Chapter 5
Science, Technology and National Security

In your Ninth Standard Work Book on Defence Studies, you had learnt that; to protect its national interests and core values in this world, a nation requires to develop credible National Power. You also learnt about the various factors which go into constituting National Power. Among the material factors; Science, Technology and Manufacturing capability are factors which need to be developed by our nation on priority if it aspires to become a modern, developed, and prosperous Nation State.

Relationship between Science, Technology and Engineering

Technology is often developed from the basic knowledge of science combined with engineering. For example, science might study the flow of electrons in electrical conductors by using already-existing tools and knowledge. This new-found knowledge may then be used by engineers to manufacture new tools and machines such as semiconductors, computers, and other forms of advanced technology. In this sense, scientists and engineers may both be considered as technologists. Therefore the three fields i.e. Science, Technology and Engineering are often considered as one for the purposes of research and development.

Science is the systematic study of the structure and behaviour of the physical and natural world. Technology is the application of practical sciences for Industry or Commerce. Technology refers to methods, systems, and devices which are the result of scientific knowledge being used for practical purposes. A modern example is the rise of Information Technology (IT) which is the combined application of Computer Science and Electronics. Engineering is the application of mathematics, as well as scientific, economic, social, and practical knowledge. This helps to invent, innovate, design, and manufacture, materials, components, tools, machines, weapon systems etc.

Scientific, Technological and Industrial Development in India

Looking back into ancient and medieval history, India gave the world great knowledge in Astronomy, Mathematics, Textiles and in many other fields. Until the 17th century India was economically and militarily at par with the European nations. In 1780 Tipu Sultan surprised the British forces in battle by using rockets against them; the British copied these rockets and used them against Napoleon in Europe in 1812. The industrial revolution in Europe in the 18th century rapidly changed the industrial capacity of Europe and it progressed rapidly. However, due to the British rule such an industrial revolution did not take place in India.

India has taken major strides in science and technology since its independence and today it is recognized for its achievements in many fields. These include Agriculture, Textiles, Health-care and Pharmaceuticals, Information-Technology, Space Technology, Defence Technologies and Nuclear Technology.

Several initiatives have been taken in the field of Science and Technology by the Indian government to enhance the security of the Nation. Some of these initiatives were for civilian use while some had defence applications. It is necessary to understand that it

is not possible to say that certain technology is only for civilian use or for defence use. For example, satellites are used for regular mobile phone communication; they are also used by Defence Forces for their communication. Similarly, Nuclear Science is used for production of electricity; it is also used for production of nuclear weapons.

Dual-Use Technology : It is that technology which can satisfy more than one goal at any given time. Thus, expensive technologies used for military purposes can also be used to benefit civilian interests for peaceful purposes, these are termed as dual use technologies. Example : Global Positioning System - GPS

This chapter focuses on three areas of technology that are used by the Armed Forces to ensure security of India : Space Technology, Nuclear Technology and Electronics. All these are 'dual use' technologies.

Space Technology

Space technology is critical to human survival and progress. Satellites are now being used for many purposes: Meteorology, Television Broadcasting, Mobile Telephony, Navigation and Internet. Space systems are also used in multiple fields, such as Financial Management, education, Tele-Medicine, Scientific Research and Disaster Management. The use of outer space is also done for military support functions like reconnaissance, communication and navigation.

Space technology is an area of notable success, thanks to the efforts of Dr Vikram Sarabhai and many other scientists. The Indian Space Research Organisation (ISRO), has made the nation self-sufficient in building and launching rockets, spacecraft and satellites. Space Technology also provides the ability to build missiles for military purposes.

The Indian Space Research Organisation (ISRO) was set up in 1969. Its vision was to harness space technology for national development. India produced its first indigenous satellite, Aryabhata, in 1975. This was launched by a Soviet (rocket) termed as space launch vehicle. India's first successful space launching programme was accomplished in 1983. Starting with Rohini, ISRO has developed several Satellite Launch Vehicles (SLVs), Augmented Satellite Launch Vehicles, Polar Satellite Launch Vehicles and Geosynchronous Satellite Launch Vehicles. The use of the Indian Remote Sensing Satellite (IRS) for reconnaissance purposes is the first major defence application of the Indian satellite.

Dr. Vikram Ambalal Sarabhai (1919-1971) is considered as the Father of the Indian space program. The establishment of the Indian Space Research Organization (ISRO) was one of his greatest achievements.

