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B. S. Yediyurappa: The Game-Changer of Karnataka Politics

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Defence Prowess Towards New Horizon

Gaganyaan

Time to Get Back to Work

BY PRITAM ARORA

On August 15,2018, Prime Minister Narendra Modi surprised the world by announcing an ambitious national mission to send an Indian vyomanaut into space, onboard an indigenously-developed spacecraft launched into orbit by using an Indian rocket lifting-off from an Indian spaceport by the year 2022. If successful, the mission codenamed- 'Gaganyaan-1', will place India in the elite league of three other superpower nations- the United States of America, Russia and China, who have developed such technological capabilities of launching such highly complex missions. While the year- 2020 was a dampener with reference to the Covid-19 pandemic affecting ongoing preparations for the Gaganyaan mission, the new year- 2021 has brought new rays of hope with ISRO scientists and engineers having a serious relook at the delays caused in the human spaceflight programme after the conclusion of Aero India exhibition in Bengaluru.

Path towards heavy-lift capability

While the history of the Indian space programme dates back to late 1960s, the country became an orbital launch capable nation on July 18, 1980 with the first successful launch of 'Rohini RS-1' satellite to Low-Earth Orbit (LEO) onboard an SLV-3 (Satellite Launch Vehicle-3) rocket which lifted-off from Sriharikota. ISRO (Indian Space Research Organisation) has come a long way since then. While SLV-3 was the first generation of Indian rockets capable of lifting very lightweight satellites weighing up to 40 kg to LEO, the much improved ASLV (Augmented Satellite Launch Vehicle) with a lift-off capacity of 150 kg to LEO replaced it as a more robust launcher by the late 1980s. But with the advent of newer platforms like the medium-lift capable PSLV (Polar Satellite Launch Vehicle) rocket during the 1990s and the medium-heavy lift GSLV Mark-1 launcher armed with a Russian made cryogenic upper stage engine during the early 2000s, the foundations were gradually laid towards development of a heavy lift capability.

Finally, Indian space history reached a major milestone on January 5, 2014 when the GSLV Mark-2 rocket equipped with an indigenous CE-7.5 cryogenic engine successfully launched the 1982 kg GSAT-14 communication satellite to Geosynchronous Transfer Orbit (GTO). This was the first ever successful launch of a spacecraft from Indian soil by using an Indian made cryogenic rocket engine. As the GSLV Mark-2 rocket matured with back to back successful launches in 2015, 2016 and 2017, the more powerful GSLV Mark-3 made its maiden sub-orbital flight on December 18, 2014 with the CARE (Crew Module Atmospheric Re-entry Experiment) onboard. The new rocket, equipped with the third largest solid-fuel boosters in the world (S-200) and the more powerful CE-20 cryogenic engine, is capable of lifting spacecrafts weighing up to 8000 kg to LEO and 4000 kg to GTO. The GSLV Mark-3 underwent two more successful launches (developmental flights) in 2017 and 2018, thus rendering the rocket fit for full-fledged operational launches. The maiden operational flight of GSLV Mark-3 was executed on July 22, 2019 with the successful launch of Chandrayaan-2 spacecraft.

While the lifting capacity of Indian rockets kept evolving over the last 40 years with improvement in aerospace propulsion technologies, the heavy-lift capability gave enough confidence to the political establishment for discussing the proposal of a prospective manned spaceflight which may be executed in the near future. The Indian human spaceflight programme was the brainchild of eminent engineer and former Indian President Dr APJ Abdul Kalam. He had written and envisioned this dream project in two of his books published towards the end of the last century- 'The Wings of Fire' and 'India in 2020: A Vision for The New Millennium'. The proposal reached the policy formulation stage during the UPA-1 era in 2006 when 80 eminent scientists met at the ISRO headquarters in Bengaluru on November 7, 2006 and endorsed the plan. The proposal with an estimated budget of `5000 crores was also backed by then ISRO Chairman Dr. G Madhavan Nair and also by the first Indian astronaut- Wing Commander Rakesh Sharma, who had flown onboard the Russian Soyuz T-11 spacecraft to Salyut-7 space station in 1984.

