Commemorative Issue of *Defence Science Journal* on Golden Jubilee of DRDO

Defence Research and Development Organisation (DRDO), Ministry of Defence, is dedicatedly working towards enhancing self-reliance in Defence systems. DRDO undertakes design and development leading to production of world class weapon systems and equipment in accordance with the expressed needs and the qualitative requirements laid down by the three Services. The vision of DRDO is to make India prosperous by establishing world class science and technology base and provide the Defence Services a decisive edge by equipping them with internationally competitive systems and solutions.

DRDO was formed in 1958 with the amalgamation of the then already functioning Technical Development Establishments (TDEs) of the Indian Army and the Directorates of Technical Development and Production (DTD&P) with the Defence Science Organisation (DSO). The process of transformation of DSO to DRDO was then initiated for undertaking R&D in hardware, software and processes to meet the requirements of the user services and to develop frontier defence technologies with futuristic applications. The formation of DRDO resulted in the change of its main role from mere advising to design and development and subsequently leading to production of weapon systems, sensors, combat systems, communication equipment, and electronic warfare systems.

Today, after more than 50 years of its existence, DRDO is one of the leading R&D organisations in the world. Today, DRDO is a network of more than 50 laboratories engaged in developing defence technologies. These laboratories are grouped under various Directorates—Aeronautics, Armaments, Combat Vehicles and Engineering, Electronics and Computer Sciences, Life Sciences, Materials, Missiles, Naval Systems.

The Aeronautics group of laboratories has responded to the far reaching vision of the DRDO's leadership in developing a variety of aeronautical systems for military applications over the past decades. These include the flagship light combat aircraft; unmanned vehicles for reconnaissance, surveillance and target practice, and a variety of lighter-than-air systems. DRDO's electronic warfare systems fly in virtually every military aircraft, and its avionics capabilities have been used to upgrade our legacy systems. A great deal of maturity has been achieved through decades of efforts in gas turbine propulsion and related materials, and manufacturing. The development of these systems has energised the aeronautics industry, both private and public, in the creation of design, development, and production capability for a host of supporting technologies that cover flight controls, composite structures, display systems, navigation and guidance, and safety and reliability. DRDO has also successfully developed and productionised pilotless target aircraft (*Lakshya*) and unmanned aerial vehicle (*Nishant*), and efforts are on to develop long-endurance and medium altitude UAVs. A national initiative to focus on micro-UAV technology is being worked out. All these technologies will go a long way to substitute manned air vehicles.

DRDO's flagship programme, India's own fourth-generation multi-role combat aircraft *Tejas*, is just about a year short of induction into the Indian Air Force. This light combat aircraft compares with the best ones in the world. Understanding the flight dynamics and control of an unstable supersonic agile lightweight aircraft is a hallmark achievement. Other versions of this aircraft, namely, the trainer and the naval versions, are also being progressed concurrently.

The electronics weapons technology too has become a DRDO forte. Indigenously developed electronic weapons technology is already installed in most of the Indian military aircraft and helicopters. This technology is of contemporary class, comparable with the best in the world. DRDO is now foraying into those electronic weapons areas, which are still under development even in the most advanced countries of the world.

Future research in Aeronautics group of laboratories will focus on a variety of advanced technologies that will support next generation combat aircraft such as unstable configurations and stealth, advanced avionics and flight controls, and propulsion.

In the field of Armaments and Explosives, DRDO has made remarkable progress and made the nation proud by delivering advanced systems and technologies to the Armed Forces. DRDO has developed the INSAS whose production has crossed a million; *Pinaka*–a mult- barrel rocket launcher accepted by the Indian Army. FSAPDS for the MBT *Arjun* has been developed and delivered. Various types of ammunitions and rockets developed are in the armoury of the Armed Forces. Wide varieties of rocket propellants, high explosive fillings for warheads for *Prithvi, Akash,* and *Nag* and other missiles have been developed and are being productionised at Ordnance Factories. DRDO also has established state-of-the-art test and evaluation facilities for evaluation of explosives, propellants and armaments with high precision. It plans to develop soldier-as-a-system, more refined precision-guided munitions, high explosive systems and other technologies in the near future.

In the field of Combat Vehicles and Engineering, DRDO has delivered state-of-the-art MBT *Arjun* to the Indian Army. It has successfully developed and delivered bridge laying tank T-72, carrier command post tracked, modular bridge—*Sarvatra*, and armoured engineer reconnaissance vehicle (AERV). DRDO has demonstrated the technology vehicle ICV *Abhay* and Ex-Tank. Remotely operated vehicle has also been developed and is undergoing user acceptance trials. DRDO efforts have resulted in saving the precious life of our soldiers and civilians in the Himalayan range by forecasting avalanche, thus giving early warnings in that region. It endeavours to develop the state-of-the-art technologies for realising future main battle tank (FMBT), future infantry combat vehicle (FICV), autonomous robot,

autonomous ground vehicle and all weather roads in the Himalayan region in near future.

