Chapter III

Outer Space Applications

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For a long time space was mainly the domain of scientific and R&D technological programmes, telecommunication and military activity. But since the last few years, space has gradually become a domain of human activity not only in social communication services but also in natural resources management, environmental monitoring, disaster mitigation, surveillance, navigation supported traffic management as well as industrial activity. Still space activity is a significant element of international policy competition and technological standardization. Space is now a big global market where countries advanced in space technology are the main partner. Hence, before embarking onto the various applications of space and space technology, the meaning of outer space needs to be clearly understood in detail.

3.1 Meaning of Outer Space

Outer space usually denotes the relatively empty regions of the universe outside the atmospheres of celestial bodies. It is different from airspace, which has been defined in the previous chapter. Theodore Von Kármân, a Hungarian-American engineer and physicist who was active primarily in the fields of aeronautics made an attempt to define outer space. He first calculated that around a particular altitude the Earth's atmosphere becomes too thin for aeronautical purposes (because any vehicle at this altitude would have to travel faster than orbital velocity in order to derive sufficient aerodynamic lift from the atmosphere to support itself). Also, there is an abrupt increase in atmospheric temperature and interaction with solar radiation.

The Kármán line lies at an altitude of 100 km (62.1 miles) above the Earth's sea level, and is commonly used to define the boundary between the Earth's atmosphere and outer space. This definition is accepted by the Federation Aeronautique Internationale (FAI), which is an international standard setting and record-keeping body for aeronautics and astronautics.

When studying aeronautics and astronautics in the 1950s, Kármán had made certain calculations and inferred from them that above an altitude of about 100 kilometres (62 m), vehicles need to increase their speed so that it is more than orbital velocity. If the speed is less than that, they would not be able to support themselves up in the atmosphere. Though the calculated altitude was not exactly 100 km, Kármán proposed that 100 km should be the designated boundary to space as the round number is more memorable and the calculated altitude varies minutely as certain parameters are varied. An international committee recommended the 100 km line to the FAI, and upon adoption it became widely accepted as the boundary to space for many purposes.[1] However, there is still no international legal definition of the demarcation between a country's air space and outer space. The issue whether it is possible or useful to establish a legal boundary between airspace and outer space has been debated in the doctrine for quite a long time.

Strictly speaking, there is no such thing as an end to the Earth's atmosphere. An atmosphere does not technically end at any given height, but becomes progressively thinner with altitude. At higher and

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[1] *http://en.wikipedia.org/wiki/Karman_line*

higher altitudes, the atmosphere becomes so thin that it essentially ceases to exist. Gradually, the atmospheric halo fades into the blackness of space. Also, depending on how the various layers that make up the space around the Earth are defined (and depending on whether these layers are considered as part of the actual atmosphere), the definition of the edge of space could vary considerably. If one were to consider the thermosphere and exosphere as part of the atmosphere and not of space, one might have to place the boundary to space as high as about 10,000 km (6,210 miles) up.

Another hurdle to strictly defining the boundary to space is the dynamic nature of the Earth's atmosphere. For example, at an altitude of 1,000 km (621 miles), the atmosphere's density may vary by a factor of five, depending on the time of day, time of year, AP magnetic index, and recent solar flux (instability or fluctuations in solar radiation).

Daily regular magnetic field variations arise from current systems caused by regular solar radiation changes. Various magnetic activity indices (for e.g. kp index, ap index) were designed to describe variation in the geomagnetic field caused by these irregular current systems. This planetary index is designed to measure solar particle radiation by its magnetic effects.

The FAI apparently does not itself use the precise words "boundary to space" or "edge of space"; the FAI uses the term "Kármán line" or speaks of a "100 km altitude boundary for astronautics", as also reflected in their following two definitions[2]:

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[2] *http://en.wikipedia.org/wiki/Karman_line*

- *Aeronautics — For FAI purposes, aerial activity, including all air sports, within 100 kilometres of the Earth's surface.*

- *Astronautics — For FAI purposes, activity more than 100 kilometres above the Earth's surface.*

Some people (including the FAI in some of their publications) also use the expression "edge of space" to refer to a very vaguely defined (essentially undefined) region below the actual 100 km boundary to space, which is often meant to include substantially lower regions as well. Thus, certain balloon or airplane flights might be described as "reaching the edge of space", when they really don't even go half as high as 100 km up. In such statements, "reaching the edge of space" merely refers to going some distance higher than the average aeronautical vehicles would commonly go.

Although the United States does not officially define a "boundary of space", the US definition of an astronaut, which is still held today, is a person who has flown above 80 km (50 miles) above mean sea level. This is approximately the line between the mesosphere and the thermosphere. This definition of an astronaut had been somewhat controversial, due to differing definitions between the United States military and NASA. In 2006, two veteran X-15 pilots were retroactively awarded their astronaut wings, as they had flown higher than 110 km in the 1960s, but at the time had not been recognized as astronauts.[3]

3.2 The Big Bang Theory

The term *Big Bang* generally refers to the idea that the Universe has expanded from a primordial hot and dense initial condition at some

[3] *http://en.wikipedia.org/wiki/Karman_line*

finite time in the past (currently estimated to have been approximately 13.7 billion years ago[4]), and continues to expand to this day. Fred Hoyle is credited with coining the term *'Big Bang'* during a 1949 radio broadcast. After the discovery of the cosmic microwave background radiation in 1964, and especially when its spectrum (i.e., the amount of radiation measured at each wavelength) sketched out a blackbody curve, most scientists were fairly convinced by the evidence that some Big Bang scenario must have occurred.

The core ideas of the Big Bang theory are –

- the expansion of the universe
- the early hot state
- the formation of helium and
- the formation of galaxies.

In the beginning the Universe was all in one point, all its matter and energy were squished into an infinitely small volume. Immediately after the explosion the small space was filled with energy (as radiation) and had an extremely high temperature, one million billion billion billion (10 with 32 zeros) degrees Kelvin. This stage is called the primordial fireball[5].

In a fraction of a second elementary matter came into existence – protons, neutrons and electrons, followed by a very fast expansion or inflation. Since the beginning the Universe has been cooling down and expanding more and more. This time is called the radiation era, as electromagnetic radiation was the most important thing in the Universe.

[4] *http://en.wikipedia.org/wiki/Big_Bang*
[5] *www.bigbang.mht*

After several hundred thousand years the temperature drop was large enough for atoms to develop from elementary particles, in particular hydrogen and helium, and this is called the matter era. After 300,000 years the Universe had cooled down enough to become transparent for radiation, at that time the first Galaxies arose. A combination of observations and theory suggest that the first quasars and galaxies formed about a billion years after the Big Bang, and since then larger structures have been forming, such as galaxy clusters and super clusters.

3.3 Black Holes

In general relativity, a black hole is a region of space in which the gravitational field is so powerful that nothing, not even light, can escape. The black hole has a one-way surface, called an event horizon, into which objects can fall, but out of which nothing can come. It is called "black" because it absorbs all the light that hits it, reflecting nothing. Despite its invisible interior, a black hole can reveal its presence through interaction with other matter. A black hole can be inferred by tracking the movement of a group of stars that orbit a region in space which looks empty. Alternatively, one can see gas falling into a relatively small black hole, from a companion star. This gas spirals inward, heating up to very high temperatures and emitting large amounts of radiation that can be detected from earthbound and earth-orbiting telescopes. Such observations have resulted in the scientific consensus that black holes exist in our universe.

Once a black hole has formed, it can continue to grow by absorbing additional matter. Any black hole will continually absorb interstellar dust from its direct surroundings and omnipresent cosmic background radiation. A black hole sometimes merges with other stars or compact objects. The super massive black holes suspected to be in the centre of most galaxies are expected to have formed from the coagulation of many smaller objects. As an object approaches the event horizon, the horizon near the object bulges up and swallows the object. Shortly thereafter the increase in radius (due to the extra mass) is distributed evenly around the hole.

3.4 Outer Space Applications

Over the years, the range of civilian space applications has increased significantly. Three main types of space applications currently dominate the space business and will continue to do so in the medium term:

i) Telecommunications

ii) Earth observation and

iii) Positioning and navigation systems

Significant benefits have been derived for society at large from these applications, and further progress could be achieved in the coming decades. However, the future of the sector looks bleak. Notably, the development of commercially viable applications has proved very difficult. As a result, both the industry and the financial community are hesitant to embark upon the development of a good many potentially promising applications. This situation is leading a number of countries already active in space to reassess their overall space strategy. Many of them are facing difficult choices, in particular on the overall level of effort that should be devoted to space, on how that effort should be allocated, and on the role that could be expected of the private sector. Moreover, there is a growing feeling among experts that the policy and regulatory frameworks that currently govern space activities are unlikely to be able to meet the challenges of the future or to provide the necessary support to the further development of the commercial space sector. With the increasing use of space for several applications, they need to be revised and altered suitably if not completely revamped. Some of the current applications of space are in the fields of telecommunications, meteorology, environment monitoring, remote sensing, military, space tourism, etc.

3.5 Satellites

A satellite is an object that has been placed into orbit by human endeavour. Hence it is also sometimes called artificial satellite to distinguish it from natural satellites such as the Moon.

The first artificial satellite, Sputnik 1, was launched by the Soviet Union in 1957. By 2009 thousands of satellites have been launched into orbit around the Earth. These originate from more than 50 countries and have used the satellite launching capabilities of ten nations. A few hundred satellites are currently operational, whereas thousands of unused satellites and satellite fragments orbit the Earth as space debris. A few space probes have been placed into orbit around other bodies and become artificial satellites to the Moon, Venus, Mars, Jupiter and Saturn. The largest artificial satellite currently orbiting the Earth is the International Space Station.

