UL SPACE CLUB

KOZHIKODE

Presents it's quarterly E-MAGAZINE

STELLAR CHRONICLE

SPACE AND BEYOND

UL SPACE CLUB

For Curious minds

EDITORIAL BOARD

INDEX

EDITORIAL

With the launch of “STELLAR CHRONICLE” a Quarterly E Magazine, the UL Space Club is embarking on yet another ambitious voyage. A voyage fuelled by the enormous enthusiasm and youthful exuberance of its members and well-wishers. Complementing the other activities of the club, Stellar Chronicle intends to facilitate a platform for exploring, expressing, and conveying the views, observations and creative outputs of the club members and well-wishers amidst a wider audience. I am sure that this objective will eminently be fulfilled, considering the track record of the club powered by the effervescent youth and the galaxy of patrons it has.

More than 50 years of Human activities in space has resulted in a continuing flow of social benefits improving the quality of life on earth. Critical knowledge and capabilities for developing Satellite Telecommunications, Global Positioning, Earth Observation, Weather forecasting, Manned spaceflight etc. have emerged. Space exploration has sparked new scientific and technological ingenuity and innovation not to mention the better understanding of our universe and the solar system that has accrued.

A new perspective on our individual and collective place in the universe has evolved. It will therefore be our endeavour to bring to you in the form of articles and excerpts, the history of space exploration as also technology as it unfolds. We are fortunate to have a galaxy of eminent space scientists and technologists as also other science and technology domain veterans amidst us, to hold our hands in this onerous task. I take this opportunity to seek their continued support and guidance, as also, invoke their blessings.

The magazine is structured in such a way as to kindle the interest of everyone it intends to reach out to. Scholarly articles by industry veterans followed by expressions by our student members on what they perceive and comprehend on technology - primarily space related will be on offer. Some columns and features are also included to keep the readers engaged and educated. The avowed aim is to kindle, promote and shape the written and creative faculties of our very gifted student members.

We proudly present this inaugural edition before you. We sincerely look forward to your critique towards betterment of quality, content, and structure. On behalf of the editorial team, I take this opportunity to congratulate everyone associated with this

venture. It is truly a milestone in our march forward. My sincere gratitude to our magnanimous patrons S/Shri Jyoti Basu, Dr S Rangarajan, Dr M R Sivaraman and P J Bhat for the inspiring felicitari messages. We will strive to live up to your expectations. Final words of gratitude to our editorial team, especially the student members for their devotion and commitment.

Welcome to STELLAR CHRONICLE. Happy reading!

Jayaram Kolangara

Chief Editor

MENTOR'S VOICE

E K KUTTY, Founder & Mentor
UL SPACE CLUB

1. Confronting Competency

1.1 Every class on any topic on Space is an excitement. School kids take part in it with high hopes, aspirations, expectations and even dreams. In such a class, I began shooting questions to them on Indian Space Programme, one after another. Smallest looking boy amongst them jumped up every time excitedly. Stunningly, I find his answer to the point, and sharp, each time. Deliberately, I kept posing tougher and tougher questions. This kid kept answering every question, posing a learned face. My attempts failed to derail him in the class. I changed my strategy and advised him to refrain from answering the next few questions. That was to give a chance to his classmates too. Thus, ensuring equitable chances to all kids. Reassuring him that if they fail, chance will again be his. He agreed, albeit reluctantly.

1.2 Suddenly, class turned serious. Expectant eyes turned against me, awaiting the next question. A cute girl with a peaceful face stood up and answered my next question. The subsequent two questions, too, got correct answers, one from the same girl and the other from another boy. However, questions that followed failed to elicit answers from them. So, I turned to him, the hero, whom I had given such a word. He had answers for every other question - on astronomy, astrophysics, rocketry, satellite, space applications, interplanetary missions and so on. That day turned out to be a highly satisfying day for me.

1.3 Concluding the class, I asked the hero boy and the cute girl to meet me before leaving the place. As I expected, the hero rushed up first with a curious face. I conversed with him about his academic and other interests and wanted to know what he wished to be as he grows. He wanted to work for NASA. That kicked a quick thought

in me. A Space Camp was scheduled in Bangalore a fortnight later. A NASA returnee is one among several other space scientists who will be taking classes in that Space Camp. I extended an invitation to our space hero for participation in that week-long Space Camp. He instantly agreed. The rest is history.

2. Hidden Talents

2.1 This happened during April 2015 at Vaghbhatanada mandir, Karaparamba, Kozhikode. The hero was P S Abhinand, then a 9 th standard student in GVHSS, Balussery. The cute girl, Noor Jaleela of 9 th class in a Kunnamangalam Convent School Both of them subsequently became well known students of Kozhikode for their achievements in academic excellence, social skills and leadership qualities. I kept on monitoring and enquiring the progress of their growth, with them and their parents, academically and otherwise.

2.2 Within a fortnight, on April 17, 2015, Abhinand travelled with me to Bangalore, stayed over there in my home and participated in a weeklong Space Camp there. He had the fortune of attending sessions handled by veterans of ISRO. He went on meeting most of them personally and he succeeded in building a bridge between them and him. He developed good rapport with many including Chairman Prof U R Rao (in whose name the ISRO Satellite Centre is now named). Abhinand wisely utilised the Space Camp to interact intensely to quench his thirst on what lies in deep space. Space Camp opened up enormous opportunities to him. Spending my 24x7 time with him that week, I found him to be an extraordinary student. He possessed a stupendous capacity far beyond his age in normal cases. My mind kept on telling me two things. Firstly, there may be many more Abhinands in and around Kozhikode. Secondly, Noor Jaleela has a bright future, academically and otherwise and students of her ilk, too, could be longing for nurturing in Kozhikode schools.

3. Birth of UL Space Club

3.1 I returned to Kozhikode with Abhinand. His father, an ordinary looking yet conversing with knowledgeable accent, came to the alighting point in Kozhikode and took charge of him. Reaching back home in Kozhikode, I chartered my new journey. A journey to find talented school students, nurture them well, develop them into what best they are suited for. Go even beyond that by identifying the top brains - groom them along. This dream project got shaped up well. It started in 2016 with ULCCS hosting the first ever Space Camp of Kozhikode in UL Cyber Park on 8th October 2016. Abhinand, Noor Jaleela and several talented students participated. Padmashri M

Chandra Duthan who did don the roles of Director, VSSC (so also that of SDSC SHAR, LPSC before that) excited the students with his motivating talk.

Several VVIPs blessed the students in their newfound path. It included Hon. Minister TP Ramakrishnan, ULCCS President Ramesan Paleri and so on. This new beginning heralded a new era, an era of UL Space Club. I became an integral part of students of Kozhikode who are driven by a Space dream and a definite destination.

3.2 The UL Space Club is a body of students who were selectively chosen to acquire and spread knowledge on Space Science, Space Technology, Space Applications as well the STEM. It comprises mainly students in 9th class and beyond in high schools and higher secondary schools with few exceptions in lower as well as higher classes. It draws support, help, guidance, and cooperation from many agencies such as ISRO, Regional Science Centre and Planetarium, Calicut, University of Calicut, NIT Calicut and so on. ULCCS, Kozhikode provides overall protection, care, and resources, as if it is the mother institution. Selfless and dedicated services of teachers and others at ULCCS make this Space Club totally unique in its service to students, typical work culture, its productivity and so on.

3.3 Horizons of the UL Space Club began widening as years passed by. Several Space Camps got organised. Most of it being residential, lasting two days and a night. Some of it on the campus of University of Calicut. Also, at NIT Calicut. Many students subsequently got the opportunity to visit ISRO centres such as VSSC, LPSC, IIST, URSC, ISTRAC, etc. Abhinand and one other student, Aniket Sanghi visited ISRO launch complex in Sriharikota, stayed overnight there and witnessed the launch of PSLV on a special invitation from Chairman, ISRO: a rare privilege.

4. Webinars

4.1 With the onslaught of Covid epidemic, physical activity had to end. We thus embarked on a series of weekly webinars involving veterans not only from ISRO but also several prominent R&D laboratories, Universities, NIT and even from abroad. First such webinar happened on 23 May 2020.These weekly webinars became popular as a Saturday Webinar series. Quiz competitions during the webinar became another attraction, attracting several students from within and outside Kerala to participate in the webinar and compete in the quiz. Webinar and quizzing participants are spread across the country and even abroad. Winner of the quiz this month is from Switzerland.

5. Capacity Building

5.1 We have made special efforts for augmenting capacity building in our students through various means. Chosen ones are trained to succeed in national level competitive tests like NTSE, JEE, KVPY, etc. Skill acquisition and leadership development is happening by engaging student leaders in planning, organising, executing various programmes by themselves. A website was recently launched for the use of our students, academics, beneficiaries, associates, and general population.

5.2 This E-Magazine is the brainchild of our own students. They conceived the idea themselves, worked out its contents and coverage, designed its layout, sought blessings, encouragement and articles from veterans of ISRO and others, brought out a worthy issue and launched it today, the 23rd May, 2021: the day we are celebrating the anniversary of the launch of our first ever UL Space Club Webinar. I am happy that Shri K Jayaram played a key role in leading and guiding the students in this novel venture donning the role of the chief editor.

5.3

It is gratifying to note that the launch of the E-magazine is being done by none other than Padma Shri M. Chandraduthan who helped herald the onset of Space Club in Kozhikode through the very first Space Camp at UL Cyber Park on 8th October 2016. I am sure that this E-Magazine will be of immense utility to space enthusiasts globally. I expect the very same students and their worthy successors will make it excel in every subsequent issue.

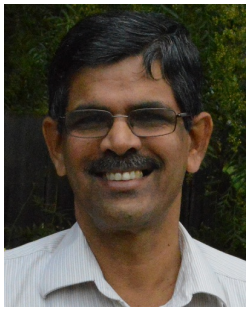
6. Conclusion

UL Space Club may be the only such body of its kind in Kerala, and perhaps in India. It is active throughout the year. It is popular amongst veteran scientists in space and associated areas including STEM. A large section of students across the country are its beneficiary.

All these are made possible by very many large hearted, selfless souls whose names I refrain from mentioning since the list is too long. I salute them and seek their continued support, guidance, and help.

With Best Wishes to the UL Space Club and to one and all associated with it.

FELICITARI MESSAGE



JYOTHI BASU

Former Director, SRA India

I am very glad to learn about the new initiative from ULCCS Space Club, the launch of the E-Magazine STELLAR CHRONICLE. My congratulations to the whole team behind this endeavour. This is going to be a good platform especially for our young students to explore and express. I am sure they will make good use of it. In whatever new areas they venture into, I hope they try to see the solid use of basic sciences. Once the hold on the basic sciences is firm then anything is possible. With the release of the STELLAR CHRONICLE, the onus will be mostly on the students to keep it alive with participation and active involvement. Wish the E-magazine a great success.

FELICITARI MESSAGE

Dr. S Rangarajan

Director (Rtd), ISRO

I am glad that UL Space Club is embarking on yet another milestone with the launch of its e-magazine. During the very successful series of weekly webinars, I have noted with immense satisfaction the enormous enthusiasm as well as deep understanding of the frontiers of knowledge by the young and energetic members of the club. “Stellar Chronicle” would surely complement the webinar series with a vehicle to express their thoughts in a written form and exchange thoughts among themselves and with the galaxy of well-wishers of the UL club. Unlike the webinars that occur once a week, the magazine would provide something to write as well as read as often as needed. Some of the resource personnel who find it difficult to accommodate a time slot for the lecture would now more willingly write an article for the magazine. One of the outstanding merits of the UL Club is the organizational skills. This would help create a unique format for Stellar Chronicle, with features and columns to keep each of the readers engaged and educated, in keeping with tremendous growth in this sector, which is truly multidisciplinary. With experts willing to clear their doubts, the younger minds get a much-needed outlet to express their thoughts Freely. My best wishes to the dedicated editorial team and I am sure the magazine will bloom to project the important happenings and in-depth articles on space, astronomy, and allied fields. Set your targets high and you will well go to stellar heights!

FELICITARI MESSAGE

Dr. M R Sivaraman
Deputy Project Director (Rtd)
SAC, ISRO

With recent advances in Space Science and Technology, interest among the School and College going students to learn more about Science, especially Space Science, Space Technology, Astronomy, and Astrophysics have increased. The successful “Chandrayan & Mars Orbiter Missions (MOMS)” and future planned missions of ISRO, like “GAGANYAN, ISRO’s First Crew Mission” & “Aditya Mission, ISRO’s first mission to explore the Sun” are good examples. The recent Missions to Moon by the US, China, and UAE, have also created more interest among the students. I am very happy that UL Space Club, Kozhikode, has almost for the last one year, successfully arranged a lot of Webinar lectures on many topics of Popular Interest in Space Sciences like Expansion of the Universe, Black Holes, GPS, Remote Sensing, etc. This Webinar Series ran successfully despite the Covid Pandemic in our country. These lectures have created more interest in Space Science and Technology, among students not only in Kerala but outside Kerala. I am very happy to hear that UL Space Club from Kozhikode, Kerala, has now taken a good step to start an E-Magazine, “STELLAR CHRONICLE”, mainly for the students and followers of UL Space Club, with an aim to educate them, motivate them and create more interest among them in Space Science and Technology. I am sure that many articles (many of them on popular topics of today, in simple Language) published in this E-Magazine, by many experts from Indian Space Research Organisation (ISRO) and many other Institutes, will be helpful to many School and College going students. In addition, many School and College Students in India, have started building satellites for Scientific Studies and many of them are successfully launched by ISRO and even by NASA. I am sure that this E-magazine can be helpful to the interested students to learn more about Space-related activities, discuss their ideas and even participate in future Space Programs. I like building simple satellites and carrying out advanced research in Space science and Astronomy. I wish the organizers Great Success in their new venture!!

FELICITARI MESSAGE

P J BHAT

Former Deputy Director, URSC ISRO

It has been a great pleasure interacting with members of the UL SPACE CLUB all these years. I have continuously observed and admired the efforts of this team which has been mentored by Shri E. K. Kutty in kindling scientific awareness among enthusiastic and talented youth. My association with this team began a few years ago, at a Space Camp organized by them in association with Cindrebay Nurture at City College, Bangalore. Then I went on to collaborate with them as a resource person in the multiple Space Camps organized by this team at IISc and NIAS in Bangalore and a couple of camps at Kozhikode. Every one of these events enabled me to connect with several intelligent, enthusiastic youngsters who were deeply curious about space and astronomy. The bond with these youth further developed when they later joined the WhatsApp group 'Bahyakasha' created by me with the aim to spread awareness on these topics. I have also had the honour of participating in several events conducted by them in Kerala and Karnataka. The organizational and planning capabilities of the students, elders, and mentors in this group have often impressed me. The onset and ongoing situation of the pandemic have not deterred this strong team from their endeavours towards motivating the youth with scientific zeal. On the contrary, their grit and determination in organizing talks (in the form of Webinars) almost every week for the last eight months are exemplary, especially given that it involved coordinating with various resource persons, planning topics, and delivering sessions of very high quality consistently. These efforts of the UL SPACE CLUB have enabled it to reach out to an exceptionally large audience all over India. I am also pleased to know that the Club is planning to bring out a quarterly online magazine titled 'Stellar Chronicle'. I look forward to reading their first issue with delight and have no doubt about them coming out with flying colours in this new venture, as has been the case in all their endeavours in the past. My sincere best wishes to the enthusiastic student team.

AIMS AND OBJECTIVES

Curiosity is the basic quality of a child and the responsibility of the educators is to maintain the curiosity and foster it throughout the long journey of education. Sky is ever curious for all humans from the time of his special brain development. But there is a great distinction between mere watching and observation and some external influences are essential to transform mere sky watching to observation. When the process of observation is flavoured with curiosity and scientific methodology, it will trigger a spark in the minds of students. The application of information received from the observation will cause the opening of infinite windows of knowledge beyond the sky to space.

Environment is the pivot component in the development of a student. In fact, the formal educational system provides ample scope for development of our students. But that is not enough to raise the students to their zenith of maximum attainability in a normal course. These facts and philosophies are the foundation of the U L Space club, which was established in the year of 2016. By this, an ecosystem for STEM is being evolved at Kozhikode under the guidance of the visionary Mr. E K Kutty, former Director of ISRO and the mentor of U L Space Club under the umbrella of ULCCS, a major contributor in infrastructural development of the country. However U L space club envisaged to create an enthusiastic environment with unprecedented events and opportunities. It happened due to the widening web of the team including academicians from higher education institutions like National Institute of Technology Kozhikode, University of Calicut and many veteran scientists and technocrats from ISRO and allied institutions who are wholeheartedly supporting this endeavour.

Five years back the only major highlight of this venture was the face-to-face interactions at limited occasions with available resource persons in the annual space camps at different venues. Fortunately, the pandemic made us more active on online platforms. Now we are well adapted to the situation as it proved that distance and availability of resource persons is not at all a barrier for our programs.

