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(a) Major S&T and Related Developments.

(1) The New Indian Express reports "*The made-in-India Sukhoi (Su-30MKI) is up and flying*. Amid Diwali fireworks, the Ozar air base in Nashik witnessed a silent, yet stellar affair. The desi Sukhoi, a 4.5 generation fighter, took to the skies for the first time and performed a 55-minute supersonic ballet. Also flying high was the Swadeshi pride considering that this was the first aircraft manufactured from a complete raw material phase. The striking feature was the pilots pulling 9g at the first attempt itself, a pointer to its structural integrity. Indian Air Force (IAF) sources confirmed to Express that the Sukhoi was piloted by Wg Cdr S C Sharma with co-pilot Wg Cdr S S Mallick in the rear. The Aircraft Manufacturing Division of Hindustan Aeronautics Limited (HAL), Nashik, produced this metal bird with close to 28,000 parts and using 1,20,000 tools. "This flight was undertaken with full confidence in the technical prowess and expertise of HAL. It went smoothly as planned and the aircraft handled beautifully," the pilots were quoted by sources after touch-down. HAL has so far delivered 99 Sukhois to the IAF, out of a total order of 180, produced under licence from Russia at an approximate cost of Rs 250-300 crore each. The raw material phase Sukhoi is the first from Phase-IV of the project. The avionics and accessories have come from HAL's Lucknow, Hyderabad and Korwa divisions, while the engine was produced at Koraput. "HAL will have to complete the deliveries by 2014-15, but we expect a delay of three years," IAF sources said. ***Express has learnt that the delay in the design and development phase of Sukhoi in Russia impacted the receipt of technology and tooling in India. HAL too had issues in absorbing new technologies".***

(2) According to a report in Business Line, "Uranium Corporation of India Limited, which mines uranium for the programme, has been pitching hard to expand its activity to Andhra Pradesh, Gulbarga in Karnataka, Meghalaya and within Jharkhand. But here again, there are land issues and groups protesting against the projects. The DAE pins big hopes on its project in Tummalapalle in Kadapa district of AP. It announced a massive find of uranium reserves in the village, estimated to be 49,000 tonnes in July. This would be enough to support around 8000 MW capacity for 40 years. It is estimated that a 700 MW plant would require 100 tonnes per year. DAE is confident that the plant will become operational by the end of 2011. At present, it has only two functional mines, both in Jharkhand, and the total estimated reserves of uranium are 1, 70,000 tonnes.

(3) Times Higher Education has released the 2011-12 World University Rankings on October 6. As the website explains, the rankings are the product of a cooperative effort between Times Higher Education and Thomson Reuters. The continental break-up of the top 200 universities is: Europe 86, North America 84, Asia 20, and Oceania 8, with South America and Africa one each. Of the 20 in Asia, the top position has been occupied by University of Tokyo, with second, third and fourth places taken respectively by University of Hong Kong, National University of Singapore and Peking University and, with from China. Not a single institution from India is in the top 200. In addition to the top 200, an additional 202 universities are listed, we find the Indian Institute of Technology, Bombay. The Times HE site also provides rankings of top universities by discipline. IIT-B did not make it to the list of top 50 institutions offering engineering and technology. The World University Rankings are based on 13 different indicators of performance classified into five categories: teaching (learning environment), research (volume, income and reputation), citations (influence of research), industry income, and international outlook pertaining to staff, students and research. The weights for the five categories are: 30% for teaching, research (30%), citations (30%), industry income (2.5%) and international outlook (7.5%). India has excellent scientists and other academicians. Consider physics, for instance. Data on citations per paper are available from the Essential Science Indicators data base of Thomson Reuters covering journal articles over the period 2000-10. A summary tabulation covering top 20 countries shows Switzerland at the top with 15.4 citations per paper, followed by the Netherlands [14.4] and the US [14.1], with the world average of 8.7. India, with a citation rate of 6.9, has a slightly better showing than China [5.7], but that is no consolation when one is targeting, say, a place well above the average.

(4) A Gopalakrishnan, former Chairman/AERB writes in an article in News & Analysis, "The first Russian VVER-1000 reactor went into commercial operation in 1981 at the Novovoronezh power plant in Russia. There are 11 VVER-1000 reactors safely operating in Russia today, with an additional seven such reactors operating in Bulgaria, the Czech Republic, China and Iran. There are two more under construction in Bulgaria and two just contracted by Bangladesh last week. In addition, there are several earlier generation VVER-440 MWe and VVER-210/365 MWe units still in operation in Russia, where the design has already been up-rated to VVER-1200 MWe units, a few of which are in late stages of construction.