DRDO has accomplished path breaking R&D in the field of electronic systems, which includes communication, command and control systems, radars, EW, and electro-optical systems. There is also significant development in the areas of advanced computing, image processing, microwave tubes, crypto-analytical tools, cryptography, microwave tubes, special sensors, artificial intelligence, robotics, solid-state material devices and sub-systems, directed energy weapons, avionics, geographical/terrain information system, etc.

DRDO exhibited its capability by successful development, acceptance, and induction of a host of radars—BFSR, 3-D CAR, *Indra; Rohini*; *Revathi; Rajendra; Bharani; Ashlesha* and weapon-locating radars; maritime surveillance airborne radar; EW systems, integrated comint system; artillery combat command and control system; combat net radio; command information and decision support system; image intensifier sights; night vision devices, etc.

The Life Sciences group endeavors to optimise performance of the human capital of the manpower-intensive combat forces, and to create a soldier system to fit in the weapon development programmes while fulfilling the unique operational requirements in non-conventional warfare. The Life Sciences laboratories are putting up concerted efforts covering a wide spectrum of areas, such as recruitment and selection; health and well-being; protection against extreme and toxic environments; life- and strategic-support systems, and technologies for fresh and processed food for specialised missions.

DRDO has successfully developed systems for personnel selection and trade allocation for both Officers and other ranks. This includes a computerised pilot selection system (CPSS) for the selection of candidates for flying branch of the Indian Air Force. Others include development of protection equipment, life-support systems, and biomedical technologies to meet the requirements of the Armed Forces. A number of products/technologies have been developed for the protection of soldiers from heat and cold. Important amongst these are specialised yoga packages for the Armed Force; solid-state cooling system complete with liquid-cooled garment to provide comfort to tank crew operating under high heat stress; carbogen breathing system for protection against noise-induced hearing loss; submarine escape suits and integrated life-support system including helmet, flying overalls and anti-G suits for aircrew. Several agro-technologies have been developed for fresh food production at high altitudes which have been able to meet 56 per cent of fresh vegetable requirements of the Armed Forces stationed at high altitudes.

Materials play a vital role in the development of any advanced Defence system. A reliable, timely and affordable availability of materials is the key requirement to produce defence products critical to national security. Realising the importance of materials technologies, the Materials group of laboratories has successfully developed a number of technologies and products to address a wide range of problems of Armed Forces related to high altitude clothing; habitat and logistics; efficacy of materials in sub-zero temperatures; water, heat and soil management in desert; system performance in the desert; and specialised materials for aero and naval systems. These cover an enormous range of applications ranging from ballistic protection, and antitank ammunition for armoured vehicles and protective clothing/equipment for personnel to nuclear, chemical, and biological defence; from materials and coatings for stealth and camouflage to high performance textiles, specialty magnetic materials for guidance, navigation and power systems to friction materials for aircraft brake pads. Technologies for the structural materials, steel, titanium, aluminum, nickel, advanced metals and alloys, new generation polymers and composites, specialty fibres and fabrics, ceramics, etc., have been developed and productionised for aircraft, missiles, armoured vehicles, and military bridges.

In the field of Missiles, during the initial phase, by developing wire-guided antitank missile (ATGM) system, and Devil, a medium range surface-to-air missile, DRDO exhibited its capability and successfully developed various systems. A large number of infrastructure and test facilities were also established, which proved very useful for the development of futuristic missiles. The Integrated Guided Missile Development Programme (IGMDP) was undertaken in 1983 that gave a quantum jump to indigenous missile development programme. Missiles developed under IGMDP got success all the way. *Prithvi* has already been inducted into the Services. Ship-launched *Dhanush* (Naval version of *Prithvi*) has been weaponised. Development of *Trishul, Akash,* and *Nag* has been completed. *Akash* is being productionised for the Air Force, and *Nag* has entered into the user trial phase. The development of re-entry technology gave impetus to *Agni* class of long-range missile systems *(Agni I, II, III). BrahMos*, an Indo-Russian joint venture of a supersonic cruise missile system, which has been inducted into the Services. AD programme, wherein exo- and endo-atmospheric interception of incoming ballistic missiles has been demonstrated successfully, has further proved the ballistic missile interception capabilities of DRDO. DRDO has also undertaken development of beyond visual range air-to-air missile *Astra*, hypersonic technology demonstration vehicle (HSTDV), and joint venture projects like LRSAM (70 km surface-to-air missile). Missile technology has reached a high degree of maturity and has made the country self-reliant despite missile technology control regime and international restrictions and embargos.

Naval warfare is highly complex and technology intensive. To cope up with this fast changing requirement of the Navy, R&D activities are also needed to be dynamic. The naval platforms are very big in size and operate under entirely different geographical and environmental conditions. Thus, DRDO required entirely different set of technologies to be developed for naval warfare. Moreover, the development of naval platforms, sonar systems, underwater weapons, and materials for these platforms demand incorporation and integration of multidisciplinary technologies to match the unfriendly sea environment. The Naval Systems laboratories are involved in design and development of underwater sensors; underwater weapons, metallic and non-metallic materials, anti-corrosive, and anti-fouling technologies for specific applications in marine environment, and fuel

cell technology. DRDO has achieved self-reliance in the design and development of underwater sensors for integration with naval platforms.