Missile Technology

The Integrated Guided Missile Programme began in 1983. The five missile programmes included in this category are :

(i) Agni, an Intermediate Range Ballistic Missile

(ii) Trishul, a low-level quick reaction surface to air missile (SAM)

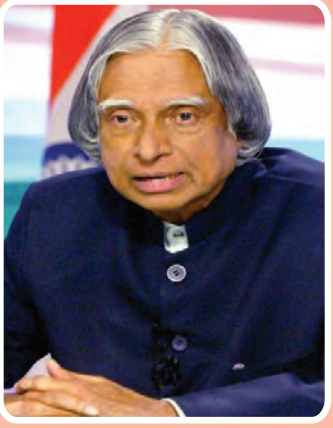
(iii) Akash, a medium to high altitude (SAM)

(iv) Prithvi, a tactical surface to surface missile (SSM)

(v) Nag, a third generation anti-tank missile.

The Integrated Guided Missile Development Program laid down the foundation of missile technology. Development of a number of different types of missiles with improved technology and capability followed. These included the **Prithvi II** and **III** Short Range Surface to Surface Ballistic Missiles, **Agni III** and **Agni IV** Surface to Surface Intermediate Range Ballistic Missiles, **Agni V** Surface to Surface Intercontinental Ballistic Missiles, the **Brahmos** Supersonic Cruise Missile, the **Nirbhay** Subsonic Cruise Missile, Submarine launched **K4** and **K15** Ballistic Missiles, the **Pradyuman** and **Prithvi** Air Defence Surface to Air Missiles and the **Astra** Air to Air Missile.

Dr. A P J Abdul Kalam (1931 – 2015) was responsible for the evolution of ISRO's launch vehicle programme. He took up the responsibility of developing Indigenous Guided Missiles at Defence Research and Development Organisation. He was the Chief Executive of Integrated Guided Missile Development Programme (IGMDP). He is popularly known as India's Missile Man. Dr. Kalam became the 11th President of India on 25th July 2002.



Classification of Missiles

A combination of factors is generally used to classify a missile, Range being one of the factors :

Tactical Missile : For example Prithvi I (150-300 kms)

Short Range Ballistic Missile : For example Agni 1. (300-1000 kms)

Medium Range Ballistic Missile : For example Agni II and K4 Sagarika. (1000-3500 kms)

Intermediate Range Ballistic missile : For example Agni III and Agni IV. (3500 - 5500 kms)

Intercontinental Ballistic Missile : For example Agni V. (more than 5500 kms)

Prithvi Missile I and II

Agni Missile

Trishul Missile

Nag Missile

Akash Missile

Brahmos Missile

Height : 22.7m
Lift-off weight : 17 t
Propulsion : All Solid
Payload mass : 40 kg
Orbit : Low Earth Orbit

SLV-3

ASLV

Height : 23.5m
Lift-off weight : 39 t
Propulsion : All Solid
Payload mass : 150 kg
Orbit : Low Earth Orbit