"Many of the initial VVER-1000 reactors are of the V-320 version. As notable improvements are made, the Russian design bureau gives each updated design a new version number. *An export design of later vintage is the V-392 version, with enhanced safety and seismic features, which is the basis for the AES-92 now being commissioned in Kudankulam. These reactors have modern western control and instrumentation systems and a molten-core catcher to take care of beyond-design-basis accidents.* A slightly different version (AES-91) of the same reactor was supplied to the Tianwan Station in China and the two units there have been commercially operating since 2006 and 2007. These two Chinese reactors also have similar core catchers. Construction of two further VVER-1000 units is about to start at Tianwan in 2012".

Meanwhile PTI has reported that "a delegation of five scientists from the United States Nuclear Regulatory Commission are scheduled to visit two nuclear

establishments in Tamil Nadu next week, Department of Atomic Energy sources said. "Five scientists from US Nuclear Regulatory Commission including its Chairman Mr Gregory B Jaczko will be visiting Indira Gandhi Centre for Atomic Research (IGCAR) and Madras Atomic Power Station (MAPS) (at Kalpakkam) between November 16 and 18," the sources said. The team would also visit nuclear facilities in Mumbai — (Tarapur Atomic Power Station and *Bhabha Atomic Research centre*.) The visit is to exchange information and share experience on safety standards and regulations for the safe operation of nuclear power plants".

(5) Rustom-1, the indigenously designed and developed unmanned air vehicle, made its fifth successful flight on November 11, 2011. It flew for 25 minutes near Hosur at an altitude of 2,300 ft and at a speed of 100 knots, a DRDO release said. The UAV, a "MALE" or medium altitude long endurance type, has been developed by the DRDO with the Aeronautical Development Establishment, Bangalore, as the nodal laboratory. It first flew in 2010. Mr P.S Krishnan, ADE Director, said in total, it was a success as all the modifications worked well and the 661-kg UAV achieved all the parameters. Specifically the objective was to test the modified lift-off scheme; modified altitude and speed hold logics, all of which "worked excellently". When fully developed, it can attain a maximum speed of 150 knots, height of 22,000 ft and fly for 12-15 hours in a range of 250 km. The Army is interested in the programme. The release said, "The UAV can do military missions like reconnaissance and surveillance, target acquisition, target designation, communications relay, battle damage assessment and signal intelligence."

(6) Students will soon be able to pursue two courses simultaneously in two different institutions. The Government has proposed setting up a 'meta university', which will make it possible for, say, an IIT Kanpur student to also enrol in the Ancient History course in Jawaharlal Nehru University or a mathematics student from Indian Institute of Science to pursue a course in comparative literature from Jadavpur University. The setting up of the 'meta university' was announced by the Prime Minister, Dr Manmohan Singh, on Tuesday, while releasing the first report of the National Innovation Council (NIC). The Government also announced a Rs 5,000-crore National Innovation Fund, with initial infusion of Rs 100 crore, to support new ideas that will be useful for the common people. The Chairman of the NIC, Mr Sam Pitroda, said, "They (students) would be tested for their competencies before enrolling into a programme in another university and will be awarded degrees." He said the idea was to enable students to use open source learning material from across the globe, including material prepared by Indian Institutes of Technology. The Finance Minister, Mr Pranab Mukherjee, said the 'meta university' would be operational from next year. "It will be a collaborative and multi-disciplinary learning platform," he added. The university will leverage the national knowledge network programme that already connects major institutes across the country through high-speed fibre-based broadband connectivity. It also promises an unique opportunity to the country for innovation, given the huge unmet demand for high quality education in an environment of limited resources and availability of a dedicated national network, said the report.

(7) India launched its most advanced long range missile, Agni-IV from Wheeler Island off the coast of Odisha On November 15. The team led by Ms Tessy prepared

and integrated the missile system and launched it from a road mobile system at around 0900 hrs from Wheeler Island. The intermediate range ballistic missile can carry both conventional and nuclear warhead and reach over 3,000 km. It gives a two-pronged capability to the strategic forces along with Agni-III, which has a range of 3,000 km. The first test of the Agni-IV last year failed as the missile veered off immediately after launch and fell into the Bay. **The success of the missile marks a quantum jump in technology and launch capability. It is highly flexible in operation and ready to use system will add lot of strength to the strategic deterrence capability of the country, he told Business Line. The two-stage solid propulsion missile is lighter in weight than the existing Agni variants. Indigenously developed composite rocket motor has been successfully demonstrated. Similarly, the ring laser gyros and micro navigation systems, which complement each other, have been flown in guidance mode for the first time, according to DRDO.** The missile system is equipped with compact avionics, the high performance onboard computer and reliable communication and digital control system, which guide the missile to the target. The success of Agni-IV has boosted the confidence of defence scientists who are preparing for the big launch of Agni-V, the inter-continental ballistic missile.