The most common types of satellites are military (spy) and civilian Earth observation satellites, communication satellites, navigation satellites, weather satellites, and research satellites. Space stations and human spacecraft in orbit are also satellites. Satellite orbits vary greatly, depending on the purpose of the satellite, and are classified in a number of ways. Well-known (overlapping) classes include low Earth orbit, polar orbit, and geostationary orbit.

Satellites are usually semi-independent computer controlled systems. Satellite subsystems attend to many tasks, such as power generation, thermal control, telemetry, altitude control and orbit control.

Most of the applications of outer space are carried out through satellites. Data from one point on the earth to another or from some place in space to one on earth is transmitted via satellites. They touch nearly every aspect of our lives in some way or the other and pervade our information-driven society.

3.6 Uses of Satellites

Taking a look at the different types of satellites would be better to give a clearer picture of the vast range of the utility of satellites.

- Anti-Satellite weapons/"Killer Satellites" are satellites that are armed, designed to take out enemy warheads, satellites, and other space assets. They may have particle weapons, energy weapons, kinetic weapons, nuclear and/or conventional missiles and/or a combination of these weapons. Thus they are immensely useful for security and defence purposes.

- Astronomical satellites are satellites used for observation of distant planets, galaxies, and other outer space objects.

- Biosatellites are satellites designed to carry living organisms, generally for scientific experimentation.

- Communications satellites are stationed in space for the purpose of facilitating telecommunications. They are used among others for television transmissions, broadband internet access, intercontinental telephone calls, etc. Today it is difficult to imagine life without these facilities for communication.

- Miniaturized satellites are satellites of unusually low weights and small sizes. New classifications are used to categorize these satellites: minisatellite (500–100 kg), microsatellite (below 100 kg), nanosatellite (below 10 kg)[6].

- Navigational satellites are satellites which use radio time signals transmitted to enable mobile receivers on the ground to determine their exact location. The relatively clear line of sight between the satellites and receivers on the ground, combined with ever-improving electronics, allows satellite navigation systems to measure location to accuracies on the order of a few meters in real time.

- Reconnaissance satellites are Earth observation satellites or communications satellites deployed for military or intelligence applications. Very little is known about the full power of these satellites, because governments who operate them usually keep

[6] *http://en.wikipedia.org/wiki/Satellite*

information pertaining to their reconnaissance satellites classified.

- Earth observation satellites are satellites intended for non-military uses such as environmental monitoring, meteorology, land-use planning, map making, etc.

- Space stations are man-made structures that are designed for human beings to live on in outer space. A space station can be differentiated from other manned spacecraft by its lack of major propulsion or landing facilities. This necessarily entails the use of other vehicles for transport to and from the station. Space stations are designed for medium-term living in orbit, for periods of weeks, months, or even years.

- Tether satellites are satellites which are connected to another satellite by a thin cable called a tether.

- Weather satellites are primarily used to monitor the Earth's weather and climate.

There are several other possible uses for satellites in the future like road user charging, prisoner tagging, flood damage, etc. Satellite navigation is an important commercial application of satellites and the world market today is about £13 billion, which is estimated to be £200 billion by 2020.

3.7 Meteorology

This is a term usually associated with the science of the weather and with weather forecasting, but it also includes the study of the ionosphere and ozonosphere. Meteorology as an exact physical science started developing about 1800, with new inventions like the barometer and the thermometer that enabled improved observation and research techniques. During the 19th century weather observation stations were set up in several countries. The International Meteorology Organization (IMO) was set up in 1873. It became an agency of the UN with the name of World Meteorology Organization. The World Wars emphasized the need for better and quicker meteorology information for both aviation and military planning, and the introduction of radar technology meteorology science received a tremendous boost.

The first meteorological satellite TIROS-I was launched on 1st April, 1960 by the USA. In 1968 the UN Conference on the Exploration and Uses of Outer Space was organized. In the report of this conference, the benefits of satellites were described as follows –

"Daily surveillance of ocean areas permits early detection of developing storms, typhoons and hurricanes, determination of their tracks, and estimation on a daily basis of storm development and intensity."[7]

Three kinds of satellites are active in relation to climate –

(a) Meteorological satellites

(b) Telecommunications satellites

(c) Remote sensing satellites

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[7] *Prof. Dr. I. H. Ph. Diederiks-Verschoor & Prof. Dr. V. Kopal, 'An introduction to space law', 2008*

The European Organization for the Exploitation of Meteorological Satellites (Eumetsat) was created in 1986. Eumetsat is an international organization based on an inter-governmental convention to which all European states can accede. Meteorological data obtained from remote sensing satellites are free.

3.8 Telecommunication

The Secretary-General of the International Telecommunication Union had once remarked – *"Telecommunications provide the only link between space and the earth, and whatever happens in space or whatever use is made of space, telecommunications are required to make it possible."*[8]

Satellite technology has brought about a revolution comparable to the industrial revolution of the 18th and early 19th centuries. Communication means imparting or transmitting signals or messages to others; it is an interaction between two or more persons or groups of persons, large or small. Telecommunications involve this process taking place over a long distance. It is currently the most important and the most dynamic market for space applications. It includes fixed telecommunications services (voice, data, internet, multimedia); broadcasting (TV and radio services, video services, internet content); mobile services (data, voice, internet, multimedia, digital radio). Originally conceived with limited coverage and to serve a limited number of professional users, satellite communication systems are evolving towards large regional or global coverage.

[8] *Prof. Dr. I. H. Ph. Diederiks-Verschoor & Prof. Dr. V. Kopal, 'An introduction to space law', 2008*

Satellite communication, with its vast reach and flexibility has become the most powerful engine of growth for development. The emergence of digital broadcasting, direct-to-home television and global mobile personal communication systems has made the dream of establishing instantaneous global connectivity anywhere on land, air or sea, a space age reality. The confluence of computer and communication technologies has paved the way for establishing national and global information infrastructures. The global village is on the verge of transition from a concept to reality, with information super highways providing instantaneous access to the vast data bases and information network, an essential requirement for any nation to compete in the knowledge based global economy. Satellite communication, combined with the phenomenal developments in GPS and geographic information systems, has totally revolutionised navigation bringing the concept of free flight within the realm of our horizon.

The rapid growth in commercial satellites has largely been fuelled by the tremendous growth in the telecommunications industry. The first international consortium to provide communication satellite services – the International Telecommunication Satellite Organization, or Intelsat – started operations in 1965. Communications satellites currently provide a variety of services - including long distance telephony, data transmission, paging, and television broadcasting - that have become routine features of life and business in modern economies. They have also been particularly attractive to developing countries and regions that do not already have a communications infrastructure based on more conventional cable and microwave relay systems.

Satellite remote sensing, using optical and microwave techniques, now provides vital inputs on land use practices, forest monitoring, water resource management, soil classification, wasteland identification, agricultural monitoring, ocean dynamics, cartography and environmental pollution. Advanced earth observation systems with very narrow band spectroscopy and platforms capable of imaging at a resolution of better than one meter have been developed. Continuous monitoring of ozone, rain precipitation, aerosol content and green house gases are providing valuable inputs to study global climatic changes. Remote sensing and meteorological satellites are helping us to keep a constant vigil on cyclones, hurricanes, landslides, forest fires and other natural disasters. In combination with geographic information systems, satellite remote sensing has emerged as the most versatile and powerful tool for supporting the decision-making process on resource management, even at the micro-level. The practical benefits of space technology applications today virtually touch every facet of human endeavour extending over communication, navigation, meteorology, education, health, agriculture, resource management, environmental protection, disaster management and entertainment.

3.9 Earth Observation

Earth Observation (EO) helps to measure and monitor the Earth's climate and environment, and to map its resources. Following in the pioneering footsteps of meteorology, the field of application of EO is extending to a growing number of domains, including agriculture, resource management, exploration, mapping and planning, hazard monitoring and disaster assessment (landslides, earthquakes, volcanic eruptions, floods and droughts) as well as security, defence and the enforcement of international agreements.

3.10 Positioning and Navigation

The use of satellites for localisation and navigation purposes is rapidly expanding. The implementation of the Global Positioning System (GPS) has allowed the development of a growing number of applications (air transport, maritime transport, land transport, localisation of isolated individuals) and also provides a universal referential time and location standard for a number of systems. In the coming years, the European civilian Galileo system will complement GPS.

3.11 Interplanetary Internet

The 'Interplanetary Internet', as presently conceived, is a set of floating nodes in space which can communicate with each other. Because of the large speed of light delays involved with interplanetary distances, a new set of protocols and technology are needed that are tolerant to large delays. While the Internet as we know it tends to be a busy "network of networks" with high traffic, negligible delay and errors, and a wired backbone, the Interplanetary Internet is a store-and-forward "network of Internets" that is often disconnected, with a wireless backbone fraught with error-prone links and delays ranging to tens of minutes, even hours, even when there is a connection.

Looking at space communications from the historical perspective, there has been a steady evolution from expensive one-of-a-kind point-to-point architectures, to the re-use of technology on successive missions, to the development of standard protocols agreed upon by the space agencies of many countries. This last phase has gone on since 1982 through the efforts of the Consultative Committee for Space Data

Systems (CCSDS), a body composed of the major space agencies of the world. It has ten member agencies, twenty-two observer agencies, and over 100 industrial associates[9].

The evolution of Space Data System standards has gone on in parallel with the evolution of the Internet, with conceptual cross-pollination where it could be fruitful, but as a separate evolution to a large degree. Since the late 1990s, familiar Internet protocols and CCSDS space link protocols have integrated and converged in several ways, for example, the successful FTP file transfer to Earth-orbiting STRV-1b on 2nd January, 1996. Internet Protocol use without CCSDS has also been demonstrated on spacecraft, e.g. the UoSAT-12 satellite and the Disaster Monitoring Constellation. Having reached the era where IP on-board spacecraft, and IP or IP-like Space Communications Protocol Specifications (SCPS) for short hops have been shown to be feasible, a forward-looking study of the bigger picture was the next phase.