PSLV-XL

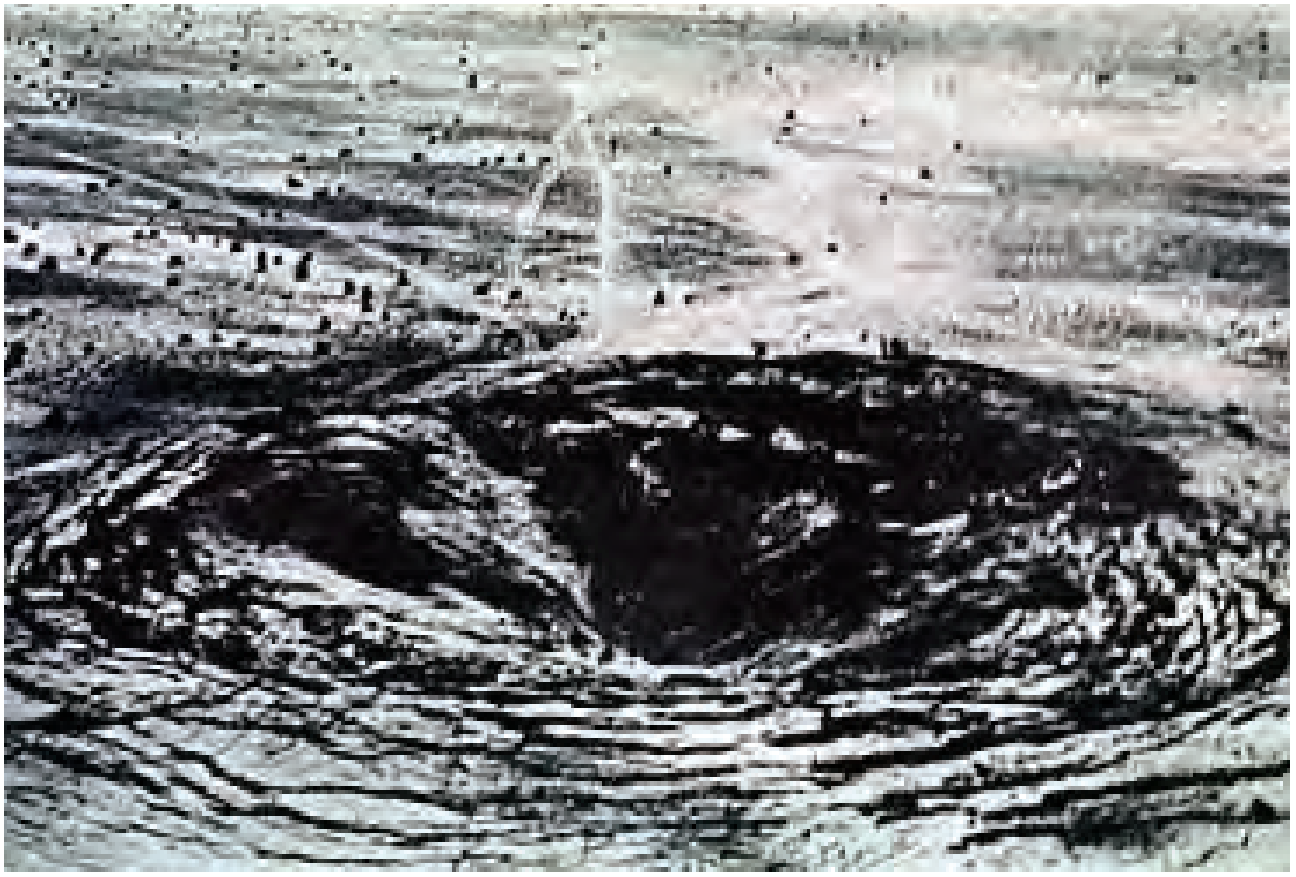
Height : 44m
Lift-off weight : 320 t
Propulsion : Solid & Liquid
Payload mass : 1860 kg
Orbit : 475 km Sun Synchronous Polar Orbit (1300 kg in Geosynchronous Transfer Orbit)

GSLV Mk II

Height : 49m
Lift-off weight : 414 t
Propulsion : Solid, Liquid & Cryogenic
Payload mass : 2200 kg
Orbit : Geosynchronous Transfer Orbit

GSLV Mk III

Height : 43.43 m
Lift-off weight : 640 t
Propulsion : Solid, Liquid & Cryogenic
Payload mass : 4000 kg
Orbit : Geosynchronous Transfer Orbit



Pokhran Test Site

India began its nuclear programme soon after independence. Two scientists, Meghanand Saha and Homi Bhabha played an important role in the development of India's nuclear policy. India's nuclear policy revolved around two principles: promotion of research and development for harnessing nuclear energy for peaceful purposes, and attainment of self-sufficiency in the nuclear programme.

Use of atomic energy for electricity production was considered as the most important aspect of atomic research. Nuclear energy is going to play an increasingly important role in India's energy security and sustainable development plans.

The Department of Atomic Energy (DAE), was established in 1954. Its task is the development of nuclear power technology, applications of radiation technologies in the fields of agriculture, medicine, industry, and basic research. The Department of Atomic Energy's vision is to empower India through technology, creation of more wealth and providing better quality of life to its citizens.

India carried out its first nuclear test at Pokhran in 1974. India made it clear to the world that this test was carried out for peacful purposes. The then Prime Minister Indira Gandhi clarified in the Parliment that this Nuclear Test was essential for research and development of peaceful uses of nuclear energy.

Dr. Homi Jehangir Bhabha (1909-1966) was a multifaceted personality, a scientist, visionary and institution builder. Bhabha was instrumental for the formation of Atomic Energy Commission in 1948 and the Department of Atomic Energy in 1954. He chalked out a focussed research and minerals exploration programme for nuclear energy. He was such a visionary that he had realized the importance of nuclear power programme way back in 1950s and enunciated a nuclear programme so as to meet the energy security of the nation.

Nuclear Weapon Test

In 1998 India carried out several nuclear tests again at Pokhran. India declared that it was now a nuclear weapons state. The then Prime Minister Atal Behari Vajpayee's statement after the nuclear tests gives the reasons for India's decision to become a nuclear weapons country. He said that nuclear weapons had increased in our neighbourhood. India has also been the victim of terrorism, militancy and clandestine war. At a global level, the nuclear weapons states have not taken any steps in moving towards a nuclear-weapon-free-world. Therefore for India's national security India became a nuclear weapons country. India does not intend to use these weapons for aggression or for mounting threats against any country. These are weapons of self-defence, to ensure that India is not subjected to nuclear threats or coercion. India has not given up its policy of peaceful uses of nuclear technology. It continues to support global nuclear disarmament. But it wants to develop its nuclear weapons capability so that it can defend itself.