(8) ***The rules notified by the government under the Civil Nuclear Liability Act have diluted the provisions of liability for the foreign suppliers. The right to recourse for the operator to claim damages from the foreign supplier has been limited to the duration of the initial licence period or the product liability period, whichever is longer. The initial duration of the licence is normally five years and the product liability period will also accordingly be limited. Such rules do not cover even a reasonable period of the functioning of the reactor and its equipment, quite in variance with the Liability Act passed by the parliament after much discussion and debate. Interestingly, these rules have been notified on the eve of the Prime Minister's meeting with the US President during the ASEAN summit meeting! Will these rules, being out of tune with the content of the Act, be legally valid? May be only our Apex Court will have to decide, if brought for its appeal through a PIL.***

(9) According to the latest WIPO Report – "The Changing Face of Innovation" – in high-income countries, estimates show that innovation accounts for as much as 80 per cent of economy-wide productivity. Though no data is available for the medium- and low-income countries, evidence shows that companies with higher levels of innovation outperform companies with little or minimal level of innovation. The report states that for East Asian countries, innovation has been an important factor in their quest to catch up with the advanced nations. South Korea has been a good example of this over the last few decades and China, too, has been focussing very hard on this aspect in the last four to five years. nnovation is becoming important since companies worldwide are spending more on research and development (R&D) to ensure they remain competitive in a globalised world where technology plays a very crucial role in accessing markets. The WIPO report states that global R&D expenditure has almost doubled in real terms from 1993 to 2009. However, due to an increased globalisation of economies across the world, the share of global gross domestic product (GDP) devoted to R&D increased only from 1.7 per cent in 1993 to 1.9 per cent in 2009. However, interestingly low- and middle-income countries increased their share of global R&D expenditure by 13 per cent between 1993 and 2009 with China accounting for majority of this increase. China was the second

largest R&D spender in 2009. The report also states that the demand for patents has risen from 800,000 applications worldwide in the early 1980s to 1.8 million in 2009 due to the efforts of different countries like Japan in the eighties, Europe and South Korea in the nineties and more recently by China. Trademark applications, too, have seen a tremendous rise from about one million in the 1980s to over three million in 2009. The other areas of intellectual property like industrial designs, according to the WIPO report, have also seen serious increases in applications. This obviously has led to tremendous increases in receipts of royalty and fee for companies and institutions across the globe. What is important to note in the report, though it does not primarily focus on countries per se, is that India is still not seen as a major contributor to the growing focus on intellectual property, especially innovation. While industry and some public research organisations have been making a serious effort towards rectifying this position, there is a need for a tremendous push from the government to make India move towards this trend so that the country finds easier and more sustainable ways of ensuring economic growth. The report provides some pointers towards what governments need to do to focus the country towards greater innovation. Since the government is among the core stakeholders in the national innovation systems, it has to continue to directly fund research and provide incentives to firms to invest in innovation that includes protection of intellectual property. Governments also need to review the current policies to ensure that they focus companies towards changing trends around the globe so that they remain competitive in world markets.

(10) ***Just like the Indian economy, Corporate India too has much to lose from a depreciating rupee. This is because the foreign exchange expenditure for India Inc, on an aggregate basis, is nearly 80 per cent higher than its foreign exchange earnings.*** In 2010-11, India Inc spent nearly Rs 10.2 lakh crore ($196 billion at current exchange rates) on forex-denominated imports of materials, fuel and other items used in production. This was against forex revenues of Rs 5.8 lakh crore (roughly $112 billion) for the same year from exports. Only revenue earnings and expenses in foreign exchange, which determine profit or loss, are considered here. The net forex spending (expenses minus income) by companies has in fact increased in the last five years, mainly because imports (in value terms) have galloped ahead at a much faster rate than exports. The higher value of imports was probably driven by runaway commodity prices. ***The unexpected names in the list turn up from sectors such as engineering and capital goods, where ABB, BHEL, L&T and Bharat Electronics have incurred large import bills, making them sizeable net spenders of forex last year. Overall, roughly 51 per cent of the companies were net spenders of forex. Does this not raise very important issues on indigenous manufacture itself?***

(11) On Saturday November 6, Dr Varghese Kurien, Founder of Amul, turned 90. After retirement, he settled down in Anand, the small town he made world-famous through the co-operative movement launched at the instance of his mentor, Sardar Vallabh Bhai Patel. People were surprised to notice this morning when they saw quarter-page advertisements put out across many newspapers by the Gujarat Cooperative Milk Marketing Federation (GCMMF), which markets milk and milk products under the Amul brand: "You changed the lives of 15 million farmers' families. You revolutionized the dairy sector. You gave India 200 Amul brands. We give you 90 candles," the grateful Amul girl, attired in her trademark polka frock and hair band, told Dr Kurien in the advertisement. The Milkman affectionately

held a calf in the ad as the smiling mother-cow looked on. And no wonder Dr Kurien must have felt more overwhelmed with this unique Operation Flood of Emotions than when he was decorated with the Padma Vibhushan.

