operational Oceanography as a **Category-2** Centre (C2C).

Importance

- It is aimed at supporting day-to-day operations and **providing information services** to various **sectors of the blue economy** viz. fishing, disaster management, shipping and ports, coastal management, environmental management, offshore industries and defense forces i.e. navy, coast guard.
- It will provide **an opportunity for India** to emerge as a **leader in the Indian Ocean**, forging cooperation among South Asian and African countries. The Centre may thus contribute to achieving **SDG 14** and fulfill commitments to support **Small Island Developing States, Least Developed Countries.**

Information Fusion Centre – Indian Ocean Region

- The IFC-IOR stems from the importance of the Indian Ocean to world trade and security, and the need for the various maritime nations and organisations to collaborate towards enhancing maritime safety and security on the seas of this region.
- IFC-IOR will help interface and integrate, wherein, all partners and stakeholders would benefit from each other's best practices and expertise.
- The IFC has been established at Gurugram, India and is collocated with Information Management and Analysis Centre which is jointly administered by the Indian Navy and Indian Coast Guard.
- IFC-IOR is established with the vision of strengthening maritime security in the region and beyond, by building a common coherent maritime situation picture and acting as a maritime information hub for the region.
- Establishment of IFC- IOR would ensure that the entire region is benefitted by mutual collaboration and exchange of information and understanding the concerns and threats which are prevalent in the region.
- The information Exchange at the IFC-IOR would be initially undertaken by virtual means, using telephone calls, faxes, emails and video conferencing over internet.
- Additionally, towards enhancing capability building, the IFC-IOR would undertake conduct of exercises and training capsules in maritime information collection and sharing.

The setting up of IFC-IOR underscores the governmental approach and effort in line with the vision of us towards **Security and Growth of All in the Region (SAGAR)**.

10. ACHIEVEMENTS OF INDIANS IN SCIENCE & TECHNOLOGY & SCHEMES FOR PROMOTING SCIENTIFIC TEMPER

1. CONTRIBUTION OF INDIANS

Towards the 2nd half of 19th century, Sir C.V. Raman brought about an unprecedented change in Indian scientific thought, Dr. Homi J. Bhabha, known as the father of our Nuclear Physics, predicted the future of Indian science.

Dr. J.C. Bose, in the field of plant physiology, Dr. Vikram Sarabhai, in the field of atomic energy and industrialization and Dr. Abdul Kalam, in the field of defence technology, brought about revolutionary changes to reawaken the glory of Modern India.

1.1 SRINIVASA RAMANUJAN (1887-1920)

- Better known as Srinivasa Iyengar Ramanujan
- One of India's greatest **mathematical genius**, was born at Erode (Tamil Nadu) on 22 December, 1887.
- Numbers seemed to draw him by a strange magnetism.
- He used to write his ideas and results and make notes on his findings.

His achievements:

- Three of his research note books are available to us. They are called **Ramanujan's Frayed Notebooks**.
- He **could not complete his college education as he kept on developing his ideas and started posing problems** and solving them in the *Journal of Indian Mathematical Society.*
- In 1911, he published in the same journal a brilliant **research paper on Bernoulli Numbers**.

- He worked out **the Riemann series, the elliptic integrals, hypergeometric series, the functional equations of the zeta function**, and **his own theory of divergent series**.
- In England Ramanujan made further advances, especially in the partition of numbers (the number of ways that a positive integer can be expressed as the sum of positive integers; e.g., 4 can be expressed as 4, 3 + 1, 2 + 2, 2 + 1 + 1, and 1 + 1 + 1 + 1).
- Astounding formulae for **infinite divergent series, continued fractions, irrational number, improper integrals, number theories where infinite series of Pi(π)** is significant.
- The **Ramanujan Conjecture**, which is an assertion of tau-function.
- The **Hardy-Ramanujan number**, 1729 – smallest number expressible as the sum of cubes of two numbers in two different ways, (1, 12) and (9,10).
- **Generalization of the Jacobian functions** with Ramanujan Theta, which finds application in String theories.
- Mock theta functions that later evolved into Infinite theta functions and Fourier coefficients for Jacobi forms.
- Ramanujan ternary quadratic form.
- Development of Bernoulli's number properties, selective for research work used currently.
- **Classification of whole number**.
- Calculated Euler's constant to 15 decimal places.
- Contribution to quadratic equation and discovery of hypergeometric series.

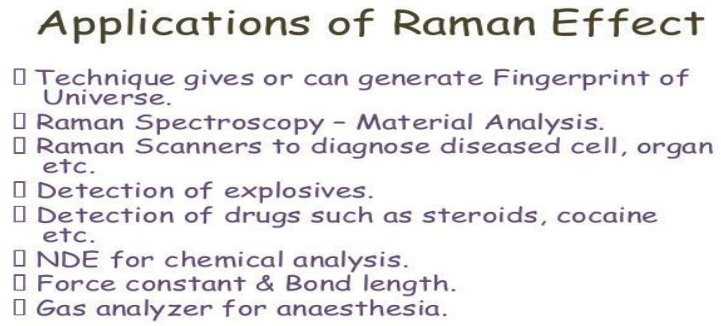
India declared **December 22 as the National Mathematics Day**, to celebrate mathematics in deep respect of this great mathematician.

1.2. CHANDRASEKHARA V. RAMAN (1888-1970)

- C.V. Raman won the **Nobel Prize for Physics in 1930**.
- Ist Asian to receive this award.
- Born on 7 November 1888 in Tiruchirapalli (Tamil Nadu)

His achievements:

- **Raman Effect : When a beam of monochromatic (having single colour) light passes through a transparent substance, it scatters**.
- Raman studied the broken light. He found that there were two spectral lines of very low intensity (strength) parallel to the incident monochromatic light.
- This **showed that broken light was not monochromatic**, though the incident light was monochromatic.
- This phenomenon became famous as Raman Effect and spectral lines in the scattered light as Raman Lines.
- While scientists had been debating over the question whether light was like waves or like particles, the **Raman Effect proved that light is made up of particles known as photons**.



1.3. JAGDISH CHANDRA BOSE (1858-1937)

- Born on 30 November, 1858 at Mymensingh, now in Bangladesh

His achievements:

- He **made an apparatus to study the properties of electric waves.**
- For his paper on "The Electromagnetic Radiation and Polarization of Electric Ray", he was made a Knight in 1917 and Fellow of the Royal Society of London in 1920.
- Invented the **Crescograph** that **can record even the millionth part of a millimeter of plant growth and movement**.
    - Dr. Bose proved through graphs taken by the Crescograph that **plants have a circulatory system too**.
    - Crescograph has also shown that **the upward movement of sap in plants is the activity of living cells**.
- Dr. Bose also made many other instruments famous all over the world as Bose instruments, to prove that
    - **Even metals react to outward stimuli**.
    - **Even steel and metals used in scissors and machinery get tired and regain efficiency after a period of rest**.
- Besides Crescograph and other Bose instruments, his wireless inventions too antedated those of Marconi.
    - He was the **first to invent a wireless coherer** (radio signal detector) and **an instrument for indicating the refraction of electric waves**.