The space club is having a three-tier system comprising an outer tier with global accessibility named cosmos and anybody interested in space activities with an interactive mind can join there. The second tier is for the highly enthusiastic and interacting students to explore and enjoy the exposures of the club activities directly. These students are being given the opportunity to expertise in organizing and presenting skills. The inner tier is the highly privileged group who are selected through

a series of procedures like paper presentation in high academic bodies, organizing and communication skills, and skill in nurturing young space club members.

We are active with a working calendar of activities including sky watch, space camps, webinars, quiz programs, Science Projects, discussions and debates and academic practices for entry to premier higher education institutes of India. There are enough opportunities for the public all over the globe to know about these activities through our website, Facebook page, YouTube channel and other social platforms. Of Course, our children are moving in the right direction with big dreams in their curious minds along with the support and blessings of their well-wishers to be the pride of our nation.

Shajil U K

Evolution of Satellite Navigation

Introduction:

Throughout time, People have developed many methods to determine their position on earth and the means to navigate from one place to another. Early mariners relied on angular measurements to celestial bodies such as the sun and stars to calculate their location. The magnetic compass was invented in the early 1200s and was followed soon by the sextant, which underwent refinement over the next several centuries. Marine chronometers, developed in the late eighteenth century, provided precise timing measurements that, when coupled with sextant sightings of planets and stars, signified the only reliable means of determining a ship's position in unfamiliar waters.

With the development of Radios in the early 1920s, another class of Navigation aid was born. These included Radio Beacons, VHF Omnidirectional Radios (VOR), Long Range Radio Navigation (LORAN), and OMEGA. But the military recognized that surface-based beacons suffered at least one strategic flaw—they were vulnerable to enemy attack. They were also less accurate and did not provide Global Coverage.

The space race provided a solution to this by placing the beacons in earth-orbiting satellites. Following the 1957 launch of the Soviet Union's Sputnik 1, the world's first artificial satellite, a team of US scientists monitored Sputnik's radio transmissions. They discovered that, because of the Doppler effect, the frequency of the signal being transmitted by Sputnik was higher as the satellite approached, and lower as it moved away. They realized that since they knew their exact location on the globe, they could pinpoint where the satellite was along its orbit by measuring the Doppler distortion. Thus, a new Technique "Satellite Navigation" was born.

Evolution of Transit, the first Satellite Navigation System and GPS (Global Positioning System):

The first US satellite navigation system, Transit, was a constellation of six navigational satellites that was declared operational in 1964. The US Navy developed and deployed Transit to help guide its Polaris ballistic missile submarines and missiles. The system provided a two-dimensional navigational fix approximately once per hour, with a rated accuracy of 100-200 meters. Russia also developed a similar Satellite Navigation System "Tsikada''. Both these served Ships but were not suitable for safe Aircraft Navigation, especially during Landing and Take Off !!!

The GPS project was launched in the United States in 1973 to overcome the limitations of Transit. The U.S. Department of Defense developed the system, which originally used 24 satellites. It was initially developed for use by the United States military and became fully operational in 1995. Civilian use was allowed from the 1980s.

Principle of GPS:

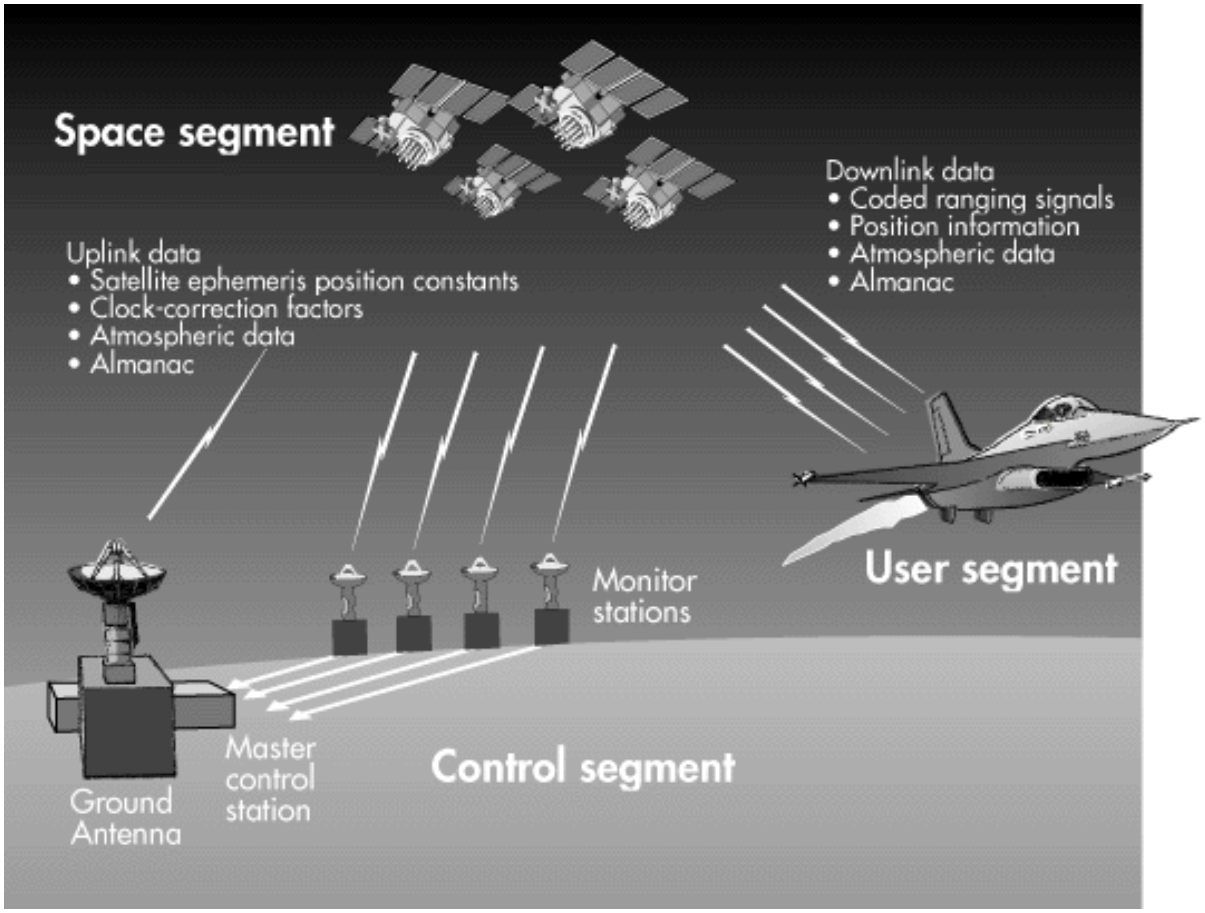


Fig. 1: Principle of GPS

The basic Principle of GPS is shown in fig. 1 above. It consists of (1) A Space segment (2) A Control Segment (3) A User Segment. The Space segment consists of 24 orbiting satellites at a height of 20,000 kms, at 6 different orbital planes. This makes sure that a minimum of 4 satellites are visible at a time anywhere, All the satellites carry an Atomic Clock (either a Cesium Beam or Rubidium Vapor Clock), a memory, a receiver, and a transmitter. The GPS satellites transmit continuously at two frequencies viz. 1575.42 and 1227.6 MHz (commonly known as L1 and L2), a 1.023 MHz or 10.23 MHz ranging signal and 50 Hz Navigation data. The ranging signal can be used to determine distance to the satellite by a Handheld receiver on Ground. The Navigation data can be used to compute the position of the satellites. The satellites are continuously tracked by a Worldwide Network of tracking stations, known as Monitor stations, that

forms part of the Control Segment. The Monitor stations transmit in real time, the tracking data (distance to the satellites and other parameters), to a Master Control Station located in the US. This data is used to compute the Satellite Ephemeris of the satellites for next 12 hours (useful to compute satellite positions), the satellite clock correction factors and other atmospheric parameters. This is transmitted to the respective satellites to be stored and retransmitted to the Users. The User Segment has a Receiver, that determines range to the satellites and collects the Navigation Data, to compute its position. The receiver collects data from four satellites and determines its position (Latitude, Longitude and height) and its Receiver Clock Offset with respect to the satellite Clock, by solving four observation equations. Typical accuracy of GPS is about 100m in positioning.

Other Satellite Navigation Systems:

Since GPS is a system belonging to the US Department of Space, there was a doubt among other countries like Russia, European Countries, China, and India, whether GPS may be available during War. In fact, GPS was available during the Iraq War only to the US and their allies. During the Kargil War in 1999, our army and air force were denied the use of GPS. Thus, other countries like Russia, European countries, China and India started developing their own Satellite Navigation System. In Principle, they work like GPS.

Glonass

Russia (formerly USSR), also started development of GPS like Satellite Navigation System, known as GLONASS in 1976, with a goal of a Global Coverage by 1991. But only in 2011, GLONASS Program completed the full constellation of 24 satellites and the goal achieved – Performance significantly improved. Glonass is not as popular as GPS, outside Russia. It is stated that at peak efficiency the system's standard positioning and timing service provide horizontal positioning accuracy within 57–70 meters, vertical positioning within 70 meters, velocity vector measuring within 15 cm/s, and time transfer within 1 μs (all within 99.7% probability).

Galileo :

Galileo is a global navigation satellite system (GNSS) that went live in 2016, created by the European Union through the European Space Agency (ESA), operated by the European GNSS Agency (GSA), headquartered in Prague, Czech Republic, with two ground operations centres in Fucino, Italy, and Oberpfaffenhofen, Germany. The €10 billion project is named after the Italian astronomer Galileo Galilei. One of the aims of Galileo is to provide an independent high-precision positioning system so that

European nations do not have to rely on the US GPS, or the Russian GLONASS systems, which could be disabled or degraded by their operators at any time. The use of basic (lower precision) Galileo services is free and open to everyone. The higher-precision capabilities are available for paying commercial users. Galileo is intended to provide horizontal and vertical position measurements within 1-metre precision, and better positioning services at higher latitudes than other positioning systems. Galileo is also to provide a new global search and rescue (SAR) function also.

Beidou: The original idea of a Chinese satellite navigation system was conceived by Chen Fangyun and his colleagues in the 1980s. The risk of denied access to GPS, including an alleged case in 1996 during the Third Taiwan Strait Crisis, gave impetus to the creation of BeiDou.

NavIC: NavIC, formerly known as IRNSS (Indian Regional Navigation Satellite System), is an independent Regional Satellite Navigation System, developed by Indian Space Research Organisation (ISRO), similar in Principle to Global Positioning System (GPS) of the US. It will provide positioning services, in Land, Air and Sea, including Location Based Services (LBS) over an area, within Indian Subcontinent plus around 1500 kms, beyond the Indian subcontinent, continuously. The Principle of "NavIC" is very similar to the Popular "Global Positional System (GPS)" of the US Department of Defence.

NavIC was developed by ISRO, because access to foreign government-controlled Global Navigation Satellite Systems (GNSS) is not guaranteed in hostile situations, as happened to the Indian military in 1999, when it was dependent on the American Global Positioning System (GPS) during the Kargil War. The Indian government approved the IRNSS project in May 2006. The system is now fully operational over Indian subcontinent! The NavIC provides a position accuracy better than 20 m to the Civilians (known as Standard Positioning Service) and better than 10 m to our Defense Services (known as Restricted Service).

NavIC basically consists of three segments viz. (1) A Space segment (2) A Control Segment (3) A User Segment as shown in Fig. 2 below.

a) NavIC Space Segment:

The Space Segment consists of seven satellites, three Geostationary satellites at 34^0, 83^0 and 132^0 E and four Geosynchronous satellites (inclined at 29^0), at longitude crossings at 55^0 and 111^0 E (a pair of satellites in the same plane), as shown in Fig. 2.

The satellites carry:

(1) A Rubidium Vapour Clock (three for redundancy), which has a stability better than 10^{-12} and an accuracy of time transmission better than 100 n.sec.

(2) Two transmitters at 1176.45 MHz (L Band) and 2492.028 MHz (S Band)

(3) A Memory to store Navigation Data, computed by IRNSS Master Control Centre and uplinked from IRNSS Telemetry and Command Station,

(4) PRN (Pseudo Random Noise) code generators (both civilian and encrypted codes).

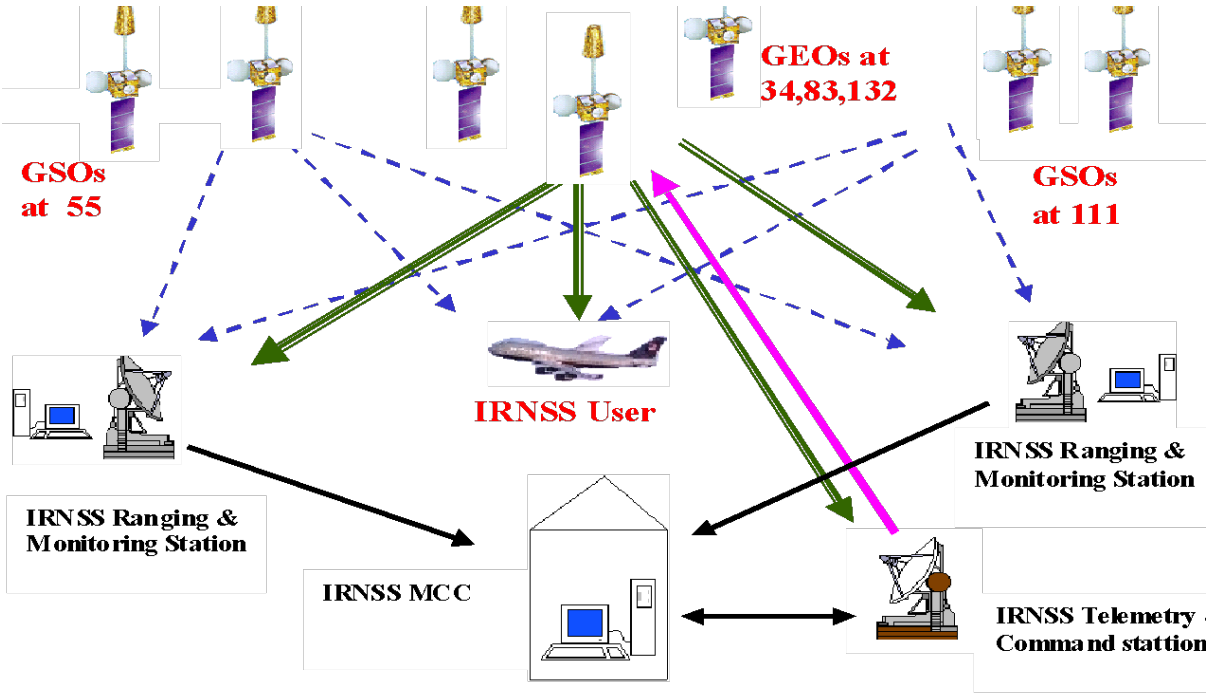
The satellite generates a 1 MHz PRN (Pseudo Random Noise) Code, well synchronised with its clock to an accuracy better than 100 n.sec. The Navigation Data along with PRN code are modulated on S and L Band and transmitted continuously to the users. Binary Phase Shift Keying (BPSK) Modulation is used to provide Standard Positioning Service to the Civilians and Binary Offset Carrier Modulation (BOC) is used to provide Restricted Service to Defense.

b) NavIC Control Segment:

The NAVIC Control Segment mainly consists of

(1) A network of IRNSS Ranging and Integrity Monitoring Stations (IRIMS)
(2) IRNSS Master Control Centre (INMCC)
(3) IRNSS Telemetry & Command Station.

The IRNSS Ranging & Monitoring Stations collect pseudorange and carrier phase data from all the seven IRNSS satellites, continuously. The data will be sent in real time to IRNSS MCC, which will compute satellite ephemeris, satellite clock corrections parameters, Ionospheric correction parameters and satellite integrity parameters (Viz. Navigation Data). This will be sent in real time to IRNSS Telemetry & Command station (IRNSS TTC & upload station), which will transmit this to the respective satellites for onboard storage and retransmission to the users.



C) NavIC User Segment :

The User segment mainly consists of either,

- Single frequency IRNSS receiver capable of receiving SPS/RS signal at L or S band frequency for Civilian Use.
- A dual frequency IRNSS receiver capable of receiving SPS/RS signal in both L and S band frequencies.

An accuracy of the order of 20 m for a Single Frequency Receiver and better than 5m for a Dual Frequency receiver can be expected.

Fig. 3: Qualcomm Snapdragon 460, 662, and 720G Mobile Platforms - Chip Case

Many Companies in India are making NavIC Receivers in Chip form, for use in mobiles in future. Prominent among them are Qualcomm Technologies, Xiaomi, Accord, Dhruva etc. Qualcomm has launched three new chipsets -- Snapdragon 720G, 662 and 460 --, in collaboration with ISRO, with support for Navigation with Indian Constellation (NavIC) and is shown in Fig.3 above.