(12) According to a report in Economic Times "Unless India agrees to open its military facilities to nuclear inspectors, sale of Uranium by Australia to that country will be a breach of Federal government's obligations under the South Pacific Nuclear Free Zone Treaty, a noted legal expert said today. "Australia would be in breach of the so-called Rarotonga Treaty, if India does not change its stand," Donald Rothwell of Australian National University said in a written legal opinion. The Rarotonga Treaty bans uranium sales to most countries unless they agree to "full-scope safeguards" defined by the Treaty on the Non-Proliferation of Nuclear Weapons. The uranium sale policy is said to be the hot topic of discussions at this week's national conference of Australian Labor Party in Sydney. The Labor Party will debate on lifting its long standing ban on uranium sale to India. "If India does not agree to Article 3.1 Non-Proliferation Treaty (NPT) safeguards and Australia were to export uranium to India, Australia would be in violation of its Treaty of Rarotonga obligations," Rothwell was quoted as saying by 'Herald Sun'. This could lead to a challenge from other countries that are part of the treaty, he added. Australia is not saying India shouldn't be subject to safeguards. The real question is the extent and scope of the safeguards. India would need to sign up to full-scope safeguards that would require it to open military facilities. He said India ratifying IAEA standards was "one step". **All countries - apart from the five nuclear powers recognised in 1967 as weapons states (China, France, Russia, Britain and the US) - are required to "not only have open inspections of civil facilities but any military facilities that use nuclear material. "The five nuclear weapons states aren't required and that is the crux of why India thinks the NPT is discriminatory," Rothwell said" (emphasis – ADD).**

Last but not the least,

Nobel laureate Dr Har Gobind Khorana, the pioneering biochemist who trained thousands of scientists all over the world and inspired many more to truly love science, died in a hospital in Concord, Massachusetts, on November 9. Dr Khorana, who received the Nobel Prize in physiology or medicine in 1968, was 89, although his exact date of birth is unknown. He was born in a poor family in a small village in Punjab, and by dint of sheer talent and tenacity rose to be one of science's immortals. *Till his death, he was the Alfred P Sloan Professor of Biology and Chemistry emeritus at MIT.*

The scientific world mourned Dr Khorana's death and wondered how someone from such a humble background came to have such an enduring impact on modern science, especially the unravelling of the mystery surrounding genetic codes. "Dr Khorana was simply a true scientist — more interested in the next project and experiments than in capitalising on his fame," Dr Venkatraman Ramakrishnan, who won the Nobel Prize in chemistry in 2009, told *India Abroad* in an interview from London. "His former post-docs (students) tell me that he was very hard-driving and expected total dedication from his lab members; but I think they all felt they benefited greatly from the experience," added Ramakrishnan, the India Abroad Person of the Year 2009. In a note after winning the Nobel Prize, Dr Khorana wrote: 'Although poor, my father was dedicated to educating his children and we were practically the only literate family in the village inhabited by about 100 people.' For more than half a century, Dr Khorana had carried on his father's legacy — by imparting scientific education to thousands of students, and by advancing the realms of human knowledge. He loved his students so much that he would sometimes part with a project on which he had deep interest, and give it to some student. "He wanted everybody to succeed," said Dr Uttam L Rajbhandary, the Lester Wolfe Professor of Molecular Biology and associate head of the department of biology at MIT, who conducted research under Dr Khorana. Dr Khorana was born in 1922 in a small village called Raipur in Punjab (now in Pakistan) and was the youngest of five siblings — one daughter and four sons. His father was a patwari, an agricultural taxation clerk in British India.

Dr Khorana attended high school in the nearby city of Multan before enrolling in Punjab University, where he received his bachelor's degree in 1943 and masters in 1945, both in

chemistry and biochemistry. After graduation, he received a fellowship from the Indian government to study at the University of Liverpool in the United Kingdom where he received his PhD in 1948. He did postdoctoral work at Switzerland's Federal Institute of Technology, where he met his Swiss wife Elizabeth Sibler. Dr Khorana, according to MIT, wrote later that Esther brought a consistent sense of purpose in his life at a time when, after six years' absence from the country of his birth, he felt 'out of place everywhere and at home nowhere.' After returning to the UK for another post-doc position at Cambridge University, Dr Khorana moved in 1952 to Vancouver, Canada, where he took a job at the British Columbia Research Council and where he stayed for eight years, continuing his pioneering work on proteins and nucleic acids. "In some ways Dr Khorana's talent and pursuit for scientific research flourished in the BCRC lab where he could work freely," Rajbhandary said. "That, I think, prepared him for what he would be doing in later years in terms of research that ultimately helped him win the Nobel Prize." Dr Khorana joined the University of Wisconsin in 1960, and 10 years later joined MIT. He won numerous prestigious awards, including the Albert Lasker award for medical research, the National Medal of Science and the Ellis Island Medal of Honor. But he remained modest to a fault — his students and colleagues said he always wanted to stay away of from the glare of publicity. The Washington Post noted that he would talk about important scientific announcements not through the media, but only in scientific publications and at departmental seminars. 'When he spoke out it was against declines in scientific funding by the government and against the Vietnam War or more recently against the invasion of Iraq,' the newspaper wrote. A measure of his success as a scientist is that a Vancouver park was named after him long after he left the city. A conference hall at the University of Wisconsin, that has started the Khorana Program, a student exchange program between India and the United States, is named after the pioneer.

