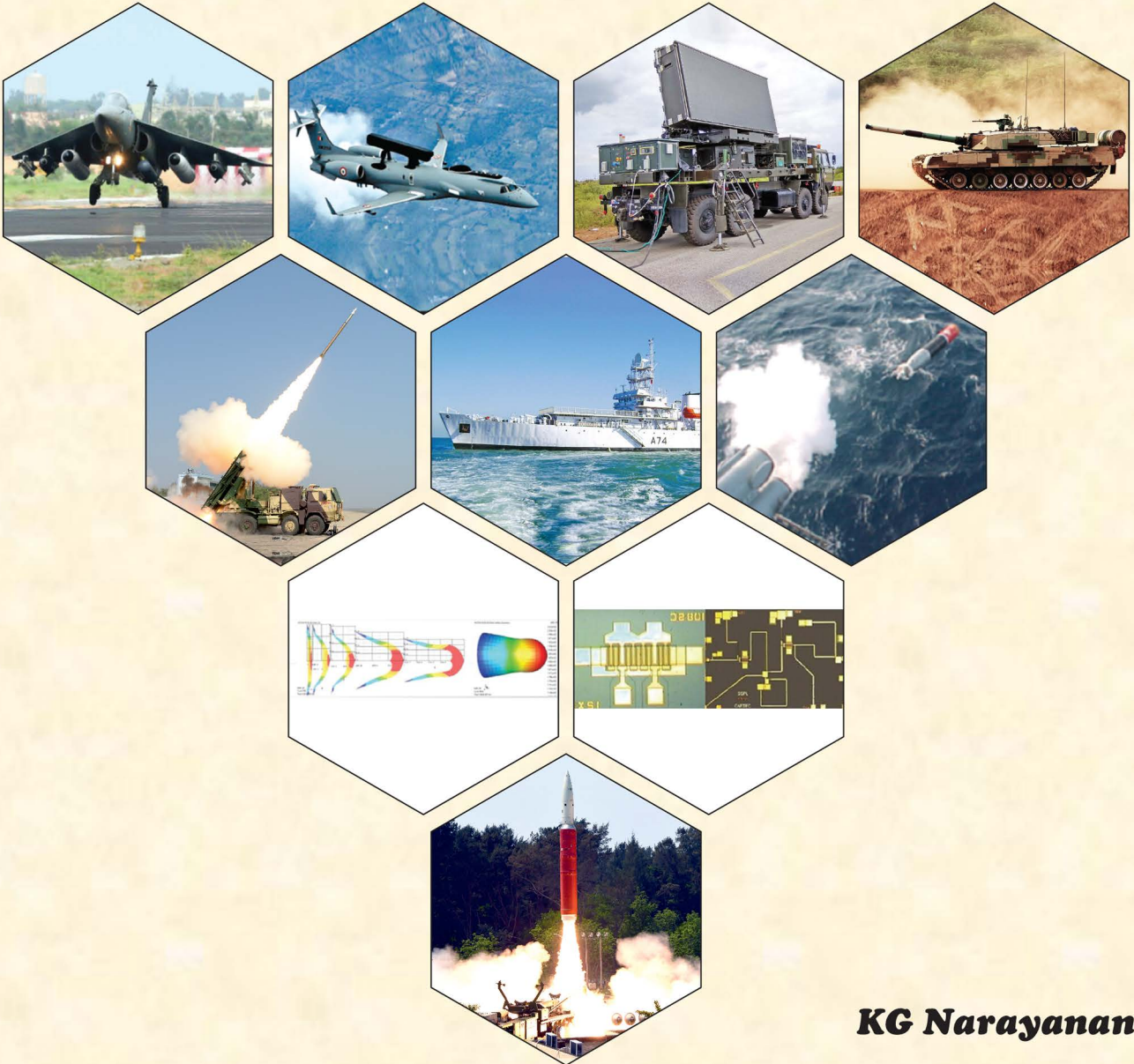


ENDEAVOURS IN SELF-RELIANCE

DEFENCE RESEARCH (1983 - 2018)



KG Narayanan



**DEFENCE RESEARCH & DEVELOPMENT ORGANISATION
MINISTRY OF DEFENCE, INDIA**

Endeavours in Self-Reliance Defence Research (1983–2018)

Dr KG Narayanan

Principal Editor

formerly Chief Advisor

Defence Research & Development Organisation



2022

**Defence Research & Development Organisation
Ministry of Defence, New Delhi**

**DRDO MONOGRAPHS/SPECIAL PUBLICATIONS SERIES
ENDEAVOURS IN SELF-RELIANCE–DEFENCE RESEARCH (1983–2018)**

Dr KG Narayanan (Principal Editor)