The Interplanetary Internet study at NASA's Jet Propulsion Laboratory (JPL) was started by a team of scientists at JPL led by Vinton Cerf and Adriarn Hooke. Cerf is one of the pioneers of the Internet on Earth, and currently holds the position of distinguished visiting scientist at JPL. Hooke is one of the directors of the CCSDS.

While IP-like SCPS protocols are feasible for short hops, such as ground station to Orbiter, Rover-to-Lander, Lander-to-Orbiter, probe-to-flyby, and so on, delay-tolerant networking is needed to get information from one region of the solar system to another. It becomes apparent that the concept of a "region" is a natural architectural factoring of the Inter-Planetary Internet.

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[9] *http://en.wikipedia.org/wiki/Interplanetary_Internet*

A "region" is an area where the characteristics of communication are the same. Region characteristics include communications, security, maintenance of resources, perhaps ownership, and other factors. The Interplanetary Internet is a "network of regional internets".

What is needed, then, is a standard way to achieve end-to-end communication through multiple regions in a disconnected, variable-delay environment using a generalized suite of protocols. Examples of regions might include the terrestrial Internet as a region, a region on the surface of the moon or Mars, or a ground-to-orbit region.

The recognition of this requirement led to the concept of a "bundle" as a high-level way to address the generalized Store-and-Forward problem. Bundles are an area of new protocol development in the upper layers of the OSI model, above the Transport Layer with the goal of addressing the issue of bundling store-and-forward information so that it can reliably traverse radically dissimilar environments constituting a "network of regional internets".

Bundle Service Layering, implemented as the Bundling protocol suite for Delay Tolerant Networking, will provide general purpose delay tolerant protocol services in support of a range of applications: custody transfer, segmentation and reassembly, end-to-end reliability, end-to-end security, and end-to-end routing among them. The Bundle Protocol was first tested in space on the UK-DMC Disaster Monitoring Constellation satellite in 2008.

An example of one of these end-to-end applications flown on a space mission is CFDP, used on the comet mission, Deep Impact. CFDP is the CCSDS File Delivery Protocol, an international standard for automatic, reliable file transfer in both directions. CFDP should not be confused with Coherent File Distribution Protocol, which unfortunately has the same acronym and is an IETF-documented experimental protocol for rapidly deploying files to multiple targets in a highly-networked environment.

In addition to reliably copying a file from one entity (i.e. a spacecraft or ground station) to another entity, the CCSDS CFDP has the capability to reliably transmit arbitrary small messages defined by the user, in the metadata accompanying the file, and to reliably transmit commands relating to file system management that are to be executed automatically on the remote end-point entity (i.e. a spacecraft) upon successful reception of a file.

The dormant Inter-Planetary Internet Special Interest Group of the Internet Society has worked on defining protocols and standards that would make the IPN possible. The Delay Tolerant Networking Research Group (DTNRG) is the primary group researching Delay-tolerant networking which has several major arenas of application in addition to the Interplanetary Internet, including stressed tactical communications, sensor webs, disaster recovery, hostile environments, and remote outposts. As an example of a remote outpost, imagine an isolated Arctic village or a faraway island, with electricity, and one or more computers but no communication connectivity. With the addition of a simple wireless hotspot in the village, plus DTN-enabled devices on, say, dog sleds or fishing boats, residents would be able to check their e-mail or click on an article in a search engine, and have their requests forwarded to the nearest networked location on the sled's or boat's next visit, and get the replies on its return.

NASA cancelled plans to launch the Mars Telecommunications Orbiter in September 2009; it had the goal of supporting future missions to Mars and would have functioned as a possible first definitive Internet hub around another planetary body.

3.12 Environmental Monitoring

The initiative by the world's space powers to monitor the planet will have direct economic impact on the sector as well as a wider impact on the society at large. The Global Monitoring for Environment and Security (GMES) programme can and should assist the emergence of a commercial Earth Observation marketplace. The Disaster Monitoring Constellation is based on SSTL satellites.

Seeking new water supply sources may also be yet another thrust area for space science and technologies. Space science and technology can surely find sustainable regional solutions for abundant and perennial supply of fresh drinking water. In our country, redistribution of water supply through networking of rivers is now being taken up as a critical mission. Remote sensing to survey and evolve optimum water routes, environmental mapping and afforestation requirements, and continuous monitoring of the networked water flow through all seasons and at all times may require a dedicated satellite constellation for our networked river systems. Reverse osmosis technology for sea water desalination in a new energy efficient manner is rapidly evolving. Space based solar power stations have six to fifteen times greater capital utilization than equivalent sized ground solar stations. Linking space solar power to reverse osmosis technology for large-scale drinking water supplies to coastal cities is thus yet another major contribution which could be made by space technologies for sustainable economic development through regional solutions for the impending drinking water crisis.

3.13 Military

The 1991 Gulf War vividly demonstrated the enormous potential of space systems to support conventional military operations. Reconnaissance satellites assisted the targeting of Iraqi forces and helped to assess the effects of the air campaign. Early-warning satellites, originally designed to detect Soviet intercontinental and sea-launched ballistic missiles, picked up the launch of Scud missiles and alerted Patriot missile batteries of their impending arrival. They also played a politically important role in providing civil defence warnings for civilian populations in both Saudi Arabia and Israel. More than 90 percent of all the long distance communications used by American forces in the theatre of operations were routed through space, including commercial as well as military communications satellites. Weather satellites helped forecast conditions that could favourably or unfavourably impact military operations, such as rainstorms that would obscure targets from aircraft, cause tanks to get bogged down in the desert sand, or adversely affect the performance of precision guided weapons. By far the biggest space story during the Gulf War was the coalition's use of navigational signals from the Air Force's Global Positioning System (GPS) to guide soldiers across featureless terrain during the large ground assault into Iraq. Tank commanders involved in the action subsequently concluded that it would have been virtually impossible to execute their battle plans with the same speed and precision without GPS, even though the system was not even fully operational in 1991.

In fact, the U.S. Air Force Chief of Staff at the time referred to Desert Storm as history's "first space war". Many analysts concluded that future wars would entail an even greater reliance upon space systems to support more traditional operations on and near the Earth's surface. Victory would, in turn, depend upon maintaining 'control' of space in any conflict. Hence there is growing concern in the US that future adversaries could use space to support their own forces in conflicts with them. The Gulf War vividly demonstrated the enormous importance of space systems to the American military. It also suggested to thoughtful observers that the United States should not count on an indefinite monopoly in this field, particularly as spaced-based products and services became increasingly available in the commercial market. The consequences of facing an enemy with the same or similar capabilities of observing the battlefield from space or providing precise navigation data to its forces would be profound. If, for example, Iraq had had access to this kind of information, the coalition's victory would not have been as easy. Commercially available satellite imagery might have unmasked preparations for the ground force's "left hook" into Iraq. As satellite communications, remote sensing, and navigation services become more widespread, future adversaries – including those with otherwise limited military capabilities – would be able to acquire, process, and quickly disseminate information that could be used against American forces. As a rule, military commanders seek to gain the high ground – not to share it. Thus, in future conflicts, the United States would no doubt want to deny the use of space capabilities to its enemies, lest they achieve the same advantages in space. The central dilemma is how to accomplish both ends – protecting one's own use of space, while at the same denying it to an adversary.

Since Desert Storm, all four U.S. military services have systematically explored ways in which space systems can better support traditional military operations. As a result of improvements in space systems and related ground equipment, the military has grown even more reliant on space. For example, procedures for processing data from early-warning satellites have been streamlined to sharply reduce the time required to alert field commanders of the launch of Scud-class ballistic missiles.

The Air Force is also developing a new fleet of satellites designed to provide even more precise detection and tracking of missile launches. Additionally, the military is making more extensive use of GPS navigation data, which continues to dramatically improve the accuracy of battlefield weapons. The Air Force recently demonstrated the ability to conduct precision strikes with the B-2 bomber using conventional bombs aided by GPS. Most new weapons currently in development will employ GPS data in some form.

The military's interest in space will no doubt continue to grow. The so-called "revolution in military affairs" that seeks to capitalize upon the current American lead in information technologies depends in large part on spaced-based sensors and communications. In fact, the major portions of five major military missions closely tied to achieving "information dominance" on the battlefield-communications, navigation, ballistic missile warning, weather observation, and intelligence gathering-have already migrated to space. The next military mission that might move there is real-time surveillance by space-based radars capable of detecting the movement of tanks and other vehicles at or near the Earth's surface. The Air Force, the National Reconnaissance Office, and the Defence Advanced Research

Projects Agency have embarked upon a joint project to develop such a capability.[10]

3.14 Remote Sensing

Another major area of commercial interest in space has been remote sensing. This activity entails the collection of data from the Earth's surface using a variety of techniques, including photography, infrared detection, and radar scanning. The first use of space-based remote sensing was intelligence gathering. However, satellites can provide data of considerable interest to urban planners, cartographers, geologists, farmers, and environmentalists. Several commercial ventures are poised to develop radar satellites that can peer through clouds and darkness to produce images with similar resolutions.

A brand new industry has emerged to provide GPS gear for customers ranging from car owners to outdoor enthusiasts. The current worldwide GPS equipment market is about $10 billion. Beyond the economic impact, the use of GPS has become ubiquitous throughout society. The civil aviation industry has become increasingly reliant on GPS-aided navigation. Several industries use the highly accurate timing signals generated by the GPS satellites' atomic clocks to synchronize their operations. Large telephone companies, financial institutions, and the Internet rely upon GPS for this service. Thus, it is obvious that GPS is becoming a critical element of the technological infrastructure that underpins the entire global economy.

