Current and Future Utilities of Near-Earth Space

SPACE technology has become one of the most indispensable tools for the overall advancement of science and technology. This technology has had a phenomenal growth in the last four decades or so, after the first successful launch of satellite on October 4, 1957 by the erstwhile USSR (Sputnik I, 84 kg, 229- and 946-km altitudes at perigee and apogee respectively). The growth is due to the excellent utilities that the near-Earth space offers through the satellites positioned there. Specific areas of satellite-utilities are many. A few important ones are telecommunications, Earth-resources research, Earth environmental and meteorological studies, surveillance, reconnaissance, navigation, scientific experiments in space, atmospheric and astronomic research, and space station.

Based on orbital parameters, satellites are grouped into four types. The first type is low-Earth-orbit (LEO) satellite. This type of satellite operates in an elliptical orbit usually in the corridor above 200- and below 600-km altitude. "Reach LEO and you are halfway to anywhere in the Solar system" is the often-repeated quote regarding the importance of LEO-technology. Over ninety per cent of current satellites are in LEO. Hence a growing concern prevails about debris there. From the tiny Rohini satellite (see Table 1) launched by the Indian Satellite Launch Vehicle (SLV) to the most advanced Space Shuttle of USA come under this type. The next satellite-type is one of Sun-synchronous-orbit. This operates in a near-circular polar-orbit running nearly north to south at a fixed altitude ranging from 500- to 1000-km. Periodically within a fixed number of days (say, 20 days), it records at an approximately constant local time the best possible view of the entire surface of Earth. Every time the satellite passes from north to south, it has a consistent and constant sunlit view of a swath (say, 150 km width) of Earth's surface. Indian Remote-Sensing (IRS) Earth-observation satellite, launched by the Indian Polar-Satellite Launch-Vehicle (PSLV), comes under this kind. The third type is geo-synchronous satellite. This satellite, in a circular equatorial-orbit at a fixed altitude of about 36,000 km (to be exact, 35,786 km), goes around Earth once in about 24 hours (to be exact, 23 hours 56 minutes 4.09 seconds). As Earth also requires this time to rotate once on its axis with respect to "fixed" stars, the satellite in its geo-synchronous orbit (GEO) appears to be stationary as observed from Earth. The use of geo-synchronous satellite was well recognized only in 1945. Within a span of 18 years the first geo-synchronous satellite was launched. However, only a year later when the 1964 Olympic games in Japan were telecast live by the geo-synchronous satellite Syncom III, the World realized the importance of this type of satellites. The positions of geo-synchronous satellites are so important commercially that they are "rationed" by an international agreement. Surprisingly, placing a satellite in GEO requires as much an energy and hence the level of technology as launching a planetary flight. INSAT class of Earth-observation and communication satellites of India comes under this variety. Many INSAT satellites have been successfully launched by the satellite launch vehicles constructed by other countries. India is planning to launch shortly another such satellite by its own Geo-synchronous Satellite Launch Vehicle (GSLV). The last type of satellite is one of long-elliptical Molniya-orbit (for example Molniya 1-73 satellite with 504- and 39,834-km altitudes at perigee and apogee respectively). Given that the available launch sites in its region are with high latitudes, the erstwhile USSR devised this orbit to provide the features of GEO with a better coverage of the Northern Hemisphere.

By being in the near-Earth space, some of the facilities which have extensive potential for development but are yet to be exploited even to a microscopic scale are (1) unlimited and unconstrained access to the full power emitted by the Sun, (2) in the absence of gravity an ability to build gigantic structures presently impossible on Earth, (3) special industrial manufacturing-processes that can take advantage of contamination and gravity-free, perfect, and infinite vacuum, and (4) availability of the space as a perfect black-body heat sink at a temperature of about 4 K which is ideally suited to apply the advances of superconductivity. Furthermore, the future use of near-Earth space by humans may be viewed at yet another angle. The evolution of human colonisation on Earth has always followed the path that whenever new environments having potentials for developments open up humans find required technologies for penetration, exploitation, and eventual colonisation. This happens even when such environments have hostile weather conditions — the developmental potentials always play as powerful "market-forces". Similarly, the space with its unlimited potential for developments in energy, materials, medicines, and other resources will eventually be colonised through the development of required technologies despite its hostility to life due its vacuum, radiation, and extreme thermal conditions.

Table 1 Details of Indian satellites and their launch vehicles

Launch vehicle name, launch weight, height, and date of first successful launch	**Number of stages, types of propulsion systems, and propellants used**	**Name of satellite, weight, and type of orbit**
SLV 17.0 tonne 22.0 m July 18, 1980	Four stage All solid motors Polybutadiene acrylonitrile(PBAN) & Ammonium perchlorate (AP) / "High Energy Fuel" (HEF — a variant of polybutadiene) & AP propellants	Rohini satellite 40 kg Low Earth orbit: 280- and 800-km (altitudes at perigee and apogee respectively)
ASLV 41.7 tonne 23.8 m May 20, 1992	Four and "half" stage All solid motors Hydroxylterminated polybutadiene (HTPB) & AP / HEF & AP propellants	SROSS 113 kg Astronomy and aeronomy experiments Low Earth orbit: 437- and 938-km
PSLV 283 tonne 44.0 m Oct. 15, 1994	Four stage Solid and liquid motors; HTPB & AP for solid motors Unsymmetricaldimethyl hydrazine (UDMH) & N_2O_4 / Monomethyl hydrazine & N_2O_4 for liquid motors	IRS 804 kg Earth observation Polar Sun-synchronous near circular orbit: 820 km
GSLV 402 tonne 51.0 m (to be launched)	Three stage Solid, liquid, and cryogenic motors HTPB & AP for solid motor UDMH & N_2O_4 for liquid motor Liquid oxygen & liquid hydrogen for cryogenic motor	INSAT ~2500 kg Communication and Earth observation Geo-synchronous orbit: ~36000 km

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— A version of this appeared in The Hindu, May 6, 1999