NavIC is useful in following Applications.

1. Integration with Mobile Phones to provide Location Based Services
2. Terrestrial Navigation for Car or Truck (Visual and Voice Navigation for Drivers)
3. Terrestrial Navigation aid for Hikers and Travellers
4. Marine Navigation.
5. Aircraft Navigation at least during Enroute
6. Geodesy and Mapping
7. To develop Geographic Information Systems (GIS)
8. Ionospheric Studies
9. Satellite Meteorology
10. Precise Time and Time Interval measurements
11. Satellite Orbit Determination and Launch Vehicle Tracking
12. Detecting Landslides and monitoring Tectonic movements
13. Disaster Management
14. Emergency Messaging Services

1. GPS Augmentation Systems (Wide Area Differential GPS):

For Civilian Aircraft take off and safe landing at Airports, an accuracy in positioning better than 5m is required. None of the above Satellite Navigation Systems can provide that. So, the International Civil Aviation Organisation (ICAO) encouraged many Civil Aviation Authorities, including Airport Authority of India (AAI), to develop Satellite Based Augmentation Systems (SBAS), to enhance the accuracy of existing systems from 100 to better than 5m. So US developed “Wide Area Augmentation System '' (WAAS), Europe developed European Geostationary Navigation Overlay System (EGNOS) and India developed GAGAN (GPS Aided Geo Augmented Navigation) systems. The principle of GAGAN, developed by Indian Space Research Organisation (ISRO) in collaboration with AAI is explained below.

GAGAN :

The principle of GAGAN, shown in Fig. 4 below, is very similar to other GPS augmentation systems. It has mainly the following Components viz.

(1) A network of Ground Reference Stations known as INRES (Indian Reference Stations)

(2) Indian Master Control Centre (INMCC)

(3) Indian Uplink Station (INLUS)

(4) Geostationary Satellite (GEO).

(5) A GAGAN Receiver on an Aircraft

INRES (Indian Reference Station) are GPS Tracking stations, set up at well surveyed points, whose coordinates in WGS-84 are well known. They have mainly an Atomic Clock and redundant (at least three) GPS Dual Frequency Receivers. The Receivers collect Pseudorange and Carrier Phase measurements at Dual frequencies and transmit the data in real time to INMCC (Indian Master Control Centre). Either a Fibre Optic cable or a Vsat terminal is used for Data Transmission.

INMCC collects GPS data transmitted from all the INRES in the network in real time. They process the data to compute WADGPS Correction Data viz. (1) GPS Orbital Correction Parameters and Clock Errors (2) Integrity (3) Parameters GIVE (Grid Ionospheric Vertical Delay) and GIVE (Grid Ionospheric Vertical Error) in a 5^0 by 5^0 over Indian region to correct Ionospheric delay. This data is sent to a Navigation Land Earth Station (NLES).

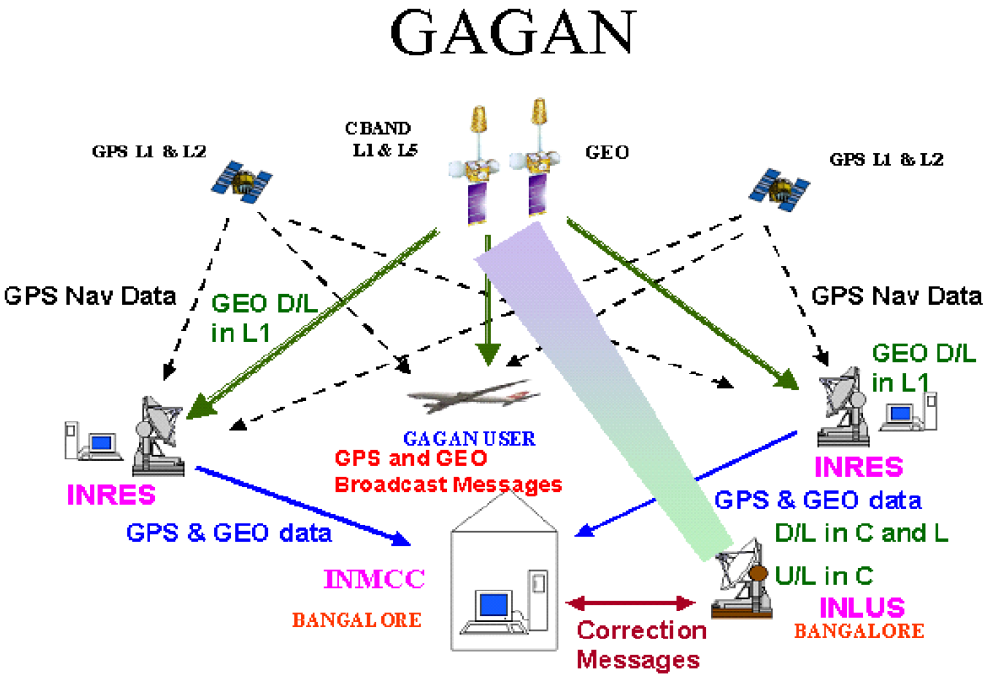


Fig. 4 : Principle of GAGAN

INLUS receives the WADGPS Correction data from INMCC. It suitably formats the data and transmits to Geostationary Satellites (GSAT-8, GSAT-10, GSAT-15 in GAGAN). The satellite re-transmits the data in C Band to INLUS and INLUS receives back in C Band the stored data in the Satellite. INLUS verifies the Data for its validity.
The 3 **GSAT** satellites carry two CXL1 and CXL5 Transponders. They receive data (ADGPS Correction Data), from INLUS in C band and retransmits to users in L1 and L5 frequencies used in GPS.

The **GAGAN Receiver** on Aircrafts receive both GPS and GAGAN Transmission. The receiver determines its position from GPS measurements from 4 satellites, after applying WADGPS Correction data and parameters for correction of Ionospheric Delay. The accuracy positioning improves from 100 m to better than 5 m by this. This improved accuracy of positioning using GPS and GAGAN, is good enough for safe landing and take-off of Aircrafts, better navigation of ships near harbour and inland waterways, better Land Survey and many other applications. But still there is a risk to use this, as at times of war GPS may be denied or degraded in service.

Dr M R Sivaraman
Deputy Project Director (Retd), SAC, ISRO

Satcom Applications in COVID conditions and beyond:

The day is 15th August 2021. India marches on to the 75th year of its hard-won independence.

This day will also be a personal landmark for Sunita, a nurse in the Primary Health Centre of Harehalli, a small village in Karnataka. All the 4,832 residents of her village will complete their second dose of COVID vaccination. The most recent update at the satellite-linked Village Resource Center (VRC), a 2-minutes' walk from her home-slash-health center, indicates that 23 citizens will turn up today. But, thanks to the educational videos delivered in Kannada to the community, no more than 10 will be at the center at any given time to keep up with the social-distancing norms.

India has been the leader in harnessing space technology for societal applications for the last five decades. One such successful model is the *Village Resource Center* (VRC), which has proven to be a one-stop shop for multiple communication requirements of the village community. It can be used to monitor and contain the spread of Covid-19, enhance digital education distribution capabilities, and help in job creation and skill building. The VRC can deliver services to any number of recipients without network congestion, Internet availability or power connection.

The VRC uses Satellite Communications (Satcom), a cost-effective extra-terrestrial relay system that can link the sender and receiver across continents. Besides the extensive geographical coverage, satellites have inherent multicast capabilities, limited demand on infrastructure, and accessibility by an unlimited number of terminals.

The Covid-19 pandemic has dramatically changed the world, placing tremendous stress directly on the healthcare systems and indirectly on the economy. With lockdowns and social distancing in place, **connectivity is vital** in the Covid-19 response.

A suitable Satcom solution in rural areas, particularly regions underserved by wireline or wireless infrastructures, will mitigate the economic and social impacts of Covid-19 across multiple sectors.

Sector	**Satcom Connectivity**	**Typical Use cases**
Healthcare	Geostationary satellite; DVB-RCS links	Frequent remote training for PHC staff at their own location.

		Automated field data aggregation at the central location for analytics
Education	Geostationary satellite; Spread spectrum access	Curated contents delivered via a satellite link to a wireless local server for use by teachers and students
Precision Agriculture. Asset Management	Mini LEO constellations. Space-enabled Narrowband IoT	Two-Way data communication and Reliable location information. data gathering services for M2M and IoT devices
Emergency Alerting	Geostationary satellite; Multicast solutions	Under COVID conditions emergencies arise quickly and alerts must reach the right people at the right time
Working from rural homes	Mega LEO constellations	Provide high bit rate 2-way connectivity at any geographical location for video conferencing etc.

HEALTHCARE:

What makes this pandemic so dangerous is that it takes time for those infected to show symptoms. Essentially, they remain unaware and active – spreading the virus at scale. Strengthening the public health systems with equal emphasis on curative and preventive care, down to the Primary Health Care (PHC) at every village, is the way to go.

Unfortunately, an acute shortage is predicted for doctors, nurses, frontline workers and support staff. In addition to the increased workload, the PHC staff are also vulnerable to the Covid-19 infection. The health system therefore requires large-scale intervention and training of the health workforce. Satcom allows remote distance learning from a central facility to every PHC as often as needed, with the most up-to-date content.

The training could be based on:

- Video content specific to coronavirus care in the local language for community education
- Content curated by the authorities and other experts in health
- Anticipate and monitor the emotional resilience and well-being of frontline workers.

By facilitating uniformity in information delivery and training, Satcom technology will ensure support for effective case detection, containment, case-management, capacity building, and monitoring and evaluation capabilities. This is a big advantage under the present conditions.

EDUCATION

A satellite signal is broadcast by nature and effectively supports a one-to-many architecture. To arrive at the best connectivity configuration for primary education, we utilize the common curriculum and common schedule of multiple schools in a region in order to meet their needs simultaneously.

A satellite-enabled delivery scheme can be implemented immediately without the need for expensive gadgets or broadband connectivity. By riding on the existing satellite channels, it is possible to push centrally controlled, curated content as well as teacher resources on a lesson-by-lesson basis into a compact receiver-server at all the desired locations. Teachers and students can then access the received information on their own devices from a local hotspot on a lesson-by-lesson basis.

Since the Satcom solution supports replenishing the hotspot contents as per a schedule, the student device will continue to receive the contents irrespective of the days they are in the class or not. So, students will never miss anything, and the contents are expected to be up to date. Teachers get coached daily on what they must teach and how. This can help to understand the concepts well and get them across to every student better.

In cases of pandemic and other outbreaks it is vital to continue education so that students stay connected and achieve their learning objectives. The satellite enabled tablet is the most cost-effective and fastest way to provide equity in education and raise educational standards universally.

EMERGENCY ALERTS:

The recent series of disasters have reiterated the importance of timely and addressable delivery of emergency alerts. Delivering hazard information to the remotest regions has been a major challenge.

In the context of the pandemic, based on new evidence, frontline workers must become aware of changes in procedures at the earliest.

Digital broadcast satellites can deliver signals into compact and inexpensive receivers that hardly require any local infrastructure and, hence, are ideal candidates for deployment in public outreach applications, for awareness and preparedness.

AGROBUSINESS:

Agrobusiness includes agrichemicals, breeding, crop production-distribution, agricultural machinery, agricultural development, agricultural technology, traditional agriculture, agricultural production, processing, and seed supply, as well as marketing and retail sales.

The present conditions have a dire impact on agriculture production, productivity, and manpower. Livelihoods will soon be threatened because there is a desperate need for workers with newer skills.

Satellite-based connectivity solution at the VRC is versatile. It is tailored to meet the immediate and long-term needs of the community, including the delivery of remote training, agro weather bulletins and remote data collection on a near-real-time basis. This can help farmers adopt digital agriculture solutions that link farmers to buyers and logistics services etc. The Satcom link at the VRC provides timely targeted data, which can surely help the farmers in making appropriate decisions in production, protection, and marketing.

Under the current conditions, the use of satellite data transmission is the most cost-efficient means to simultaneously strengthen the healthcare system at the point of delivery and improve various aspects of the economy. The Satcom solution would check the spread of Covid-19 by (i) training large populations or groups, and (ii) capturing data to monitor, evaluate, track and improve performance. We can then turn this crisis to an opportunity to build a resilient infrastructure for the future.

Mahatma Gandhi said, **“The real India lies in its 700,000 villages.”**

Once the VRC is established in one village, having it in every village and providing similar services uniformly is straightforward. Removal of the geographical restriction on the services makes Satcom the greatest leveler.

Sunita is happy. Gandhi's vision has become a reality. She hoists the national flag in her house and is ready for the first person to be vaccinated for the day.

Jai Hind.

Dr. S Rangarajan

Former Director, MCF, ISRO

SKYSAFARI

To join Skysafari community: ulspaceclub.info@gmail.com

LET'S LOOK AT THE SKY

The sky is an ocean of infinity - the human race has always been pursuing the magical wonders of the sky, and amateur astronomers are eternal lovers of the infinite beauty of stars. Firstly, all you need is the mindset to look at the sky, everything else will come later. Secondly, we can choose a wide yard or lawn or terrace to get acquainted with the sky. It is not necessary to have a telescope or binoculars at the beginning as many people think. It can be arranged later.

As the earth rotates from west to east, we feel as if the sky and its objects are moving from east to west. It is good to keep a simple star map of the month in hand. There are no specific rules for getting to know the stars. Everyone is free to find their own methods. I only intend to explain some of the methods that can be used in general.

As the sun sets in the west, the planets and stars begin to shine. Venus and Jupiter appear to be bright. However, the red planet Mars may only be bright at times. Blurred planets are easier to spot when they are near the crescent moon. A constellation is the shape of a group of stars found in a particular region.

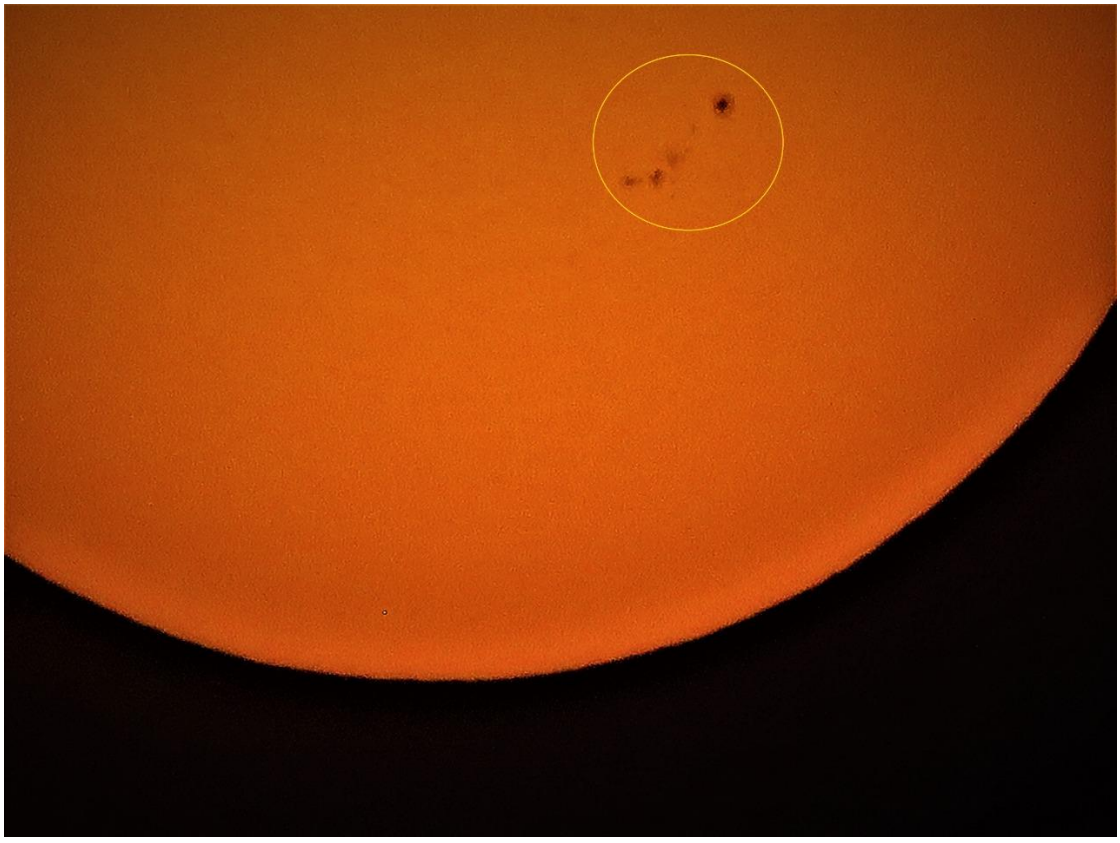
The International Astronomical Union recognises 88 constellations, including the twelve zodiacal constellations from Leo to Crab and the twenty-seven lunar constellations from Aswathi to Revathi.