1.4 HOMI JEHANGIR BHABHA (1909-1966)

- He led India into atomic age.
- He is called **the father of Indian Nuclear Science**.
- He was born on 30 October, 1909 in a famous Parsi family.
- He took a degree in Mechanical Engineering from Cambridge, completed research work there and received his doctorate in 1935. Till 1939, he carried outstanding original research relating to cosmic radiation. He returned to India when the Second World War started.

His achievements:

- He wrote a letter to Sir Dorabji Tata suggesting that **an institution should be established which would lay the foundation of India as a world nuclear power**. This institute would produce its own experts and the country would not have to depend on outside sources. As a result, **Tata Institute of Fundamental Research (TIFR) was started in 1945**, at Dr. Bhabha's ancestral home.

- **India's first atomic research centre** now called **Bhabha Atomic Research Centre (BARC)** was established at Trombay.
- **India's First atomic reactor, Apsara was also established under his expert guidance**.
- Bhabha became the **first chairman of the Atomic Energy Commission** set up in 1948.
- He served as the chairman of international conference on peaceful uses of atomic energy, supported by the United Nations.

1.5. DR. VIKRAM AMBALAL SARABHAI (1919-1970)

- He was the **main personality behind the launching of India's first satellite Aryabhatta**.
- He studied cosmic rays under the guidance of Dr. C.V. Raman and received his Ph.D. degree from Cambridge University.

His achievements:

- His studies of cosmic rays have made it clear that **cosmic rays are a stream of energy particles coming from the outer space**. **While reaching the earth, they are influenced on the way by the sun, the earth's atmosphere and magnetism**.
- He was a great industrialist.
- He **helped in saving crores of rupees for India by starting the mission of manufacturing military hardware and producing antibiotics and penicillin in India** which were being imported from abroad.
- Dr. Vikram Ambalal Sarabhai established Indian Institutes of Management (IIMS)
- He was the Chairman of the Indian National Commission for Space Research (INCOSPAR) and of the Atomic Energy Commission.
- He directed the setting up of Thumba Equatorial Rocket Launching Station (TERLS).
- He also **made plans to take education to the villages through Satellite communication**.

1.6. DR. A.P.J. ABDUL KALAM (1931-2015)

- 11th President of India, was born on 15 October, 1931, in the island town of Rameshwaram (Tamil Nadu).

His achievements:

- Dr. Kalam served in ISRO from 1963 to 1982.
- At Vikram Sarabhai Space Centre, he **developed the Satellite Launch Vehicle (SLV 3), which put the satellite Rohini into orbit**.
- In 1982, as Director, Defence Research Development Organisation (DRDO), he was given the responsibility of **Integrated Guided Missile Development Programme** (IGMDP).
- He **developed five projects for defence services - Prithvi, Trishul, Akash,Nag and Agni**.
- He **led India into an era of self-dependence**.
- Agni, which is a surface to surface missile, is a unique achievement. Its successful launch made India a member of the club of highly developed countries.
- The **light weight carbon material designed for Agni** has been **used to make calipers for the polio-affected**.
    - The material has **reduced the weight of calipers to 400 grams from 4 kgs**.
    - The material has also been **used for making spring like coils called stents**, which are used in Balloon Angioplasty for treating heart patients.

1.7. BIRBAL SAHNI (1891-1949)

- Birbal Sahni was a famous paleobotanist of India, who studied the fossils of the Indian subcontinent.
- He accredited for establishing the **Birbal Sahni Institute of Paleobotany at Lucknow** in the state of Uttar Pradesh.
- He was a pioneer in palaeobotanic research in India and was also a geologist who took an interest in archaeology.

1.8 DR. KOTI HARINARAYANA

- He was renowned genius scientist.

His achievements:

- It is recognized that the brain behind India's first indigenously built combat aircraft, TEJAS.
- It was a result of the weakening value of the country's soon to be obsolete Mig-21 fighter jets and, true to its name, made our defence sector's future a lot healthier.
- Mangalyaan, or Mars-Craft, this program by own space research organisation has been praised as one of the lowest costs but high functioning space missions till date. With this scientific development, Indians can reach Mars orbit on its first attempt.
- India's first moon probe was efficaciously inserted into the lunar orbit in 2008 and pushed India's space program into the world map, putting India side by side with NASA and the European Space Agency. Chandrayaan's greatest achievement was the discovery of the extensive presence of water molecules in the lunar soil.

1.9. ANIL KAKODKAR:

- Dr Anil Kakodkar is famous as a distinguished nuclear scientist of India.
- He holds the post of the chairman of the Atomic Energy Commission of India (AECI) as well as the Secretary to the Government of India, Department of Atomic Energy. He received Padma Shri in 1998 and Padma Bhushan in 1999.

1.10. ADITI PANT:

- She is eminent Indian oceanographer.
- She was a part of the Indian expedition to Antarctica in 1983 and became the first Indian woman to visit Antarctica (along with Sudipta Sengupta).

2. SCHEMES FOR PROMOTING SCIENTIFIC TEMPER

2.1. RAMANUJAN FELLOWSHIP SCHEME

- For brilliant scientists and engineers from **all over the world** to take up scientific research positions in India. Means, it is for those scientists who want to return to India from abroad.
- **Eligibility:**
    - Only for those candidates who are doing Post-Doctoral abroad.
    - Not for the people who already have permanent position in a scientific organization in the country.
- **Scope:**
    - **All Areas of Science** (in the broadest terms) are covered by this fellowship.
    - The fellowships are scientist-specific and very selective.

- The Ramanujan Fellows could work in any of the scientific institutions and universities in the country.

- **Term:** The Ramanujan Fellowship duration is **for 5 years only.**
- **Benefits:**
  - They would be eligible for receiving **regular research grants through the extramural funding schemes of various S&T agencies of the Government of India.**
- Managed by Science and Engineering Research Board under the Department of Science & Technology.

2.2. INNOVATION IN SCIENCE PURSUIT FOR INSPIRED RESEARCH (INSPIRE) FACULTY SCHEME

- INSPIRE is an **innovative programme** sponsored and managed by **Department of Science & Technology** for attraction of talent to Science
- Objective of INSPIRE
  1. To communicate to the youth of the country the excitements of creative pursuit of science;
  2. Attract talent to the study of science at an early age;
  3. To **build the required critical human resource pool** for strengthening and expanding the Science and Technology system and R&D base.
- **Components:** INSPIRE has three components:
  1. Scheme for Early Attraction of Talent (SEATS)
  2. Scholarship for Higher Education (SHE)
  3. Assured Opportunity for Research Careers (AORC)
- It does not believe in conducting competitive exams for identification of talent at any level.
- It believes in and relies on the efficacy of the existing educational structure for identification of talent.

2.3. SCIENCE AND ENGINEERING RESEARCH BOARD (SERB)'S SCHEMES:

1. **Teacher Associate ship for Research Excellence (TARE):**
   - It aims **to tap the latent potential of faculty** working in state universities, colleges and private academic institutions **who are well trained but have difficulty in pursuing their research** due to varied reasons including lack of facilities, funding and guidance.
   - This scheme **facilitates mobility of such faculty members to carry out research in a well-established public funded institution such as IITs, IISc, IISERS** and other National Institutions (NITs, CSIR, ICAR, ICMR labs, etc) and Central Universities **located preferably nearer to the institution where the faculty member is working**.
   - Up to 500 TAs will be supported under this scheme.
2. **Overseas Visiting Doctoral Fellowship (OVDF):**
   - **Offers opportunities for up to 100 PhD students** admitted in the Indian institutions for gaining exposure and training in overseas universities / institutions of repute and areas of importance to country for period up to 12 months during their doctoral research.
3. **SERB Distinguished Investigator Award (DIA):**
   - To recognize and reward Principal Investigators (PIs) of SERB/DST projects who have performed remarkably well.
   - The scheme aims
     - to reward the best PIs of completed projects
     - to motivate the ongoing PIs to perform exceedingly well.