A number of analysts have predicted that the U.S. military and other government agencies (and their counterparts in other countries) could

[10] *http://www.cfr.org/publication.php*

become major customers for the even more detailed commercial satellite imagery that will soon be available. The American military will almost certainly have a requirement for communications and remote sensing capabilities unique to armed combat and, therefore, not likely to be offered by commercial vendors seeking the widest possible market.

Some nations have expressed objections to the unrestricted use of space to conduct remote sensing over their territory. These objections are based on two concerns. The first is national security. As the market for remote sensing products has expanded – although slowly – and the quality of commercial satellite imagery has improved dramatically, several governments have expressed fears that their potential adversaries will purchase remote sensing products or technology in the open market to obtain information with intelligence or military value that would not otherwise be available to them. The Israeli government, for example, has been especially sensitive to the possibility that the deliberate uncertainty surrounding its nuclear and ballistic missile potential would be undermined by commercially available high-resolution imagery.

The second objection to unrestricted remote sensing has been economic. The developing nations in particular have expressed concerns that nations who can acquire detailed economic data from space will have an unfair advantage in competing for contracts to develop indigenous resources. Other countries have worried about paying higher costs for obtaining remote sensing data from private companies as opposed to governments.

Efforts to restrict remote sensing have taken essentially two forms. First, within the context of the United Nations and its Committee on

SMT. HANSA MEHTA LIBRARY

the Peaceful Uses of Outer Space (COPUOS), several nations have sought to establish internationally agreed rules of the road for remote sensing. Early views ranged from requiring prior approval from the nation being remotely observed to creating an international agency to control the gathering and distribution of remote sensing data. In 1986, after 14 years of deliberation within COPUOS, the U.N. General Assembly adopted a resolution on principles relating to remote sensing. They state, among other things, that remote sensing should be carried out for the benefit and in the interests of all countries, taking into particular consideration the needs of the developing countries.

Additionally, remote sensing activities should not be conducted in a manner "detrimental to the legitimate rights and interests of the sensed State". Likewise, when one country acquires data over another country, the sensed country should have access to the data on a "non-discriminatory basis and on reasonable cost terms".

Yet in no way were any specific restrictions or regulatory mechanisms imposed on remote sensing by these principles. What is more, the major space powers do not consider the principles to be binding.

A second approach has been to bring pressure to bear on individual governments to restrict the activities of their domestic companies in the sale and distribution of remote sensing products. Lobbying by the Israeli government is widely credited with convincing the U.S. Congress to specifically prohibit companies licensed by the American government from selling images of Israel that are of higher resolution than is available from non-U.S. commercial sources. There also have been suggestions to establish multilateral mechanisms along the lines of various export control regimes (for example, those concerning missile technology) to monitor and where necessary restrict the sale of remote imaging equipment and products.

3.15 Flights of Fancy – Space Tourism

It can be said that space tourism is 'Travel into nothingness'. You pay money for travelling to nowhere. Space Tourism is the term that has come to be used to mean ordinary members of the public buying tickets to travel to space and back. Many people find this idea futuristic. But over the past few years a growing volume of professional work has been done on the subject, and it's now clear that setting up commercial space tourism services is a realistic target for business today.

On 28th April, 2001, Mr. Dennis Tito of the USA, a businessman and a former scientist, was the first person from earth to make a trip to the International Space Station (ISS) after making a payment of 20 million US dollars. He visited the ISS for seven days. He was followed in 2002 by South African computer millionaire Mark Shuttleworth. Since then a few other persons from various countries have also made such trips including several days' stay in space.

Encouraging such ventures, a prize was announced for the first private company to reach and surpass an altitude of 62 miles, or in other words, to cross the boundary of space (the Karman line, defined to be at an altitude of 100 km. or 62 miles above the earth). On 4th October, 2004, the SpaceShipOne, designed by Burt Rutan of Scaled Composites and funded by Virgin Galactic, won this $10,000,000 X Prize. The first flight was flown by Michael Melvill on 21st June, 2004 to a height of 62 miles, making him the first commercial astronaut.[8]

The prize-winning flight was flown by Brian Binnie, which reached a height of 69.6 miles. Though it is not a proper spacecraft able to make orbital flights around the earth, this vehicle for proposed commercial suborbital flights is a major step towards eventual commercial spaceflights. In 2010 space tourism to the ISS could become much more common as NASA hopes to rely on COTS (Commercial Orbital Transportation Systems) to send both astronauts and cargo to the ISS.

3.16 Space Stations

In this bustle of outer space activities going on at present, space stations are playing a prominent role, and it seems certain that they will continue doing so in the foreseeable future. Space stations are a kind of spacecraft. Structures like Salyut-Soyuz, Skylab, Spacelab, Mir and the International Space Station (ISS) fall under this category.

One of the common characteristics of space stations is that they all share a high level of international co-operation that is required to assemble them and to ensure their operational efficiency. The main reason for this is their multi-purpose activities and the complexity of the structures involved. Another feature common to all of them is the size of these structures, which is necessary because of their wide-ranging functions. Yet another common feature is that space stations must be adequately equipped for many years of service. For this reason it has been felt that Skylab was not a real space station as it was not a facility that could have been used over a multi-year period.

A space station is an artificial structure designed for humans to live in outer space. So far only low earth orbit (LEO) stations are implemented, also known as 'orbital stations'. A space station is distinguished from other manned spacecraft by its lack of major propulsion or landing facilities – instead, other vehicles are used as transport to and from the station. Space stations are designed for medium-term living in orbit, for periods of weeks, months, or even years. The only space station currently in use is the International Space Station. Previous ones are the Almaz, Salyut series, Skylab and Mir.

These stations have various issues that limit their long-term habitability, such as very low recycling rates, relatively high radiation levels and a lack of gravity. Some of these problems cause discomfort and long-term health effects. In the case of solar flares, all current habitats are protected by the Earth's magnetic field.

Future space habitats may attempt to address these issues, and are intended for long-term occupation. Some designs might even accommodate large numbers of people, essentially "cities in space", where people would make their homes. No such design has yet been constructed, since even for a small station, the current launch costs are not economically or politically viable.

Possible ways to deal with these costs would be building a large amount of rockets (economies of scale), reusable rockets, in situ resource utilisation or if space elevators are ever able to be constructed.

The International Space Station (ISS) (USA, Russia, Japan, European Space Agency, Canada, Brazil, Italy) is the only space station currently in orbit. It has been continuously occupied since 30th October, 2000.

China has plans to create a manned space station by 2012, with the working name Project 921-2.

3.17 Functions of Space Stations

Space stations are currently used to study the effects of long-term space flight on the human body as well as to provide platforms for greater number and length of scientific studies than available on other space vehicles. Since the ill-fated flight of Soyuz 11 to Salyut 1, all manned spaceflight duration records have been set aboard space stations. The duration record for a single spaceflight is 437.7 days, set by Valeriy Polyakov aboard Mir from 1994 to 1995. As of 2008, three astronauts have completed single missions of over a year, all aboard Mir.

Space stations have been used for both military and civilian purposes. The last military-use space station was Salyut 5, which was used by the Almaz program of the Soviet Union in 1976 and 1977.

Space stations can be designed to perform activities as diverse as data-gathering, transmitting of information, material processing, repairing facilities, energy-generation and scientific research. It is even possible to construct space stations capable of accommodating population centres.

The individual space station components mentioned most often are the following –

- laboratory modules for scientific research
- unmanned, remote-controlled 'orbital manoeuvring vehicles' to service instruments on platforms and free-flying satellites

- orbital construction facilities, fuel dumps and dry docks for satellite assembly and maintenance

- a reusable orbital transfer vehicle to ferry satellites into geosynchronous orbit

The function of a space station has been described by Gorove as follows –

'Such a station can function as a laboratory, as a permanent observatory, a transportation and communications mode (including data-processing), a facility for servicing, assembly or manufacturing, or as a storage depot'.[11]

3.18 Space Technology: A Bane or a Boon?

As the spectacular pictures of our neighbouring planet Mars which the European space probe MarsExpress sent back once again show, space has lost none of its fascination in the years since 1969 when man first set foot on the moon. Since 1997, the first Friday in May is being celebrated as 'Space Day' to celebrate humankind's accomplishments in our exploration of space, as well as recognizing the benefits and opportunities that space exploration provides. However, what is decisive here is that space technology has become one of the key tools of modern industrial and information society in the intervening years.

Television and telephoning via satellite, for instance, are just a part of everyday life that is hardly associated with space any more. The applications market for satellite communication totals some €45

[11] *S. Gorove, 'Legal Aspects of Stations in Space', in Space Stations (note 92, supra), pp.143-152*

billion a year in Europe alone. The American GPS system revolutionised positioning on earth, water and in the air. Europe's civilian Galileo navigation system which is currently being set up will significantly improve this technology and open up new growth opportunities in Europe. Space-based earth observation, alongside navigation and communication, is on the threshold of broad use. It will increasingly play a decisive role in the discharge of government and societal tasks - in, for instance, the areas of environmental protection, traffic surveillance, disaster management and security matters. Thus, actual benefits to man and the development of new markets take centre stage in the work being done today to progressively develop and refine space technologies.

The world has witnessed tremendous developments in different branches of space technology and its applications. It is not just that applications of space have expanded, but significantly, several more countries too have begun to participate in space endeavours and derive benefits from space technology. Above all, space provided a new perspective to humanity to view the planet Earth as a total system. With its ability to integrate diverse aspects which affect the quality of life, space inspires a new vision to humanity, unfolding new vistas for cooperation and progress towards a common destiny.

Space exploration has generated findings that have radically expanded our knowledge of the solar system. This has been impressively demonstrated by the current Cassini/Huygens Mission to Saturn and the MarsExpress mission to Mars. Automated systems such as the Mars Rover are being built to continue our exploration of outer space. Besides being able to take the place of astronauts, such systems are also pacemakers for technologies that can be used on earth as well. Research under zero-gravity conditions on the International Space

Station and experiments in the Drop Tower in Bremen, parabolic flights and missions with small rockets are all being used to obtain insights into gravity's effects on animate and inanimate natural systems.