Series Editors

Editor-in-Chief

Dr K Nageswara Rao

Editor

Alka Bansal

Sub Editor

NK Chawla

Editorial Assistant

Gunjan Bakshi

Cataloguing-in-Publication

Narayanan, KG (Principal Editor)

Endeavours in Self-Reliance–Defence Research (1983–2018)

DRDO Monographs/Special Publications Series

1. DRDO–Organisations

2. Missile Systems

3. Armament Systems

4. Naval Systems

5. Defence Technologies

I. Title

II. Series

356.252 “1983/2018”

© 2022, Defence Research & Development Organisation, New Delhi – 110 011

ISBN 978-93-94166-06-6

All rights reserved. Except as permitted under the Indian Copyright Act 1957, no part of this publication may be reproduced, translated, distributed or transmitted, stored in a database or a retrieval system, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the Publisher.

Cover Design

Raj Kumar

Printing

SK Gupta

Marketing

Tapesh Sinha

Published by Director, DESIDOC, Metcalfe House, Delhi – 110 054

*“A small body of determined spirits fired
by an unquenchable faith in their mission
can alter the course of history.”*

*- Mohandas K. Gandhi
(Harijan, 1936)*

Contents

<i>Foreword</i>		<i>ix</i>
<i>Preface</i>		<i>xi</i>
<i>Grateful Acknowledgements</i>		<i>xiii</i>
<i>Defence R&D Laboratories & Programmes</i>		<i>xiv</i>
Chapter 1	Defence Technologies and Self-Reliance	1
1.1	Preparedness	1
1.2	Technology in War	1
1.3	National Goal of Self-Reliance	2
1.4	New Environment	3
1.5	Shared Goal	4
Chapter 2	Story So Far	5
2.1	The Beginnings	5
2.2	DRDO	6
2.3	Systems to the Fore	6
2.4	Marching Forward	7
Chapter 3	Mandate and Organisation	8
3.1	Twin Objectives	8
3.2	Research, Design and Development	8
3.3	Evolution of Organisation	9
3.4	Programmes and Projects	11
3.5	Human Resources	12
3.6	Finances	13
Chapter 4	At the Helm	14
4.1	Scientific Leadership	14
4.2	Dr DS Kothari (1948–1961)	14
4.3	Prof S Bhagavantham (1961–1969)	15
4.4	Dr BD Nagchaudhuri (1970–1974)	15
4.5	Prof MGK Menon (1974–1978)	16
4.6	Dr Raja Ramanna (1978–1982)	16
4.7	Dr VS Arunachalam (1982–1992)	17
4.7.1	<i>The Blossoming of DRDO</i>	18
4.8	Dr APJ Abdul Kalam (1992–1999)	22
4.8.1	<i>Dr Abdul Kalam Speaks On</i>	23
4.9	Dr VK Aatre (2000–2004)	29
4.9.1	<i>Down Memory Lane as SA to RM</i>	30
4.10	Shri M Natarajan (2004–2009)	34
4.10.1	<i>DRDO—A Perspective Through Three Decades</i>	35
4.11	Dr VK Saraswat (2009–2013)	38
4.12	Dr Avinash Chander (2013–2015)	38

