

SPACE

SCIENCE. TECHNOLOGY. APPLICATION.



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SOMETHING SPECTACULAR IS HAPPENING IN SPACE COMMUNICATION!

In 2013 NASA's New Mexico observatory transmitted an infra-red laser signal encoded with a HD video file to an orbiting satellite at 382400 Km away. The satellite received the data and faithfully transponded it back to earth. We should say this is beginning of a new era in space communication.

Advantage in laser link is that lot more data can be transmitted compared to conventional radio waves. Explanation is simple for this difference. Frequency of oscillation in light is as high as 1000 times compared to radio frequency. Faster the frequency of oscillations, higher the data rate that can be encoded in each cycle of transporting wave. No wonder, light signal can carry 1000 times or greater information than radio waves. When we talk of space communication the conventional radio wave is no more enough. If it were this day, with laser communication, we could have received terabytes of data continuously gathered by Hubble Telescope much more faster than it was. (Ref: Sophia Chen, Science, Feb18)

There are additional advantages with laser communication. We know laser signals travel as pencil beams while radio waves do not. Radio waves spread as they propagate. Considering a low earth orbiting satellite, the area of spread will be few hundred square meters for lasers when compared to several 1000 square miles for radio waves. With the use of Ka band, the spread could be brought down to few 10s of square miles. For this reason, we need 50 times less power for lasers. Of course, there are attendant challenges in handling narrow pencil beams.

When we are talking of cube sats say 4x4x7inch size and data transfer rates 100 to 200 Gigabytes/sec, it sounds possible now. We need to build good ground station infrastructure laser network, light weight high power laser sources...sometimes even hybrid radio and laser systems...as we venture into outer space exploration. In a

very recent study, the Optical Communication and Sensor Demonstration (OCS-D) mission has successfully transmitted data at a rate of 100 Mbytes/Sec which is 50 times faster than normal communication for the size of space craft(aerospace.org press release (2018)). This is a major mile stone which should become the order of the day. GSAT-29 has an experimental laser communication system for 1 GBPS from Geo Satellite to Earth. Kudos to ISRO!

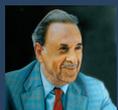
INDIA'S SPACE PROGRAM TO AID DIGITAL GOVERNANCE

We know we can solve many problems on earth by going to outer space. At a time when whole world is turning its attention on how to solve the Sustainable Development Goals in the world, Earth observation technology developed by ISRO is playing a major role in providing data required towards achieving these SDGs. India has adopted the SDG 2030 Agenda during the United Nations Summit held in September 2015. For implementing the SDG agenda, the Government of India has launched several ambitious programmes.

As one example, telemedicine is one of the unique applications of Space Technology for societal benefit. ISRO Telemedicine programme started in 2001 has been connecting remote/rural/medical college hospitals and Mobile Units through the Indian satellites to major specialty hospitals in cities and towns. ISRO Telemedicine network covers various states/regions including Jammu & Kashmir, Ladakh, Andaman & Nicobar Islands, Lakshadweep Islands, North Eastern States and other mainland states. Many tribal districts of Kerala, Karnataka, Chhattisgarh, Punjab, West Bengal, Orissa, Andhra Pradesh, Maharashtra, Jharkhand and Rajasthan are covered under Telemedicine Programme.

Presently, the Telemedicine network of ISRO covers about 384 hospitals with 60 specialty hospitals connected to 306 remote/rural/district/medical college hospitals and

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18 Mobile Telemedicine units. The Mobile Telemedicine units cover diverse areas of Ophthalmology, Cardiology, Radiology, Diabetology, Mammography, General medicine, Women and Child healthcare.

While DOS/ISRO provides Telemedicine systems software, hardware and communication equipment as well as satellite bandwidth, state governments and the speciality hospitals have to allocate funds for their part of infrastructure, manpower and facility support. In this regard, technology development, standards and cost effective systems have been evolved in association with various state governments, NGOs, specialty hospitals and industry. DOS interacts with state governments and specialty hospitals for bringing an understanding between the parties through MOU.

Challenge for India

Large areas in India are already covered with fiber optic based internet. But, there are places where we need G-SAT based internet. ISRO successfully launched GSAT-29 on November 14, 2018 which started providing the much needed high speed internet towards realizing Digital India dream. With GSAT-20 ready for launch next year, nearly 100 GBPS data link will be available.