Notwithstanding such advances in technology and applications of the current century, humanity is still at the cross roads, looking at the challenges for future assuming formidable proportions. Advances in technology while improving the pace of development, have also been increasing gaps in society – between the rich and the poor, the haves and the have-nots, and the educated and the deprived. As the technology changes are becoming more rapid, these gaps are also widening further. Such rapid advancements in technology and its applications, if not properly integrated into the entire structure of society, pose the danger of isolating large sections of society, thus making human civilization fragile.

Another major challenge before humanity today is unsustainable exploitation of natural resources and consumption patterns, which can lead to irreversible damage to earth's environment and ecology, if it is not reversed. A paradigm shift of global values towards the preservation of the integrity of Earth and its environment, recognising its delicate balance and vulnerability to human action needs no emphasis. Global welfare goals, assuring a certain basic minimum quality of life to all sections of humanity should be the fundamental part of our vision for human development for the next century.

3.19 Access to Space

The development of the commercial space sector, or for that matter, the commercialization itself of the space sector is not possible without unrestricted access to space. The first challenge to unimpeded access to space concerns the placement of satellites into a so-called geosynchronous orbit. As noted above, the most dynamic market for commercial ventures in space has been the telecommunications industry. Many communications satellites are placed into an orbit roughly 23,000 miles above the equator. At this altitude, a satellite can "see" and therefore receive and transmit signals to a very large portion of the globe.

Equally important, the satellite also circles the Earth at the same rate as the Earth revolves on its axis – hence the term "geosynchronous". The satellite thus appears to be stationary to an observer on the ground. This phenomenon confers important technical advantages and cost savings because it does not require sophisticated tracking equipment to follow the satellite and home in on its signal. For these reasons, geosynchronous orbit is an attractive place to park communications satellites. However, the number of satellites that can be put into a given location 23,000 miles above the equator is limited by the need to prevent radio interference.

Space has always been regarded as an arena open to all nations and reserved for peaceful use. In fact, the United States has traditionally been a leading proponent of this view. At the outset of the space age, the United States insisted on unimpeded access to space and rejected the notion that nations could interfere with – forcibly or otherwise – satellite operations of any kind. Its original motive was to guarantee the right for its satellites to fly over countries at will so that it could conduct reconnaissance over the Soviet Union. Naturally, the Soviets objected, but they had already undercut their own argument by orbiting Sputnik over the United States and other countries without asking anybody's permission. Indeed, the laws of physics make it impossible to operate satellites in low Earth orbit without flying over the territories of many different nations.

To preclude an unregulated scramble for geosynchronous "slots", nations turned to the already existing International Telecommunications Union (ITU) – an agency loosely affiliated with the United Nations – to allocate the satellite positions and frequencies in geosynchronous orbit. At first, the ITU discharged this task on a first-come, first-served basis. However, as the United States and other space powers launched increasing numbers of communications satellites, the developing nations grew concerned that the geosynchronous belt would be filled up before they developed the technical and financial wherewithal to enter the market.

The developing nations attempted to break the space powers' perceived dominance of the geosynchronous belt on several different fronts. For example, in 1976, eight countries signed the so-called Bogotá Declaration, which asserted that the portions of the geosynchronous belt directly over the nations along the equator were part of their national territory and therefore subject to their jurisdiction. But this position directly contradicted the Outer Space Treaty's prohibition against national claims in space. Not surprisingly, it attracted little support from non-equatorial countries.

The developing nations had more success in the mid-1980s by forcing the ITU to revise its procedures for allocating satellite positions and frequencies in geosynchronous orbit by reserving at least some slots for every member nation to use itself or lease to others. Their concerns about access to the geosynchronous belt were not, however, completely resolved by the ITU's new procedures, because the right to an orbital slot did not guarantee that the holder could benefit economically from it. At the urging of nations belonging to the Group of 77 and the Group of Latin American and Caribbean States, the subject remains on the agenda of the United Nations' Vienna-based Committee on the Peaceful Uses of Outer Space (COPUOS) despite the efforts of some nations to drop an issue that for the moment seems to have gone as far as it can.

Still, as a result of crowding of the geosynchronous belt, access to that region of space is no longer entirely "free"; rather, it is subject to limits and restrictions imposed by a perceived need on the part of most nations, including the United States, to coordinate their activities and to accept the authoritative allocation of an increasingly scarce resource by an international body.

3.20 Extraterrestrial Life

Extraterrestrial life is life originating outside the Earth. It is the subject of astrobiology and its existence remains hypothetical, because there is no credible evidence of extraterrestrial life which has been generally accepted by the mainstream scientific community. Hypotheses regarding the origin(s) of extraterrestrial life, if it indeed exists, are as follows:

i) It may have emerged independently, from different places in the universe.

ii) An alternative hypothesis is pan-spermia, which holds that life emerges from one location, and then spreads between habitable planets.

These two hypotheses are not mutually exclusive. The study and theorization of extraterrestrial life is known as astrobiology, exobiology or xenobiology. Speculated forms of extraterrestrial life range from sapient or sentient beings, to life at the scale of bacteria.

Suggested locations which might have once developed, or presently continue to host life, include the planets Venus and Mars, moons of Jupiter and Saturn (e.g. Europa, Enceladus and Titan) and Gliese 581 c and d, recently discovered to be near Earth-mass extra-solar planets apparently located in their star's habitable zone, and with the potential to have liquid water.[12]

3.21 Scientific Search for Extraterrestrial Life

The scientific search for extraterrestrial life is being carried out in two different ways: directly and indirectly.

Direct search

Scientists are directly searching for evidence of unicellular life within the solar system, carrying out studies on the surface of Mars and examining meteors which have fallen to the Earth. A mission is also proposed to Europa, one of Jupiter's moons with a possible liquid water layer under its surface, which might contain life.

[12] *http://en.wikipedia.org/wiki/Extraterrestrial_life*

There is some limited evidence that microbial life might possibly exist (or might have existed) on Mars. An experiment on the Viking Mars Lander reported gas emissions from heated Martian soil that some argue are consistent with the presence of microbes. However, the lack of corroborating evidence from other experiments on the Viking indicates that a non-biological reaction is a more likely hypothesis. Independently, in 1996, structures resembling nano-bacteria were reportedly discovered in a meteorite, ALH84001, thought to be formed of rock ejected from Mars. This report is also controversial, and scientific debate continues.

In February 2005, NASA scientists reported that they had found strong evidence of present life on Mars. The two scientists, Carol Stoker and Larry Lemke of NASA's Ames Research Centre, based their claims on methane signatures found in Mars' atmosphere resembling the methane production of some forms of primitive life on Earth, as well as on their own study of primitive life near the Rio Tinto river in Spain. NASA officials soon denied the scientists' claims, and Stoker herself backed off from her initial assertions.

Though such findings are still very much in debate, support among scientists for the belief in the existence of life on Mars seems to be growing. In an informal survey conducted at the conference at which the European Space Agency presented its findings, 75% of the scientists in attendance were reported to believe that life once existed on Mars, and 25% reported a belief that life currently exists there.

The Gaia hypothesis stipulates that any planet with a robust population of life will have an atmosphere not in chemical equilibrium, which is relatively easy to determine from a distance by spectroscopy. However, significant advances in the ability to find and resolve light from smaller rocky worlds near to their star are necessary before this can be used to analyze extra-solar planets.

Indirect search

It is theorised that any technological society in space will be transmitting information. Projects such as SETI (Search for Extra-Terrestrial Intelligence) are conducting an astronomical search for radio activity which would confirm the presence of intelligent life. A related suggestion is that aliens might broadcast pulsed and continuous laser signals in the optical, as well as infrared, spectrum; laser signals have the advantage of not "smearing" in the interstellar medium, and may prove more conducive to communication between the stars. While other communication techniques, including laser transmission and interstellar spaceflight, have been discussed seriously and may well be feasible, the measure of effectiveness is the amount of information communicated per unit cost, resulting with radio as the method of choice.

Extra-solar planets

Astronomers also search for extra-solar planets that they believe would be conducive to life, such as Gliese 581 c and OGLE-2005-BLG-390Lb, which have been found to have Earth-like qualities. Current radio detection methods have been inadequate for such a search, as the resolution afforded by recent technology is inadequate for a detailed study of extra-solar planetary objects. Future telescopes should be able to image planets around nearby stars, which may reveal the presence of life – either directly or through spectrography which would reveal key information, such as the presence of free oxygen in a planet's atmosphere.

Drake equation

In 1961, University of California, Santa Cruz, astronomer and astrophysicist Dr. Frank Drake devised the Drake equation. This controversial equation multiplied estimates of the following terms together:

- The rate of formation of suitable stars.
- The fraction of those stars which contain planets.
- The number of Earth-like worlds per planetary system.
- The fraction of planets where intelligent life develops.
- The fraction of possible communicative planets.
- The "lifetime" of possible communicative civilizations.

Drake used the equation to estimate that there are about 10,000 planets containing intelligent life, with the possible capability of communicating with Earth in the Milky Way galaxy.

Based on observations from the Hubble Space Telescope, there are at least 125 billion galaxies in the universe. It is estimated that at least ten percent of all sun-like stars have a system of planets, thus if a thousandth of a percent of all stars are sun-like, and there are roughly 500 billion stars, on average (estimates may vary), in each galaxy, there are 6.25*1018 stars with planets orbiting them in the universe.

If even a billionth of these stars have planets supporting life, there are some 6.25 billion life-supporting solar systems in the universe[13].