WHILE THE INDIAN SCIENCE COMMUNITY WAS EAGER ON TAKING THE PROPOSAL OF HUMAN SPACEFLIGHT FORWARD, THERE WAS SOME INITIAL CONFUSION REGARDING THE ROCKET WHICH CAN BE USED FOR LAUNCHING SUCH A HEAVY MANNED SPACECRAFT INTO LEO (LOW EARTH ORBIT). HISTORY SAYS THAT THE UNITED STATES HAD USED THE TITAN-2 GLV ROCKET WITH A LIFTING CAPACITY OF 3580 KG INTO LOW EARTH ORBIT FOR LAUNCHING MANNED GEMINI CAPSULES WITH 2 CREW MEMBERS.

However, the then spineless and visionless UPA government gave a lukewarm response to the proposal by allocating merely `95 crores for pre-project activities. The mission never received the much-required cabinet approval during the UPA regime despite of basic technologies like the re-entry heat-shield mechanism already being developed during the SRE-1 (Space Capsule Recovery Experiment-1) spacecraft launched in January, 2007. The mission proposal was kept on hanging in abeyance. A natural follow up to the SRE-1 mission in 2007 was supposed to be the SRE-2 (Space Capsule Recovery Experiment-2) spacecraft with a proposed launch window in 2009. But unfortunately, SRE-2 was supposed to test some very critical technologies for a future Indian human spaceflight programme. The mission was supposed to execute microgravity experiments related to biological science and improved isothermal surfaces capable of withstanding temperatures up to 1000 degree Celsius during atmospheric re-entry. The crucial mission was put into the cold storage by the inefficient UPA government and the Comptroller and Auditor General (CAG) finally released a report in 2014 titled- 'Inordinate delay in realisation of SRE-2 mission'.

SRE-2 was finally cancelled on January 4, 2018. "While most of the aerostructures, engines and hot-structures for the SRE-2 mission was ready, there were some initial hiccups regarding the parachute and aerobraking mechanism after atmospheric re-entry of the capsule. The mission was finally cancelled due to the advent of the bigger CARE 2014 mission (Crew module Atmospheric Re-entry Experiment), which was conceptualised as a full-scale model of the atmospheric re-entry vehicle to be used in the manned spaceflight mission in 2022", says Dr S Gopalakrishnan, Chairman of the Department of Aerospace Engineering, IISc- Bangalore.

NDA-2 government accords cabinet nod

While the Indian science community was eager on taking the proposal of human spaceflight forward, there was some initial confusion regarding the rocket which can be used for launching such a heavy manned spacecraft into LEO (Low Earth Orbit). History says that the United States had used the Titan-2 GLV rocket with a lifting capacity of 3580 kg into low earth orbit for launching manned Gemini capsules with 2 crew members. Such a feat was achieved by the United States of America during the 1960s. China has reportedly reverse engineered the Russian manned 3-seater Soyuz capsule which has resulted in the Shenzhou programme taking shape and maturing during the last three decades. India's GSLV Mark-2, which is equipped with an indigenous CE-7.5 staged-combustion based cryogenic engine yielding 73.5 kilonewtons of thrust in vacuum, is potentially capable of being used for such missions provided ISRO manages to design a miniaturised2-seater spacecraft. By the end of the term of the worthless UPA-2 regime, there were talks of a prospective Indian strategic tie up with Russia for the transfer of Soyuz spacecraft technology to India for the manned mission. But the deal never materialised.

The success of the CARE mission in fall 2014 changed all dynamics and the Indian scientific community got the

confidence to launch the ambitious manned mission onboard a GSLV Mark-3 rocket. The indigenous CE-20 gas-generator based cryogenic upper stage engine of GSLV Mark-3 yielding 200 kilonewtons of thrust in vacuum, is potentially capable of launching a heavy 3-seater manned spacecraft to LEO. As the new rocket underwent two more developmental flights in successive years, it was finally selected by ISRO for launching the human mission.