4.13	Dr S Christopher (2015–2018)	39
4.13.1	<i>My Days in DRDO HQ</i>	40
4.14	Distinguished Leadership	44
Chapter 5	Sinews of Strength	51
5.1	Missile Systems	52
5.1.1	<i>Defence Research and Development Laboratory (DRDL), Hyderabad</i>	53
5.1.2	<i>Prithvi's Funny Guys</i>	67
5.1.3	<i>Leadership, Challenges and Heroes</i>	69
5.1.4	<i>Advanced Systems Laboratory (ASL), Hyderabad</i>	72
5.1.5	<i>Research Centre Imarat (RCI), Hyderabad</i>	73
5.1.6	<i>Building Enabling Technologies for Missiles</i>	78
5.1.7	<i>Challenges in Missile Manufacturing</i>	81
5.1.8	<i>BrahMos Aerospace</i>	83
5.1.9	<i>Space Systems and Missiles - Achievements and Lessons</i>	86
5.1.10	<i>Terminal Ballistics Research Laboratory (TBRL)</i>	88
5.1.11	<i>Integrated Test Range (ITR), Chandipur</i>	95
5.1.12	<i>Strengths Rooted in Science and Self-reliance</i>	97
5.2	Aeronautical Systems	99
5.2.1	<i>Aeronautical Development Agency (ADA), Bengaluru</i>	100
5.2.2	<i>HF24 to LCA - Early Encounters</i>	113
5.2.3	<i>A National Mission Accomplished</i>	117
5.2.4	<i>Taking Indian Fighter into Air</i>	121
5.2.5	<i>Moments of Excitement and Elation</i>	123
5.2.6	<i>How the Wings Were Built</i>	127
5.2.7	<i>LCA for Indian Navy's Aircraft Carrier</i>	129
5.2.8	<i>Romance of Flight Testing</i>	132
5.2.9	<i>Aeronautical Development Establishment (ADE), Bengaluru</i>	136
5.2.10	<i>Bridging Technology Gaps</i>	145
5.2.11	<i>Gas Turbine Research Establishment (GTRE), Bengaluru</i>	148
5.2.12	<i>Centre for Airborne Systems (CABS), Bengaluru</i>	154
5.2.13	<i>Indian AEW&CS—Agony and Ecstasy</i>	158
5.2.14	<i>Aerial Delivery Research and Development Establishment (ADRDE), Agra</i>	160
5.2.15	<i>Centre for Military Airworthiness and Certification (CEMILAC), Bengaluru</i>	163
5.2.16	<i>HAL-DRDO Synergy, A Strategic Asset</i>	165
5.2.17	<i>An Air Warrior's Reflections</i>	168
5.3	Armament Systems	172
5.3.1	<i>Armament Research and Development Establishment (ARDE), Pune</i>	173
5.3.2	<i>Fire Power of R&D</i>	178
5.3.3	<i>Collaboration for Self-Reliance</i>	181
5.3.4	<i>High Energy Materials Research Laboratory (HEMRL), Pune</i>	185
5.3.5	<i>Proof and Experimental Establishment (PXE), Chandipur</i>	191
5.3.6	<i>Defence Terrain Research Laboratory (DTRL), Delhi & Defence Geoinformatics Research Establishment (DGRE), Chandigarh</i>	193
5.4	Combat Vehicles and Engineering	195
5.4.1	<i>Combat Vehicles Research and Development Establishment (CVRDE), Avadi</i>	196

5.4.2	<i>Challenges and Ecstatic Moments</i>	207
5.4.3	<i>Experiences in Technologies in Transition</i>	209
5.4.4	<i>Vehicles Research and Development Establishment (VRDE), Ahmednagar</i>	211
5.4.5	<i>DRDO and BEML–Partnership in Product Development</i>	214
5.4.6	<i>Research and Development Establishment (Engineers), [R&DE(E)], Pune</i>	216
5.4.7	<i>Snow and Avalanche Study Establishment (SASE), Chandigarh</i>	220
5.4.8	<i>Icy Continent and Himalayan Snows</i>	224
5.4.9	<i>Centre for Fire, Explosive and Environment Safety (CFEES)</i>	226
5.4.10	<i>Recalling Experiences with Indigenous Development</i>	229
5.5	Naval Systems	232
5.5.1	<i>Naval Physical & Oceanographic Laboratory (NPOL)</i>	233
5.5.2	<i>Straddling Mathematics and Systems Development</i>	238
5.5.3	<i>Naval Science and Technological Laboratory (NSTL)</i>	240
5.5.4	<i>Naval Materials Research Laboratory (NMRL)</i>	244
5.5.5	<i>From Research to Development</i>	248
5.5.6	<i>Air Independent Propulsion for Submarines</i>	250
5.5.7	<i>The Navy-DRDO Relationship–A Shared Synergy</i>	252
5.6	Electronics & Communication Systems	257
5.6.1	<i>Electronics and Radar Development Establishment (LRDE), Bengaluru</i>	258
5.6.2	<i>Systems Engineering in Radar Development</i>	264
5.6.3	<i>Defence Electronics Research Laboratory (DLRL), Hyderabad</i>	267
5.6.4	<i>Realising Dreams of Indigenous EW Systems</i>	271
5.6.5	<i>Defence Avionics Research Establishment (DARE), Bengaluru</i>	274
5.6.6	<i>Accomplishments and Hard Lessons in EW Development</i>	279
5.6.7	<i>Winning Through Collaboration and Trust</i>	282
5.6.8	<i>Defence Electronics Application Laboratory (DEAL), Dehradun</i>	284
5.6.9	<i>Instruments Research and Development Establishment (IRDE), Dehradun</i>	288
5.6.10	<i>Laser Science and Technology Centre (LASTEC), Delhi</i>	291
5.6.11	<i>Centre for High Energy Systems & Sciences (CHESS), Hyderabad</i>	293
5.6.12	<i>Challenges in Transferring R&D to Production</i>	294
5.7	Microelectronics and Microwave Devices	297
5.7.1	<i>Solid State Physics Laboratory (SSPL), Delhi</i>	298
5.7.2	<i>Raising a New Laboratory</i>	306
5.7.3	<i>Gallium Arsenide Enabling Technology Centre (GAETEC), Hyderabad</i>	309
5.7.4	<i>Building MMICs and Infra-Red Detector Arrays</i>	312
5.7.5	<i>Steep Climb in Solid State Technology</i>	314
5.7.6	<i>Microwave Tubes Research and Development Centre (MTRDC), Bengaluru</i>	316
5.8	Materials Science and Technology	318
5.8.1	<i>Defence Metallurgical Research Laboratory (DMRL), Hyderabad</i>	319
5.8.2	<i>Materials and Systems - Personal Journey Across DRDO</i>	327
5.8.3	<i>Defence Materials and Stores R&D Establishment (DMSRDE), Kanpur</i>	330
5.8.4	<i>Defence Laboratory (DL), Jodhpur</i>	333
5.9	Computational Systems	339
5.9.1	<i>Centre for Artificial Intelligence and Robotics (CAIR), Bengaluru</i>	340
5.9.2	<i>Advanced Numerical Research and Analysis Group (ANURAG), Hyderabad</i>	345
5.9.3	<i>Scientific Analysis Group (SAG), Delhi</i>	346