3.22 Extraterrestrial Life in the Solar System

Many bodies in the Solar System have been suggested as being capable of containing conventional organic life. The most commonly suggested ones are listed below; five of these are moons, and are thought to have large bodies of underground liquid (streams), where life may have evolved in a similar fashion to deep sea vents.

Mars –

Life on Mars has been long speculated. Liquid water is widely thought to have existed on Mars in the past, and there may still be liquid water beneath the surface. Methane was found in the atmosphere of Mars. By July 2008, laboratory tests aboard NASA's Phoenix Mars Lander had identified water in a soil sample. The Lander's robotic arm delivered the sample to an instrument which identifies vapours produced by the heating of samples. Recent photographs from the Mars Global Surveyor show evidence of recent (i.e. within 10 years) flows of a liquid on the Red Planet's frigid surface.

Mercury –

The MESSENGER expedition to Mercury has discovered that a large amount of water exists in its exosphere.

[13] *http://en.wikipedia.org/wiki/Extraterrestrial _life*

Europa –

Europa may contain liquid water beneath its thick ice layer. It is possible that vents on the bottom of the ocean warm the ice, so liquid could exist beneath the ice layer, perhaps capable of supporting microbes and simple plants.

Jupiter –

Carl Sagan and others in the 1960s and 70s computed conditions for hypothetical amino acid-based macroscopic life in Jupiter's atmosphere, based on observed conditions of this atmosphere. These investigations inspired some science fiction stories.

Ganymede –

There is the possibility of an underground ocean.

Callisto –

It is believed that there could be an underground ocean.

Saturn –

There is believed to be the possibility of floating creatures.

Enceladus –

Geothermal activity and water vapour has been observed. There is possibility of under-ice oceans heated by tidal effects.

Titan (Saturn's largest moon) –

The only known moon with a significant atmosphere was recently visited by the Huygens Probe. The latest discoveries indicate that there is no global or widespread ocean, but that small and/or seasonal liquid hydrocarbon lakes are present on the surface (the first liquid lakes discovered outside the Earth).

Venus –

Recently, scientists have speculated on the existence of microbes in the stable cloud layers 50 km above the surface, evidenced by hospitable climates and chemical disequilibrium.

Numerous other bodies have been suggested as potential hosts for microbial life. Fred Hoyle has proposed that life might exist on comets, as some Earth microbes managed to survive on a lunar probe for many years. However, it is considered highly unlikely that complex multi-cellular organisms of the conventional chemistry of terrestrial life (i.e. animals and plants) could exist under these living conditions.

3.23 The Indian perspective on space

India has had a glorious past. Not only ideas from India's creative minds but also Indian products had dominated world trade right from the ancient times, and even during the seventeenth century, when India was under foreign rule. There was, of course, a marked decline over the earlier centuries since the seventeenth century. Due to various reasons, India missed the benefits of the Industrial revolution. The key to India's future was the dream for its first revolution which started somewhere during the middle of the nineteenth century, i.e. the first war of Indian independence. Its success, after the first major attempt in 1857, came after about 90 years, when India finally became independent of foreign rule in 1947. Jawaharlal Nehru's famous speech mentioning India's tryst with destiny was a proud moment and a moment of hope. India's march towards the well being of its entire people and the strength of the nation began in earnest since then. More than a half century of endeavours have yielded some extraordinary results and some average results.

India is one of those developing countries fortunate to have realised the potential of space technology from the very early times of evolution of global space endeavours. The vision of India for space is to make it a strong tool for national development. Starting with scientific pursuits in the fields of astronomy and atmospheric sciences, and conducting unique sociological experiments like the Satellite Instructional Television Experiment (SITE), India has come a long way in developing a multi-faceted and multidimensional space program, which is self reliant and applications driven. India now builds its own state-of-the-art satellite systems INSAT (Indian National Satellite System) and IRS (Indian Remote Sensing) and has launch capabilities. Operational space systems have been established for services in meteorology, telecommunications, television broadcasting and generating information for natural resources management. A wide range of applications which are of societal value, have been developed. Remote Sensing data are integrated with other relevant data to derive information for assessing agricultural crop acreage and yields, monitoring of forests, reclaiming degraded lands, locating ground water, management of surface water, drought monitoring and assessment, flood mapping and damage assessment, land use monitoring, coastal area management, urban planning and environmental impact assessments. Through a program called Integrated Mission for Sustainable Development, several of the above applications are integrated to derive comprehensive development plans at a watershed level, with the participation of the local community. In the field of telecommunications, television broadcasting and meteorology, which is being served by geostationary satellites of INSAT, there are diverse applications. It is worth mentioning that several development oriented programmes are implemented with focus on rural communications, search and rescue, cyclone disaster warning and educational services. One of the recent examples is the adoption of the tribal district of Jhabua in Central India where a major developmental communications project is under evaluation, for assisting the local population in health, education, watershed development and empowerment of women. This societal focus of Indian space program will continue and grow stronger in the future.

Recognising that Space programs cannot be developed in isolation from other national institutions, strong linkages were developed with industry and academic institutions which participate in the national space program. In areas such as telecommunications, television and value added services for Remote Sensing, where commercialisation could lead to sustainable growth, economic returns and efficient services to users, facilitation for commercial services through the private sector is undertaken. Antrix Corporation established by the Department of Space also promotes commercial use of space and markets the Indian space capabilities in global markets.

International cooperation has been the hallmark of Indian space program, which endeavoured to enhance cooperation with several space agencies and institutions around the globe. The data from Indian remote sensing satellites are made accessible through a number of international receiving stations around the globe. Similarly through bilateral arrangements, the meteorological data gathered through INSAT are disseminated to other agencies. India also participates in all relevant international fora including the United Nations Committee on Peaceful Uses of Outer Space to promote coordination, cooperation and orderly conduct of space activities. The Indian Space Research Organisation, as a member of the Committee on Earth Observation Satellites (CEOS), is contributing to evolve the Integrated Global Observing Strategy (IGOS), harmonising the space and ground based observation systems for meeting the user requirements. Flight opportunities in Indian satellites for the instruments developed by other agencies are also provided.

The Indian space program began in 1963 under the Department of Atomic Energy and it was formalized in 1972 with the establishment of the Space Commission and Department of Space. India has made steady progress in the development of launch vehicles and satellites. The first Indian satellite was Aryabhatta, which was launched by a Soviet rocket on 19th April, 1975. The SLV-3 was successfully launched on 18th July, 1980 by which a 35kg satellite called 'Rohini' was placed in orbit, and with this India became only the seventh nation in the world to achieve space orbit capability.

The primary objective of the Indian Space Program is to achieve self-reliance in space technology and develop application driven programs to meet the national needs. Space technology in India is primarily geared towards improving telecommunications, meteorological forecasting, providing advanced natural disaster warning, distance education and remote sensing for agriculture, soil, mineral and water resources management.

India's first operational Earth Observation satellite IRS-1A, an 850 kg satellite was launched into a 900 km polar orbit on 17th March, 1988 by a Soviet rocket. Two satellite launch vehicles, the Polar Satellite Launch Vehicle (PSLV) primarily for launching remote sensing satellites into polar orbits and the Geosynchronous Satellite Launch Vehicle (GSLV) for launching communication and meteorological satellites into 36,000 km high Geosynchronous Transfer Orbit (GTO), have been put into operation. In 1997, India used its own rocket PSLV to place IRS-1D into polar orbit. With the development of PSLV, India has the capability to place up to 1,200 kg satellites into polar orbit. The Indian Remote Sensing Satellite (IRS) system has the largest constellation of commercial earth observation providing data in a variety of spatial and spectral resolutions.

Indian National Satellite (INSAT) is the first operational system of India. INSAT satellites are multipurpose satellites, providing telecommunication, television, radio broadcasting and meteorological sources. Four satellites in the INSAT-1 series were designed and built by a US company to Indian specifications. Five satellites in the INSAT-2 series with enhanced capability, were designed and fabricated by India and were launched by a European launch vehicle "Ariane". The work on INSAT-3 series of satellites is on, while the work has begun on INSAT-4 series of satellites.

Apart from these, INSAT is being used for communication purposes, radio and TV transmission, mobile communication purposes, determination of accidents and providing relief measurements and for navigation purposes. Also, IRS - satellites are used in the detection and management of natural resources, surveys such as water survey, forest survey, land survey, ocean survey, etc.

India's first operational telecommunications satellite was INSAT-1A, which was launched by a NASA Delta rocket on 10th April, 1982. Since then, India relied on European Space Agency's Ariane rockets to launch its INSAT series satellites into geostationary orbit.

On 18th April, 2001, India blasted itself into the elite space club of heavy satellite launchers with the successful test-flight of GSLV-D1. The successful launch of India's first educational communication satellite "EDUSAT" by GSLV-F01 on 20th September, 2004 heralds the operational reliability of the heavy lifter to geostationary orbits.

Rakesh Sharma was the first Indian to go to space by a Russian space shuttle; Kalpana Chawla was the first Indian woman to go to space via an American Space Shuttle, Columbia. But no manned missions have been performed by India.

Turning a new page in its modest space odyssey, the Indian Space Research Organization successfully launched India's first unmanned mission to the moon, Chandrayaan-1 on 22nd October, 2008 at 6.22 AM IST atop the PSLV-C11 launcher. Chandrayaan-1 carried 11 scientific instruments to prepare 3-dimensional chemical and mineralogical mapping of the lunar surface. The payload consists of five Indian instruments, two from NASA, three from ESA and one from Bulgaria. A Moon Impact Probe (MIP) consisting of Altimeter, Video Imager and a Mass spectrometer will be released from the final orbit of 100 km above the moon's surface. Chandrayaan-1 marks the beginning of deep space exploration by ISRO and is slated to be followed by Chandrayaan-2, a Moon Lander/Rover by 2012, mission to Mars by 2014 and a planned Manned Mission by 2015.