The NDA-2 government led by Prime Minister Narendra Modi finally accorded the much-awaited union cabinet approval to India's human spaceflight programme on December 28, 2018 and formally made it a national mission, thereby clearing the final bureaucratic hurdle. The union cabinet also simultaneously approved a whopping `10,000 crores for the dream project, to be spent in phases over the next 3 years. The project officially christened- 'Gaganyaan' is slated to launch a 3-member crew to LEO for a week-long mission by 2022, when India celebrates the 75th anniversary of her independence from British rule. ISRO also carried out a successful Pad Abort Test (PAT) of the Crew-Module on July 5, 2018, a few months before the union cabinet approval of the programme.

Design of the manned spacecraft

With ISRO developing a highly durable and robust 3735 kg atmospheric re-entry vehicle (crew-module) for bringing back the crew back to earth, the plans for developing a separate 3000 kg service-module have also been finalised. The service-module will be mated with the crew-module and both will have a combined gross launch-weight of around 7800 kg (including fuel and other supplies), thus forming the orbital-module. The service module will also be equipped with two liquid-propulsion engines for gliding through the vacuum of space and orbital correction. The spacecraft will be equipped with life-support and environmental-control systems. It will also be armed with emergency mission-abort and emergency-escape systems which will enable the crew to handle all contingencies if there is a malfunction in GSLV Mark-3 rocket's first or second stages during the boost-phase of flight. The nose of the original version of the orbital module is also expected to contain a docking-mechanism (for docking with future Indian space stations), but primary entry will be reportedly through a side-hatch secured by explosive bolts. The service-module will carry solar-panels for electrical supplies.

The crew-module will be equipped with two parachutes for redundancy, while one parachute is good enough for decreasing the velocity for a safe splashdown into the sea. The two parachutes are expected to reduce the velocity from 216 meters per second to almost 11 meters per second when the spacecraft finally splashes down into the water. A set of retro-rockets installed under the crew-module will cushion the final impact. As the landing-zone has been designated in the Bay of Bengal, the crew-module will be armed with a balloon based floating-mechanism which will prevent it from sinking until Indian Navy/ Coast Guard ships locate the point of impact in the ocean and rescue and recovery teams are immediately redirected towards the exact landing-zone. Some of the systems, subsystems and manoeuvres, which will be used in the manned mission, have already been successfully tested during the CARE mission of 2014 that included orbital injection, separation from launch vehicle, atmospheric re-entry procedure, capsule separation, heat-shields and aero-braking systems, deployment of parachute, retro-firing, floatation systems and procedures to recover the crew-capsule from a remote area in the Bay of Bengal.

THE NDA-2 GOVERNMENT LED BY PRIME MINISTER NARENDRA MODI FINALLY ACCORDED THE MUCH-AWAITED UNION CABINET APPROVAL TO INDIA'S HUMAN SPACEFLIGHT PROGRAMME ON DECEMBER 28, 2018 AND FORMALLY MADE IT A NATIONAL MISSION, THEREBY CLEARING THE FINAL BUREAUCRATIC HURDLE. THE UNION CABINET ALSO SIMULTANEOUSLY APPROVED A WHOPPING `10,000 CRORES FOR THE DREAM PROJECT, TO BE SPENT IN PHASES OVER THE NEXT 3 YEARS.

Preparations in full swing

While the basic foundations of the mission have been laid, the final testing phase of many of the critical components are slated to begin by June 2021, with the maiden orbital flight of the orbital-module (in uncrewed version) also taking place by the end of this year. Meanwhile, ISRO is also in the process of launching two communication satellites under the IDRSS (Indian Data Relay Satellite System) programme, which will aid the manned spaceflight mission after launch. The two IDRSS satellites will provide seamless data communication links between the Indian remote sensing satellites in orbit, the Gaganyaan spacecraft and the ground stations. The new satellites will be placed in geostationary orbit. The Defence Food Research Laboratory (DFRL) is also developing 'space food' for the astronauts which will be consumed during the mission. A prototype 'Advanced Crew Escape Suit' (space suit) weighing 13 kg has also been developed, tested and performance verified by Sure Safety (India) Private Limited based on ISRO's requirements.