Hold a star map over your head and adjust the direction. You can use a slightly reddish torch in the absence of other lights (the front of the torch can be covered with red paper).

The Green Laser Torch is one of the commonly used tools for the sky watch today, but one must know the rules before using it. If you can use it to locate a constellation, you

will also be able to pinpoint the nearby stars. It’s better to consider the stars a part of the constellation rather than trying to identify them individually. For example, Sirius is the brightest star in the night sky, but it's fascinating to see the big dog's eye in the Canis Major constellation. The galaxies, nebulae, and star clusters can be easily comprehended by just identifying a few constellations. Planets, comets, and asteroids can all be spotted at any time with the help of these constellations.

In summary, skywatching will be the key to broadening your knowledge with a cheerful experience as it unlocks the gates of celestial space.



Sun spot larger than earth appeared November 2020..

Photography by : Surendran Punnassery, Amateur astronomer & Astro photographer from Nayanukunnu mala ,Kakkoor,Kozhikode,Kerala using spl solar filter

Surendran Punnassery, Amateur Astronomer / Astro Columnist

HUMAN SPACEFLIGHT

Introduction

Humans have always looked up into the sky and pondered about the limitless expanse since time immemorial. Over the course of centuries, stargazing had become a part of human culture. It was the Ancient Greeks who developed ‘Astronomy’, which means the science that studies the laws of stars, as a branch of Mathematics. In that era, Astronomy was inclusive of observation and prediction with naked eyes. The invention of the telescope and the first telescopic observation of the night sky made great changes in the field of astronomy. Discovery of the Moon and other planets, the first exposition of the rocket equation, in the 20th century, etc. were the events that led to the idea of space exploration. And it became a reality by launching an artificial satellite to space. And that information gathered from the satellite induced humans to think about space exploration. And they performed ‘Spaceflights’ to make their dreams come true.

Human spaceflight [also referred as manned spaceflight or crewed spaceflight] is spaceflight with a crew or passengers aboard a spacecraft. It is an extremely challenging and expensive task that only three countries in the world have achieved independent human spaceflight capability – The United States of America, Russia and China. The ultimate purpose of going into space is to find a sustainable human habitat in space that would enable us to live and work there.

History of Human Spaceflight

The rockets that were developed in the latter half of the 20th century were powerful enough to overcome the force of gravity to reach orbital velocities, and for paving the way for space explorations to become reality. On 4th October 1957, the Soviets launched the first artificial satellite in the world, Sputnik 1, into space. It was an important milestone in the history of space exploration. Four years later, on 12th April 1961, Russian Lt. Yuri Gagarin became the first human to orbit Earth in Vostok 1.

On 20th July 1969, Neil Armstrong, the American astronaut took ''one giant leap for mankind'' as he stepped onto the moon from Apollo 11, launched by a Saturn V rocket, with his companions Edwin Buzz Aldrin and Michael Collins. After that 21 more astronauts also stepped onto the Moon. Moon is the only celestial body on which humans have landed and last among them in 1972. Further to the moon missions, NASA’s space shuttle program conducted regular human spaceflights between 1977 and 2011.

Launching the International Space Station (ISS) was another milestone in the history of space exploration. ISS is a habitable artificial satellite in low Earth orbit. It is a multinational collaborative project involving 5 participating space agencies - NASA (USA), Roscosmos (Russia), JAXA (Japan), ESA (Europe), and CSA (Canada). Its ownership and use is established by the intergovernmental treaties. The station serves as a space environment research laboratory in which scientific research is conducted in astrobiology, astronomy, meteorolog,physics, and other fields. There have been continuous humans in the international Space Station since 2000.

Challenges in Human Spaceflight

The environment of space is lethal without appropriate protection. Lack of oxygen and pressure, temperature and radiation pose risks and threaten the life of astronauts. The effects of space exposure can result in ebullism, hypoxia, hypocapnia, and decompression sickness. And also space dust is another biggest obstacle to today's space travel. According to NASA, there are 5 major hazards for travelling to space.

Radiation:

The first hazard of a human mission to space is the most difficult; space radiation which is invisible to the human eye. Radiation is not only stealthy, but considered as one of the most menacing of the five hazards.

Isolation and Confinement:

Behavioral issues emerge amongst groups of people crammed in a small space over a long period of time. On Earth, we have the luxury of picking up our cell phones and instantly being connected with nearly everything and everyone around us. On a trip to space, astronauts will be more isolated and confined than we can imagine. Sleep loss, circadian desynchronization, and work overload compound this issue and may lead to performance decrements, adverse health outcomes, and compromised mission objectives.

Distance from Earth:

The third and perhaps most apparent hazard is distance. While International Space Station expeditions serve as a rough foundation for the expected impact on planning logistics for such a trip to space, the data isn't always comparable. Even though, if a medical event or emergency happens on the station, the crew can return home within hours.

Gravity:

The variance of gravity is the fourth hazard of a human space mission. Besides deep space, there is a third gravity field that must be considered. When astronauts finally return home, they will need to readapt many of the systems in their bodies to Earth's gravity. Bones, cardiovascular system, etc. have all been impacted by years without standard gravity. To further complicate the problem, when astronauts transition from a gravity field to another, it's usually quite an intense experience.

Hostile/closed Environments:

A spacecraft is not only a home but also a machine. The ecosystem inside the vehicle plays a big role in the everyday life of an astronaut. The important habitability factors include temperature, pressure, lighting, noise and quantity of space. Technology, as often in the case with out-of-this-world exploration, comes to the rescue in creating a habitable home in a harsh environment. Everything is monitored, from air quality to possible microbial inhabitants. Microorganisms that naturally live on your body are transferred more easily from one person to another in a closed environment.
Human Spaceflight in the present Space exploration supports innovation and economic prosperity by stimulating advances in science and technology, as well as motivating the global scientific and technological workforce, and enlarging the sphere of human economic activity. Space agencies,governments, researchers and commentators have isolated a large number of direct and indirect benefits of space exploration programs including:

- New technologies that can be utilized in different industries and for society.
- Improved knowledge about space and the origin of the universe.

Cultural benefits

Unlike the days of the past, spaceflight is no longer an activity entirely participated in by government organizations. Involvement of private players has resulted in a quantum jump in the space arena. Space tourism, commercial private spaceflight and passenger travel via spacecraft are all being experimented by different organisations such as SpaceX, Virgin Galactic, Blue Origin etc. The Crew Dragon program by SpaceX has resulted in the human spaceflight missions from US soil since the space shuttle program.

Currently, India is also attempting to achieve human spaceflight capability through its Gaganyaan program. Gaganyaan is the Indian crewed orbital spacecraft intended to be the formative spacecraft of the Indian Human Spaceflight Programme. The spacecraft is being designed to carry three people, and a planned upgraded version will be equipped with rendezvous and docking capability. In its maiden crewed mission, Indian Space Research Organisation (ISRO)'s largely autonomous 5.3 t capsule will orbit the Earth at 400 km altitude for up to seven days with a two or three-person crew on board. The crewed vehicle is planned to be launched on ISRO's GSLV Mk III launch vehicle.

Conclusion

Humans have always been fascinated by space and they will continue to be so. The technological advancements have facilitated humankind in finding answers to many fundamental questions about the universe. As often said, today's fiction is tomorrow's science. Human settlements beyond earth and colonisation of planets like Mars may happen in a few decades. Exploratory mission and human spaceflight has to play the most vital role if it has to materialise. In today's challenging world, finding outer space human settlements might indeed become an inevitability in near future. Let us hope that mankind will be able to find greener pastures in outer space and preserve our mother earth at the same time by making the best use of technology, resources and more than anything else, our wisdom.

ASWATHI O T
UL SPACE CLUB Member

BEYOND FUTURE

Human curiosity, the greatest gem which humanity has earned since time immemorial. We have reached so far more than we expected. Few of our brothers experienced the silent beauty of the space and few are still enjoying it. A few of them had their feet on the lunar surface. The 20th Century Space race enabled the fast-paced growth of space science and technology which currently is really advanced and we all are looking forward to the mind blowing things going to happen in the near future.

Observing the Space

We started observing space a long time ago with our naked eyes. Then came the revolutionary invention, Telescope, which allowed us to look deeper. Obviously, it advanced and now we have large observatories in the ground and advanced telescopes orbiting the earth eagerly staring into the void, hunting for answers. There are more to come in the future, here let's take a look at some special near future telescopic missions.

JWST:

It is the James Webb Space Telescope by NASA. Webb will be the largest, most powerful space telescope ever launched into space. We know how much Hubble pushed our explorations to the next level, obviously every space enthusiast is looking forward to Webb. As per Nasa, it’s an infrared observatory that will be a successor and extend the discoveries of the Hubble Space Telescope. It has longer wavelength coverage and greatly improved sensitivity. This enables Webb to look much closer to the beginning of time and to capture the formation of the first galaxies which we never witnessed, as well as to look inside dust clouds where stars and planetary systems are forming today.
This telescope is being scheduled for 31st October this year

The X-ray Polarimeter Satellite (XPoSat) :

It's an Observation satellite developed by ISRO and RRI(Raman Research Institute). ISRo approved the The X-ray Polarimeter developed in rri to be launched on a dedicated satellite.

The X-ray polarimetry is an area yet to be explored in high energy astronomy. XPoSat is expected to be launched in November 2021.

Euclid:

This near-infrared space telescope is by ESA and is currently under development by Euclid Consortium and ESA. Its objective is to study more about dark energy and dark matter by measuring the acceleration of the expansion of the universe. Methods to measure redshift of galaxies the probe uses the aid of gravitational lensing, measurement of baryon acoustic oscillations, and measurement of galactic distances by spectroscopy. The mission duration will be 6 years and it is expected to be launched in July 2022.

Laser Interferometer Space Antenna(LISA):

This space based observatory is a collaboration between ESA, NASA and the International Consortium of scientists. Thi is the first space-based observatory with the objective to detect and accurately measure gravitational waves after the success of LIGO in finding the gravitational waves and LISA pathfinder by ESA. LISA will consist of three spacecraft separated by 2.5 million km in a triangular formation, following Earth in its orbit around the Sun. Launch is planned to be in 2034.

Aditya - L1:

This is not a telescope, instead it's India's first Sun Study satellite. The Aditya-L1 mission is planned to be launched in January 2022. It's a 400kg class satellite carrying one payload, the Visible Emission Line Coronagraph (VELC) and was planned to launch in a 800 km low earth orbit. The satellite will be launched to the Lagrangan point L1 and will be inserted in a halo orbit around the L1, which is 1.5 million km from the Earth.

Extremely Large Telescope (ELT):

It is planned to be the world's largest optical/near-infrared extremely large telescope located on top of Cerro Armazones in the Atacama Desert of northern Chile. It's a ground based Astronomical Observatory. A chief goal will be to track down Earth-like planets around other stars in the habitable zones. The ELT will also make fundamental contributions to cosmology by measuring the properties of the first stars and galaxies and probing the nature of dark matter and dark energy as it will gather 13 times more light than the largest optical telescopes existing today. Also its images will be 16 times sharper than Hubble's. Once the construction is completed it is expected to be opened by 2024.

Satellite Technologies

Satellites have proven to be one of the most successful commercial applications of space technology. And it really changed the way we live. Internet, communication, navigation, weather predictions, space travel, human habitations, etc. Day by day improving satellite technologies helps us go to the next level in near futures. These satellites are some of those coming out in the near future.

Starshot:

Breakthrough Starshot is an initiative to prove ultra-fast light-driven nanocrafts under Yuri Milner, Stephen Hawking, and Mark Zuckerberg founded in 2016. This involves a ground-based light beamer pushing ultra-light nano crafts – miniature space probes attached to lightsails – to speeds of up to 100 million miles an hour. Such a system would allow a flyby mission to reach Alpha Centauri in just over 20 years from launch. Along the way, the project could generate important supplementary benefits to solar system exploration. A number of hard engineering challenges remain to be solved before these missions can become a reality. It is expecting to have its first launch around 2036

NISAR:

NISAR is a joint venture by NASA and ISRO. NISAR Stands for NASA-ISRO Synthetic Aperture Radar. The satellite will be the first radar imaging satellite to use dual frequencies. It will be used for remote sensing, to observe and understand natural processes on Earth. It will use advanced radar imaging to map the elevation of Earth's land and ice masses 4 to 6 times a month at resolutions of 5 to 10 meters. After the launch on 29 January 2023 it will continue in mission for 3 years.

NEAScout:

Near Earth Asteroid Scout is a special mission by NASA which is going to reconnaissance an asteroid to survey the destination and learn about the risks and challenges they may pose to future human explorers. This innovative, low-cost concept will map an asteroid and demonstrate several technological experiments. This space probe will be using a CubeSat and solar sail propulsion, which offers navigation agility during cruise for approaching the target. So it will also be the first CubeSat to reach an asteroid. The launch is scheduled to be in November 2021.

Antimatter Propulsion:

This is a theoretical technology, In 2006 the NASA Institute for Advanced Concepts (NIAC) funded a team Gerald Smith of Positronics Research, designing an antimatter-powered spaceship. They calculated just 10 thousandths of a gram of antimatter would be enough to send a ship to Mars in 45 days. Antimatter is made of antiparticles, which have the same mass as particles of ordinary matter but opposite charge and spin. Antimatter also has the highest energy density of any known substance. And if used as fuel, it could provide by far the most efficient propulsion system, with up to 40% of the fuel's mass energy being converted directly into thrust, the next most efficient when compared with 1% for fusion! CERN produces about 1x10^15 antiprotons every year, but that only amounts to 1.67 nanograms. Unfortunately this area is still understudied and not so practical because of its extreme explosive nature, radioactive nature and also it's more expensive than the national debt (about $62.5 trillion per gram). But let's hope for the future in which this would be used as a propulsion system.

Human Space Flight

Space travel has had a relatively short history. Despite its recency, the field has seen rapid development over the last several decades. Space travel is now also in the private sector. Since the first commercial human space flight took place in 2001, several other wealthy space tourists purchased their rides into space. Currently, more than 625 people have signed up for suborbital space flights with Virgin Galactic. There are a lot of revolutionary changes that are yet to happen. These are some future manned missions that the world is looking forward to now.

Gaganyaan:

As we all know, the spacecraft is going to start India's Human space Flight program.

The spacecraft is being designed to carry three people, and a planned upgraded version will be equipped with rendezvous and docking capability. In its maiden crewed mission, ISRO's largely autonomous 5.3 t capsule will orbit the Earth at 400 km (250 mi) altitude for up to seven days with a two or three-person crew on board. The crewed vehicle was originally planned to be launched on ISRO's GSLV Mk III in December 2021, but this has since been delayed to no earlier than 2023.

Artemis:

After 50 years from the last human Moon Landing NASA started the mission to return humans to the moon again, Artemis. There will be 3 launches and on the 3rd human returns to the moon. The uncrewed launch of Artemis 1 will be on November 4th this year. The main goal of 'Artemis' mission will be to send the next man and first woman to the moon by 2024 which, also and establish sustainable exploration for the first time and through the experiments and learning to make the next giant leap, humans going to mars! Launching is said to be on the most powerful rocket NASA ever built, SLS. Crew will be inserted to lunar orbit on a space capsule named ORION then moved to a lunar landing system which the agency picked SpaceX to move forward with their Starship HLS design for a crewed demonstration. Astronauts will be wearing the new xEMU space suits. The sustained travel to and back from the moon is simplified through a Gateway, a small space station around lunar orbit, which serves as a communication hub, science laboratory, short-term habitation module, and holding area for rovers and other robots.

SpaceX Mars Mission:

SpaceX, a successful private aerospace manufacturer, and a Space organisation is planning to colonize mars by 2050! The goal is to make humans multiplanetary. The mission will send humans to mars by the year 2026 as per the CEO Elon Musk. His revolutionary Multi Planetary vehicle Starship finally achieved safe landing on May 5. This will be the vehicle he is going to use for the mars mission as it is designed to return back to earth from mars. And he also plans a orbital refueling procedure and a fuel making procedure using local resources (such as by electrolysis on CO2 to get O2) in mars for sustained missions and research and finally he will launch crewed missions to mars, and build a base there for more research and experiments.

Space Tourism:

In this section of space research, private space companies are more involved, though ROSCOSMOS had flown with tourists to the ISS before and ROSCOSMOS also declared

they will send 2 tourists to ISS in 2023 and one of them will space walk! There are various missions for space tourism such as, Inspiration4 project which is planned as SpaceX Crew Dragon mission to low Earth orbit operated by SpaceX on behalf of Jared Isaacman, Spaceship III by Virgin Galactic, another low earth space flight experience for civilians using the vehicle VSS Imagine by Virgin galactic, and DearMoon Project by Yusaku Maezawa using a SpaceX rocket starship on a private spaceflight flying a single circumlunar trajectory around the Moon in which the passengers will be Maezawa, 8 civilians, and one or two crew members.