Antrix, the commercial arm of ISRO is responsible for marketing to international customers and the PSLV launcher has launched several medium to small sized foreign satellites/payloads, including one astronomy satellite for Italy and one remote-sensing satellite for Israel successfully in 2007. In a major commercial deal, ISRO has built and delivered a 3,462 kg Telecom satellite with 32 transponders to Europe's EADS Astrium in 2008.

Telemedicine network

The telemedicine network of ISRO was started in 2001 for extending expert medical consultation to remote and rural area population and has expanded substantially during the years. The network covers more than 100 hospitals, the majority of them being remote rural hospitals and some super speciality hospitals in major cities. More than 25,000 patients have availed of the benefit of telemedicine so far.

Disaster Mitigation – Deploying Space Resources

The Disaster Management Support System (DMS) of the Department of Space (DOS) addresses vital requirements of disaster management through the use of remote sensing and communication satellite capabilities, creation of digital database, hazard zonation, damage assessment, monitoring of major natural disasters using satellite and aerial data, acquisition of close contour data using Air-borne Laser Terrain Mapper, strengthening the communication back-bone for timely dissemination of information and emergency support, development of Air-borne Synthetic Aperture Radar (ASAR) and R & D support for improved warnings, etc.

While a space based system cannot detect and predict natural calamities like earthquake and its after-effects like tsunami, in the aftermath of the tsunami that struck India in December 2004, DOS put into operation all its resources for disaster mitigation. It provided VSATs operating through INSAT-2E, Mobile Satellite Service (MSS) phones and INMARSAT telephones to augment the telecommunications links in Andaman and Nicobar Islands. VSAT based video conferencing facilities were set-up to connect remote talukas. Telemedicine facilities were in operation at Port Blair and Car Nicobar to enable local doctors to consult speciality hospitals in major cities on the mainland. Data from IRS satellites and aerial surveys helped in assessing the damage and to support mitigation efforts. DOS also supported disaster management efforts by providing emergency communications through INSAT as well as survey and monitoring of disaster-prone and affected areas using the IRS system during floods.

3.24 Chandrayaan : Mission to Moon

Chandrayaan literally means 'Moon vehicle'. Chandrayaan-1 is India's first mission to the Moon, launched by India's national space agency, the Indian Space Research Organisation (ISRO). The unmanned lunar exploration mission includes a lunar Orbiter and an Impactor. This spacecraft was launched with the help of a modified version of a Polar Satellite Launch Vehicle (PSLV), PSLV C11 on 22nd October, 2008 from Satish Dhawan Space Centre, Sriharikota, Nellore District, Andhra Pradesh about 80 km north of Chennai. It was launched using ISRO's 44.4 metre tall four-stage PSLV launch rocket, and it took 21 days to reach final lunar orbit. ISRO's telemetry, tracking and command network (ISTRAC) at Peenya in Bangalore, would track and control Chandrayaan-1 over the next two years of its life span.[14]

According to the plan of action, the mission has put an unmanned spacecraft into the orbit around the moon for about two years, during which time it will perform remote sensing of the earth's satellite with 11 payloads (scientific instruments), including cameras and spectrometers.

The mission aims to achieve scientific knowledge through high-resolution remote sensing of the moon in the visible, near infrared, microwave and X-ray regions of the electromagnetic spectrum. With this, the preparation of a three-dimensional atlas of the lunar surface and chemical and mineralogical mapping of the entire moon surface can be achieved.

The mission is a major boost to India's space program, because India competes with Asian nations China and Japan in exploring the Moon. The vehicle was successfully inserted into the lunar orbit on 8th November, 2008.[15]

On 14th November, 2008, the Moon Impact Probe (MIP) separated from the Moon-orbiting Chandrayaan and impacted the lunar South Pole in a controlled manner, making India the fourth country to place its flag on the Moon. The MIP impacted near the crater Shackleton, at the lunar South Pole, releasing subsurface debris that could be analysed for presence of water or ice.

[14] *http://en.wikipedia.org/wiki/Chandrayaan-1*
[15] *http://en.wikipedia.org/wiki/Chandrayaan-1*

The remote sensing lunar satellite had a weight of 1,380 kg (3,042 lb) at launch and 675 kg (1,488 lb) in lunar orbit and carries high resolution remote sensing equipment for visible, near infrared, and soft and hard X-ray frequencies.[16] Over a two-year period, it is intended to survey the lunar surface to produce a complete map of its chemical characteristics and 3-dimensional topography. The polar regions are of special interest, as they might contain ice. The lunar mission carries five ISRO payloads (equipment) and six payloads from other international space agencies including NASA, European Space Agency(ESA), and the Bulgarian Aerospace Agency, which were carried free of cost.

Objectives of the Moon Mission

There are certain objectives of this mission, which can be enumerated as follows -

→ To design, develop, launch and orbit a spacecraft around the Moon using an Indian-made launch vehicle.

→ Conduct scientific experiments using instruments on-board the spacecraft which will yield the following results –

- Preparation of a three-dimensional atlas (with high spatial and altitude resolution of 5-10 m) of both the near and the far side of the Moon.

- Chemical and mineralogical mapping of the entire lunar surface at high spatial resolution, mapping particularly

[16] *Ibid*

the chemical elements Magnesium, Aluminium, Silicon, Calcium, Iron, Titanium, Radon, Uranium & Thorium.

- The impact of a sub-satellite (Moon Impact Probe) on the surface on the Moon as a fore-runner to future soft-landing missions.

Specific areas of study

Certain areas have been identified as specific areas to be studied by the mission over a period of two years.

- High-resolution mineralogical and chemical imaging of the permanently shadowed north and south polar regions.

- Search for surface or sub-surface water-ice on the Moon, especially at the lunar poles.

- Identification of chemicals in lunar highland rocks.

- Chemical stratigraphy of the lunar crust by remote sensing of the central uplands of large lunar craters, and of the South Pole Aitken Region (SPAR), where interior material may be expected.

- To map the height variation of the lunar surface features.

- Observation of X-ray spectrum greater than 10 keV and stereographic coverage of most of the Moon's surface with 5 m resolution

- To provide new insights in understanding the Moon's origin and evolution.

Beyond the limit of the sky

The sky is not the limit anymore for us. ISRO is planning a second version of Chandrayaan named Chandrayaan II. According to ISRO Chairman G. Madhavan Nair, "The Indian Space Research Organisation hopes to land a motorised rover on the Moon in 2012, as a part of its second Chandrayaan mission. The rover will be designed to move on wheels on the lunar surface, pick up samples of soil or rocks, do on-site chemical analysis and send the data to the mother-spacecraft Chandrayaan II, which will be orbiting above. Chandrayaan II will transmit the data to Earth.

End of the mission

The Indian lunar orbiter Chandrayaan-I has made over 3,000 orbits and its high-resolution cameras relayed over 70,000 digital images of the lunar surface, providing breathtaking views of mountains and craters, including those in the permanently shadowed area of the moon's polar region. It has also confirmed the presence of water on the moon. Chandrayaan-1 and NASA's Lunar Reconnaissance Orbiter had teamed up on 20th August to perform a bi-static radar experiment.

On 29th August 2009 Chandrayaan-1 lost contact with ISRO's ground station[17]. ISRO stopped receiving data and was unable to send commands. The 11 scientific payloads onboard the orbiter had been operating normally, and the spacecraft was sending data during a

[17] *http://www.ptinews.com/news*

planned sequence to its ground station when contact was lost. Thus India's first unmanned mission to the moon came to an abrupt and unexpected end just a little before it could complete half of its life.

3.25 Human Endeavours to Reach the Moon

- September 1959: Luna 2 of the USSR, the first ever successful expedition to the moon, landed safely on the lunar surface.

- December 1968: The first man, Neil Armstrong – commander of the US mission Apollo 11 – set foot on the surface of the moon.

- November 1970: Lunokhod 1, the first robotic rover, which was a part of the Luna 17 mission of the USSR, made a successful landing on the moon.

- January 1990: Japan launched 'Hiten', thus becoming the third country after the USSR and the US to send a mission to the moon.

- September 2003: SMART -1, a low cost lunar orbiter, launched by the European Space Agency

- 2007 – Selene, Japan's lunar orbiter, launched for mapping the topography of the moon.

- 2007: China made its foray into Lunar Exploration with the launch of its unmanned moon mission named Chang'e 1.

3.26 India and Space Laws: A Millennium Perspective

The launch of Sputnik 1 by the former Soviet Union in 1957, followed by a similar feat by the U. S. within a few months, heralded the birth of the space age. The development and application of space technology has since made a tremendous global impact in diversified fields including social, economic, cultural and scientific. The early efforts of the Indian space programme in the Sixties were confined to getting familiar with space technologies, and developing technical and organisational infrastructure in order to develop satellites and satellite launch vehicles.

During the Nineteen Seventies, they were primarily geared towards carrying out research and development in a variety of scientific and engineering disciplines for launch vehicles and satellites. During the Eighties, the space programme moved closer to realising the goal of self-reliant use of space technology for national development. With the launching of Bhaskara II, SLV-3 and APPLE in the early Eighties, the programme entered the operational stage to provide space services in communications, meteorology and remote sensing and development of launch vehicles. The INSAT-1 series of communication satellites and the IRS series of remote sensing satellites were operationalised for well- defined applications.

Significantly, all operational satellites of the Eighties were indigenously designed. The Indian space programme was conceived with three crucial components: applications, satellites which would make the applications possible, and launch vehicles to put these satellites into orbit. India entered the Nineties with the launch of more ASLV and PSLV launchers. With the launch of IRS-IB and INSAT 2A and 2B, the

Indian space programme became fully operational through its own communication and remote sensing satellites.