While the astronauts for the first Gaganyaan mission are likely to be trained in Russia, simultaneous preparations have begun to set up an Indian Human Spaceflight Centre in Bengaluru. Indian astronauts will be called 'Vyomanauts' and will be trained at the new centre in Bengaluru for future Gaganyaan missions. The new `1000 crore centre will impart training to the vyomanauts regarding rescue and recovery efforts, operations in zero-gravity environment and monitoring of radiation environment. ISRO has also signed a Memorandum of Understanding with the Institute of Aerospace Medicine (a prestigious institution under the Indian Airforce) for conducting research on the psychological and physiological needs of the crew, development of training facilities and the development of 'space medicine'.

Meanwhile, as of January 2021, the first batch of first four vyomanauts (including one backup crew member) is undergoing their year-long training programme at the Gagarin Research & Test Cosmonaut Training Centre (GCTC) in Russia. For obvious reasons, the first batch of vyomanauts consist of Indian Airforce test pilots. "Airforce test-pilots are perfectly fit for the Gaganyaan job as they have a very good knowledge and first-hand experience of different gravity environments and can face dangerous challenges in the skies due to their flying skills", says Flight Lieutenant Arvind Sharma, a recently retired officer of the Indian Airforce. "The task of training the initial batch of vyomanauts have just begun. If all goes as per plan, female vyomanauts can also be accommodated in successive Gaganyaan missions in the very near future", confirms Yash Guha, a former scientist at ISRO's Vikram Sarabhai Space Centre.

Deep space rendezvous dreams

While the Gaganyaan programme will be an ambitious beginning for the ISRO, the interstellar journey to the inner solar system and deep space will continue in the decades to come. ISRO is already working on the more powerful SCE-200 Semi-Cryogenic Engine

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(fuelled by Kerolox) with a thrust of 2,030 kilonewtons in vacuum, which will replace the current L-110 liquid propulsion stage of GSLV Mark-3 rocket that is presently propelled by a clustered stage of two 'Vikas' engines. Propellant weight of the hydrolox fuelled upper-stage cryogenic booster will also be increased from the current 25 tonnes to 30 tonnes. This new redesign will give the GSLV Mark-3 far higher lifting capability (up to 6 tonnes to GTO/ 12 tonnes to LEO) and will enable the rocket to carry very heavy space-station modules in the not too distant future. Upcoming new rockets with modular architecture like the ULV (Unified Launch Vehicle) can also give the country a Super heavy-lift capability which may open the doors for Indian manned lunar landing missions and further exploration (flyby and landing missions) of Mars and Venus and asteroids in the distant future. After the inner solar system is explored, ISRO may eventually set its goal on exploring the realms of the outer solar system in the latter half of the current century.

"Naturally, as ISRO starts sending manned missions to LEO, an orbital docking with a space station followed by a lunar human landing are the next logical steps in this direction. It is good that the government has now opened up this sector to large-scale private sector investments. There are already ongoing discussions towards the full-fledged involvement of the private sector in the industrial production and launching of PSLV rockets. But more needs to be done. The country needs a brand-new outer space policy initiative as well. India needs to be ready by the time the next generation of vyomanauts come up", says Sanjay Rathee, Founder of Space Development Nexus (SDNx), a collaborative platform for academia, entrepreneurs, technocrats and aerospace researchers. With a decisive, strong and visionary union government led by Prime Minister Narendra Modi at the helm of affairs, ISRO can always take giant leaps into the future. The potential is enormous and distant horizons beyond the earth's gravitational forces are ready to be explored with manned spacecrafts in this century.