- DIA is a one-time career award devised to specifically cater to the younger scientists who have not received any other prestigious awards or fellowships.

2.4. SCIENTIFIC RESEARCH INFRASTRUCTURE FOR MAINTENANCE AND NETWORKS (SRIMAN)

Why need SRIMAN?

- In recent years India has seen **a growth in acquisition of research equipment (mostly imported)**.
- In many laboratories, expensive equipment lies idle or underutilized.
- According to a recent study by NSTMIS, DST (2013),
  - **94% of the research equipment used in India are imported** while **only 6% are being manufactured indigenously**.
  - **large number of equipment are not shared** and are marred with issues related to maintenance and want of spares.
  - This adds to the burden of research infrastructure costs.
- **A suitable ecosystem for sharing of scientific equipment** is a solution to this problem.
  - A culture of collaboration/sharing between institutions
    - **helps in optimum utilization of equipment => better maintenance of the equipment**.
    - **it eliminates duplicate purchase of expensive scientific equipment**.
  - Greater awareness of available equipment **can aid in cost reduction, attracting new minds to research and income generation from latent equipment through time sharing**.

Components of SRIMAN

- Procurement and maintenance of equipment and infrastructure for research
- Providing access and sharing of scientific equipment and infrastructure
- Disposal of scientific equipment and infrastructure
- Capacity Building of operators and technicians for efficient operations
- Monitoring of usage of expensive scientific research infrastructure
- Infrastructure Management for efficient operations

Features of Policy: It plans to hire out to researchers all lab equipment that cost more than ₹10 lakh.

How does it work?

- It envisages institutions declaring on a website **how often their instruments would be available for use by those outside the department or university**.
- Those who would like to use, for example, a DNA-sequencing machine, **would have to pay a fee and specify the purpose and time they would want it for.**

Advantages

- The Govt would now **rent instruments in government labs generating a steady rental income**
- This would **reduce the amount of time such expensive instruments remain idle**.
- The policy also aims through its proper implementation to increase **scientific output by wider access and reduce brain drain by providing access to wide section of researchers.**

Significance:

- It **will promote the creation of a regional ecosystem**, by galvanizing relevant stakeholders of scientific research infrastructure that provides wider access to scientists, researchers and industry professionals across the country.
- It **will also help in creating a pool of trained operators for operation and maintenance of the equipment**.

Benefits of SRIMAN

- **Maximizing use by providing equity of access:** Ready access to government funded scientific research infrastructure will enable more extensive and optimal use of a valuable public resource for the benefit of the community.
- **Avoiding Duplication:** By facilitating sharing of scientific research infrastructure and broadly monitoring utilization, duplicate purchasing of expensive scientific equipment will be avoided resulting in significant cost savings in research. This will also facilitate a mechanism to monitor the creation and maintenance of research infrastructure.
- **Efficient use of Public Expenditure:** Sharing of expensive public funded scientific research infrastructure will improve the efficiency of the public expenditure and also help reduce brain drain. This will provide enhanced access to scientific research infrastructure to scientists, researchers and industry professionals.

2.5. YOUNG SCIENTIST PROGRAMME

- Announced by Indian Space Research Organisation (ISRO)
- **Aim:** To **inculcate and nurture space research fervour in young minds**.
- **Eligibility:**
    - Mostly 8th standard passed out students will be given lecturers and access to research laboratories.
    - 3 students from each of the 29 States and 7 Union Territories will be selected for the Young Scientist program.
- It would be a **1-month programme**.
- The students will be exposed to the practical experience of building small satellites.
- ISRO also announced about setting up of an incubation centre in Tripura, Trichy, Nagpur, Rourkela, and Indore.

2.6. VISITING ADVANCED JOINT RESEARCH (VAJRA)

VAJRA Faculty Scheme has been conceptualized to bring an international dimension to the R&D ecosystem of India by leveraging overseas scientists' expertise to the Indian research framework.

The Objectives of the Scheme are:

- To tap the expertise of International Faculty / scientists/technologists including Non-resident Indians (NRI) and Persons of Indian Origin (PIO) / Overseas Citizen of India (OCI) in highly competitive areas of research and development by offering them adjunct / visiting faculty positions in Indian Institutions / Universities for specific period of time.
- Engaging NRI / PIO / OCIs in National R&D Programs and thereby deepen their engagement for value addition to various S&T programs, projects and missions of the Government.
- To catalyse possible institutional collaborations through faculty exchange.

The area of research under taken by the Faculty should be of interest to India including translation of science to practice. Faculty can also do teaching / mentoring during the period of stay. They could play other related roles in scouting for potential technologies within the Institution, review etc. and act as Mentors of start-ups housed at the Institution.

2.7. ATAL INNOVATION MISSION (AIM)

Atal Innovation Mission (AIM) is Government of India's flagship initiative to promote a culture of innovation and entrepreneurship in the country. AIM's objective is to develop new programmes and policies for fostering innovation in different sectors of the economy, provide platform and collaboration opportunities for different stakeholders, create awareness and create an umbrella structure to oversee innovation ecosystem of the country.

Five major initiatives taken in first year of establishment:

1. **Atal Tinkering Labs**-Creating problem-solving mindset across schools in India.
2. **Atal Incubation Centers**-Fostering world class startups and adding a new dimension to the incubator model.
3. **Atal New India Challenges**-Fostering product innovations and aligning them to the needs of various sectors/ministries.
4. **Mentor India Campaign**- A national Mentor network in collaboration with public sector, corporates and institutions, to support all the initiatives of the mission.
5. **Atal Community Innovation Center**- To stimulate community centric innovation and ideas in the unserved /underserved regions of the country including Tier 2 and Tier 3 cities.
6. **ARISE** (Atal Research & Innovation for Small Enterprises)-To stimulate innovation and research in the MSME industry.

The 42nd Amendment to the Constitution inserted one article namely Article 51 (A).

- 51(A)-h says that "It shall be the duty of every citizen of India to develop the scientific temper, humanism and the spirit of inquiry".
- Thus, a good citizen of India is duty bound to develop a scientific temper. Development of scientific temper among the people could, in fact, bring into focus the essence of all religions- the universal laws governing the inner world of human beings and, thus, promote communal harmony in a multilingual, muti-religious and multiracial country like India.
- Jawaharlal Nehru who popularised the term "scientific temper" in India. He dreamt of a nation with a "scientific temper". By this he meant people who would be able to think independently, understand and practice scientific methods in their daily lives, analyse and take informed and calculated decisions rather than taking statements at their face value and avoid simplistic reasoning

MISCELLANEOUS

1. E-CIGARETTES

Electronic cigarettes or e-cigarettes are **electronic nicotine delivery systems**, operated by battery, that people use to **inhale an aerosol**, which typically contains nicotine, flavorings, and other chemicals. They resemble traditional tobacco cigarettes. Its consumption is also called **vaping**.