Now India is one of the six countries with homemade satellites in orbit. The Indian space programme has an impressive array of achievements in putting to use space technology for vital applications - for telecommunications, TV broadcasting, weather monitoring, forecasting agricultural crop and forest wealth assessment, water resources management, flood mapping, drought forecasting, identification of marine resources, protection of the environment and rural literacy campaign.

The new economic policies of liberalisation that were promulgated since the early Nineties have opened up even the space sector for private investments. The realisation of a number of operational satellite systems in the areas of communications, remote sensing as well as space science, operational launch capability, large scale utilisation of these systems for a variety of applications, initiation of major application projects (such as the Integrated Mission for Sustainable Development (IMSD) covering more than 170 districts and nearly 60% of the total geographical area), led to the next stage of commercialisation and partnership building with the private sector.

Besides national accomplishments, India also achieved recognition in the international arena as one of the major space faring nations, which in turn opened up global opportunities and demand for Indian services. The Antrix Corporation, the commercial wing of ISRO deals with the transfer of technology developed under the Indian space programme to Indian industry and provides consultancy services. It also co-ordinates the space hardware and software products among ISRO and the Indian industry involved in the space programme. A significant accomplishment in this regard is the global marketing of Indian Remote Sensing (IRS) data and consequent establishment of associated infrastructure in association with the Indian industry in the private sector.

Though space activities are proliferating, there is no space legislation in India. However, the time has come now for the preparation of an appropriate legal framework, keeping in view the recent national and global developments which include the active involvement of the private sector and the commercialisation of space activities, and the agreements concluded nationally and globally with various agencies, governments and international intergovernmental organisations. On the domestic front the cable and satellite TV revolution, court judgments and other developments remind us of the need for a fresh legal framework.

Space and space-related matters in India are regulated by legal rules belonging to different areas of the Indian domestic law, since there is no special space legislation. The legal position of the space industry is largely determined by the Constitution of India. The constitutional provisions relating to general international law are also relevant to aerospace law. They include the following articles –

Article 51 of the Constitution imposes on the state the obligation to strive for the promotion of international peace and security, including maintaining just and honourable relations between nations, respect for international law and treaty obligations, and settlement of international disputes by arbitration. Under Article 73 the executive power of the Union extends (a) to the matters with respect to which Parliament has power to make laws, and (b) to the exercise of such rights, authority and jurisdiction as are exercisable by the government of India by virtue of any treaty or agreement.

Article 245 empowers the Parliament and state legislatures to enact laws. The Constitution enumerates three lists of subjects - the Union list, the State list and the Concurrent list - in respect of which the legislative power may be exercised, provided that the legislative power of Parliament overrides that of the state legislature in respect of the concurrent list.

Space as a subject is not mentioned in the Union List. The reason for this is that our Constitution was adopted in 1950, but space activities in India started in the early Sixties. A number of items on the Union list are related to aerospace activities in India.

They include items relating to defence and armed forces of India, foreign affairs, UNO, participation in international conferences, associations and other bodies and implementing decisions made thereat, entering into treaties and agreements with foreign countries and implementation of treaties, agreements and conventions with foreign countries, foreign jurisdiction, piracies and crimes committed on the high seas or in the air, light-houses, including lightships, beacons and other provisions for the safety of shipping and aircraft, airways, aircraft and air navigation, provision of aerodromes, regulation and organisation of air traffic and aerodromes, provision for aeronautical education and training, regulation of such education and training provided by the states and other agencies, carriage of passengers and goods by railways, sea or air, posts and telegraphs, telephones, wireless, broadcasting and other similar forms of communication, trade and commerce with foreign countries, insurance, patents, inventions and designs, copy rights, trade mark and merchandise marks, etc. By virtue of item 97 read with Article 248, Parliament retains residuary legislative power in respect of "any matter not enumerated" in any of the three lists.

Article 253 empowers Parliament to make any law for the whole or any part of the territory of India for implementing treaties, international agreements and conventions. It enables the Government of India to implement all international obligations and commitments. Following the commonwealth practice treaties are not required to be ratified by Parliament in India. They are, however, not self-executory. Parliamentary legislation is necessary for implementing the provisions of a treaty within the country. The Parliament has passed many Acts to implement international treaties and conventions but not in outer space activities.

India is a party to all important space treaties that form the main body of international space law such as the Outer Space Treaty of 1967, the Rescue Agreement of 1968, the Liability Convention of 1972, the Registration Convention of 1975 and the Moon Agreement of 1979. But India is notorious for its lack of speed in ratifying or acceding to treaties and takes its own time to incorporate its obligations under various conventions into municipal law. This has resulted in the absence of any legislation relating to space activities in India.

The International legal principles in these five treaties provide for non-appropriation of outer space by any one country, arms control, the freedom of exploration, liability for damage caused by space objects, the safety and rescue of space craft and astronauts, the prevention of harmful interference with space activities and the environment, the notification and registration of space activities, scientific investigation and the exploration of natural resources in outer space and settlement of disputes. Each of the treaties lays great stress on the notion that the domain of outer space, the activities carried out therein and whatever benefits might accrue there from should be devoted to enhancing the well- being of all countries and humankind, and each includes elements elaborating the common idea of promoting international co-operation in outer space activities. India has also played a significant role in the adoption of five sets of legal principles by the U.N. General Assembly which provide for the application of international law and promotion of international cooperation and understanding in space activities, the dissemination and exchange of information through trans-national direct television broadcasting via satellites and remote satellite observations of Earth and general standards regulating the safe use of nuclear power sources necessary for the exploration and use of outer space.

While the country has achieved international acclaim in the area of space technology development and utilisation, it is yet to see an integration of efforts at the national level from the standpoint of the private sector. Indian space activities have to be linked to other applications and activities. Space activities cannot remain in isolation. For example, in the area of telecommunications, space activities have to become an integral part of telecommunications service. If we are providing broadcasting service, then space has to become part of it. The same is true of education services. In order to ensure that a particular application is sustainable and continuous, the roles of the government and the private industry have to be determined. This entails, among other things, whether the government should be a policymaker or a promoter, and whether it should also play a role in R&D in order to show that specific applications are economically viable or sustainable. Social development and capacity building are other areas where the government should play a leading role and above all the government must ensure that there is a level playing field.

Multiple ministries to deal with and approvals to be obtained before starting a space business and that too when the legal framework is yet to be fully established, are acting as major deterrents in recent years. A case in point is the cable TV revolution and broadcast sector. To give effect to Entry 31 i.e. posts and telegraphs, telephones, wireless broadcasting and other like forms of communication, the Government of India promulgated the cable TV Networks (Regulation) Act, 1995, which brought the cable operators into a legal framework for the first time.

Almost at the same time, in February 1995, the Supreme Court, in a landmark judgment in The secretary, Ministry of I&B v. Cricket Association of Bengal and Others, A.I.R.1995 S.C. 1 ruled that access to air is a part of the fundamental rights of citizens under Article 19(1) of the Constitution and the right to broadcast is also enshrined under Article 19(2) of the Constitution, though reasonable restrictions can be placed in the allocation of frequencies, etc. by the Government. Delivering the judgment, Mr. Justice B.P. Jeevan Reddy said: "It is no longer possible for any government to control or manipulate the news, views and information available to its people. No nation can remain a fortress or an island in itself any longer". The judgment also directed the government to set up an independent authority to regulate its use of airwaves, which is public property, for its optimum usage.

Subsequently, the Indian broadcasting industry demanded the Government's permission for DTH (Direct-to-Home) television operations in the country. Though the government came out with a notification regarding licensing for the import of Ku band equipment in

December 1996, a subsequent notification in July 1997 banned the import or operation of associated equipment till further decision by the government. The reason for such a decision was given to be the need to have a comprehensive broadcasting law and an independent broadcasting authority to oversee the implementation of such a law. The process of enacting a comprehensive broadcasting law and the broadcasting authorities of India are yet to be completed. In the area of remote sensing, the Department of Space has taken the initiative to establish operational guidelines for private entrepreneurs. A national level committee periodically reviews various issues in this regard and provides the overall guidelines that act as the operational framework for remote sensing related to private sector activity in the country. However, remote sensing activity also needs an appropriate legal framework. The Indian space programme has been encouraging the transfer of technologies to the Indian industry to support various space objects, to promote space applications and market development, and for disseminating spin-off space technologies to diverse economic sectors. Several technologies have been transferred to the industry in the areas of electronics, communications, computers, optical and remote sensing data utilisation equipment. In this regard the protection of intellectual property rights is important to safeguard the interests of technological development agencies on the one hand, and those of the technology licences on the other.

ISRO has provided the necessary support within the organisation to identify and obtain patents, copyrights and trade mark registration. It may, however, be of interest to examine the adequacy of the Indian intellectual property laws to protect the intellectual property rights of the organizations, scientists and other innovators. The space insurance problems are generally tackled in accordance with national insurance regulations.

As of today, there is no comprehensive or specific law dealing with space activities in India. However, with the rapid development of activities in space, there is a growing need for enacting a new domestic space law, and integrating divergent regulations dealing with space and space-related matters.

Such a law should define the role of the Department of Space and its various organs and different governmental and non-governmental agencies in space matters, the procedure for adoption and implementation of space programmes, and regulations on the safety of launch and space flight, the question of transit of foreign space objects through national airspace, questions of liability and insurance, protection of intellectual property rights, spin-off benefits, and above all, implementation of international obligations under the various treaties. Further, it should also formally incorporate the objectives of India's space policy, reiterating the country's commitment to the peaceful uses of outer space and to international cooperation in carrying on all legitimate activities in space.

Practical work on the elaboration and drafting of the domestic space law evidently calls for a good knowledge of the interaction between international law and municipal law of India. The exercise of drafting the space legislation should involve scientists, legal experts, international space lawyers, the relevant industrial sectors and technocrats.