5.9.4	DRDO Rapid Online Network Access (DRONA)	347
5.10	Life Sciences	348
5.10.1	Defence Bioengineering and Electromedical Laboratory (DEBEL), Bengaluru	349
5.10.2	Defence Food Research Laboratory (DFRL), Mysuru	352
5.10.3	<i>Don't Soldiers Eat Like Everyone Else?</i>	355
5.10.4	Defence Institute of Bio-Energy Research (DIBER), Haldwani	357
5.10.5	Defence Institute of High Altitude Research (DIHAR), Leh	360
5.10.6	Defence Research Laboratory (DRL), Tezpur	364
5.10.7	Defence Research and Development Establishment (DRDE), Gwalior	366
5.10.8	Defence Institute of Physiology and Allied Sciences (DIPAS), Delhi	368
5.10.9	Defence Institute of Psychological Research (DIPR), Delhi	371
5.10.10	Institute of Nuclear Medicine and Allied Sciences (INMAS), Delhi	373
5.11	Systems Analysis, Training and Information	376
5.11.1	Institute of Systems Studies and Analyses (ISSA), Delhi	377
5.11.2	Defence Institute of Advanced Technology (DIAT), Pune	381
5.11.3	DRDO Young Scientists Centres (DYSC)	385
5.11.4	Defence Scientific Information and Documentation Centre (DESIDOC), Delhi	388
5.11.5	<i>Information for Technology Development</i>	389
5.11.6	National Research Base	391
5.12	Management of Technology	396
5.12.1	Institute of Technology Management (ITM), Mussoorie	397
5.12.2	<i>Technology Meets Finance—Memorable Interactions</i>	399
5.12.3	Transfer of Technology	403
5.12.4	<i>Commercialisation of Technologies—The Beginnings</i>	404
5.12.5	Technology Forecast and Forward Planning	406
5.12.6	<i>Administering R&D Laboratories</i>	408
5.12.7	<i>DRDO Works</i>	410
Chapter 6	Recently (2019–2021)	413
Chapter 7	Impact	419
7.1	Evaluation	419
7.2	Defence Capabilities—Then and Now	419
7.3	The Economics	424
7.4	Industrial Capabilities and Skilled Employment	426
7.5	Human Capital	427
7.6	Other Views	428
7.7	Summing Up Impact	432
Chapter 8	Images	434

डॉ जी. सतीश रेड्डी
FNAE, HFCSI, FRIN (London), FMACANUD (Russia), FAeSI, FRAeS (UK),
HFPMAI, FSSWR, FIET (UK), FIE, FAPAS, FIETE, AFAIAA (USA)

Dr G. Satheesh Reddy
FNAE, HFCSI, FRIN (London), FMACANUD (Russia), FAeSI, FRAeS (UK),
HFPMAI, FSSWR, FIET (UK), FIE, FAPAS, FIETE, AFAIAA (USA)



भारत सरकार
Government of India



FOREWORD

Every dynamic organization must necessarily keep track of its history of growth and evolution. Defence Research and Development Organization published an authentic historical account of its genesis and growth during the period 1958-82, capturing the early phases. The next volume of the history of Defence Research is covering the momentous period 1983-2018 which saw a tremendous expansion of activities and achievements.