Status in India

Government **opposes use of e-cigarettes and favours its ban** citing various reports including that of WHO in 2018 which highlighted harmful effects of their use.

Possible harmful effects:

- It vaporises nicotine containing solution which can have **adverse effects on the development of the foetus** during pregnancy and may contribute to cardiovascular disease.
- It may function as a "**tumour promoter**" and seems to be involved in the biology of malignant disease, as well as of **neurodegeneration**
- It can have **long-term consequences for brain development**, potentially leading to learning and anxiety disorder.
- E-cigarettes may promote carcinogens

The Prohibition of Electronic Cigarettes Bill, 2019, was passed by parliament.

- The bill defines electronic cigarettes (e-cigarettes) as electronic devices that heat a substance, which may contain nicotine and other chemicals, to create vapour for inhalation.
- The bill provides for imprisonment of up to one year, or a fine of up to one lakh rupees, or both to a first-time violator.
- For any subsequent offence, it says that the crime will be punishable with an imprisonment of up to three years, along with a fine of up to five lakh rupees.
- Under the Bill, no person is allowed to use any place for the storage of any stock of e-cigarettes. If any person stores any stock of e-cigarettes, he will be imprisoned for up to six months, or slapped with a fine of up to fifty thousand rupees, or both.

2. UAV REGULATIONS IN INDIA

A drone (or UAV) is a flying robot that can be **remotely controlled** or fly autonomously through software-controlled flight plans in their embedded systems, working in conjunction with onboard **sensors and GPS.** Government in August 2018 announced the **regulations** for use of Unarmed Aerial Vehicles or drones by **civilian population** in India.

Salient provisions

- Setting up the **Digital Sky Platform**, the national Unmanned Traffic Management (UTM) platform **to give or deny permission** to fly drones.
- Requirement for **one-time registration of drones**, pilots and owners and to obtain Unique Identification Number (UIN) from DGCA.
- Need to get a **Unmanned Aircraft Operator Permit** (UAOP) for the drone operators from the DGCA.
- **5 categories of drones** categorized by weight, namely Nano (Less than or equal to 250 grams), Micro (250 grams to 2kg), Small (2kg-25kg), Medium (25kg-150kg) and Large (Greater than 150kg): each having different level of regulations
- **Restriction on drone flights** to the daytime only and also around strategic & important places like airports, Vijay chowk in Delhi, border areas, sea coasts etc
- **Qualification required**: someone over 18 years of age, having passed 10th exam in English, and undergone ground/ practical **training** as approved by DGCA.

Applications

- Drones can be used in various civilian functions e.g. **crop and disaster damage assessment, border security management, e-commerce delivery, surveillance, traffic management, wildlife monitoring, aerial mapping, surveying, photography** and even in **product delivery**.
- For example: Government of India is developing drones for **SENSAGRI** (Sensor based smart agriculture) for crop and soil health monitoring using hyperspectral remote sensing.

3. TWO TIME ZONES IN INDIA

India's longitudinal extent ranges from **68°7'E to 97°25'E** and hence the middle longitude of 82°30'E has been taken as a **single Indian Standard Time**. However, India's longitudinal spread represents almost **two hours** from geographical perspective.

News:

- Recently, several leaders, civil society groups and experts from Northeastern India have called for **two time zones** in the country.
- **CSIR National Physical Laboratory** in October 2018, published a research report **supporting the idea**.
- A high-level committee under the **Department of Science and Technology had rejected** the idea in 2002 but the **Planning Commission in 2006 supported** the idea.

Need for two time zones:

- **Early sunrise** in North-east and Eastern India causes **loss of crucial daylight hours** as office, school and work timing is synced across India, hence a lot of sunlight is already wasted by the time work starts and this **pushes the closing hours well beyond sunset**, further wasting energy and **evening time for recreation**.

- Single time zone causes electricity loss of about **20 million kWh** annually which can be conserved if a separate time zone for East and Northeast India is allowed.
- A separate time zone will also positively impact circadian rhythm which will **increase productivity of workforce**.
- Countries like **USA, Russia** etc have adapted **multiple time zones** as well.

Challenges

- **Resetting clocks**: if the country were divided into **two time zones**, there would be **chaos at the border** between the two zones. It means adjusting the clocks with each crossing of the time zone.
  - For Instance, country like Russia has as many as nine time zones across contiguous territory, having to cope with the zones and to be forced to reset the watch each time you need to cross a domestic line could be complicated.

- **Confusion at railway signals: Railway traffic signals** are not fully automated and many routes have single tracks. Trains may meet with **major accidents** owing to human errors. Just one such accident would wipe out any benefits resulting from different time zones in the country.

- With a time difference of one hour in the mornings and in the evenings, there would be **nearly 25% less overlap between office timings in the two zones**. This could be important for banks, offices, industries and multinational companies which need to be constantly interconnected.

- Negative impact on NE region: This will be further **detrimental to productivity** and to the interests of the eastern region. There is already a **sense of alienation** between the relatively prosperous and industrialised western zone and the less developed eastern zone. The people in the Northeast sense a distance from the mainland and a separateness in clock time may accentuate it.

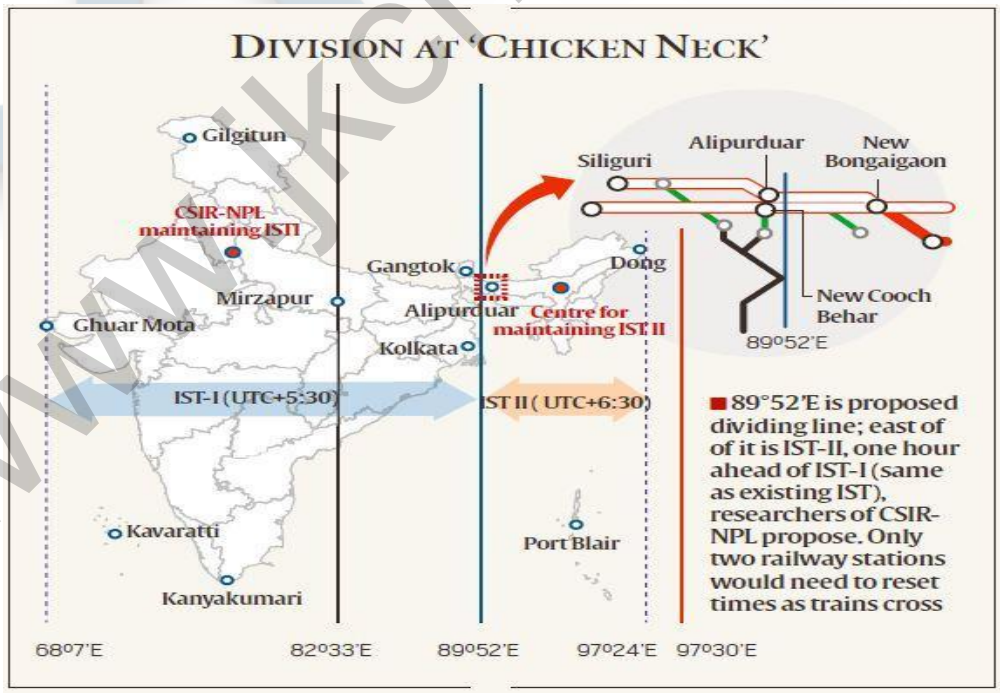


Figure: Indian time zone

4. 3D PRINTING

- Also known as "**additive manufacturing**".
- Technologies that build 3D objects **by adding layer-upon-layer of material**, whether the material is plastic, metal, concrete or one day.... human tissue.
- Any given shape can be formed by adding various layers of material.
- **Components of AM technologies:** the use of a computer, 3D modeling software (Computer Aided Design or CAD), machine equipment and layering material.
- **Process:** Once a CAD sketch is produced, the AM equipment reads in data from the CAD file and lays downs or adds successive layers of liquid, powder, sheet material or other, in a layer-upon-layer fashion to fabricate a 3D object.