(b) Revisiting Homi Bhabha's "Growing Science" Model, Series 24, ISRO The November issue ended like the following:

"While the Aryabhatta and similar indigenously made 'long distance' satellites were being launched through help of advanced nations including US and USSR from their launch pads, the TERLS in Thumba complex was engaged in launching a series of Sounding Rockets and their Satellites meant for atmospheric studies program involving United State, France and so on, with the Soviet systems in use almost every week. The long term significance of those experiments in the ISRO programme would be dealt with in a separate issue. This was also the true beginning of the long-sustained India – French collaboration referred to by the ISRO Chairman Radhakrishnan even recently. In other words, thanks to a very well orchestrated techno-political strategy, ISRO was able to duly achieve meaningful experience and expertise to plan for larger, more resourceful and more versatile multi-purpose (with national coverage to provide TV broadcast, telecommunications and meteorological services) and obviously more economic in the Indian context satellites-based space programs "in the interest of national development", as projected by its founder late Vikram Sarabhai and more often that not by his true successor Satish Dhawan. Obviously it was essentially based on such a steadily gained self confidence that ISRO then entered by early eighties the next stage through issue of a commercial order to Ford Aerospace to manufacture, supply and maintain the multi-purpose INSAT- I (One sees great similarity of this self-reliance oriented policy initiative of Satish Dhawan with that of Homi Bhabha in the early sixties in going for the turn-key basis Tarapur nuclear power reactors

from the General Electric strictly on commercial lines for immediate demonstration of the "nuclear power feasibility" and the CANDU units in Ranapratap Sagar more as a joint effort for the nation's "nuclear future", not to say at all notwithstanding that the two technologies were that similar in content and sweep!)". It was planned in the beginning itself that whereas INSAT- I&II would be the development satellites, the ones to be followed would be the operational units.

2. In a very important review paper on "The Indian Space Programme" by Satish Dhawan and UR Rao, the major development stages have been exquisitely highlighted, the true saga of the 'slow and steady' indigenous capability-building to its more or less state-of-art technology levels in terms of well-known quantifiable evaluation parameters (undoubtedly this would have matched even those of any other one in the world if our country was capable of producing within equally state-of-art electronics components, ICs, cameras, and so on). And undoubtedly this was done under the pioneering leadership of none other than UR Rao who eventually took over as Chairman/ISRO itself. To quote Dhawan and Rao *very briefly* from the above article,

"The Space Research Activities in India are aimed at developing an integrated program encompassing three major elements namely investigations in space sciences using ground-based, balloon, rocket and satellite techniques, development of satellite launch vehicles, development of satellite technology for practical applications through the conduct of major experiments in the areas of communication, meteorology and remote sensing of earth resources……(through) efforts in achieving self-reliance" through well-articulated scientific-technological work-schedules and modern project management techniques, an attribute in which ISRO had always maintained a leadership status in the country! Tracing the history of this exciting 'learning trajectory' (1972 – 82) the authors go on to highlight stage-by-stage experience gained both in hardware and software techniques in these areas using aerial flights, indigenous satellites and other satellites such as ATS -6 and Symphonie "*in cooperation with other space agencies*" *(emphasis – ADD) and how* those efforts culminated in turn to go for a commercial/operational multipurpose INSAT –I system itself – (a) Project Aryabhatta as a technological program to develop and set up core facilities (b) Bhaskara I and II providing system experience on an end-to-end basis in remote sensing (c) APPLE (Ariane Passenger Payload Experiment) for acquiring first-hand experience in designing, building, launching and operating a three axis stabilized spacecraft in geostationary orbits and a variety of digital communications (d) Rohini satellites such as RS – 1 and RS – D – 1 providing information in miniaturization and high density packaging and so on. ISRO correctly recognized the potentialities of satellite TV in mass communication and education particularly in remote and rural India and went for the historic SITE (Satellite Instructional Television Experiment). To demonstrate the mode of telecommunication, STEP (Satellite Telecommunication Experimental Project) was undertaken with the Franco-German SYMPHONIE satellite in 1977 – 79, to continue the communication experiments in a systematic and uninterrupted way, APPLE was taken up for extensive experiments on time. Frequency and code division multiple access systems (TDMA, FDMA and CDMA), radio-networking, computer interconnect,

random access and packet switching experiments with a variety of multiple access protocols and so on and so forth.