SATELLITE MAPPING OF POVERTY ACROSS CONTINENTS

Scientists have come up with an accurate machine learning (ML) based model of mapping poverty using satellite images as supplementary to time consuming and expensive ground surveys. These models have been tested extensively against standard measured data and confirmed to be very accurate.

As we know, in ML, the researchers provide a computational model with satellite data and poverty measurement as objective but without directly providing the system a software program to solve the problem. Through ML, the system is trained to develop its own algorithm that rummages through heaps of satellite data and intelligently arrive at area wise pattern of poverty. Basically, the algorithm compares day time and night time satellite images to arrive at poverty levels. (Ref Sci American, vol 315(6) Dec 2016).

Challenge for India

This type of work is multidisciplinary with interface of humanities, economists, engineers all put together and of course, big data scientists. Many Institutions and Universities have started Centers of Excellence in Bigdata Science which should take up these kind of problems also.

PROTECTION OF EARTH FROM PLANETARY CONTAMINATION

Scientists are aware of contamination caused by introduction of extra-terrestrial biological material (Forward contamination) being brought by astronauts, rovers, landers, reusable vehicles, robots etc.,. Similar thing (Reverse Contamination) will happen when astronauts walk, rovers scoop materials, robots collect samples etc activities from other planets. It is necessary for our space agencies to take great care not to infect either Earth or other planets by any chance.

NASA's Planetary Protection Policy and requirements documents, NPD 8020.7 and NPR 8020.12 and COSPAR Planetary Protection Policy respectively give detailed guidelines and provide information to facilitate their implementation of planetary protection requirements, enable effective and timely communications, and contribute to the success of their missions. Procedure has been established for each mission on how to calculate probability of contamination versus allowable level of contamination. Astrobiology, an interdisciplinary field deals with this subject of contamination from both scientific and ethical reasons. Fortunately lot of good work has been done by USA, Russia, ESA in this very important domain since 1958.

We should work in the spirit of Outer Space Treaty of UN, Article IX which states: "States Parties to the Treaty shall pursue studies of outer space...and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extra-terrestrial matter" (1967)

The planetary missions which are currently underway to handle extra-terrestrial material housing possible contamination are:

Hayabusa1 craft launched by Japan in 2010 brought back a tiny amount of dust from asteroid Itokawa.

Hayabusa 2 craft launched in 2018 to asteroid Ryugu due to reach next year. Likely to return to Earth with a larger material sample by end 2020.

Osiris-Rex craft was launched by the US space agency Nasa in 2017 to reach a near-Earth asteroid Bennu in 2018. Expected to collect up to 2kg of soil or rock and return to Earth with the sample in 2023.

The first human landings on Mars is expected to happen early 2040s accompanied by large mass of equipment required for entry, descent and landing.

There is huge proposal by 2020 to create a fuel depot in space by using water from asteroids, splitting it O₂ and liquid hydrogen for rocket fuel in International Space Station and shipping to Earth orbit for refueling commercial satellites or cargo spacecraft .

Raw materials are also planned to be sourced from other bodies within planetary system and processed at a low expense rather than sourcing from earth.eg. Minerals: Near earth asteroids, lunar surface, planetary bodies. Volatile organic compounds: comets, Phobos, Deimos. Organic compounds are known to be best carriers of contaminating biological material.

Challenge for India

This is major global area of research. Knowing, the no. of upcoming exploration of extraterrestrial resources programs by many countries, Indian centers working on global health, astrobiology, infectious diseases, planetary chemistry etc. should look at this issue which may affect the humanity.

WATER AS SATELLITE PROPELLANT

A satellite can be provided with a water propulsion system with inbuilt thermal design which heats up water from freezing to steam. The steam is exhausted through the thrusters for propulsion. This water propulsion can be used to control the satellite movement without using any hazardous chemicals making it safer for payloads during the launch. In fact, Bellatrix Aerospace a start-up housed in IISc is the company from India who have mastered microwave induced EM thermal thruster for space propulsion. This is first of its kind development in the world.

EXCITING SPACE NEWS

MULTI BILLION RUSSIAN SOTEL IS GETTING READY FOR SPACE TRAVELERS.

Like motels for motorists on high ways, sotels are for space travelers up in the sky in Earth's orbit. If Russian grand scheme goes smoothly then there will be a luxury sotel with 4 sleeping suits with WiFi, gym etc. by 2022. This will be parked to international space station whose life is coming to an end in 2028 with cosmonauts doing the honors of an air host. Two weeks trip will cost \$40m per person and costs additional \$20m if spacewalk is included entailing one month stay onboard.