Applications:

- AM application is limitless.
- Early use of AM in the form of **Rapid Prototyping focused on preproduction visualization models**.
- More recently, AM is being **used to fabricate end-use products in aircraft, dental restorations, medical implants, automobiles, and even fashion products**.
- **In Medical:**
    - Surgeons are using this technique **to print body parts for reference before complex surgeries**.
    - **To construct bone grafts for patients who have suffered traumatic injuries**.
    - A "surgical bolt" to facilitate less invasive foot surgery and remove the need for drilling through bone.
    - Printable resins, quaternary ammonium to combat dental diseases.
    - Highly porous pills (high dosage in small pills) have been produced.
- **In Engineering design:** It **allow engineers and designers to test out ideas for 3D products cheaply before committing to expensive tooling and manufacturing processes**.
- **Environment friendly:** This technique **generates low wastes than traditional techniques as 3D printing is additive in nature**.
- In design visualization, prototyping/CAD, metal casting, education, healthcare etc.

Prospects:

- **Space:** Offers the ability to print parts or tools on-site, as opposed to using rockets to bring along pre-manufactured items for space missions.
- **Bio-printing** is being explored.
    - It can be used to create organs and body parts. (through tissue and biomolecular printing).
    - Such products can be made in a cost-effective manner thus giving benefits to consumers.

5. 4D PRINTING

- 4D printing is the process through which **a 3D printed object transforms itself into another structure over the influence of external energy input as temperature, light or other environmental stimuli**.

Difference between 3D Printing and 4D Printing:

3D Printing	*4D Printing*
3D Printing is about **repeating a 2D structure, layer by layer in a print path, from the bottom to the top, layer by layer until a 3D volume is created**.	4D Printing is referred to **3D printing transforming over time**. Thus, **a 4th dimension is added: time**. So, the big breakthrough about 4D Printing over 3D Printing is **its ability to change shape over time.** A **4D printed object is printed just like any 3D printed shape**. The difference is that **the 4D Printing technology uses programmable and advanced materials which perform a different functionality by adding hot water, light or heat**. That's why **a non-living object can change its 3D shape and behavior over time**.
Objects printed with 3D Printing technology, are **characterized by rigidity**. ● That means that the 3D printed objects are going to keep their 3D shape once printed.	4D printing technology **uses commercial 3D printers, such as Polyjet 3D printers**. ● The **input is a "smart material", that can be either a hydrogel or a shape memory polymer**. ● Thanks to their **thermomechanical properties and other material properties, smart materials are given the attributes of shape change.**

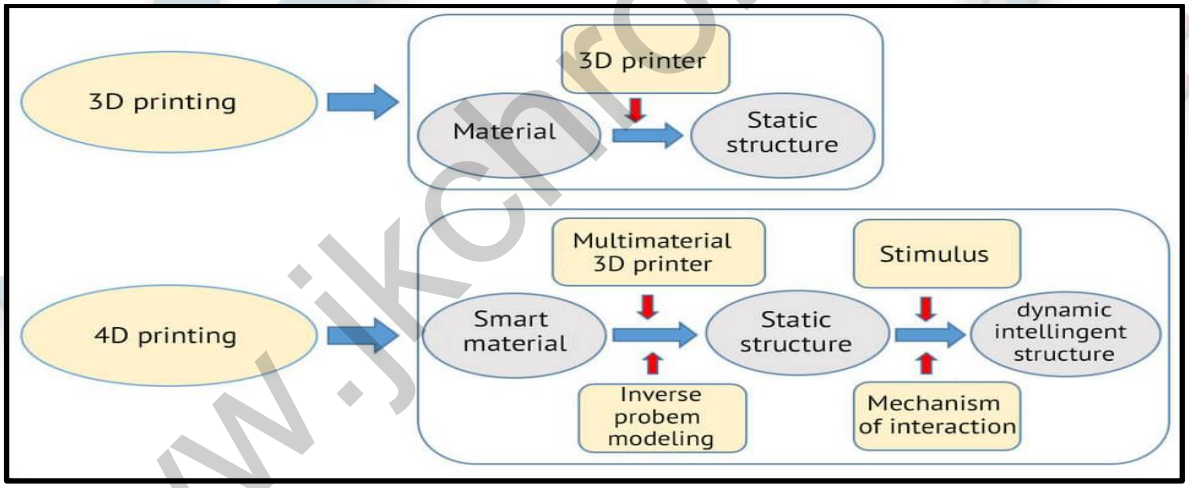


Figure: comparing 3D and 4D printing

Advantages of 4D Printing:

- Through computational folding, **objects larger than printers can be printed as only one part**.
- Since the 4D printed objects **can change shape, can shrink and unfold, objects that are too large to fit a printer can be compressed for 3D printing into their secondary form**.

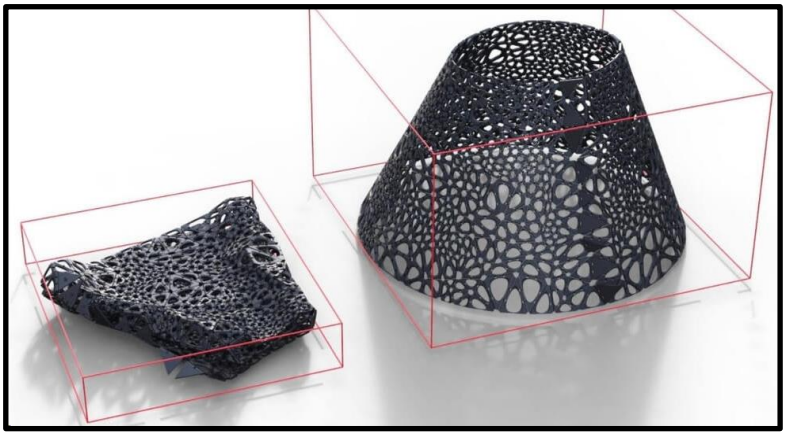


Figure: 4D printing

- Usage of the possible applied materials: 4D printing has a vast potential to revolutionize the world of materials as we know it today.
    - Multi Material Shape Memory Polymers.
    - Some materials **"remember" their shape, actively transforming configurations over time in response to environmental stimuli**.

