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# Space Research Contemporary & Expected Topics

- Dr. Manishika Jain, NTSE Scholar, UGC NET JRF, CSIR NET JRF  
Gold Medalist, Jawaharlal Nehru University, Delhi  
Planner, City of Hillsboro, Oregon, USA

## RLV-TD

Reusable Launch Vehicle –Technology Demonstrator

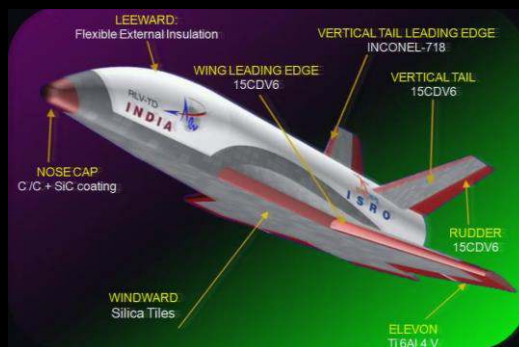
India's first winged body aerospace vehicle operating in hypersonic flight regime

To decrease the space cost and space debris

Capable of launching satellites into orbit around earth and then re-enter the atmosphere

Speed: Mach 5

Launched in 2016



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## ASTROSAT

- India's first multi-wavelength space observatory in 2015
- 6 billion year old vampire star captured – called blue straggler
- Launch Vehicle: PSLV — C30
- Understand high energy processes in binary star systems - neutron stars & black holes.
- Estimate magnetic fields of neutron stars
- Study star birth regions and high energy processes in star systems lying beyond our galaxy
- Detect new briefly bright X - ray sources in the sky
- Perform a limited deep field survey of the Universe in the Ultraviolet region
- Ultraviolet Imaging Telescope (UVIT): Observe Visible, Near Ultraviolet and Far Ultraviolet regions of electromagnetic spectrum.
- Large Area X-ray Proportional Counter (LAXPC): Study variations in emission of X-rays from sources like X-ray binaries, Active Galactic Nuclei and other cosmic Sources.
- Soft X-ray Telescope (SXT): Studying X-ray spectrum of 0.3-8 keV range from distant celestial bodies.
- Cadmium Zinc Telluride Imager (CZTI): Function in X-ray region, sense X-rays of high energy in 10-100 keV range
- Scanning Sky Monitor (SSM): Scan sky for long term monitoring of bright X-ray sources in binary stars, and detect and locate sources that become bright in X-rays for a short duration



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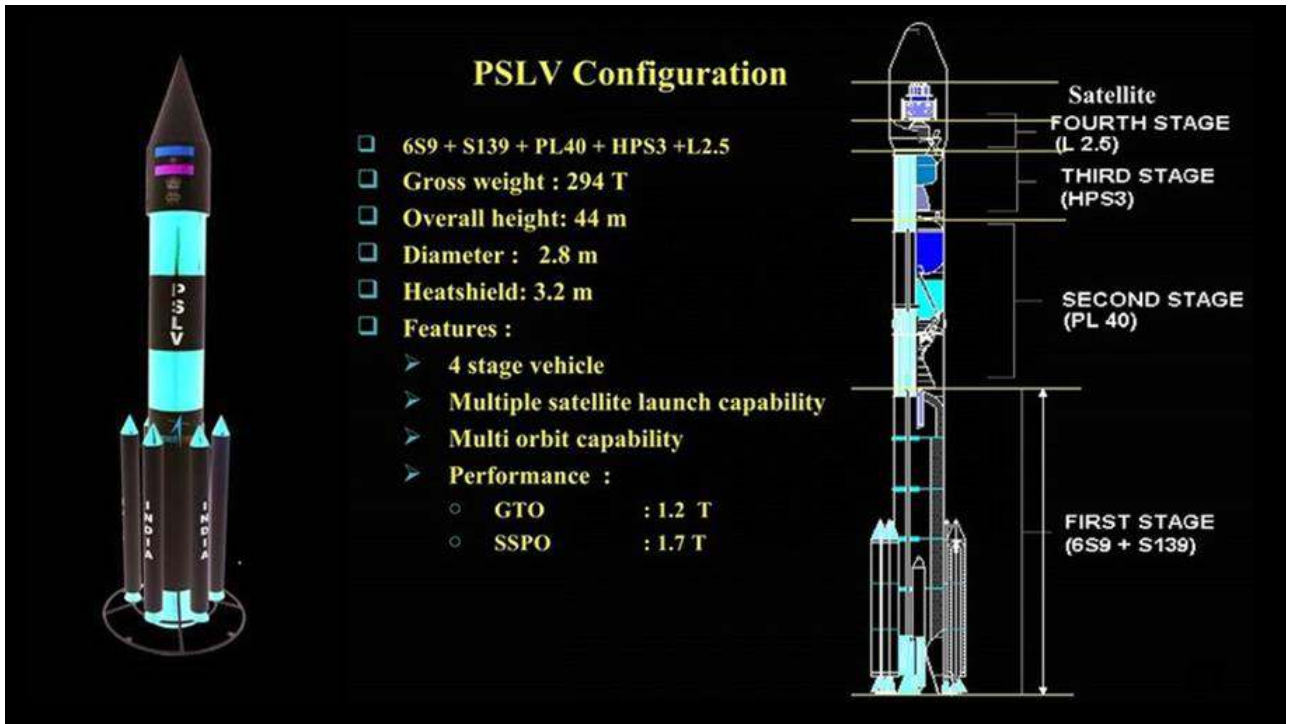
### Polar Satellite Launch Vehicle (PSLV)