Based on the expertise and experience gained through the above described systematic and gigantic efforts ISRO then went for the historic INSAT - 1 developmental system and which thus became "the first operational space system of India to be used for domestic communication and meteorology…designed for seven year operational life". This was as planned was initially built by the Ford Aerospace Communications Corporation (FACC) , USA to meet its multipurpose requirements. This was to be followed by INSAT – IB as well, both belonging to the development series. And the next step was to convert this acquired knowledge totally indigenous in all sense of the word including the scope and realizable limits through trade-off studies. In the words of the authors again, "The operationalized communication and meteorological services through foreign procured INSAT – IA and IB will have to be eventually replaced by indigenous operational satellites to provide continuity of service in these areas. The indigenously built Proto-INSAT spacecrafts with high reliability and long life are intended as second generation INSAT test satellites for future applications. The final choice between a multipurpose satellite as a replacement of INSAT – IA and multipurpose satellite system will depend on design definitions, user requirement including future projections, resultant trade-off analysis and development of large geostationary launch capabilities".

More of the details has been ably described by Dhawan himself in his Aryabhatta Lecture, "Application of Space Technology in India", for the Indian National Science Academy, August 2, 1985. Tracing the history of this activity itself – "In 1962 when Vikram Sarabhai and Homi Bhabha suggested support to space science & technology for possible application to Indian problems, the Sputnik era was just 5 years old. At the time there were no established applications of space technology to problems on earth, although among the scientific community there did exist considerable activity and excitement about the uses of instrumented platforms orbiting above earth's atmosphere. Operational space systems were still in the future. Nehru's approval for the application of space technology in India was an act of extraordinary foresight and courage", Dhawan says. The major highlights in the paper are again summarized as follows:

(a) Application of space technology in India must be fully directed towards assisting the solution of large scale identified problems.

(b) While remaining fully cognisant of developments elsewhere and encouraging international cooperation, the essential components must be mastered and grown within India as speedily as possible.

© Going through SITE, STEP, APPLE and so on, the INSAT –I system evolved through various phases eventually into a multi-mission spacecraft with an integrated ground segment carrying four major services, namely, (i) telecommunications (ii) TV and Radio (iii) meteorological services and (iv) data relay and disaster warning service.

In summary, INSAT-1 was designed as a multi-purpose satellite system to provide two high power TV broadcast and twelve telecommunications national coverage transponders, in addition to also providing meteorological services. The **INSAT-1A was launched by a Delta in April 1982 but was abandoned in September 1983 when its attitude control propellant was exhausted**. **When INSAT-1B was launched on 30 August 1983, it almost suffered the same fate as the Insat-1A. It was not until mid-September that Ford and Indian controllers succeeded in deploying its solar array. By then it had been stationed at 74°E in place of INSAT-1A. Full operational capability was achieved in October 1983. It continued to operate into 1990 with all its 4375 two-way voice or equivalent circuits in use. Around 36,000 earth images were returned. Eleven of its 12 C-band transponder and its two S-band transponders provided direct nationwide TV & communications to thousands of remote villages, plus a detailed weather and disaster-warning service. Around 35,000 Indian built 3 to 3.6 meter diameter, earth receive only terminals were in place to supply rural communities with social and educational programs. It was relegated to spare status on 17 July 1990 by the Insat-1D. The Insat-1B was finally removed from GEO in August 1993, after being replaced at 93.5°E by Insat-2B. Total cost of INSAT-1B and its backup INSAT-1C, including the PAM-D launch was estimated at $140 million. The INSAT-1C satellite was launched on 21 July 1988 from Kourou for location at 93.5°E to bring the INSAT system up to full capacity. Half of the 12 C-band transponders and its two S-band transponders were lost when a power system failure knocked out one of the two buses, but the meteorological earth images and its data collection systems were both fully operational. Earth lock was lost 22 November 1989 and the satellite was abandoned. Reported insurance payout was $70 million. The specification for the Insat-1D is the same as the Insat-1B but with expanded battery and propellant capacities. Launched on 12 June 1990 to conclude the first generation INSAT series. Launch was planned for 29 June 1989 but 10 days before it was seriously damaged during launch preparation, when a crane hook fell on it. The fully insured satellite was repaired by Ford Aerospace at a reported cost of $10 million. It also suffered $150,000 of damage during the October 1989 Californian Earthquake. It assumed prime role from Insat-1B on 17 July 1990. Design life was seven years. Further on there was no looking back in the total sense of the word!**

Some of those failures were widely reported by the press as well. Thus under the title "A Setback for ISRO", The Hindu correspondent TS Subramanian elaborated the ISRO 'agony & ecstasy" as follows:

"THE loss on October 4 of INSAT-2D (INSAT is an acronym for Indian National Satellite), the indigenously built communication spacecraft, has come as an unexpected blow to the Indian Space Research Organisation (ISRO). The loss of INSAT-2D will slow down the communication revolution that was brought about in India by the deployment of the first and second generation INSATs - the INSAT-1 and INSAT-2 series, which comprised eight spacecraft. INSAT-2D is the third INSAT that has had to be abandoned. INSAT-2D, weighing about 2,500 kg, was built and launched at a cost of Rs. 300 crores. The recent setback to ISRO comes at a time when its engineers have succeeded in raising the perigee of the Indian Remote-sensing Satellite (IRS-1D) that was injected into a lower elliptical orbit (instead of the planned circular orbit) by the Polar Satellite Launch Vehicle (PSLV-C1) on

September 29. INSAT-2D had been in space for exactly four months before it was abandoned. It was built by the ISRO Satellite Centre (ISAC), Bangalore. It was launched on June 4 by the Ariane rocket of Arianespace organisation from Kourou island in French Guyana and deployed in a geosynchronous orbit at a height of about 36,000 km above the earth. At that altitude, satellites move at the same speed as the earth's rotation. Because of this, they appear to be stationary over the same place above the earth and for that reason are called geostationary satellites. These satellites help beam television and radio programmes, transmit telephone calls and take weather pictures. They also function as navigational aids for ships and aircraft. INSAT-2D had 23 transponders that were meant to be used to relay telephone calls and beam radio and television signals. Of these, only seven had been switched on when the mishap occurred on October 1. At 10 p.m. on October 1, INSAT-2D lost the earth lock because of a short circuit in one of its two power lines (or power "buses"). These lines supply electricity from the solar panels and batteries to the satellite systems. If the satellite's antenna does not point towards the earth, it is not possible to use its transponders for communication. The satellite then loses its earth lock. After INSAT-2D lost the earth lock, scientists at ISRO's Master Control Facility (MCF) at Hassan in Karnataka switched off its transponders. One of the scientists said that the cause of the short circuit in the power line was not known and had to be investigated. Scientists' hopes rose when the satellite regained the earth lock on October 2. Three transponders were switched on. However, ISRO personnel were fully aware of the gravity of the problem. One of the scientists said that it was a "fairly serious problem" even though three transponders had been switched on. The scientists were to have watched the behaviour of the satellite over the next few days and then taken a decision on whether any more transponders can be switched on. However, on October 4, the satellite lost the earth lock again and became inoperable". ***Subramanian had also highlighted the fact as "A unique technical triumph, INSAT-1 satellites are the first operational spacecraft ever built to combine communications, direct broadcast television and meteorological capabilities in one package" (emphasis – ADD).***

In essence the learning curve of the complex technology was indeed daunting to the persevering ISRO "breed", to quote Menon again! And yet the ultimate success was theirs as the Faustian quote always loudly proclaimed! From then onwards ISRO has indigenously produced and launched nearly three dozen satellites of varying size and complexity through depending on outside sources for launch *only* for larger (more than two tons) ones, pending its GSLV yet to be operationalized, the latest in the series being the one to study the behaviour of monsoon jointly with France. *In other words, ISRO has fully mastered the technology of producing satellites of great complexity, with the successful Moon Impact Probe experiment jointly with NASA being often described in popular parlance as its crowning glory of recent times.*

It was already pointed out that while the Aryabhatta and similar indigenously made 'long distance' satellites were being launched through help of advanced nations including US and USSR from their launch pads, the TERLS in Thumba complex was engaged in launching a series of Sounding Rockets and their Satellites meant for atmospheric studies program involving United State, France and so on, with the Soviet systems in use almost every week. The long term significance of those experiments in the ISRO programme would be dealt with in a separate issue. This was also the true beginning of the long-sustained India –

French collaboration referred to by the ISRO Chairman Radhakrishnan even recently. In other words, thanks to a very well orchestrated techno-political strategy, ISRO was able to duly achieve meaningful experience and expertise to plan for larger, more resourceful and more versatile multi-purpose (with national coverage to provide TV broadcast, telecommunications and meteorological services) and obviously more economic in the Indian context satellites-based space programs "in the interest of national development", as projected by its founder late Vikram Sarabhai and more often that not by his true successor Satish Dhawan. It was also mentioned earlier that TERLS was already engaged in carrying out a series of sounding rockets based geomagnetic research studies as a UN supported facility in international cooperation. The first launch took place on November 21, 1963 involving a two-stage US Nike-Apache rocket carrying a Sodium Vapour Payload releasing the vapour in the sky between 8- - 180 km altitudes. For conduct of the experiments, the rockets and some ground equipments were supplied by member countries, launch training was provided by NASA and CNES of France and the assembly, integration, etc carried out by the TERLS staff. To quote SC Gupta himself (op.cit) "The rocket flight was completely successful, meeting the objectives in their totality. This was the first historic step taken in the long and eventful march of India for the peaceful and national development oriented utilization of outer space". Very soon TERLS earned total appreciation from the international community in terms of "inestimable confidence in Indian skills and sense of commitment". The facility was dedicated to the UN on February 2, 1968, by the then Prime Minister Ms Indira Gandhi in a momentous function attended by the UN Secretary General himself. It was from this centre that was born alongside the Space Science & Technology Centre (SSTC) which itself eventually was renamed as Vikram Sarabhai Space Centre (VSSC) after the sudden demise of its veteran founder Vikram Sarabhai. How this expansion in turn gave birth to en equally crucial element of space technology itself is another great scientific-technological saga to be described in subsequent series.