Houston based company Orion Spans proposes a compact Aurora station with the cabin interior equal to that of a speed jet for 4 tourists to height of 200 miles for 12 day stay at one fourth the cost of Russia in 2021.

But Russians can boast that they are in this tourist business from 2001 onwards and several people have travelled since then in a limited way. Dennis Tito was their first space traveler.

The competition is slowly unfolding in this business sector . It is watch out for Indian air industry. Space X, Virgin Galactic, Blue Origin etc are giving final shape to their plans for low budget space travel and give thrills of zero gravity to the customers in their specially designed cabins. This is one area Indian industry to take lead with the support of ISRO. In economic terms and human talent wise there is good business model in this domain and make Bangalore a complete space city in the world.

MYSTERY SURROUNDING ULTIMA THULE

1st January 2019 will remain a historic day in space exploration according to NASA. Ultima Thule is a small reddish object, whose shape is still unknown, observed beyond the distant planet Pluto. NASA's satellite New Horizon will zip past by Ultima Thule at 0533 GMT towards the end of the new years day at 39000mph.

Mission scientists expected significant changes in its brightness corresponding to different orientations of this object as it rotates. But , all the first few pictures transmitted by New Horizon show its brightness is relatively constant as if it is a spherical body.

It is suspected that Ultima which is more than 4 billion miles from the sun is surrounded by a light blocking cloud of dust. But an energy source would be required to generate such a feature and it is unclear what source that would be. In order to unravel this mystery, NASA scientists have directed the New Horizon beyond the delineated scope to again visit Ultima from nearest distance. Today ie 1st January 2019, New Horizon will come closure to a distance of 2200 miles at 0533 GMT to Ultima Thule to take pictures which are expected to unravel the secret of Ultima. Studies show that Ultima is a Kuper Belt object forged during the birth of solar system 4.5 billion years ago orbiting sun beyond Pluto. This is status at the time of releasing the newsletter.

FUTURE OF SPACE PROGRAMS

Many friends and colleagues often ask this as a question. The future of space programs is incredibly bright. More than sixty years of effort is behind us. The impact of space programs is clearly visible and there is no field which it did not touch. It made human living comfortable. Examples galore: Monitoring of climate change, monitoring air pollution, detection of ship movements, maritime surveillance, monitoring the oceans and surface moisture, protecting our infrastructure from space weather, tracking trains, satellites for remote banking, agriculture and food security, support to banking systems, Earth observation for international development, tele education, telemedicine, e-Learning in rural areas, national security and many more. The list is too long. With AI coming it is going to open many new dimensions in more efficient way of using Earth observation data spurring innovation and job opportunities. As we go along, we need to build many more new vehicles, space stations, sotels and facilities. We are at the start of sub orbital space tourism. By 2025 humans will once again walk on the moon. If trend in research efforts continues, by 2040 and then, likely hood of walking on Mars is going to be a reality. Such things cannot sustain without partnership between government space agencies and private sector industry. Launches may be available to order from companies like Space X, Amazon, Virgin Galactic with airline like weekly schedules. Several new industries are going to start opening new economy and employment opportunities. Many private industries are in competition in building knowledge in exploring asteroids in search of rich minerals, organic compounds, fuel etc as valuable resources. The next wave of space stations will be designed to take up microgravity research and space manufacturing using resources acquired from extra-terrestrial sources. Already experiments and research in microgravity environment proved successful in areas ranging from production of high performance optical fibres to vaccines to drugs to treat certain diseases.

Bengaluru– A Space City

India can play a major role in all these endeavours. India's proven space program record, talent pool, upcoming industry, low labour costs, good launching

facilities, business friendly eco system - all shall help to take a lead, create an economy of scale and show a practical way for future. Bangalore will not be just a silicon valley but a space city too.

“Earth is cradle of mankind, but man cannot live in the cradle for ever” - **Konstantin E Tsiokovsky**

ABOUT THE NEWSLETTER

This quarterly News Letter from NIAS, IISc Campus is to bring out various developments likely to find place in future space programs. The future programs include man in space, exploitation of extra-terrestrial resources, space based services, space exploration, science of microgravity, space for national security etc.. The intention is to provide brief information to researchers, academicians, R&D personnel, Space industry involved in various space programs or even otherwise and to generate S&T leads in the minds of people. It is our endeavor to keep this newsletter fresh and engaging with well researched content. Any suggestion(s) for improvement of this newsletter will be highly appreciated.

EDITOR

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We would appreciate your feedback and suggestions on how to improve our newsletter.

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