The focus is to make Navy self-reliant in underwater weapons which include torpedoes, mines, countermeasures, targets, decoys, fire control systems, and UAVs. The DRDO has accomplished path-breaking R&D in the field of stealth, corrosion protection, and biodegradation. Defence shipyards and Indian Navy are effectively utilising all these technologies. The users have also recognised the indigenous development of marine steel weld consumables, underwater paints and other technologies to enhance operational capabilities of the warships. DRDO is looking forward to develop integrated coastal surveillance and defence system, stealth systems for naval platforms, advanced wire-guided torpedo for submarines, autonomous underwater vehicles and air-independent propulsion system in the future.

This issue of *Defence Science Journal* is a commemortive issue on the Golden Jubilee of DRDO highlighting some of the achievements in technologies developed by various laboratories of DRDO. The coverage of major DRDO achievements could not be exhaustive and complete as only a few subject areas are covered in this issue. Total 28 papers were received for this Issue, and after peer evaluation 14 papers have been selected for inclusion in this Issue.

In the field of Aeronautics, paper by Dr Balraj Gupta on 'Aerial delivery systems and technologies' highlights some of the technologies and systems developed by Aerial Delivery Research and Development Establishment thereby its role in achieving self-reliance in aerial delivery systems.

In the field of Armaments, 'Advances in high energy materials' by Dr U.R. Nair, *et al.,* covers a review of the high energy materials encompassing oxidizers, high-energy dense materials, insensitive high-energy materials, polymers, and plasticizers. Dr S.M. Danali, *et al.,* in their paper entitled 'Developments in pyrotechnics' present an overview of pyrotechnics development at High Energy Materials Research Laboratory covering smokes, illuminating, flares, electro-explosive devices, gas generators, delays, laser initiated pyro devices, nanomaterials, and green pyrotechnics alongwith some aspects of improved pyrotechnics.The tandem-shaped charged warhead is one of the efficient methods to defeat explosive reactive armour-protected main battle tanks while the paper 'Inconsistent performance of a tandem-shaped charge warhead' by Dr S. Harikrishnan and Dr K.P.S. Murthy, presents a case study of an investigation into the inconsistent performance of a tandem warhead for a third-generation anti tank missile. 'Smart munitions' by Dr C.P. Mahajan and Ms Vaishnavi C. Motghare, brings out the various categories of smart munitions including Armaments Research and Development Establishment's significant contributions.

In the field of Combat Vehicles and Engineering, the paper 'Design, development and validation of a vehicle-mounted hydraulically-leveled platform' by Sh K. Senthilkumar, *et al.,* covers the design, and development of a vehicle-mounted hydraulically-leveled platform and limited track trials conducted at Vehicles Research and Development Establishment for assessment of structural integrity of the platform, and constructional and mobility aspects of platform-mounted vehicle. 'Wishbone structure for front independent suspension of a military truck' by Dr V.V. Jagirdar*, et al.,* discusses about a double wishbone independent suspension designed for the front axle and successfully integrated with the military truck.

In the field of Electronics, four papers have been included. Lasers are used in many ways in defence systems. The paper entitled 'Battlefield lasers and optoelectronic systems' by Mr Anil Kumar Maini, presents an overview of the current and emerging military applications of lasers and optoelectronics systems with likely trends leading to performance enhancement of the existing systems and emergence of new application areas. Surveillance is one of the most important facet of maritime warfare and radars are very important for defence applications specially dealing with airborne weapon system. Dr S. Christopher deals with the Indian value addition to state-of-art in active electronically-steered array surveillance radar. The paper 'Maximum likelihood estimator for bearings-only passive target tracking in electronic surveillance measures electronic warfare systems' by Dr S. Koteswara Rao, covers the maximum likelihood estimator algorithm for passive target tracking applications. 'Radar cross-section (RCS) measurement techniques' by Dr V.G. Borkar, *et al.*, highlights the RCS facility at Research Centre Imarat, Hyderabad, with some details of different activities that are carried out including RAM evaluation, scale model testing and diagnostic imaging.

In the field of Life Sciences, the paper 'Control of malaria in Armed Force in northeast India' by Dr Sunil Dhiman, *et al.,* reviews the incidence of malaria in the Armed Forces and Paramilitary Forces in Northeastern region and suggests minimal measures for its control. 'Protected cultivation for food and nutritional security at Ladakh' by Dr Gyan P. Mishra, *et al.,* describes the role of Defence Institute of High Altitude Research (DIHAR) in providing adequate support and technological help to set various types of greenhouses both for the Army units deployed in the far-flung areas and for the local farmers in Ladakh. The paper entitled 'Attributes of seabuckthorn (*Hippophae rhamnoides L.*) to meet nutritional requirements in high altitude' by Dr Tsering Stobdan, *et al.,* provides research on the nutritional value of seabuckthorn for soldiers at high altitude.

The Editors of *Defence Science Journal* thank all the contributors and reviewers for their contributions in bringing out this issue.