
**India in the Space Age.** Mohan Sundara Rajan. Soochna Bhavan, CGO Complex, Lodhi Road, New Delhi 110 003. Publications Division, Ministry of Information and Broadcasting, Government of India. 2008. 262 pp. Price: Rs 235.

A country is no longer judged by its resources, but by the technologies it possesses. Vikram Sarabhai envisioned India's space programme. Starting from scratch, India has made a mark in the space technology within a short duration of 40 years – from the firing of a few sounding rockets to orbiting the moon at a low altitude. Space technology is difficult to acquire and practise and the risks involved in its development are very high. Essentially, space technology has five major areas: (i) Launch vehicle and launch pads, (ii) satellites, (iii) communication transponders and remote sensing instruments, (iv) tracking, command and control of launch vehicles and satellites, and (v) applications. This book is a walk through of the accomplishments of the Indian space programme in all these major areas.

Launch vehicles are used for putting satellites into space in their designated orbits. They comprise of (i) rocket motor, (ii) fuel tanks and pumps, (iii) igniters, (iv) navigation, guidance and control systems. The fuel could be either solid or liquid and provides thrust, when burnt with an oxidizer and exits through a nozzle. Multi-staging of rockets allows us to avoid carrying unnecessary dead weight of the burnt modules all the way into the final orbit. The percentage of fuel weight to the vehicle weight is more in case of launch vehicles which are required to reach very high velocity of the order of 40,000 km/h to escape the earth's gravity. The guidance and controls have vastly improved from the open loop system to the closed loop system. The launches include payloads from other countries also. India has the distinction of launching a record 13 satellites from a single vehicle – PSLV. One of the recent technological breakthroughs was the Space Capsule Recovery Experiment launched by PSLV and recovered from orbit through a series of complex manoeuvres. This has given valuable inputs on re-entry and recovery technologies. ISRO has always strived to excel in technological improvements driven by necessity. The future visions aim at mastering re-entry technology to interplanetary mission and human space flight.

Satellites are the platforms which carry payloads, which essentially comprise of communication transponders or remote sensing sensors. The pride of ISRO over the years has been the indigenous design and development of all the sensors and instruments and their integration at system and subsystem level. The life of a satellite is determined by the amount of onboard fuel that it carries, which is used for periodic manoeuvres by small thrusters to maintain its orbit. Satellites are generally of two types, namely, communication and remote sensing. The INSAT series of satellites has the distinction of packing multi function roles like telecommunications, broadcasting, meteorology, search and rescue, etc. IRS series of satellites on the other hand address the country's specific resource inventory and monitoring requirements and have evolved as global missions which are now providing data to several countries.

Space assets have to be properly harnessed by having a network of ground infrastructure within and outside the country with national and international linkages. The tracking, command and control network established by ISRO is used right from the launch phase onwards. It monitors the health of the satellite sub systems. Ground segment facilities comprising of earth stations for up-linking and down-linking for communications and broadcasting, and data down-linking for remote sensing, have also been established all over the country. The global network of infrastructure for satellite health monitoring, orbit corrections and payload programming have all been put in place. Data reception systems for IRS satellites have been provided to about 20 earth stations outside the country.

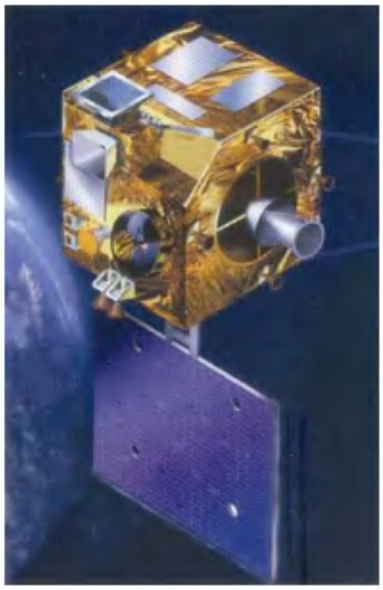
Translation of the application potential into actual delivery has been the highlight of the Indian space programme both in communications and in remote sensing. In the area of satellite communications, the rollout of pan India TV broadcasting and telephone capacity/STD network is well known. This was made possible by the close linkage with the user community through a national committee. No less important are the achievements in weather forecasting and disaster warning through INSAT images. In the area of remote sensing, the breadth of applications is truly impressive and covers land use and land cover, geological studies, wastelands, forestry, oceanography, ground and surface water, disaster management support. These applications together with other ancillary data resulted in the district-wise integrated mission for sustainable development. Other developments include extension of remote sensing techniques to cover large scale topographic mapping and modelling, digital cartography and utility GIS which have large commercial value.

The book under review is a comprehensive effort chronicling the growth of Indian space programme. The author is eminently qualified to write on the subject by virtue of his vast experience and interviews/interactions with leading personalities in India and abroad.

Starting with the accomplishments of ancient Indians such as Aryabhata and Bhaskara in the field of mathematics and astronomy, the author has recorded the vision of Vikram Sarabhai who was the chief architect of the Indian space programme, which was developed further by Satish Dhawan and others. The establishments of observatories at the turn of the 20th century, Physical Research Laboratory in 1948, Indian National Committee for Space Research in 1961 under the Department of Atomic Energy, the Space Science and Technology Centre in Thumba in 1965, are briefly described by the author as a prelude. He then describes the basic laws of physics as applicable in atmosphere and space, effect of gravity and a plethora of sounding rockets which were launched from Thumba in the initial years. The author then elaborates on the propulsion systems, both solid and liquid, the launching pads, mission control centres and the myriad facilities for post-launch control. Coming to the basic sciences, the author has dwelt upon satellite orbits, both geo synchronous and polar sun synchronous. The book provides excellent pictorial depictions to make the reading interesting.