The space race is now in another phase, we see the government organisations and private companies collaborating so much which is a great thing and results in fast paced advancements in this sector. There has been some suppression faced by private space companies even from space experts, but it's good to see those organisations rising from these suppressions. Every innovative idea must be praised, prejudicial decisions can be harmful to our fast paced development in astronomy.

This is just a starting, the revolutionary achievements in the next few years are stepping stones of conquering space and spreading human life to other planets. In the next half billion years the sun will expand and evaporate our oceans, finally engulfing the earth, the only habitat we ever got! But yes there are many other reasons humans may not survive longer on this planet. All these points towards finding another habitat which we may have in the future…

Adil Krishna P
UL SPACE CLUB Member

IGNITING THE LONG RUN

Rocket technology has evolved for over 2000 years. Today's rockets are a product of a protracted tradition of ingenuity and experimentation, and mix technical expertise from a large array of engineering disciplines. Rockets are subjected to awesome g-forces at lift-off, and skill extreme hot spots in places where aerodynamic friction acts most strongly, and extreme cold because of liquid hydrogen/oxygen at cryogenic temperature. It's no coincidence that "rocket science" is the quintessential cliché to explain the mind-blowingly complicated.

GOLDEN PERIOD OF ROCKET SCIENCE

Fortunately for us, we sleep in a time where rocketry is undergoing another golden period. Commercial rocket companies like SpaceX and Blue Origin are entering into an industry that has traditionally been dominated by government-funded space programs. But even the incumbent companies aren't resting on their laurels, and are developing new powerful rockets for deep-space exploration and missions to Mars. Recent blockbuster movies like Gravity, Interstellar and also the Martian are a sign that space adventures are another time stirring the imagination of the general public.

What better time than now to look back at the past 2000 years of rocketry, investigate where past innovation has taken us and the appearance ahead to what's on the horizon? It's certainly impossible to hide the full history of rocket science. But I'll try my best to supply a broad brush stroke of the first beginnings in China to SpaceX.

THE GREAT HISTORY BEGINS

The history of rocketry can be loosely split into two eras. First, early pre-scientific tinkering and second, the post-Enlightenment scientific approach. The underlying principle of reaction propulsion has largely remained the same, whereas the detailed means of operation and our approach to develop rocketry has changed to an excellent deal.

The fundamental principle of reaction propulsion, spewing hot gas passes through a nozzle to induce motion within the wrong way, is nicely illustrated by two historic examples. The Roman writer Aulus Gellius tells a story of Archytas, who, sometime around 400 BC, built a flying pigeon out of wood. The pigeon is held aloft by a jet of steam or compressed gas passing through a nozzle. Three centuries later, Hero of Alexandria invented the aeolipile and supported the identical principle of using escaping steam as a propulsive fluid. within the aeolipile, a hollow sphere was connected to a water bath via tubing, which also served as a primitive form of bearing, suspending the sphere in mid-air. a hearth beneath the water basin created steam

which was subsequently forced to flow into the sphere via the connected tubing. The sole way for the gas to flee was through two L-shaped outlets pointing in opposite directions. The escaping steam induced an instant about the hinged support effectively rotating the sphere about its axis.

WOOD PIGEONS TO MAGIC IN THE SKY

The Columba palumbus and aeolipile don't resemble anything that we'd recognise as a rocket. In fact, the precise date when rockets first appeared continues to be unresolved. Records show that the Chinese developed gunpowder, a mix of saltpetre, sulphur and charcoal dust, at around 100 AD. Gunpowder was wont to create colourful sparks, smoke and explosive devices out of hollow bamboo sticks, closed off at one end, for religious festivals. Perhaps a number of these bamboo tubes started shooting off or skittering along the bottom, but the Chinese started tinkering with the gunpowder-filled bamboo sticks and attached them to arrows. Initially the arrows were launched within the traditional way using bows, creating a kind of early incendiary, but later the Chinese realised that the bamboo sticks could launch themselves just by the thrust produced by the escaping hot gases.

The first documented use of such a “true” rocket was during the battle of Kai-Keng between the Chinese and Mongols in 1232. During this battle the Chinese managed to carry the Mongols unfree employing a primitive kind of a solid-fueled rocket. A hollow tube was capped at one end, stuffed with gunpowder then attached to a protracted stick. The ignition of the gunpowder increased the pressure inside the hollow tube and compelled a number of the new gas and force out through the open end. As governed by the law of conservation of momentum, this creates thrust to propel the rocket within the direction of the capped end of the tube, with the long stick acting as a primitive guidance device, abundantly harking back to the firework “rockets” we use today.

"WAN HU - THE PRIMARY MAN ON MOON"?

According to a Chinese legend, Wan Hu, a neighborhood official during the 16th century Ming dynasty, constructed a chair with 47 gunpowder bamboo rockets attached, and in some versions of the legend supposedly fitted kite wings furthermore. The rocket chair was launched by igniting all 47 bamboo rockets simultaneously, and apparently, after the commotion was over, Wan Hu was gone. Some say he made it into space, and is now the “Man within the Moon”. possibly, Wan Hu suffered the primary ever launch pad failure.

MORE SCIENTIFIC

One theory is that rockets were delivered to Europe via the 13th century Mongol conquests. In England, scientists developed a more powerful gunpowder (75% saltpetre, 15% carbon and 10% sulfur) that increased the range of rockets, while Jean Froissart added a launch pad by launching rockets through tubes to boost aiming accuracy. By the Renaissance, the employment of rockets for weaponry fell out of fashion and experimentation with fireworks increased instead. Within the late 16th century, a German tinkerer, Johann Schmidlap, experimented with staged rockets, a concept that's the idea for all modern rockets. Schmidlap fitted a smaller second-stage rocket on top of a bigger first-stage rocket, and once the primary stage burned out, the second stage continued to propel the rocket to higher altitudes. At about the same time, Kazimierz Siemienowicz, a Polish-Lithuanian commander within the Polish Army published a manuscript that included a design for multi-stage rockets and delta-wing stabilisers that were intended to exchange the long rods currently acting as stabilisers.

THE METHODOLOGY MEETS ROCKETRY

The scientific groundwork of rocketry was laid during the Enlightenment by none other than Sir Isaac Newton. His three laws of motion,

1) During a particular organization, a body will stay in an exceedingly state of constant velocity (moving or at rest) unless a net force is functioning on the body

2) The online force functioning on a body causes an acceleration that's proportional to the body's inertia (mass), i.e. F=ma

3) A force exerted by one body on another induces an equal and opposite reaction force on the primary body are known to each student of basic physics. In fact, these three laws were probably intuitively understood by early rocket designers, but by formalising the principles, they were consciously being employed as design guidelines. The primary law explains why rockets move the least bit. Without creating propulsive thrust the rocket will remain stationary. The second quantifies the number of thrust produced by a rocket at a selected instant in time, i.e. for a selected mass M. (Note, Newton's second law is just valid for constant mass systems and is therefore not resembling the conservation of momentum approach described above. When mass varies, an equation that explicitly accounts for the changing mass must be used.) The third law explains that because of the expulsion of mass, in re-action a thrusting force is produced on the rocket.

In the 1720s, around the time of Newton's death, researchers within the Netherlands, Germany and Russia began to use Newton's laws as tools within the design of rockets.

The Dutch professor Willem Gravesande built rocket-propelled cars by forcing steam through a nozzle. In Germany and Russia rocket designers began to experiment with larger rockets. These rockets were powerful enough that the recent exhaust flames burnt deep holes into the bottom before launching. The colonial wars of 1792 and 1799 saw the employment of Indian rocket fire against the British army. Hyder Ali and his son Tipu Sultan, the rulers of the dominion of Mysore in India, developed the primary iron-cased rockets in 1792 then used it against British within the Anglo-Mysore Wars.

Casing the propellant in iron, which extended range and thrust, was more advanced technology than anything a people had seen until then, and inspired by this technology, Colonel William Congreve began to style his own rocket for the British forces. Congreve developed a brand new propellant mixture and fitted an iron tube with a conical nose to enhance aerodynamics. Congreve's rockets had an operational range of up to five km and were successfully employed by land within the Napoleonic Wars and launched from ships to attack Fort McHenry within the War of 1812. Congreve created both carbine ball-filled rockets to be used against land targets, and incendiary rockets to be used against ships. However, even Congreve's rockets couldn't significantly improve on the most shortcomings of rockets: accuracy.

TO THE BATTLEFIELDS

At the time, the effectiveness of rockets as a weapon wasn't their accuracy or explosive power, but rather the sheer number that would be fired simultaneously at the enemy. The Congreve rockets had managed some kind of basic attitude control by attaching an extended keep on with the explosive, but the rockets had an inclination to veer sharply astray. In 1844, a British designer, William Hale developed spin stabilisation, now commonly utilized in gun barrels, which removed the necessity for the rocket stick. William Hale forced the escaping exhaust gases at the rear of the rocket to hit small veins, causing the rocket to spin and stabilise (the same reason that a gyroscope remains upright when spun on a table top). The utilization of rockets in war soon took a back seat another time when the Prussian army developed the breech-loading cannon with exploding warheads that proved far superior than the simplest rockets.

FICTIONS IGNITE THE MINDS

Soon, new applications for rockets were being imagined. Jules Verne, always the visionary, put the dream of space flight into words in his science-fiction novel "De la Terre á la Lune" (From the planet to the Moon), within which a projectile, named Columbiad, carrying three passengers are shot at the moon employing a giant cannon. The Russian school teacher Konstantin Tsiolkovsky (of rocket equation fame) proposed

the concept of using rockets as a vehicle for space exploration but acknowledged that the most bottlenecks of achieving such a feat would require significant developments within the range of rockets. Tsiolkovsky understood that the speed and range of rockets was limited by the exhaust velocity of the propellant gases. in a very 1903 report, "Research into part by Means of Rocket Power", he suggested the employment of liquid-propellants and formalised the rocket equation derived above, relating the jet engine exhaust velocity to the change in velocity of the rocket itself (now called the Tsiolkovsky rocket equation in his honour, although it had already been discovered previously).
Tsiolkovsky also advocated the event of orbital space stations, alternative energy and also the colonisation of the scheme. one in every of his quotes is especially prescient considering Elon Musk's plans to colonise Mars:

"The Earth is that the cradle of humanity, but one cannot board the cradle forever"
— in an exceedingly letter written by Tsiolkovsky in 1911.

The American scientist Robert H. Goddard, now referred to as the daddy of contemporary rocketry, was equally inquisitive about extending the range of rockets, especially reaching higher altitudes than the gas balloons used at the time. In 1919 he published a brief manuscript entitled "A Method of Reaching Extreme Altitudes" that summarised his mathematical analysis and practical experiments in designing high altitude rockets. Goddard proposed 3 ways of improving current solid-fuel technology. First, combustion should be contained to a little chamber such that the fuel container would be subjected to much lower pressure. Second, Goddard advocated the employment of multi-stage rockets to increase their range, and third, he suggested the utilization of a supersonic de Laval nozzle to boost the exhaust speed of the recent gases.

Goddard began to experiment with solid-fuel rockets, trying various different compounds and measuring the speed of the exhaust gases. As a result of this work, Goddard was convinced of Tsiolkovsky's early premonitions that a liquid-propellant would work better. The matter that Goddard faced was that liquid-propellant rockets were a wholly new field of research, nobody had ever built one, and therefore the system required was far more complex than for a solid-fuelled rocket. Such a rocket would want separate tanks and pumps for the fuel and oxidiser, a combustion chamber to mix and ignite the 2, and a turbine to drive the pumps (much just like the turbine during a reaction-propulsion engine drives the compressor at the front). Goddard also added a de Laval nozzle which cooled the recent exhaust gases into a

hypersonic, highly directed jet, quite doubling the thrust and increasing engine efficiency from 2% to 64%! Despite these technical challenges, Goddard designed the primary successful liquid-fuelled rocket, propelled by a mix of gasoline as fuel and atomic number 8 as oxidiser, and tested it on March 16, 1926. The rocket remained lit for 2-5 seconds and reached an altitude of 12.5 meters. Rather like the primary 40 yard flight of the Wright brothers in 1903, this feat seems unimpressive by today's standards, but Goddard's achievements put rocketry on an exponential growth curve that led to radical improvements over the following 40 years. Goddard himself continued to innovate; his rockets flew to higher and better altitudes, he added a gyroscope system for control and introduced parachute recovery systems.

On the opposite side of the Atlantic, German scientists were setting out to play a serious role within the development of rockets. Inspired by Hermann Oberth's ideas on rocket travel, the mathematics of spaceflight and therefore the practical design of rockets published in his book "Die Rakete zu den Planetenräumen" (The Rocket to Space), variety of rocket societies and research institutes were founded in Germany. The German bicycle and carmaker Opel (now a part of GM) began developing rocket powered cars, and in 1928 Fritz von Opel drove the Opel-RAK.1 on a racetrack. In 1929 this design was extended to the Opel-Sander RAK 1-airplane, which crashed during its first flight in Frankfurt. Within the land, the Gas dynamics Laboratory in Leningrad under the directorship of Valentin Glushko built over 100 different engine designs, experimenting with different fuel injection system techniques.

V2 - THE COLORFUL DREAM BEHIND BLACK AND WHITE MACHINE

Under the directorship of Wernher Wernher von Braun and Walter Dornberger, the Verein for Raum Schiffahrt or Society for voyage played a pivotal role within the development of the Vergeltungswaffe 2, also called the V-2 rocket, the foremost advanced rocket of its time. The V-2 rocket burned a combination of alcohol as fuel and oxygen as oxidiser, and it achieved great amounts of thrust by considerably improving the mass rate of flow of fuel to about 150 kg (380 lb) per second. The V-2 featured much of the technology we see on rockets today, like turbo pumps and guidance systems, and thanks to its range of around 300 km (190 miles), the V-2 might be launched from the shores of the Baltic to bomb London during WWII. The 1000 kg (2200 lb) explosive warhead fitted within the tip of the V-2 was capable of devastating entire city blocks, but still lacked the accuracy to reliably hit specific targets. Towards the end of WWII, German scientists were already planning much larger rockets, today called Intercontinental Ballistic Missiles (ICBMs), that might be accustomed to attack

the US, and were strapping rockets to aircraft either for powering them or for vertical take-off.
With the autumn of the Nazi Germany in April 1945 lots of this technology fell into the hands of the Allies. The Allies' rocket program was much less sophisticated; such a race ensued to capture the maximum amount of the German technology as possible. The Americans alone captured 300 train countless V-2 rocket parts and shipped them back to the u. s.. Furthermore, the foremost prominent of the German rocket scientists emigrated to the u. s., partly because of the far better opportunities to develop rocketry there, and partly to flee the repercussions of getting played a task within the Nazi armed forces. The V-2 essentially evolved into the American Redstone rocket which was used during the Mercury project.

THE SPACE WAR - TO MOON AND BEYOND

After WWII both the u. s. and also Russia began heavily funding research into ICBMs, partly because these had the potential to hold nuclear warheads over long distances, and partly because of the allure of being the primary to trip space. In 1948, the US Army combined a captured V-2 rocket with a WAC Corporal rocket to create the biggest two-stage rocket to be launched within the u. s.. This two-stage rocket was referred to as the "Bumper-WAC", and over the course of six flights reached a peak altitude of 400 kilometres (250 miles), just about exactly to the altitude where the International satellite (ISS) orbits today.
Despite these developments the Soviets were the primary to place a man-made object into orbit into space, i.e. a man-made satellite. Under the leadership of chief designer Sergei Korolev, the V-2 was copied and so improved upon within the R-1, R-2 and R-5 missiles. At the turn of 1950s the German designs were abandoned and replaced with the inventions of Aleksei Mikhailovich Isaev which was used as the basis for the primary Soviet ICBM, the R-7. The R-7 was further developed into the Vostok rocket which launched the primary satellite, Sputnik I, into orbit on October 4, 1957, a mere 12 years after the end of WWII. The launch of Sputnik used to be the primary major article of the space race. Only a pair of weeks later the Soviets successfully launched Sputnik II into orbit with dog Laika onboard.
One of the issues that the Soviets failed to solve was atmospheric re-entry. Any object wishing to orbit another planet requires enough speed specified that the gravitation towards the world is offset by the curvature of the planet's surface. However, during re-entry, this causes the orbiting body to literally smash into the atmosphere creating incredible amounts of warmth. In 1951, H.J. Allen and A.J. Eggers discovered that a high drag, blunted shape, not a low-drag teardrop, counter-intuitively minimises the

re-entry effects by redirecting 99% of the energy into the encircling atmosphere. Allen and Eggers' findings were published in 1958 and were employed in the Mercury, Gemini, Apollo and Soyuz manned space capsules. This design was later improved upon within the ballistic capsule, whereby a wave was induced on the warmth shield of the spacecraft via a particularly high angle of attack, so as to deflect most of the warmth far from the warmth shield.