Nuclear Non-proliferation Treaty (NPT)

The NPT is an international treaty whose objective is to prevent the spread of nuclear weapons and weapons technology, to promote cooperation in the peaceful uses of nuclear energy and to further the goal of achieving nuclear disarmament and general and complete disarmament. This treaty was signed in 1968. India did not join this treaty. The treaty prohibits those countries that do not have nuclear weapons to produce nuclear weapons. But it does not place any restrictions on those countries that have nuclear weapons. This is discriminatory. Therefore India refused to join the agreement.

Countries having nuclear weapons

According to the Stockholm International Peace Research Institute (SIPRI) the following countries have nuclear weapons: the United States, Russia, the United Kingdom, France, China, India, Pakistan, Israel and North Korea. (SIPRI information of January 2016)

Nuclear power plant

The plant converts nuclear energy into useful power. In a nuclear electric plant heat produced by a reactor is used to produce steam to drive a turbine that in turn drives an electricity generator.

Electronics

The Government of India's National Policy on Electronics (NPE) announced in 2012 seeks to promote Electronics System Design & Manufacturing (ESDM) in the country. One of the important objectives of this policy is to develop a partnership between ESDM and the core sectors of the economy like Defence, Atomic Energy and Space. It also plans to create a complete secure cyber eco-system in the country to secure Information and communication technology (ICT) infrastructure and cyber space of the country.

Electronics is an important part of India's defence preparedness. It is used in communications by satellite phones; radars; guided missiles; electronic circuits in various equipments etc. India started a program to develop indigenous supercomputers and supercomputing technologies. These supercomputers were also capable of assisting in the development of Nuclear Weapons. PARAM 800 was the first super computer developed by the Centre for Development of Advanced Computing (C-DAC). Dr. Vijay Bhatkar played an important role in its development.

Param Super Computer

The coming together of multiple technologies with the internet and the growth of social networking has added a new dimension to discussions on cyber security. The use of internet is enormous. People use the web and social networking sites every day. It is impossible to carry out surveillance of all that happens in cyberspace. The rapid advancement in technologies has led to new forms of threats which need to be understood and tackled.

Cyber security threats today have become increasingly sophisticated and complex. There can be attacks on such basic social necessities as power supplies, banking, railways, air traffic control, etc. Hackers can target government ministries, banks, utilities, other key infrastructure, and companies nationwide, demanding ransom. These acts are not a traditional law and order problem. Therefore it would be difficult to deal with them. To tackle this problem the Indian government has introduced the National Cyber Security Policy in 2013 to provide an umbrella framework for defining and guiding actions related to cyber security.

For details see :

National Cyber Security Policy-2013 (NCSP-2013)

Ministry of Electronics and Information Technology of the Indian Government

http://meity.gov.in/writereaddata/files/National_cyber_security_policy-2013_0.pdf

Promotion of Science and Technology through Education

Various scientific educational and research facilities have been established and are functioning to meet the needs of the nation. Some of these are under the control of various ministries of the government, some others are autonomous, details regarding a few which are important for students interested to become scientists and technologists are given below. Detailed information on these can be accessed on the links to various ministries in the website of the government of India at https://india.gov.in/.

Prominent Educational Institutions for Students

- The Indian Institutes of Science Education and Research (IISER)
- The Indian Institutes of Technology (IIT)

Prominent Research Organisations

- The Department of Atomic Energy (DAE).
- Indian Space Research Organisation (ISRO).
- Council of Scientific and Industrial Research (CSIR)
- Centre for Development of Advanced Computing (C-DAC)
- Indian Institute of Science (IISc).
- Tata Institute of Fundamental Research (TIFR)

Defence Oriented Research and Development Establishments

- Defence Research and Development Organisation (DRDO).

Futuristic Game Changer Technologies in the Field of Defence

- Artificial Intelligence and Robotics.
- Particle beam or laser beam weapons.
- Electromagnetic propulsion.
- Light weight Super alloys and composites having high strength and heat resistance.
- Nano Technology and Miniaturisation of systems.
- Stealth technology which can defeat detection by radars.

Activities

1. Search for information on Chandrayan and Mangalyan. Discuss these achievements in the classroom.

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2. What is GPS? What are its uses?

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3. What is the importance of nuclear energy for India? Collect information about one or two nuclear power plants in India.

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4. Collect information about cyber threats to national security. Find out the various means used to fight cyber threats.

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5 Collect pictures of missiles from newspapers and magazines and paste them below along with brief details about them :

6 Collect pictures of sattelite from newspapers and magazines and paste them below along with brief details about them :

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