- Payload Fairing: Can place multiple payloads into orbit->Multi-payload adaptors are used in the payload fairing -> Allows feat of 20 satellites launch
- Strap -On Boosters: 6 solid rocket strap-on motors by the first stage in its PSLV-G and PSLV-XL variants – not used in core alone version
- 1<sup>st</sup> Stage: PS1 is the first stage of PSLV and it provides the launcher
- 2<sup>nd</sup> Stage: PS2 & is powered by the Vikas liquid engine
- 3<sup>rd</sup> Stage: PS3 & penultimate stage of PSLV, and it uses a solid rocket motor
- 4<sup>th</sup> Stage: PS4 as final stage with two liquid engines

### PSLV – C34

- Cartosat-2 Series satellite - Earth Observation Satellite in Sun Synchronous Orbit to provide remote sensing services using panchromatic and Multi-spectral cameras
- Sathyabamasat: Satellite of Sathyabama University in Chennai
- Swayam: Satellite of the College of Engineering in Pune
- Asia: LAPAN-A3 (Indonesia)
- Europe: BIROS (Germany), M3MSat (Canada)
- North America: SkySat Gen2-1 (USA) of Terra Bella (Google); GHGSat-D (Canada); 12 Dove Satellites (USA)

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## **IRNSS (Indian Regional Navigation Satellite System)**