The ability of space scientists to learn from the failures/anomalies of launch vehicles has been described at length in the context of the development of reliable launch vehicles. GSLV and its variants are emerging as vehicles to propel India to complete self-reliance in launching the heavier INSAT satellites into GTO. Midstream, the author adds other developments/facility creation such as radars, high altitude test, computer simulations, etc. The challenge of developing the cryogenic motor to enhance the performance of GSLV has also been described in addition to the initiatives to develop the Scramjet engine. This is followed by a good description of the INSAT (communication satellite) utilization which emerged in 1977, as a joint venture of 4 ministries of the government of India. Applications include weather watch, education, television, broadcasting, search and rescue, direct to home television, tele medicine, village resource centers, etc. which have all been well brought out by the author in this book.

Experiences gained from the SITE experiment and APPLE communication satellite project have paved the way for the INSAT programme. The Apogee Boost motor, earth sensor, momentum wheel, communication transponders, deployable solar panels and tracking systems technologies were all indigenously developed. ISRO has also developed several critical technologies, such as gyroscopes, Earth/sun/star sensors, solar array drives, pressure transducers, control engines, etc.



Kalpana-1: a weather satellite

in this process on INSAT systems. The author has brought in the importance of space debris and how ISRO has already taken initiatives in this regard.

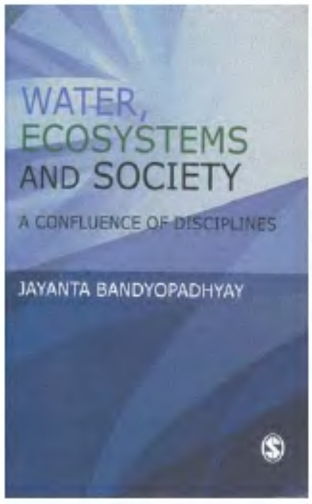
The book covers the history of satellites starting from experimental Aryabhata Satellite in 1975 to Bhaskara and Rohini, to operational systems from March 1988 with IRS 1A, through IRS 1B, 1C, 1D, P3, P4 (OceanSat 1), P5 (CARTOSAT 1), P6 (Resource Sat 1) to Cartosat 2 (launched in 2007). PSLV has become the workhorse from the launch of IRS 1D onwards. Descriptions of the CCD-based imaging sensors developed for the IRS series are also included in the book.

With regard to applications of Remote Sensing, the author has collated a good number of applications in a few pages (section 36). However, the application examples are not organized based on theme/discipline. To the reviewer the description of microwave sensor (SAR) in this section seemed rather inappropriate. The section 37 very briefly covers GIS and Village Resource Centres (VRC). This innovative concept of taking the benefits of space technology to the villages in the form of VRCs has been the brainchild of Madhavan Nair. This aspect the author has missed out. The book concludes with a brief description of Chandrayaan 1, astrosat missions, and Indians in manned space missions.

In summary, this book provides an interesting reading on how India's indigenous space programme evolved to its present state of being on the forefront of technology. It has strong technological perspective but does not provide adequate end use application examples. The author succinctly describes the growth profile, the critical stages, lessons learnt from each success as well as the few failures. Applications of remote sensing have not been covered adequately, and not mentioning the National Natural Resource Management System (NNRMS) is conspicuous. The mention of microwave as well as ocean wave in the same paragraph using the term 'wave' on page 230 is misleading. However, this is a very useful book for general reading and for libraries.

B. L. DEEKSHATULU

*10-3-123/3 East Maredpally, Secunderabad 500 026, India*
*e-mail: deekshatulu@hotmail.com*




**Water Ecosystems and Society: A Confluence of Disciplines.** Jayanta Bandyopadhyay. Sage Publications India Pvt Ltd, B1/I-1 Mohan Cooperative Industrial Area, Mathura Road, New Delhi. 2009. xiv + 191 pp. Price: Rs 550.

In the current global scenario, water and sustainable development are intrinsically linked. More so, in a developing country like India, where, without adequate supply and scientific management of water resources, sustained socio-economic development is difficult to achieve. Conventionally management of water resources in the country has been dealt under separate disciplines of engineering, geology, ecological sciences and policy studies. An absence of dialogue between the disciplines has often resulted in situations that have impacted large populations of the society. A case in point is the government initiative to provide aquifer-based drinking water to large sections of rural populace in the country to minimize risks of microbial contamination in drinking water and provide potable water, where surface water sources are inaccessible. Unmitigated extraction of the groundwater sources without due considerations of hydrogeology and geochemistry of the aquifers have exposed large sections of the society to risks of arsenic contamination (Assam, West Bengal, Chhattisgarh, Bihar, Uttar Pradesh) and the more widespread fluoride contamination (notable in states of Andhra Pradesh, Rajasthan, Karnataka, Gujarat, Punjab, Madhya Pradesh, Uttar Pradesh, Bihar, Tamil Nadu, Chhattisgarh) from drinking contaminated groundwater. The time has arrived where efficient management of water resources needs an understanding