The United States' first satellite, Explorer I, wouldn't follow until January 31, 1958. Explorer I weighed about 30 times the Sputnik II satellite, but the Geiger radiation counters on the satellite were accustomed to make the primary scientific discovery in location, the physicist Radiation Belts. Explorer I had originally been developed as a part of the regular army, and in October 1958 the National Advisory Committee for Aeronautics (NACA, now NASA) was officially formed to oversee the program. Simultaneously, the Soviets developed the Vostok, Soyuz and Proton family of rockets from the initial R-7 ICBM to be used for the human spaceflight programme. In fact, the Soyuz rocket remains employed today, is the most often used and reliable rocket system in history, and after the Space Shuttle's retirement in 2011 became the sole viable means of transport to the ISS. Similarly, the Proton rocket, also developed within the 1960s, remains getting used to haul heavier cargo into low-Earth orbit.

Shortly after these initial satellite launches, NASA developed the experimental X-15 air-launched rocket-propelled aircraft, which, in 199 flights between 1959 and 1968, broke numerous flying records, including new records for speed (7,274 km h or 4,520 mph) and altitude records (108 km h or 67 miles). The X-15 also provided NASA with data regarding the optimal reentry angles from space into the atmosphere.

YURI GAGARIN - "ADAM OF SPACE"

The next milestone within the space race another time belonged to the Soviets. On April 12, 1961, the cosmonaut Gagarin became the primary human to travel into space, and as a result became a world celebrity. Over a period of slightly below two hours, Gagarin orbited the planet inside a Vostok 1 spacecraft at around 300 km (190 miles) altitude, and after re-entry into the atmosphere ejected at an altitude of 6 km (20,000 feet) and parachuted to the bottom. At this time Gagarin became the foremost famous Soviet in the world, travelling round the world as a beacon of Soviet success and superiority over the West.

Shortly after Gagarin's successful flight, the American astronaut Alan Shepherd reached a suborbital altitude of 187 km (116 miles) within the Freedom 7 Mercury

capsule. The Redstone ICBM that was to launch Shepherd from Cape Canaveral didn't quite have the ability to send the Mercury capsule into orbit, and had suffered a series of embarrassing failures before the launch, increasing the pressure on the US rocket engineers. However, days after Shephard's flight, President John F. Kennedy delivered the now famous words before a joint session in Congress

"This nation should commit itself to achieving the goal, before this decade is out, of landing a person on the Moon and returning him safely to the world."

Despite the bold nature of this challenge, NASA's Mercury project was already well underway in developing the technology to place the primary human on the moon. In February 1962, the more powerful Atlas missile propelled cosmonaut into orbit, and therefore thereby restored some style of parity between the USA and Russia. The last of the Mercury flights were scheduled for 1963 with Gordon Cooper orbiting the world for nearly 1.5 days. The family of Atlas rockets remains one in all the foremost successful to the present day. Besides launching a variety of astronauts into space during the Mercury project, the Atlas has been used for bringing commercial, scientific and military satellites into orbit.

Following the Mercury missions, the Gemini project made significant strides towards a successful Moon flight. The Gemini capsule was propelled by a more powerful ICBM, the Titan, and allowed astronauts to stay in space for up to 2 weeks, during which astronauts had the primary experience with space-walking, and rendezvous and docking procedures with the Gemini spacecraft. An improbable ten Gemini missions were flown throughout 1965-66. The high success rate of the missions was testament to the improving reliability of NASA's rockets and spacecraft, and allowed NASA engineers to gather invaluable data for the approaching Apollo Moon missions. The Titan missile itself remains united with the foremost successful and long-lived rockets (1959-2005), carrying the Viking spacecraft to Mars, the Voyager probe to the outer scheme, and multiple heavy satellites into orbit. At about the same time, near the early 1960s, a complete family of versatile rockets, the Delta family, was being developed. The Delta family became the workhorse of the US space programme achieving quite 300 launches with a reliability greater than 95 percent! The flexibility of the Delta family was supported with the flexibility to tailor the lifting capability, using different interchangeable stages and external boosters that would be added for heavier lifting.

At this time, the tide had mostly turned. The US had been off to a slow start but had used the info from their early failures to boost the planning and reliability of their rockets. The Soviets, while being more successful initially, couldn't achieve the

identical rate of launch success and this significantly hampered their efforts during the upcoming race to the moon.

ROCKET... SET….GO……

To get to the moon, a far more powerful rocket than the Titan or Delta rockets would be needed. This now infamous rocket, the 110.6 m (330 feet) tall Saturn V (check out this sick drawing), consisted of three separate main rocket stages; the Apollo capsule with alittle fourth propulsion stage for the return trip; and a two-staged lunar lander, with one stage for descending onto the Moon's surface and therefore the other for lifting backpedal the Moon. The Saturn V was largely the brainchild and crowning achievement of Wernher von Braun, the initial lead developer of the V-2 rocket in WWII Germany, with a capability of launching 140,000 kg (310,000 lb) into low-Earth orbit and 48,600 kg (107,100 lb) to the Moon. This launch capability dwarfed all previous rockets and to the present day remains the tallest, heaviest and most powerful rocket ever built to operational flying status (last on the chart at the beginning of the piece). NASA's efforts reached their glorious climax with the Apollo 11 mission on July 20, 1969 when astronaut cosmonauts became the primary man to line foot on the Moon, a mere 11.5 years after the primary successful launch of the Explorer I satellite. The Apollo 11 mission became the primary of six successful Moon landings throughout the years 1969-1972. A smaller version of the moon rocket, the Saturn IB, was also developed and used for a few of the first Apollo test missions and later to move three crews to the US space platform Skylab.

THE STORY OF THE FOREMOST SUCCESSFUL SPACECRAFT

NASA's final major innovation was the space vehicle. The concept behind the spacecraft was to style a reusable rocket system for carrying crew and payload into low-Earth orbit. The rationale behind this idea is that manufacturing the rocket hardware could be a major contributor to the general launch costs, which allows different stages to be destroyed after launch isn't cost effective. Imagine having to throw away your Boeing 747 or Airbus A380 whenever you fly from London to ny. during this case ticket prices wouldn't be where they're now. The Shuttle consisted of a winged airplane-looking spacecraft that was boosted into orbit by liquid-propellant engines on the Shuttle itself, fuelled from an enormous orange external tank, and two solid rocket boosters attached to either side. After launch, the solid-rocket boosters and external fuel tank were jettisoned, and also the boosters recovered for future use. At the tip of a Shuttle mission, the orbiter re-entered Earth's atmosphere, then followed a tortuous zig-zag course, gliding unpowered to land on a runway like all

other aircraft. Ideally NASA promised that the Shuttle was visiting to reduce launch costs by 90%. However, crash landings of the solid rocket boosters in water often damaged them beyond repair, and therefore the effort required to service the orbiter protection, inspecting each of the 24,300 unique tiles separately, ultimately led to the value of putting a kilogram of payload in orbit to be greater than for the Saturn V rocket that preceded it. The five Shuttles, the Endeavour, Discovery, Challenger, Columbia and Atlantis, completed 135 missions between 1981 and 2011 with the tragic loss of the Challenger in 1983 and also the Columbia in 2003. While the Shuttle facilitated the development of the International orbiter and therefore the installation of the Hubble space telescope in orbit, the last word goal of economically sustainable spacefaring was never achieved.
However, this goal is now on the agenda of business space companies like SpaceX, Reaction Engines, Blue Origin, Rocket Lab and therefore the Sierra Nevada Corporation.

GIANTS TO THE MOON

After the demise of the ballistic capsule programme in 2011, the US' capability of launching humans into space was heavily restricted. NASA is currently performing on a brand new Space Launch System (SLS), the aim of which is to increase NASA's range beyond low-Earth orbit and further out into the scheme. Although the SLS is being designed and assembled by NASA, other partners like Boeing, United Launch Alliance, Orbital ATK and Aerojet Rocketdyne are co-developing individual components. The SLS specification because it stands would make it the foremost powerful rocket in history and therefore the SLS is therefore being developed in two stages (reminiscent of the Saturn IB and Saturn V rocket). First, a rocket with a payload capability of 70 metric tons (175,000 lb) is being developed from components of previous rockets. The goal of this heritage SLS is to conduct two lunar flybys with the Orion spacecraft, one unmanned and also the other with a crew. Second, a more advanced version of the SLS with a payload capability of 130 metric tons (290,000 lb) to low-earth orbit, about the identical payload capacity and 20% more thrust than the Saturn V rocket, is deemed to hold scientific equipment, cargo and also the manned Orion capsule into part. The primary flight for an unmanned Orion capsule on a visit round the moon is planned for 2018, while manned missions are expected by 2021-2023. By 2026 NASA plans to send a manned Orion capsule to an asteroid previously placed into lunar orbit by a robotic "capture-and-place" mission.

RISE OF ELON AND SPACEX

However, with the commercialisation of voyage new incumbents are now functioning on even more daunting goals. The SpaceX Falcon 9 rocket has proven to be a really reliable launch system (with a current success rate of 20 out of twenty-two launches). Furthemore, SpaceX was the primary private company to successfully launch and recover an orbital spacecraft, the Dragon capsule, which regularly supplies the ISS with supplies and new scientific equipment. Currently, the US relies on the Russian Soyuz rocket to bring astronauts to the ISS but within the near future manned missions are planned with the Dragon capsule. The Falcon 9 rocket could be a two-stage-to-orbit launch vehicle composed of nice SpaceX Merlin rocket engines fuelled by O_2 and kerosene with a payload capacity of 13 metric tons (29,000 lb) into low-Earth orbit. There are three versions of the Falcon 9, v1.0 (retired), v1.1 (retired) and last the partially reusable full thrust version, which on December 22, 2015 used propulsive recovery to land the primary stage safely in foreland. To date, efforts are being made to increase the landing capabilities from land to sea barges. Furthermore, the Falcon Heavy with 27 Merlin engines (a central Falcon 9 rocket with two Falcon 9 first stages strapped to the sides) is predicted to increase SpaceX's lifting capacity to 53 metric tons into low-Earth orbit, making it the second most powerful rocket in use after NASA's SLS. First flights of the Falcon Heavy are expected for late this year (2016). Of course, the last word goal of SpaceX's CEO Elon Musk, is to form humans a multi planetary species, and to attain this he's progressing to send a colony of 1,000,000 humans to Mars via the Mars Colonial Transporter, an area launch system of reusable rocket engines, launch vehicles and space capsules. SpaceX's Falcon 9 rocket already has all-time low launch costs at $60 million per launch, but reliable re-usability should bring these costs down over the following decade specified a flight ticket to Mars could become enticing for a minimum of 1,000,000 of the richest people on Earth (or perhaps we could sell spots on "Mars – A Reality TV show").

BLUE FEATHER FLIES TO SPACE

Blue Origin, the rocket company of Amazon founder Jeff Bezos, is taking the same approach of vertical takeoff and landing to re-usability and lower launch coasts. The corporation is on an incremental trajectory to increase its capabilities from suborbital to orbital flight, led by its motto "Gradatim Ferocity" (latin for step by step, ferociously). Blue Origin's New Shepard rocket underwent its first test flight in April 2015. In November 2015 the rocket landed successfully after a suborbital flight to 100 km (330,000 ft) altitude and this was extended to 101 km (333,000 ft) in January 2016. Blue hopes to increase its capabilities to human spaceflight by 2018.

WE NEED MORE….

Reaction Engines could be a British aerospace company conducting research into space propulsion systems focused on the Skylon reusable single-stage-to-orbit spaceplane. The Skylon would be powered by the SABRE engine, a rocket-based combined cycle, i.e. a mixture of an air-breathing reaction engine and a rocket, whereby both engines share the identical flow path, reusable for about 200 flights. Reaction Engines believes that with this method the price of carrying one kg (2.2 lb) of payload into low-earth orbit may be reduced from the $1,500 today (early 2016) to around $900. The hydrogen-fuelled Skylon is intended to take-off from a purpose built runway and accelerate to Mach 5 at 28.5 km (85,500 feet) altitude using the atmosphere's oxygen as oxidiser. This air-breathing part of the SABRE engine works on the identical principles as a reaction engine. A turbo-compressor is employed to boost the pressure ratio of the incoming atmospheric air, which is pre-staged by a pre-cooler to cool down the new air impinging on the engine at hypersonic speeds. The compressed gas is fed into a rocket combustion chamber where it's ignited with liquid hydrogen. As in an exceedingly standard reaction engine, a high ratio is crucial to pack the maximum amount of the oxidiser into the combustion chamber and increase the thrust of the engine. Because the natural source of oxygen runs out at high altitude, the engines switch to the internally stored oxygen supplies, transforming the engine into a closed-cycle rocket and propelling the Skylon spacecraft into orbit. The theoretical advantages of the SABRE engine is its high fuel efficiency and Mass, which facilitate the single-stage-to-orbit approach. harking back to the Shuttle, after deploying its payload of up to fifteen tons (38,000 lb), the Skylon spacecraft would then re-enter the atmosphere protected by a protective cover and land on a runway. The primary ground tests of the SABRE engine are planned for 2019 and first unmanned test flights are expected for 2025.

CHASING THE INFINITE DREAMS

Sierra Nevada Corporation is functioning alongside NASA to develop the Dream Chaser spacecraft for transporting cargo and up to seven people to low-earth orbit. The Dream Chaser is meant to launch on top of the Atlas V rocket (in place of the nose cone) and land conventionally by gliding onto a runway. The Dream Chaser looks plenty sort of a smaller version of the ballistic capsule, so intuitively one would expect the identical cost inefficiencies as for the Shuttle. However, the engineers at Sierra Nevada say that two changes are made to the Dream Chaser that ought to reduce the upkeep costs. First, the thrusters used for attitude control are ethanol-based, and thus not toxic and lots less volatile than the hydrazine-based thrusters employed by the

Shuttle. This could allow maintenance of the Dream Chaser to ensue immediately after landing and reduce the time between flights. Second, the thermal protection system is predicated on an ablative tile that may survive multiple flights and might get replaced in larger groups instead of tile-by-tile. The Dream Chaser is planned to undergo orbital test flights in November 2016.

ROAR OF ROCKET LAB

Finally, the New Zealand-based firm Rocket Lab is developing the all-carbon composite liquid-fuelled Electron rocket with a payload capability to low-Earth orbit of 110 kg (240 lb). Thus, Rocket Lab is specializing in high-frequency rocket launches to move low-mass payload, e.g. nano satellites, into orbit. The goal of Rocket Lab is to make access to space frequent and affordable. The rapidly evolving small-scale satellites that provide us with scientific measurements and high-speed internet are often launched reliably and quickly. The Rocket Lab system is meant to cost $5 million per launch at 100 launches a year and use less fuel than a flight on a Boeing 737 from point of entry to l. a. A special challenge that Rocket Lab is facing is the development of the all-carbon composite oxygen tanks to supply the mass efficiency required for this high fuel efficiency. So far the containment of cryogenic (super cold) liquid fuels, like liquid hydrogen and LOX, remains the domain of metallic alloys. Concerns still exist about potential leaks because of micro cracks developing within the resin of the composite at cryogenic temperatures. In composites, there's a mismatch between the thermal expansion coefficients of the reinforcing fibre and therefore the resin, which induces thermal stresses because the composite is cooled to cryogenic temperatures from its high temperature/high pressure curing process. The temperature and pressure cycles during the liquid oxygen/hydrogen fill-and-drain procedures then induce extra fatigue loading which will cause cracks permeating through the structure through which hydrogen or oxygen molecules can easily pass. This leaking process poses a true problem for explosions.

WHERE CAN WE GO FROM HERE?

As we've seen, over the last 2000 years rockets have evolved from simple toys and military weapons to complex machines capable of transporting humans into space. To date, rockets are the sole viable gateway to place beyond Earth. Furthermore, we've seen that the event of rockets has not always followed a unidirectional path towards improvement. Our capability to send heavier and heavier payloads into space peaked with the event of the Saturn V rocket. This great technological leap was fuelled, to an oversized extent, by the competitive spirit of the land and also the us. Unprecedented funds were available to rocket scientists on either side during the 1950-1970s.

Furthermore, dreamers and visionaries like writer Konstantin Tsiolkovsky and Gene Roddenberry sparked the imagination of the general public and garnered support for the space programs.

After the 2003 Columbia disaster, public support for spending taxpayer money on often over-budget programs understandably waned. However, the successes of incumbent companies, their fierce competition and visionary goals of colonising Mars are once more inspiring a younger generation. As the members of the great UL Space Club, we are also dreaming so high to the infinite canvas for more.