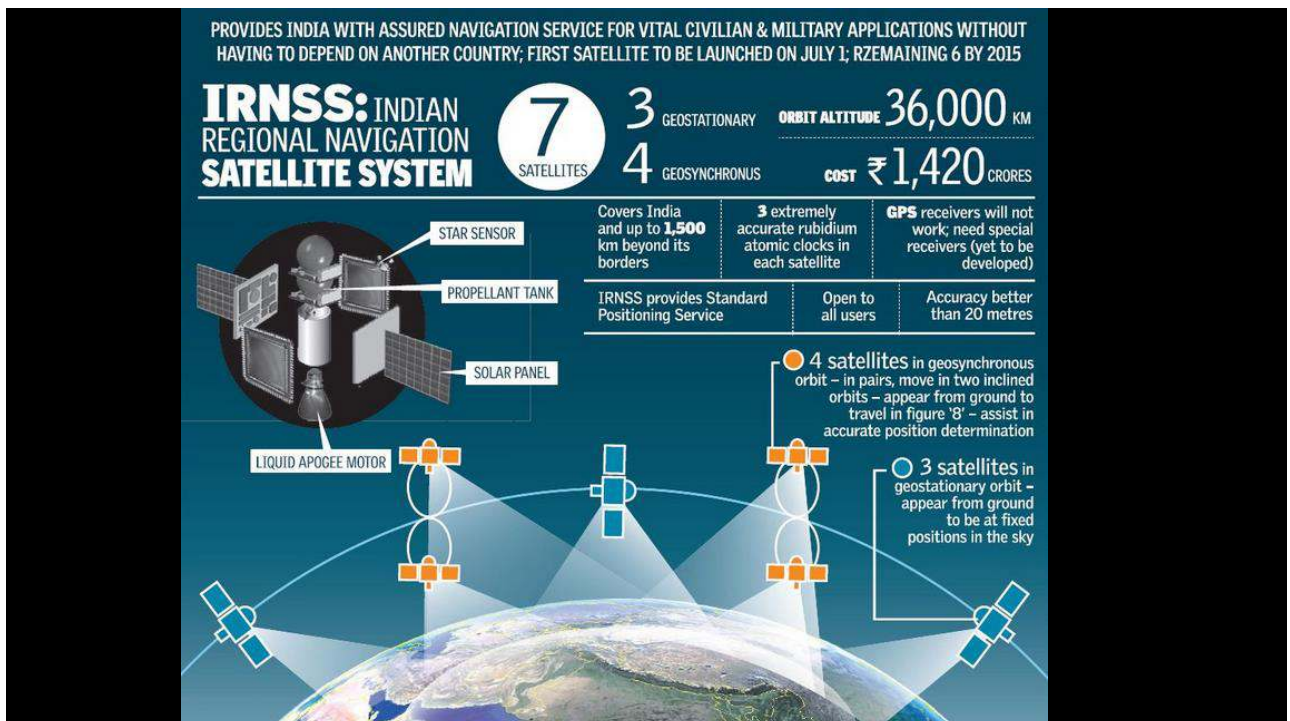
- Navigation with Indian Constellation (NAVIC) – includes atomic clock (each satellite has 3 clocks & total 27 clocks)
- Independent regional navigation satellite
- Designed to provide accurate position information service to users in India & region extending up to 1500 km from its boundary, which is its primary service area
- Standard Positioning Service (SPS) provided to all the users
- Restricted Service (RS) - encrypted service provided only to the authorized users

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## IRNSS

### Applications:

- Terrestrial, Aerial and Marine Navigation
- Disaster Management
- Vehicle tracking and fleet management
- Integration with mobile phones
- Precise Timing
- Mapping and Geodetic data capture
- Terrestrial navigation aid for hikers and travellers
- Visual and voice navigation for drivers



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### SONAR DOME

- First of its kind in India has been manufactured
- Designed by Research and Development Establishment (Engineers), DRDO laboratory in Pune
- Manufactured by Goa-based composites manufacturing company Kineco
- Technology used Vacuum Assisted Resin Transfer Molding (VARTM)
- Sonar (Sound navigation and ranging): Detect objects under water by emitting sound pulses and measure their return after being reflected
- Uses bouncing acoustic waves of objects, and determine their distances by measuring the time for return echoes.
- Used on board ships and boats to measure depths of water bodies, to locate underwater objects such as fish, submarines & shipwrecks.

### PROVe

- Indigenously-developed Remotely Operated Vehicle
- To map the coral reefs in Andaman & Nicobar Islands (hot-spots of biodiversity )
- Developed by National Institute of Ocean Technology
- Can map 4-6 sq.km per day
- Coral reef biodiversity at Andaman region, roughly around 11,000 sq.km
- Stress from the increasing sea surface temperature

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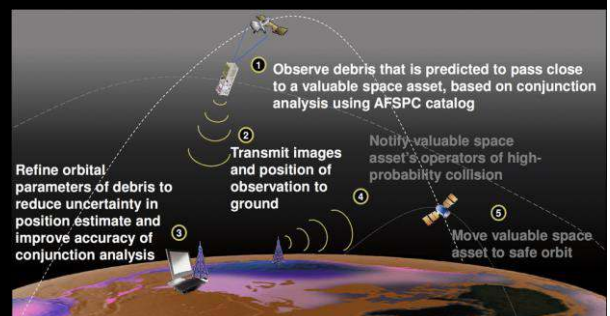
## PLANET 9

- Discovery of exoplanet or extra solar planet inside the solar system
- Exoplanet: A planet located outside our solar system
- **What happened?**-Sun, in its youth some 4.5 billion years ago, stole Planet Nine from its original star



## Space-Based Telescopes for Actionable Refinement of Ephemeris (STARE) Mission

- Help satellite operators prevent collisions in Low Earth Orbit (LEO)
- Pathfinder mission for a constellation of satellites
- "Space traffic cams" will lower false collision warnings, allow satellite operators to take action when in danger.
- Reduce uncertainty of 1 km to 100 or less to avoid and reduce number of collision of satellites and space debris.