Potential Applications of 4D Printing:

- **Pipes of a plumbing system that dynamically change their diameter in response to the flow rate and water demand**.
- Pipes that could possibly **heal themselves automatically if they crack or break**, due to their ability to change in response to the environment's change.
- Self-assembly furniture: Since 3D printing a furniture is limited by the size of the printer, 4D printing could allow to **just print a flat board that will curl up into a chair by just adding water or light to it**.
- **In space:** currently, the 3D printing process of building causes some issues related to cost, efficiency and energy consumption.
    - So, instead of using 3D printed materials, 4D printed materials could be used to take advantage of their transformable shape.
    - They could provide the solution to build bridges, shelters or any kind of installations, as they would build up themselves or repair themselves in case of weather damage.
- **In medicine:**
    - **4D printed proteins** could be a great application, as the self-reconfiguring protein.
    - **Pre-programmed self-deforming materials** in healthcare – researchers are printing biocompatible components that can be implanted in the human body.
- **Consumer products:**
    - Childcare products that can react to humidity or temperature.
    - Clothes and footwear that optimise their form and function by reacting to changes in the environment.
    - Home appliances and products that can adapt to heat or moisture to improve comfort or add functionality.

6. UMPIRE DECISION REVIEW SYSTEM (UDRS or DRS)

- It is a technology-based system used in cricket **to assist the match officials with their decision-making**.
- On-field umpires may choose to **consult with the third umpire** (known as an **Umpire Review**), and **players may request that the third umpire consider a decision of the on-field umpires** (known as a **Player Review**).
- The main elements that have been used are television replays, technology that tracks the path of the ball and predicts what it would have done, microphones to detect small sounds made as the ball hits bat or pad, and infrared imaging to detect temperature changes as the ball hits bat or pad.

The System:

A **fielding team may use the system to dispute a "not out" decision** and a **batting team may use it to dispute an "out" decision**.

- The fielding team captain or the batsman/batswoman being dismissed invokes the challenge by signalling a "T" with the arms or arm and bat.
- Additionally, at their discretion, **on-field umpires may request the Third Umpire reviews certain close calls** such as line calls (to determine run outs, stumpings and no-balls), boundary calls (to see if a batsman/batswoman hit a four or a six), or for close catch calls where neither umpire is sure if a catch was made.
- **Once the challenge is invoked, acknowledged, and agreed**, the **Third Umpire reviews the play**. The **Third Umpire then reports to the on-field umpire whether his analysis supports the original call, contradicts the call, or is inconclusive**.
- The **on-field umpire then makes the final decision**: either re-signalling a call that is standing or revoking a call that is being reversed and then making the corrected signal.
- **Only clearly incorrect decisions are reversed; if the Third Umpire's analysis is within established margins of error or is otherwise inconclusive, the on-field umpire's original call stands**.

Applications:

- While on-field Test match umpires have been able to refer some decisions to a third umpire since November 1992, the formal DRS system to add Player Reviews was first used in a Test match in 2008, first used in an ODI in January 2011, and first used in a Twenty20 International in October 2017.

Components in UDRS are:

- Television replays, including slow motion.
- **Hawk-Eye, Eagle Eye, or Virtual Eye: ball-tracking technology that plots the trajectory of a bowling delivery** that has been interrupted by the batsman/batswoman, often by the pad, and can predict whether it would have hit the stumps.

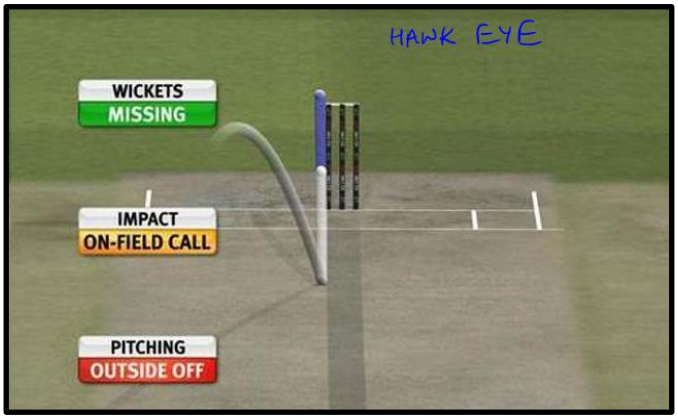


Figure: UDRS

- **Snickometer or Ultraedge** (Hawkeye's version): **directional microphones to detect small sounds made as the ball hits the bat or pad**. The use of the original Snickometer was superseded by Real Time Snicko in 2013.

Figure: Hawkeye's

- **Hot Spot**: Infrared imaging system that **shows where the ball has been in contact with bat or pad**.
    - Improved cameras were introduced for the 2012 season.
    - The system came under fire after the 2013 Ashes in England. It was claimed that using silicon tape **prevented faint edges being picked by Hot Spot**, which was later confirmed by a MIT report.

Figure: hotspot

Limitations: Each team can initiate referrals until they reach the limit on unsuccessful reviews.

- This limit is two unsuccessful review requests per innings during a Test match, and one unsuccessful review request per innings during a One Day International.
- From 2013 until September 2017, the number of reviews available for a team in a Test innings was topped-up to two after 80 overs.
- From October 2017, if the on-field decision remains unchanged because the DRS shows "umpire's call", the team will not lose its review.

7. INDIAN RAILWAYS: REGENERATIVE BRAKING SYSTEM

- **Regenerative braking** is **an energy recovery mechanism** which slows a vehicle or object by **converting its kinetic energy into a form which can be either used immediately or stored until needed**.

Regenerative braking System	Conventional braking systems	Dynamic Braking System
In this mechanism the **electric motor uses the vehicle's momentum to recover energy that would be otherwise lost to the brake discs as heat**.	In conventional braking systems, the **excess kinetic energy is converted to unwanted and wasted heat by friction in the brakes**	In dynamic brakes, energy is recovered by using electric motors as generators but is immediately dissipated as heat in resistors.

Benefits of Regenerative braking

- Improves the overall efficiency of the vehicle
- Regeneration can greatly extend the life of the braking system as its parts do not wear as quickly.

Applications:

- The most common form of regenerative brake involves an electric motor as an electric generator.
- In electric railways the electricity generated is fed back into the supply system.
- In battery electric and hybrid electric vehicles, the energy is stored chemically in a battery, electrically in a bank of capacitors, or mechanically in a rotating flywheel.
- Hydraulic hybrid vehicles use hydraulic motors to store energy in the form of compressed air.
- In a fuel cell powered vehicle, the electric energy generated by the motor is used to break wastewater down into oxygen, and hydrogen which goes back into the fuel cell for later reuse.
- **Bicycles:** Regenerative braking is also possible on a non-electric bicycle.

Regenerative braking in Indian Railways:

- When trains are required to be stopped or slowed down near railway stations or signals, the driver applies brakes. For this purpose, there are mechanical brakes, which work on compressed air, by converting the energy of the motion of a running train to frictional losses.
- However, in **three-phase locomotives**, even these losses are recovered. When the driver of a train wants to stop or slow down a train, he applies regenerative braking. The **motors of the locomotives which are normally pulling the train, change their mode of operation from motor to a generator**. The **mechanical energy of the train is converted to electrical energy by the generator**, which then

goes to the power supply grid. This feature is called regenerative braking. Thus, even braking losses are gainfully utilised in three phase locomotives.