This issue cannot be closed without highlighting that the Indian space activities in the country was started during early 1960s with the scientific

investigation of upper atmosphere and ionosphere over the magnetic equator that passes over Thumba near Thiruvananthapuram, a few meters away from the coastline St Mary Magdalene Church using small sounding rockets during the early leadership itself of Dr. Vikram Sarabhai, the visionary leader who had envisioned that this powerful technology could play a meaningful role in national development and solving the problems of common man. The history of this church and "to dedicate the church

in recognition of the national goal for the establishment of Indian Space Research Programme" by the then Bishop of Trivandrum Ret. Rev. Peter Bernad Pereira continue to proclaim eloquently the cherished values of 'science and society' of Vikram Sarabhai on the one hand and the matching sentiments of the then bishop for the same, and so also the truly secular traditions of the State in particular and of the Indian nation at large for larger causes. This is absolutely so when one reads the history of this church. To quote, "The first Church was built in 1544 by St. Francis Xavier himself, who had been the proponent in propagating Christianity throughout the southern coast of India. It was a thatched shed, all the four sides covered with dried coconut leaves. People gathered here in this shed for studying the prayers from the Catechists (Bible Teachers). Once a year or so a priest visited the place for administering sacraments. To commemorate the centenary of the temporary prayer shed built by St. Francis Xavier a century ago, a church after the name of St. Bartholomew was established in 1644 in the same place called Cherumankara (present Pallithura). This church was administered by the Jesuit Priests under the domain of the Portugal Government. With the suppression of the Jesuit Order in Portugal, from 1773 onwards the straddles of this church were carried on by the priests trained at and sent from the seminary in Goa. In 1858 Pope Pius IX made an agreement with the Portuguese Government whereby the Diocese of Cochin was established and the Church in Pallithura had become the northern tip of the 2nd Territory of Cochin Diocese and Eramanthura now in Kanyakumari District of Tamil Nadu was the Southern end. Work on the present church began with the ecclesiastical consent of Bishop Abilus of Cochin Dioceses at the beginning of the century. Suring this time on the seashore in the precincts of the church, native fishermen sighted a statue of St. Mary Magdalene
carved out of pure sandal wood. This statue was blessed and consecrated in the church (it is still preserved and venerated). The sighting of the statue coincided with a long wooded log washed up on the sea shore which the parish people erected as the flag mast in front of the Church (it is still intact in front of the church). Subsequent to the above two incidents, the church was renamed Saint Mary Magdalene. In 1933 Bishop Abilus of Cochin Diocese appointed a priest from Cochin Fr. Peter Puthenpurackal as the first residentiary parish priest of St. Mary Magdalene Church, Pallthura. Even before the completion of the Church as a full-fledged one, it was blessed by Bishop Alvarez of Cochin Diocese for conduct of sacraments. This church is the first of its kind in cross shape established in the southern coastal belt of India. The architects and sculptures were all from Tamil Nadu. The Christ Statue on the top of the tower is the handiwork of a Tamilian octogenarian; who had stayed on a temporary platform erected on the top of the tower till the statue was completed. After the consecration it was blessed by His Excellency Rt. Rev. Dr. Vincent Derera (from Belgium) who was the first Bishop of Trivandrum Diocese". The Church now continues, as in the beginning, to be a place of enlightenment and erudition, in modern scientific-technological development and from which the celebrated Space Museum of ISRO radiates the message of the origin, development and growth of national self-reliance in Space Technology for the thousands of students and visitors all round the year – perhaps a unique example of the communion of science and the holy spirit for a great national cause!

Does this not also bring back to our memory, though not exactly similar in its totality, the historic saga of late Pt. Madan Mohan Malavia in establishing a most modern and multi-disciplinary Benares Hindu University on the banks of the

Holy Ganga itself with the thousand acres land donated by an otherwise most orthodox and conservative ruler, the then Kasi Maharaja, for whom the very word 'English' was total anathema?

(To be continued)

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