Abhiram T P
UL SPACE CLUB Member

Launch Vehicle - Booster of Space Exploration

Launch vehicles are rocket propelled vehicles which are used to carry payload from the surface of earth to space. Practical launch vehicles are used to send crewed craft,uncrewed space probes and satellites into space. It mainly comprises one or more rocket engine, fuel, propellant tank, different kinds of sensors,orbiter,a crew compartment and two large solid rocket motors. Generally launch vehicles tend to be slender incorporating several shapes like cone, cylinders and planar fin. Origin of most of the launch vehicles are from ballistic missiles developed for several military uses. Konstantin Tsiolkovsky in Russia Robert Goddard in the United State and Hermann Oberth in Germany are the pioneers in space exploration who identified and led to the development of launch vehicles for successful spaceflight. Goddard was the first to build an experimental liquid fueled rocket.

Basic working of launch vehicle

Working of the launch vehicle is based on Newton's third law of motion.The rocket pushes the exhaust backward and exhaust makes the rocket move forward, the rockets burn fuel into hot gases and make the rocket move forward. The Engines of the rockets are quite different from that of jet engines. Jet engines need air to work whereas rocket engines don't need air, they can operate in the vacuum beyond the atmosphere. Two types of rocket engine are mainly used, engines which use liquid fuel and engines which use solid fuel. Liquid-fuel rocket engines are complex machines,their maximum efficiency is obtained by pumping both fuel and oxidizer into the engine combustion chamber at high rate, pressure and suitable mixer. The fuel pumps are operated by the turbine powered as a result of the burning of a small proportion of the fuel after combustion. The resulting exhaust exits through a nozzle which results in the acceleration of the rocket into high velocity. Solid propellant rocket motors are generally simple in design , they consist of a mixture of both fuel and oxidizer in a case which burns at a rapid rate after ignition. Solid rocket motors are mostly used as strapons to the liquid fueled first stage of the launch vehicle to provide additional thrust. Unlike liquid fuel rocket engines, solid propellant rocket motors burn until they are exhausted after ignition. Launch vehicles need a great acceleration to escape from earth's gravity; such a great acceleration requires one or more rocket engines and a large quantity of propellant.

Types and characteristics of launch vehicle

There are three primary aims for the launch vehicles, they are to maximize the weight lifting capacity of the vehicle, providing reliability and minimum or acceptable cost. In order to balance these three factors there are two types of launch vehicles in use. Expendable launch vehicle and reusable launch vehicle. Expendable launch vehicles are those that can be launched at only once, after which its components are either destroyed during reentry or discarded in space. Thereby total weight of the rocket can be reduced greatly as the rocket accelerates upward, in such launch vehicles small rockets are placed one on top of the other and fired in succession. Expendable launch vehicles are widely proven technology simpler in design than reusable launch vehicles, therefore its production cost is lower but since they are usable only once their per launch cost is significantly higher. In addition to this, each staging event in the expendable launch vehicle is vulnerable to failure ,due to separation failure, ignition failure or stage collision. Reusable launch vehicle is the second type of launch vehicle which is introduced as a solution to achieve low cost, reliability and on-demand space access. Such vehicles can be used for several missions, these vehicles return to earth after successfully putting the payload or people into orbit and these vehicles are recovered and reused for other missions, this is the biggest advantage of reusable launch vehicles and such a system financially supports other space programs.

Lack of reusable rockets restrict spaceflight to only the richest Nations. Reusable launch vehicles weigh more than equivalent Expendables stage since it needs some supplementary systems landing gear and surplus propellant for landing. Even after recovering the launch vehicle it needs refurbishment for its next flight, this refurbishment is often lengthy and expensive too. Launch vehicles have a limit on how many times it can be refurbished and used, before it has to be retired. Mechanism to prevent disintegration of a launch vehicle is crucial since any failure in such a mechanism results in catastrophic failure.

Akhila Ramakrishnan

UL SPACE CLUB Member

THE BIOLOGICAL LIFE OF A SAILOR OF THE HEAVENS

Most of us have been told in our childhood that Astronauts in space experience a change in their height. Although most of us have heard it earlier, I bet that only few have ever pondered over the topic - why people tend to grow taller in space. Well if you haven't, don't you worry, it is just a minor consequence of a slight change that your body experiences while being subjected to a different gravitational system. We'll get back to it later.

But are these the only changes? No, this isn't the only change. A human going to space is likely to have both physical and mental transitions. What are these other changes then? Well, let's see. Humans in the medieval period had never thought their kind ever would have a chance to go to the heavens. They didn't even believe that humans could fly. But just look at your world and see what science has done to us. The humans in the last one century saw advancement in science and daily life on a scale that could have been possible in a thousand lifetimes for Sir Isaac Newton and Galileo. And one of the great developments was the advent of space flight. We did what our ancestors thought were impossible. It is true that it did us a lot of good, like telecommunication facilities, better weather predictions, navigation and many more. We also went to the moon and sent missions which went out of our dear solar system.

Now we have an outpost in space - The International Space Station. People live there for months and do experiments. They experience an entirely different environment up there. It often causes health related issues as well. The health of the astronauts had been an issue during the prime time of space flight. The hostile environment the space presents often makes people worry about a trip to space. But the old days are gone and we have been carried forward by the strong current called science. Now we know more about the space environment and have designed better techs to help us out.

The one of the main possible threats an astronaut might face is from radiation. Here on earth we have a strong magnetic field along with a thick atmosphere which saves us from almost all sought of hazardous radiation from space. But in space the situation is different. Without a shield to stand guard, astronauts have a high chance of cancers. But luckily, due to our development in science and technology, space institutions all over the globe have taken the necessary measures to prevent radiation from reaching the astronauts.

But the Radiations are only one of them. A much more serious threat is from prolonged anomalies in circadian rhythm. A circadian rhythm can be pictured as an internal clock present in all human beings. It helps us in regulating our day to day life activities like

sleep-wake cycles. It works as a result of action of a gene called the period gene. The 2017 Nobel Prize in medical science was awarded for successfully extracting this gene. These genes manipulate the process of synthesis of a protein called the PER1 [Period Circadian Protein Homolog]. These are developed in the nucleus of a cell during the night and get destroyed during the day. This process continues throughout the life of an organism. So why is it important in the case of astronauts? Circadian rhythms of all human beings are adjusted to the rotational period of earth. But on leaving earth there is a chance that the circadian rhythm may get alternated due reasons like different dark and light cycles, change in environment etc. Different dark-light cycles mean that the circadian rhythms are disrupted and as result he or she may experience physical anomalies like weight gain, impulsivity etc.

Another important issue is related to the Variation in the Gravity field. Upon leaving earth, an average human being experiences what we call the 'microgravity'. Staying in this state which isn't the usual 'walk on the hard ground' state often affects the person in areas like spatial orientation, coordination and balance. Although this problem can be solved after rehabilitation here on earth, this can cause a traumatic experience for an astronaut on entering back on the earth's surface. Microgravity also causes another crazy effect. They make our bones lose their average density up to 1 to 2% on average along with a loss in the average muscle mass. Here on earth we all experience muscle loss due to various reasons like lack of exercise or deficiency in basic nutrients required for muscle growth and maintenance. But still we can rebuild it here on earth. But in space the story is different. Here gravity puts a load on the muscles of a person to which the muscles get adapted to. On leaving earth and attaining microgravity, the naturally placed load on muscles by gravity decreases and as a result the standard situation gets altered. As a result, the protein synthesis gets interrupted along with the muscle fibers getting atrophied. Therefore one can say that body building in space is nearly impossible.

We all know that mental well-being is almost as important as physical health. Astronauts in general undergo a different mental state. Prolonged isolation and confinement can result in psychological troubles and increase in stress hormone level. This may even worsen the physical state of an astronaut. So, as a way to remedy this issue, a person going on a voyage to space is given extreme training here on earth to prepare them physically as well as emotionally.

Science has advanced into a stage where the world is the same as the dream of a daydreamer. Interestingly it's ever advancing towards an even wonderful future which

may turnout to be a gift or a curse. It's now up to us to decide what the future of the all mighty Sapiens will be. Let's work hard for a bright future.

Before I end this let me go back to the answer for the question why do we get taller in space. It's simple when compared with certain things that we read till now. All of us know about the disks present in our spinal cord. While living on earth, these disks are in a sort of compressed state. But on attaining microgravity, the gravity loses its grip resulting in expansion of these disks. However if you are under six feet, don't you even dare to think that in space you may get as tall as the NBA player. It can only increase your height by a few centimeters.

Let me say one last thing before concluding. Although an astronaut is likely to face the threats that we discussed, thanks to science, we need not be scared anymore. Past experience of astronauts and continuous hard work of space scientists has resulted in development of new ways to prevent the threats to a great extent. But even now we are still on our way. Let us hope for a new space age with bright days ahead.

Navaneeth Shajil

UL SPACE CLUB Member

ALREADY THE EARTH NOW SPACE TOO

Have you ever wondered if you might be hit by some sort of trash or junk falling from space? Well not to worry. The chances of being hit by a piece of orbital debris or meteorite is rarer than contracting the world's rarest disease. European Space Agency suggests this risk of being hit as less than a billion to one. But, there are severe problems evolving in the space that you should know about and find way-out from these threats. The uncontrolled proliferation of orbital debris, since the beginning of the space age, can make access to space perilous in the days to come. Telecommunication, Military Surveillance, Navigation, Remote Sensing, Weather Forecasting, Nuclear Monitoring, and Space Travel & Exploration — a stunning number of the world's military, economic and scientific activities are now based on these spacecraft operations.

As long as humans have been discovering outer-space, we've also been creating a bit of a mess. Since the dawn of space age in the 1950s, humans have launched nearly nine thousand satellites in Earth's orbit (as of January 2019). Of these, more than 5,000 are still in orbit and 1,950 are still functioning. The rest are considered space debris: jettisoned artificial materials, discarded launch vehicle components, and derelict space-craft in orbit around Earth, and pose a risk for collisions with functioning satellites or even crewed spacecraft. Based on these Sources: "Space Debris by the Numbers'' (information correct as of January 2018), European Space Agency www.esa.int numbers and estimates for the number of events resulting in fragmentation of orbiting objects over time, the European Space Agency estimates there are nearly 130 million pieces of debris larger than 0.04 inch (1 mm) in orbit today. On 29 June 1961, the US Transit-4A satellite was launched on a Thor-Ablestar rocket. The spacecraft was deployed into an orbit altitude between 881-998 km, with an orbit inclination 66.8 ◦. At 06:08:10 UTC on June 29, 77 minutes after the injection and separation of Transit-4A, the Ablestar upper stage exploded, distributing its dry mass of 625 kg across at least 298 fragments, of which nearly 200 were still in orbit 40 years later. Since this incident orbital debris have been the major contributor to the observable space object population, with on-orbit explosions as its major single source.

The terms orbital debris and space debris are more often used as synonyms. As per Inter-Agency Space Debris Coordination Committee (IADC), Space debris refers to: "Space debris are all man made objects including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non functional". Space debris can travel at speeds up to 17,500 mph(28,100 km/h). Now, Earth is engulfed by about

20000 rapidly moving traceable debris. These can be generally classified into 3 wide categories(based on size):- 10cm(Traceable debris), 1-10cm (potentially traceable),<1cm (Untraceable). There are numerous contributors to the littering of space such as explosions of fuel tanks, launch vehicle upper stages and fairings as well as active and defunct satellites blitzed by debris. And some things like Ed white's glove, Sunita Williams' camera, a thermal blanket, toothbrush and so on. In 1978, Kessler syndrome effect of single collision of debris launching more debris was proposed. Now this is the biggest source of debris as the amount of 1mm debris climbed into millions. The first accidental hyper velocity collision of two intact satellites occurred on 10 February 2009 at an altitude of 790 km, when Iridium 33 (1997-51C) collided with Cosmos 2251 (1993-36A).

Space debris has been a prominent environmental problem associated with space activities for the past decades. Debris mitigations measures including reduction of mission-related objects, prevention of on-orbit explosions, prevention of non-explosive release events, collision avoidance Orbital Debris: A Perspective by Frank and Ernest (NASA)between traceable objects, post-mission disposal of space systems, removal of passive on-orbit object became the focus. But there are many troubles to face. There is no internationally agreed system to defend the debris growth nor easy to manage legal agreement under which removal of orbital debris can be easily done. There aren't any developed and verified operational means by which orbital debris can be removed from orbit, which is cost effective & accomplishable. Various studies related to the space debris population and its evolution indicate that it would be mandatory to de-orbit 5 heavy debris per year (launcher stages, satellites) from the LEOs to stabilize the evolution.

There are ideas for Debris removal with lasers, known as "Laser Brooming''. The first proposals come from John Metzger. He developed the idea of a debris sweeper with a total mass of around 6300 kg, which roams the LEO region and engages debris objects in the 1-5cm size range, about 40,000 in numbers. German Aerospace Centre suggests using an ArXe-laser with 1 kJ pulse energy and a 100 Hz repetition rate, which can make up to 2% efficiency. Another idea is developing a 'Space Station' to recycle junk in orbit itself, and the "Terminator Tape" of Prox-1,a notebook sized module which can help in the space debris scourge. Creating a Global Fund, for approving incentives or penalties to mitigate the problem. There are many Active Debris Removal (ADR) satellites including 'RemoveDEBRIS'. "e.Deorbit '' was another dropped mission by ESA. Now they're working on "ClearSpaceOne'', which will be the first space mission to remove an item of debris, planned for launch in 2025. Another approach from the International Association for the Advancement of Space Safety (IAASS), is the

formation of INREMSAT (for International Removal, Maintenance and Servicing of Satellites). Under this, registered countries would be asked to sign a legal instrument to procure INREMSAT's services for the removal of a number of existing space debris.

There is an international forum by name IADC (Inter Agency Debris Coordination Committee) which consists of almost all space faring organisations and nations. It meets regularly and additionally the members interact with each other also on specific issues. Now, Space Debris mitigation is one among the contemporary topics in international space law by the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS). India has launched Project Netra to secure satellites from debris and other dangers.

Today, in light of the ever-increasing amount of debris, the removal of existing space debris is essential to reverse the growth. The remnants of China's Long March-5B-Y2, which was launched from Wenchang recently, disintegrated over Indian ocean now. Space is not a celestial dumping ground. We should work until these snippets of danger floating in space disappear totally. We should know that we are far from solving this problem of man-made cosmic threat. Let the positive happen.

Febin Firshad
UL SPACE CLUB Member

INFINITY

SECTION FOR MATHEMATICS

AN INVITATION TO MATHEMATICS

"Mathematics, rightly viewed, possesses not only truth, but supreme beauty- a beauty cold and austere, like that of a sculpture, without appeal to any part of our weaker nature, without the gorgeous trappings of painting or music, yet sublimely pure and capable of a stern perfection such as only the greatest art can show"

-Bertrand Russell

Mathematics is a human endeavour with its own rich history of human struggle and accomplishment. At the first dawn of civilization, it started with numbers and forms. Now it is in the midst of a golden age - more mathematics is discovered each day than at any time in its long history. Each year there are more than 50,000 mathematical papers and books that are prepared for mathematical reviews. The proof of Fermat's last theorem was solved in 1993 after 350 years of intense struggle. The $ 1 million Poincare conjecture , unanswered for 100 years, was solved by Grigory Perilman. A great number of new developments and challenges are created in a short time. In the time period between when these words were written and when you read them, it is quite likely that important new discoveries adjacent to the path laid out here have been made.

Mathematics shapes our technological society and serves as an indispensable tool and language in many fields. Today it is the only language of precise communication and technical understanding of almost every field of human endeavour. But there is something more to mathematics than its usefulness and utility. There is a lot of mathematics for its own sake, only for nurturing the glory of the human mind. That puzzles us what is the driving force for mathematicians for doing mathematics beyond the usefulness of it.

In mathematics, as in the arts, the quest is after the same elusive quality: Beauty, as the famous mathematician Henry Poincare said : "The mathematician does not study pure mathematics because it is useful ; [s]he studies it because [s]he delights in it and [s]he delights in it because it is beautiful".

But what is beauty? The great Henri Poincare admitted that " it may be very hard to define mathematical beauty, but that is just as true of beauty of all kinds". I will not try to define beauty anymore than I would try to define love or fear. You don't define

these things, you know them when you feel them. It is something that cannot be communicated in words but must be experienced .The Hungarian mathematician Paul Erdos thought it futile to attempt to explain it . It is like asking" why is Ludwig van Beethoven's ninth symphony beautiful ? if you don't see why, someone can't tell you ". Philosophers can argue whether beauty is the property of an object or lies in our perception of it. In the book "A mathematician's apology" GH Hardy discusses the aesthetics of mathematics and all as a rare glimpse into the thinking patterns of pure mathematicians in which Hardy would have both ways.