- With this objective in mind, **3 phase locomotives were inducted into Indian Railways**.
    - Initially, these locomotives were imported from Switzerland on ToT basis (Transfer of Technology).
    - After 5 years, CLW (Chittaranjan Locomotives Works) started the production of three phase locomotive indigenously gradually reducing the import content to 5% only.
- North Central Railway runs around 250 passenger trains and 150 trains every day by electric locomotives. Out of these, about 25% of trains are run by about three phase locomotives.
- Since drivers running such locomotives were required to be given special training to utilise this feature, NCR has trained all its drivers to utilise regenerative braking.

8. BIODIGESTER TOILETS - DESIGNED BY DRDO

- Bio-Digester is **a decomposition mechanized toilet system** which **decomposes Human Excretory Waste in the digester tank using specific high graded bacteria** further **converting it into methane and water.**

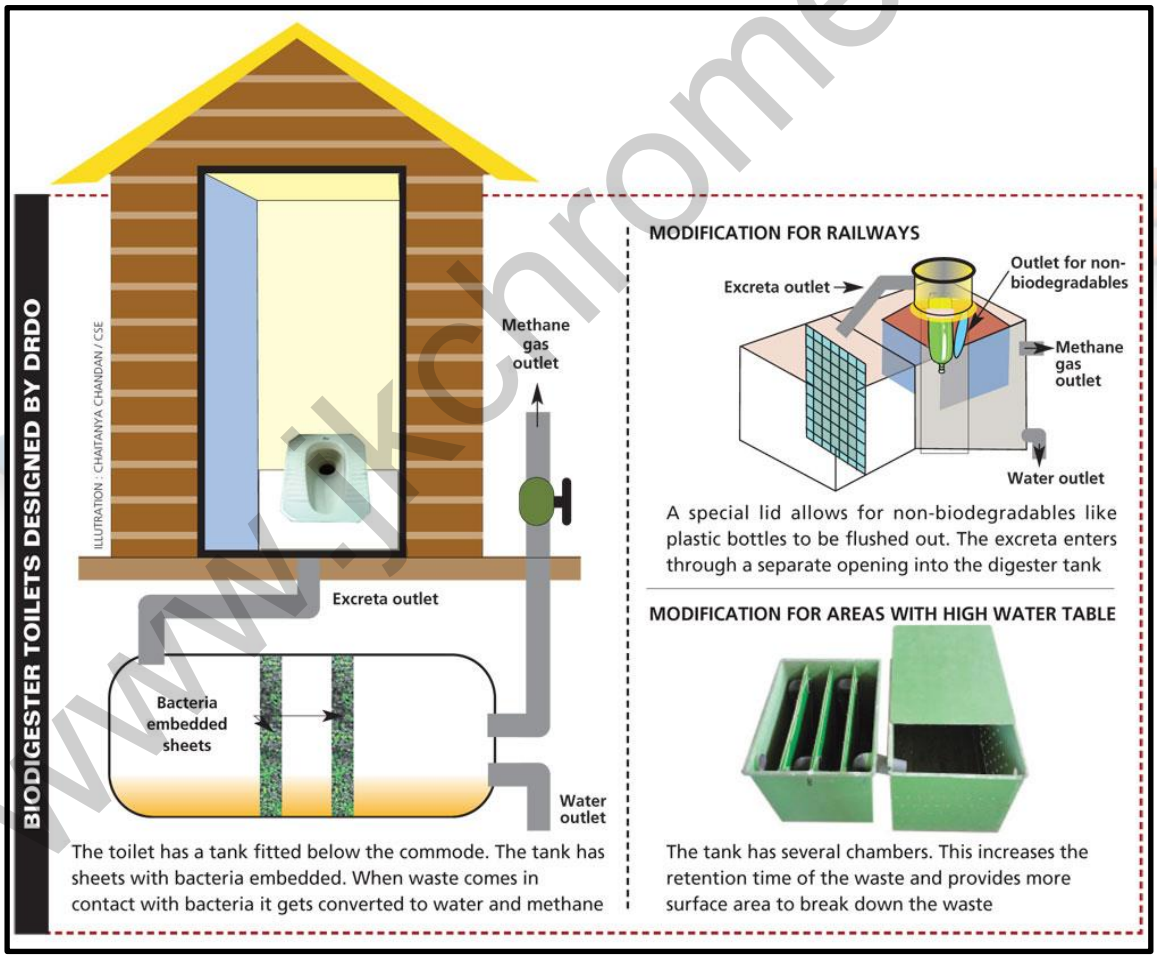


Figure: functioning of bio-digester

How does bio-digester work?

- Bio-digesters have **3 anaerobic chambers that treat Human wastes.**

- **In the 1st chamber, the Human wastes arrive** from the toilet's outlet, consequently the solids drop to the bottom of the tank because of the systematic structure of the bio-digester tank and the high graded pre residing bacteria (i.e. anaerobic bacteria, which can survive in the absence of oxygen) rushes for their job (i.e. eating away organic waste and decomposing entire occurring pathogens).
- When this chamber is filled, the **water overflows to the 2nd chamber** where more of the same happens, except at this time most of the biological/solid/sludged matter has been left in the 1st chamber. When the water overflows into the 3rd chamber, it is almost 90% clean and hence the final stage of digestion takes place.
- The treatment, the task of cleansing water is continuously carried forward from the start to the end point, till the water exits the bio-digester.
- When the treated water finally comes out from the bio-digester and into our irrigation pipelines (optional if required), it is 98% clean and free from entire pathogens.

Advantages:

- The Bio-digester is **total maintenance-free system**, which **does not require any sewage system**.
- The inoculums bacteria used in these bio-digester **procreate & generate new bacteria in an anaerobic environment** & **does not require repeat dosing**.
- It **digests organic solids in an ecological way**.
- It **prevents human waste and untreated water from contaminating groundwater**.
- It **offers an alternative to dumping of wastes into rivers/lakes/fields** in rural and semi-rural areas where there are no sewage systems.
- The effluent (i.e. the water) can be used to water plants and for irrigation purposes
- The effluent is cleaner, more effective and easier to use than a septic tank because it doesn't need to be further cleaned or emptied.
- The **effluent is odourless, non-obnoxious, colorless** as compared to the end products of the toilets being used these days.
- It **doesn't require the work and energy** involved in relocating composting toilets every year.

9. AVIATION SECTOR: GAGAN

- **GPS Aided Geo Augmented Navigation-GAGAN project**
- Implemented by ISRO and Airports Authority of India (AAI) as **a Satellite Based Augmentation System (SBAS) for the Indian Airspace**.
- **Objective of GAGAN** : To **establish, deploy and certify satellite based augmentation system** for safety-of-life civil aviation applications in India.
- **Features:**
    - The system is interoperable with other international SBAS systems like US-WAAS, European EGNOS, and Japanese MSAS etc.
    - Gagan works by **augmenting and relaying data from GPS satellites** with the help of two augmentation satellites and 15 earth-based reference stations.
    - GAGAN GEO footprint **extends from Africa to Australia** and **has expansion capability** for seamless navigation services across the region.
    - GAGAN Payload is already operational through GSAT-8 and GSAT-10 satellites.

- The third GAGAN payload will be carried onboard GSAT-15 satellite which is scheduled for launch this year.