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## Kirameki-2

- 1<sup>st</sup> military communication satellite
- On board of H2A rocket
- Upgrade communication network
- Check maritime activity & N. Korea missile threat

## TanSat

- By China
- Monitor carbon dioxide
- Launched on March 2-D rocket
- 3<sup>rd</sup> Nation after Japan & USA to have GHG monitoring satellite
- Monitor levels every 16 days



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### **Falcon 9 Rocket**

- Launches 10 satellites in orbit, part of McLean, Virginia-based Iridium's project to replace its existing network of satellites that provide global voice and data communication
- By company SpaceX – 1<sup>st</sup> privately funded company to successfully launch, orbit and recover a spacecraft (Dragon) in 2010

### **Explore Iron Rich Asteroid 16 Psyche**

- Approved by NASA
- Launched in 2023 and will reach in 2030
- Mineral contents are worth over 100-thousand times value of the entire world economy
- Diameter in excess of 125 miles & entirely made of iron and nickel
- Protoplanet i.e. its entire body is of what one day could be the core of a new planet
- Can have water – to be used for stellar fuel station, to sustain life and synthesize rocket fuel.

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## Vela Super Cluster

- Universe's biggest galaxy supercluster
- Carry 1 lakh galaxies with trillions of stars

## 104 Satellites in One Launch

- By PSLV (C37)
- In 2014 by Russia – 37 satellites
- In 2013 – NASA – 29 satellites
- In 2016 – ISRO – 20 satellites
- Separated satellites will have relative velocity of 1 m/s
- 1<sup>st</sup> satellite launched will move at relatively faster velocity than the next satellite.

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### GSLV Mk III D1

- 4 ton class of satellite into GTO (Geosynchronous Transfer Orbit) & 8 ton in LEO (Low Earth orbit)
- Heaviest rocket
- Next generation launch vehicle
- Game changer vehicle
- Payload: GSLV 19
- GSLV-19: Ka and Ku band payload with Geostationary Radiation Spectrometer Payload (GRASP)
- Indigenous cryogenic third stage - C25 - Uses Liquid Oxygen  $-193^{\circ}\text{C}$  & Liquid Hydrogen at  $-253^{\circ}\text{C}$  (generates high specific impulse)
- Cryogenic engine with complex technology only by Russia, US, France, China, Japan and India.
- 3 stage: 2 solid motor strap-ons (S200), liquid propellant core stage (L110) & cryogenic stage (C-25)
- Solid booster S200 is the third largest solid booster in the world



### LHS 1140 b

- Habitable planet
- In Goldilocks zone (habitable zone with moderate temperature)
- Orbits LHS 1140 – 39 light years away
- In Super Earth category – 6 times mass & 1.5 times large
- 1<sup>st</sup> cited in 1995
- 2018: James Webb Space Telescope (JWST) by NASA to succeed Hubble – study planets and detect familiar atmosphere will increase
- 52 potential habitable planets in solar system & 3600 outside solar system

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### Enceladus

- Saturn's moon – 6<sup>th</sup> Largest
- May be habitable
- Also Jupiter's 4<sup>th</sup> largest Moon Europa might be habitable
- Findings by NASA - Cassini-Huygens unmanned spacecraft (sent in 1997 to study Saturn) & Hubble Telescope
- Small icy moon
- Has hydrogen in water plumes
- Microbes - process of methanogenesis - hydrogen with carbon dioxide dissolved in the water helps to obtain energy

### Great Spot on Jupiter

- Second great spot
- Great Red Spot in 1830
- Great Cold Spot - magnetic forces responsible for Jupiter's polar auroras

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### Kepler-1649

- Kepler space telescope disc. Venus like planet
- 1/5<sup>th</sup> diameter of sun
- 219 light years away from Earth
- Insight into the nature of planets encircling around M dwarf stars
- Kepler space telescope – unmanned space observatory in 2009 by NASA

### Sentinel-2B

- 5<sup>th</sup> of Sentinel Earth observation satellite
- Will join Sentinel 2-A which was in orbit since 2015
- Part of multimillion Copernicus observation program (World's largest single earth observation program)
- Copernicus observation program is successor of European Envisat program (2002 to 2012)

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### **7 New Earth Sized Exoplanets**