The best mathematics is eternal and like the best literature, it will "continue to cause intense emotional satisfaction to thousands of people after thousands of years". Few years ago, in a 2014 study led by UCL neurobiologist Prof.Semir zeki, MRI scans of mathematician's were performed while they contemplated equations they'd rated as beautiful. The region of their brain lit up (the medial orbito- frontal cortex part of the emotional brain's pleasure and reward centre) has been associated in other studies with experience of beauty derived from art or music. This says that activity in the brain of a trained mathematician admiring a great equation looks very similar to that of an art enthusiast in an art gallery. Euler's Identity, for example $e^{i\pi} + 1 = 0$ Equation that combines five of the most important numbers in mathematics - often cited as the most beautiful equation of all time. Stanford mathematician Keith Devlin has likened it to “A Shakespearean sonnet that captures the very essence of love or a painting that brings out the beauty of the human form that is far more that just skin deep"

Mathematics is not merely a means to describe aesthetics; a formula or a theorem, but has an integral beauty. "There are different kinds of beauty in mathematics'' says Allex Bellows, whose new book Visions of Numberland offers a gallery of colour your own mathematical patterns chosen either for their attractive appearance or because they demonstrate an abstract beauty.

A practice in mathematical circles is to divide the field into two ," applied versus pure " or we can bisect mathematics in the same way that brain is split, with an algebraic" left hemisphere" that thinks in logical sequences and a geometric "right hemisphere" that has a more visual approach. But the field also breaks down according to a more subtle distinction: One’s preference between two flavours of mathematical beauty. Mathematical beauty can come in one of two forms, in Robert Dijkgraaf’s words, “Either generic or exceptional.”

The first variant is an eternal form of beauty, reflected in formal structures and patterns. It’s a sense of wonder at the inexorable order in which the mathematical world arranges itself or the rigor and precision of formal logic itself. These structures

are incredibly powerful and useful, and form a certain perspective that can indeed be beautiful. Most people, certainly most non-mathematicians – it's tough to get truly excited by the concept of a vector space in n - dimensions, or a continuous function on a real line. To appreciate a form of abstraction, and this sense of aesthetics often feels cold and formal. It's the beauty of an ice queen, best admired from a safe distance.

The second form of beauty is more relatable. It concerns the exceptions to the rules, the objects do not fit into any larger category. This beauty has a very different feel to it. Consider for example, the dodecahedron, a favourite object in many mathematical cabinets of curiosities. One of, only a handful of symmetric objects that fully stand their own, and are not a part of any larger pattern. For example, it is easy to generalize a cube or a tetrahedron to an analogous object in arbitrary dimensions, but there are no higher dimensional analogues of the dodecahedron. The golden ratio and beauty of specific shapes all fall in this category.

Both types of beauty have charmed mathematicians over the years and lead to many advances. Abstraction is an obviously powerful tool. It allows one to deal with all members of the family at once, and it places problems in a wider perspective. Theoretical sciences are highly appreciating this. The case of theoretical physicists, most of the time they wrestle not with reality but with mathematical representations of it. In a mathematician's view, the syncing of fireflies is the same as syncing of network connection and can even extend to the pattern of signal transfering in the brain while sleeping. The mathematician who follows the ice queen often dislikes concrete applications or specific cases. The fascination with mathematical outcasts has been a production strategy too. Such objects often live at the intersection of multiple ideas and can act as an access between completely different worlds.

The famous Indian Astrophysicist S.Chandrashekhar in his lecture on creativity, said: " 'This shuddering before the beautiful' this incredible fact that a discovery motivated by a search after the beautiful in mathematics should find its exact replica in nature, persuades me to say that beauty is that to which the human mind responds at its deepest and most profound". Isaac Newton explained the elliptical orbits based on his universal theory of gravity. In fact, he showed how all motions in the heavens were versions of circles, ellipses, parabolas and hyperbolas. The beauty lay in Newton's abstract laws, not the specific solutions. Biologists started to collect all specimens in a group of organisms, and discovered the general theory of evolution. Chemists classified all elements, and uncovered the periodic table patterns in the process. Every time they discover that the universe's beauty lies in the abstract structures underlying

physical phenomena. The structures may at first feel confusing and difficult to relate to, but taking the long view often proves much more powerful and meaningful. And indeed, more beautiful.

It's tough for non-experts to see mathematics as beautiful in the first place. Beauty is in the eye of the beholder, sure but it's also hard to see when the work of art is hidden in darkness, obscured by an impenetrable cloud of symbols and jargon. Trying to appreciate mathematics without understanding its inner work is like reading descriptions of Beethoven's fifth symphony instead of hearing it. There is a technical barrier for appreciating the beauty of maths that does not exist to the same extent in art or music. Einstein thought about pure mathematics as "poetry of logic ideas". If you want to understand and appreciate it, you want to study the language; otherwise it is like reading poetry in a language you don't speak. So I urge you to explore and enjoy this grant landscape of mathematics. Same time reminded by the words of Euclid that, "There are no royal roads to Geometry". Yet those who persist will be rewarded with a glimpse of conceptual glory and a new way of appreciation towards the world as Feynman said, "The beauty that is there is for you is also for me, too. But I see a deeper beauty that isn't so readily available to others.

Abhinand P S
Student Fellow, UL SPACE CLUB

SOLVE THE PUZZLE

I recently saw a slight variant of a very popular problem and would like to share it. Here it is:

A man in my neighborhood has three daughters. One day when I asked their ages he said, “The product of their ages is 36.”

When I still couldn’t find their ages he said, “Ok. I’ll give you another clue: the sum of their ages is the same as the number of my house.”

I knew the number but still couldn’t calculate their ages. So the man gave me a last clue, “Your daughter is older than any of my daughters”

Finally I was able to figure out their ages. How old are they?

COEXISTENCE WITH COVID: THE UL SPACE CLUB WAY

We at UL Space Club were all set to organize the NIT space camp when the pandemic struck and strict compliance to the COVID-19 protocols became mandatory. Though disheartening, we had to fall in line in the best interest of all. The planned space camp had to be dropped. Further the Covid 19 pandemic era saw all developmental events including educational activities coming to a standstill or at the best reduced to online interactions. We were left high and dry.

At this juncture UL SPACE CLUB mentor E K Kutty Sir conducted a core level meeting of the club to take stock of the situation and chart out the future . We started thinking about future activities. We thought about how we could overcome the pandemic.

Finally we decided to start a webinar series as soon as possible. The meeting was conducted on 16th of May 2020. Very next week we kicked off our webinar series. We created a webinar core team under Kutty sir. And we decided not to restrict our programs to just 40 students, but to make it accessible for any interested student in the country.

Webinar series became an instant hit and nationally popular after the first session itself. Few national media reported about our program. Our first session was about Expansion of the Universe with Dr. Jayanth Murthy (Senior professor, IIA). Around 30 students participated in the webinar. It was disappointing but we believed that in upcoming sessions the participation would improve.

The decision was to conduct the webinar weekly. We conducted sessions on all saturdays. But in 2021, it changed to every second Saturday. This decision was to adjust with the academic schedule of our members. We conducted 36 sessions of webinar. May be the longest webinar series in this country in the pandemic era. Among these sessions we conducted one session with IIST as they selected us as the collaborator of their foundation day program.

From 30 participants, the participation came to around 450. Along with the webinar series we conducted a few special webinars on special days as also provided an opportunity for students to directly interact with the national level experts from organizations like ISRO, DRDO, etc. As a part of this, we conducted events on Moon day, Kalam memorial day, Children's day, National Science day etc. And we interacted with scientists like Padmasree Mylswami Annadurai and Nikhil mukund.

Just webinars?

No. We conducted paper presentations with the student fellows and competitions for school students. As a part of our webinar series we conducted quizzes on the webinar topics after each webinar. Along with that, on Moonday 2020 we conducted several programs and we got great support in the form of good participation.

How about the reach?

The reach was about 40 students of Kozhikode district at the start of these programs. But now our primary level reach is about 800 students all over India. Along with the webinars we have a good social media wing. We have 200+ followers on Facebook, 100 followers on Instagram and 750+ subscribers on YouTube.

So COVID-19 constraints have been converted to an opportunity by UL space club. The journey for sure will continue with renewed vigor whatever be the situation and challenges thrown at us. We are nurturing a vibrant group of students with ignited minds and an untiring quest to acquire knowledge. The coevolution of the UL space club during the COVID-19 pandemic times is the best example for this resilience.

Varun K
Student Fellow, UL SPACE CLUB

HISTORY OF SPACE IN THIS MONTH

MAY

May 1

1949: Gerard Kuiper discovers Nereid, moon of Neptune

1996: Comet Hyakutake closest approach to Sun.

May 2

Astronomy Day (Spring)

May 3

2003: ISS Expedition Six crew returns to Earth after 161 days in orbit

May 4

1967: Lunar Orbiter IV launched

1989: STS-30 Atlantis launched, releases Magellan spacecraft

2002: Aqua satellite launched

May 5

1961: Freedom 7 suborbital flight; Alan Shepard is first American in space

Wednesday 6

1968: Neil Armstrong ejects safely from Lunar Landing Research Vehicle before it crashes

1975: NASA announces that Canada will build the Shuttle robot arm

May 7

1992: STS-49 Endeavour launched.

May 8

2003:GSLV D2 launched by ISRO

May 9

2003: Hayabusa launched, first mission to retrieve a sample from an asteroid

May 10

Mother's Day

1900: Cecilia Payne-Gaposchkin born

1967: M2-F2 lifting body crash-lands; footage later becomes opening scene of "The Six Million Dollar Man"

May 11

Saturn stationary

Pallas stationary

2009: STS-125 Atlantis launched, fifth and final Hubble servicing mission

May 12

Jupiter 2° north of Moon

Saturn 3° north of Moon

1930: Adler Planetarium opens, first planetarium in Western Hemisphere

May 13

Venus stationary

1964: Apollo A-001 launched (Little Joe II test flight)

May 14

1973: Skylab launched

2009: Herschel and Planck space observatories launched

2010: STS-132 Atlantis launched

May 15

1857: Williamina Fleming born

1958: Sputnik 3 launched

1963: Faith 7 launched, last Mercury program flight

1997: STS-84 Atlantis launched, sixth Mir docking mission

2012: Soyuz TMA-04M launched carrying ISS Expedition 31/32 crew

May 16

2011: STS-134 Endeavour launched

May 17

1836: Norman Lockyer born

1974: SMS-1 launched, first geostationary weather satellite

May 18

1969: Apollo 10 launched

1984: Viking 1 lander given to National Air & Space Museum

1996: First test flight of DC-XA rocket

2009: 23rd and final spacewalk to service the Hubble Space Telescope

May 19

1965: Apollo A-003 launched

1996: STS-77 Endeavour launched

2000: STS-101 Atlantis launched

May 20

1978: Pioneer-Venus 1 launched

1995: Spektr module launched to Mir space station

May 21

2010: IKAROS spacecraft launched; first successful solar-sail propulsion

May 22

1969: Apollo 10 lunar module descends to within 50,000 feet of the lunar surface

2012: Dragon C2+ spacecraft launched, first commercial mission to dock with ISS

May 23

1984: NASA selects 10th astronaut group

May 24

1962: Aurora 7 launched

May 25

1961: JFK challenges nation to Moon landing before end of decade

1965: Saturn SA-8 launched

1966: Roll-out of first full-scale Saturn V

1973: Skylab 2 begins 28-day mission

2008: Phoenix lander lands on Mars

May 26

1951: Sally Ride born

May 27

2009: Soyuz TMA-15 launched carrying ISS Expedition 20/21 crew

May 28

1959: First primates in space, Able and Baker (monkeys), complete suborbital flight

1964: SA-6 launched, second Saturn I Block 2

2013: Soyuz TMA-09M launched carrying ISS Expedition 36/37 crew

2014: Soyuz TMA-13M launched carrying ISS Expedition 40/41 crew

May 29

1919: Einstein's General Theory of Relativity tested during total solar eclipse2009: ISS Expedition 20 begins

May 30

1934: Alexi Leonov born

1966: Surveyor 1 launched

1971: Mariner 9 probe launched

May 31

1975: European Space Agency formed

1990: Kristall module launched to Mir space station

2008: STS-124 Discovery launched.

Compiled by : Abhinav Pradeep

UL SPACE Member

REVIEW POINT

A BRIEF HISTORY OF ROCKETRY IN ISRO

"We do not have the fantasy of competing with the economically advanced nations. But we are convinced that if we are to play a meaningful role nationally, we must be second to none in the application of advanced technologies to the real problems of man and society."

These are the words of Vikram Sarabhai. As ISRO worked considering these words as their motto India is now one among the world's spacefaring nations and arguably occupies a unique place when it comes to launch capabilities. In this book the detailed history of India's slow but steady development in space science and launch capabilities are briefed. The authors PV Manoranjan Rao and P Radhakrishnan, retired officials of ISRO offer the readers a broad and comprehensive knowledge about India's rocketry programs.

It would be easy for the readers to dive deep into the technical details about Indian launch vehicles, and the authors do devote a couple of chapters to specific topics like propulsion and avionics. However they also give plenty of attention to the people involved with those various launch programs and the roles they played in both successful launches and overcoming failures.

The book singles out several people, including Vikram Sarabhai, Satish Dhawan and APJ Abdul Kalam who were the main pillars of ISRO. This book was drafted in 2003 but published only in 2012 probably because in 2003 the common people were not interested in space science. The book therefore defines or describes only about space programs upto 2003 and briefly touches ISRO's future programs including GSLV Mark III and reusable launch vehicles.

This book has ten chapters and some additional sections. The first chapter provides a general background to the events that took place before the first rocket took off from TERLS on 21 November 1963.It also includes short notes on the account of Tipu Sultan, first monarch to exploit the military potential of rockets. The second chapter deals with the events that led to the birth of TERLS. The chapter also deals with the then social status and the cold war between the USA and USSR. Chapter 3 is all about

sounding rockets, which are mostly used for probing the upper regions of the earth's atmosphere. This chapter also includes the structure and functioning of Rohini sounding rockets and the help and support given by France and Centaure Indigenisation Programme. India acquired world wide recognition after the launch of SLV-3 rocket with 40-kg satellite into a low earth orbit(LEO).By this mission APJ Abdul Kalam became a national hero. These glorious incidents are described in the fourth chapter. After SLV-3 India had set its sight on a much bigger PSLV capable of launching a 1000-kg payload in a sun synchronous orbit. As there was a huge gap between these two they decided to launch Augmented Satellite Launch Vehicle(ASLV).The full stories of ASLV is described in chapter 5.Chapter six is the most integral part of this book which deals with the full story of PSLV and its evolution as the workhorse of ISRO.

Even though almost the first 12 flights of PSLV were failures there was an increase in payload capability from 1080 kg to 1750 kg. PSLV was mainly used to launch meteorological satellites into the geosynchronous transfer orbits. PSLV was not ideal for this purpose and ISRO decided to makeGSLV launch vehicles which are ideal for this purpose. In 1990 the government approved GSLV and India started its construction. These interesting phases of the GSLV project are described in chapter 7.Chapter 8 and 9 are about the launch of GSLV Mark II and GSLV-D1 and about their indigenous technologies.

The authors didn't forget to include a brief history about the main personalities who worked tirelessly for the development of ISRO. These brief sketches are included in the tenth chapter of this great book. The most attractive and striking peculiarity of this book is the end notes at the last of each chapter. The main chapter contains basic details about the theme as it can be read and understood by every common man and main scientific and technological details are included in the end notes. This makes this book more readable and suitable for everyone. This book doesn't contain that much confusing theories and equations but it contains the a to z of Indian space programme until 2003.

It includes history, technical details about the launch vehicles and brief sketches of great personalities behind the success of ISRO and India before other countries. This book can be read by a beginner in space science and also an expert in rocket science, both can enjoy this book with the same curiosity. From the beginning to the end of the book it creates a temptation for readers to know more about launch vehicles and the vast sky like wide and deep space science and the breathtaking journey of India among the developed nations to India's dignity in space technology.

This book increases our keen interest in space technology. All the programmes and missions of ISRO are ambitious and achievable.

As once said by Vikram Sarabhai ; **“He who can listen to the music in the midst of noise can achieve great things” .**

India will also achieve great things in the field of space technology overcoming all the obstructions and pressure from foreign powers.

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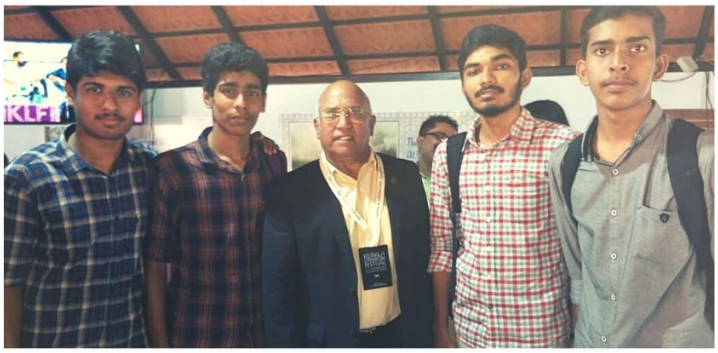

ASK THE EXPERT

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