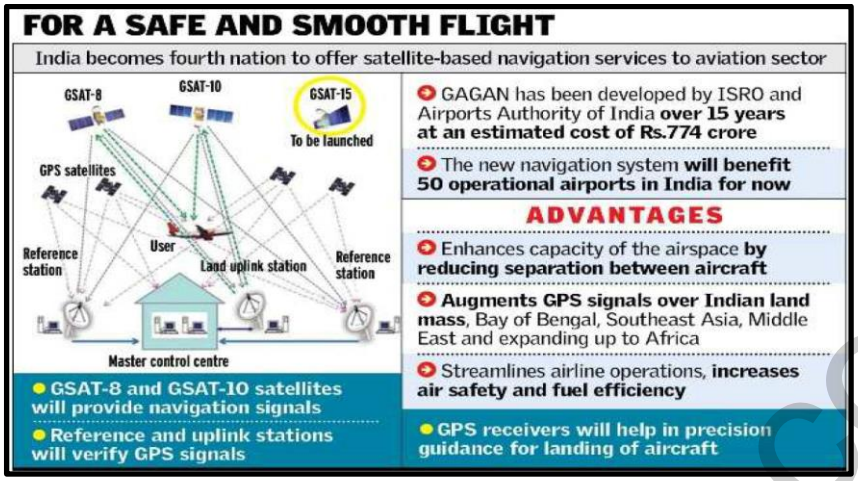


Figure: importance of GAGAN

Significance of GAGAN

- GAGAN system **corrects any anomalies in the position data + Gives accurate routes, landing guidance and time saving information** to the pilots.
- The system **bridges the gap in the coverage areas of the European Union's European Geostationary Navigation Overlay Service (EGNOS) and Japan's Multi-Functional Satellite Augmentation System (MSAS)**.
- It **will be able to help pilots to navigate in the Indian airspace by an accuracy of 3 meters**. => This **will be helpful for landing aircraft in tough weather & terrain** like Mangalore and Leh airports.
- Withdrawal of ground aids and reduced workload of flight crew and air traffic controllers => **Significant cost savings.**
- Accurate guidance for planning shorter routes and safer landing patterns.
- Improved efficiency, Direct routes, Increased fuel savings.
- GAGAN provide augmentation service for the GPS over the country, the Bay of Bengal, South East Asia and Middle East and up to Africa.
- The system would be **available for the member states of the SAARC**.

Drawback:

- One major drawback is that, **those aircraft that are fitted with satellite-based wide area augmentation system (SBAS) will be able to use the new technology**.

Applications:

- GAGAN enhances the GPS-derived details of location and time of objects.
- Focus on airlines, airports and the civil aviation sector but applicable to land and sea-based services.
- GAGAN will provide augmentation service for the GPS over the country, the Bay of Bengal, South East Asia and Middle East and up to Africa.
- GAGAN **provides the additional accuracy, availability, and integrity necessary for all phases of flight**, from enroute through approach for all qualified airports within the GAGAN service volume.

- GAGAN though primarily meant for aviation, **will provide benefits beyond aviation to many other user segments such as intelligent transportation, maritime, highways, railways, surveying, geodesy, security agencies, telecom industry, personal users of position location applications etc**.
- Karnataka Forest Department has used GAGAN to build a new, accurate and publicly available satellite-based database of its forestlands.
    - This is a followup to the Supreme Court directive to states to update and put up their respective forest maps.
    - The geospatial database of forestlands pilot has used data from the Cartosat-2 satellite.
    - The maps are meant to rid authorities of ambiguities related to forest boundaries and give clarity to forest administrators, revenue officials as also the public, according to R.K. Srivastava, chief conservator of forests (headquarters).
- Various Indian manufactured missiles including the BrahMos will use GAGAN for guidance.

Benefits:

- Improved efficiency, direct routes, increased fuel savings,
- Significant cost savings because of the withdrawal of ground aids and reduced workload of flight crew and air traffic controllers.

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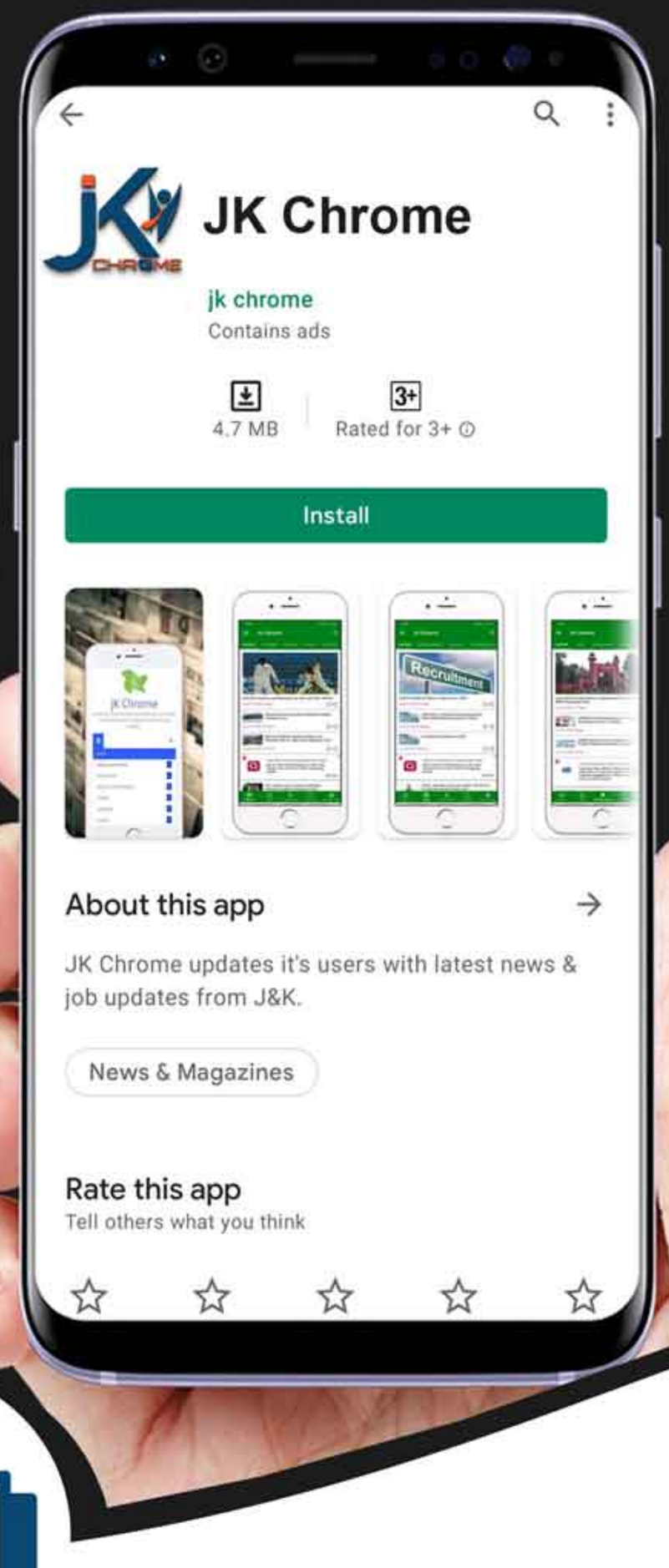

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