- These orbit dwarf planet Trappist-1
- Detected by NASA's Spitzer Space Telescope
- TRAPPIST-1 e, f and g in habitable (Goldilocks zone)
- Exoplanets do not orbit sun but any star

### **Massive Planet orbiting X-Ray Binary Star**

- MXB 1658-298 is an X-ray binary
- Part of constellation Ophiuchus (serpent bearer)
- X-ray binaries consist of a pair of stars orbiting each other of which one is compact one such as a black hole or a neutron star.
- In X-ray binaries, time in-between eclipses of source can increase, decrease and also shows abrupt changes
- In MXB 1658-298: time between eclipses increases and decreases periodically

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### Mission to Study Neutron Star

- By NASA
- Neutron Star Interior Composition Explorer, or NICER, aboard a Falcon 9 rocket.
- Will focus on Pulsars (remnant of massive star)
- 1<sup>st</sup> demonstration of X-ray Navigation in space
- Insight of structure and starquakes

### KELT-9b

- Hottest exoplanet in universe
- Published in Journal Nature
- Temperature 4236°C
- 650 light years from Earth
- 2.8 times massive than Jupiter

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### World's largest Telescope in Chile

- Extremely Large Telescope (ELT)
- 5 times larger than the existing
- 3000 mt high in Atacama desert
- Cost – 1 billion euro in 2012
- Main mirror to measure 39 mt across
- By European Southern Observatory

### Earth Sized Storms on Jupiter

- Discovered by NASA Juno Spacecraft
- Jupiter has strong magnetic field – 7.66 Gauss (10 times stronger than Earth)
- Juno – 1<sup>st</sup> solar powered spacecraft to orbit Jupiter (2<sup>nd</sup> after Galileo) – completed 4<sup>th</sup> closest flyby of Jupiter



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### **Lunar Like Environment on Earth**

- Simulated by China laboratory
- Yuegong -1 or Lunar Palace
- World's most advanced closed loop life supporting technology
- World's third bioregenerative life support base
- 2014: 'Moon Palace 1', a 160m<sup>2</sup> self-contained laboratory to prepare placing astronauts in outer space for extended periods of time.

### **Sounding Rocket to Release Radiant Artificial Cloud**

- Terrier-Improved Malemute sounding rocket into the space that will release blue-green and red artificial clouds.
- Rocket will eject vapour canisters between 10 to 20 km
- Vapour tracers will be formed due to the interaction of barium, strontium and cupric-oxide
- Help to study ionosphere
- To study wind and earth's magnetic field

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### HAT-P-26b

- Water traces discovered
- By Hubble & Spitzer telescope
- Made of hydrogen and helium
- Published in Journal Science
- 437 light years away
- Planet metallicity is 4.8 times that of Sun

### Cassini Spacecraft

- Started 22 orbits
- Plunge into Saturn on 15 Sept 2017
- Complete 20 years journey
- Was launched in 1997
- Jointly by NASA, European Space Agency (ESA) and Italian space agency, Agenzia Spaziale Italiana (ASI).
- 4<sup>th</sup> space probe to visit Saturn & 1<sup>st</sup> to enter its orbit
- Has probe Huygens for Saturn's moon

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### Tiangong-2

- Cargo spacecraft Tianzhou-1 with Toangong-2 space lab
- Establish permanently manned space station by China in 2022, in orbit for 10 years
- Carry 6 tons of goods, 2 tons of fuel and can fly unmanned for three months.

### Parker Solar Probe

- By NASA
- Will be launched in 2018
- Study sun's outer atmosphere & how sun works
- Named after Astrophysicist Eugene Parker (gave solar winds idea in 1958) – 1<sup>st</sup> time named after living person
- Study structure and dynamics of plasma and magnetic fields at solar wind source
- NASA's first mission to the sun and its outermost atmosphere corona
- Scheduled to end in June 2025
- Made of Advanced carbon composite material – allows instruments to operate at room temperature

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### ADITYA L1

- India's first solar mission
- Will study Sun's outermost layers: Photosphere, Chromosphere and Corona
- Joint Venture: ISRO and physicists from other institutes of India
- Will be Placed: Halo Orbit around Lagrangian point 1 (L1) of Sun-Earth System (L1 lies on the direct line between Earth & Sun)
- Will collect data on Coronal mass ejection & Space weather prediction
- Will be launched in 2019-20 by PSLV