This historical account covers the vast efforts of the organisation, establishment and laboratories under the aegis of the Department of Defence Research and Development. The spread of projects and accomplishments encompassing guided missiles for strategic and tactical deployments, multi-role fighter aircraft of the 4-plus generation, aerial warning and control system, UAV's, armaments, main battle tank, naval sensors and torpedoes, radars, electronic warfare, communication systems, material science and technology and numerous other capabilities including life sciences – is indeed, overwhelming.

We are very fortunate to be able to include the reminiscences of several former Chiefs of DRDO. A special feature of this book is the inclusion of special essays in chapter 5. These essays have been authored by scientists, soldiers and administrators who were involved as participants in our programmes in significant ways. Another notable aspect is the synoptic chapter 7 on the impact made by DRDO on national security capabilities, defence economics, national industrial capabilities and human capital. I strongly commend this crisp summary to all readers seeking an integrated perspective beyond the details.

I would like to record my sincere thanks to Dr KG Narayanan, Principal Editor, all the distinguished authors of special essays, the Directors and colleagues of DRDO laboratories and Programmes and colleagues in DESIDOC and DRDO headquarters for their contributions in making this remarkable publication a reality and a quality product.


(Dr G. Satheesh Reddy)

रक्षा मंत्रालय, रक्षा अनुसंधान तथा विकास विभाग, डीआरडीओ भवन, राजाजी मार्ग, नई दिल्ली-110011
Ministry of Defence, Department of Defence R&D, DRDO Bhawan, Rajaji Marg, New Delhi-110011
दूरभाष/Phone : 011-23011519, 23014350, फैक्स/Fax : 011-23018216, ई-मेल/E-mail : secydrdo@gov.in

Preface

इतिहास, *iti ha āsa*, in Sanskrit, means "so indeed it was". The word is used often in combination with Puranas to denote ancient Indian epics which continue to inspire the lives of generations. The word "Historia" in Greek language means "learning by enquiry or investigation". Aristotle believed that to understand anything, you must observe its beginning and development. Thus, the scope of History as a subject goes beyond mere narration of events. The desire to learn from past events is a powerful motivation.

Endeavours in Self-Reliance is a historical account of Defence Research and Development in India, covering the period 1983–2018. The three and half momentous decades were periods of explosive growth, achievements, expectations and challenges for Defence R&D. Annual budget grew from around Rs 314 Cr in the mid-1980s to Rs 17,000 Cr in 2018. Output of the defence R&D efforts as measured by financial value of indigenous production went up steeply to exceed Rs 300,000 Cr. Hundreds of development projects were completed covering practically every aspect of defence requirements. This chronicle covers the vast efforts of the Organisation, establishments and laboratories under the aegis of the Department of Defence Research and Development, in a single volume, as succinctly and accurately as possible.

The opening chapter prepares the ground for appreciating the Defence R&D efforts in the national and global perspectives. It explains the policy issues and the essentiality of the self-reliance goal. Chapter 2 provides a quick summary of the earlier volume which traced the history of Indian defence research up to 1982. The next chapter on the Mandate and Organisation explains how the role of DRDO evolved over the decades and how it stands ready to adapt to future changes. A description of the organisational structure as it evolved has been provided. Leadership is the theme of the Chapter 4. Profiles and reminiscences of former Heads of DRDO help to improve our understanding of the background.

Chapter 5 is devoted to the details of the research and development programmes, technological infrastructure, test and evaluation and all such elements which complete the chain. Attention is drawn to the major twists and turns in indigenous development, sweet successes and some missed opportunities. We bring you some interesting accounts of how DRDO coped with crises, turning adversities into opportunities. There is a lot of dynamism in the course of mission-oriented projects. While we were engaged in the mammoth task of collecting and compiling the data regarding the progress from 1983–2018, significant events continued to happen. These recent events "till going to press" have been collected and presented briefly in Chapter 6 "Recently (2019–2021)".

Chapter 7 deals with the key topic of evaluating the impact made by Defence R&D. We have tried to provide, in a capsule form, the entirety of contributions of DRDO by systems delivered, by production values, by employment generation, on the basis of verifiable data. We have added an analysis of the challenges and shortcomings which have hampered achievements. We hope that this chapter would provide the reader with the opportunity to assess for herself what and how much has been done and what remains to be done.

The last chapter on "Images" is a photo essay which we hope you will enjoy browsing through.

An excellent predecessor volume covering the events up to the year 1982, edited by Dr Ramadas P Shenoy blazed a trail which guides the present effort. Of course, as the scope of coverage has expanded so vastly since, we are forced to be more selective in our compilation. A new feature in the present edition is the inclusion of special essays by scientists, soldiers and administrators who were involved as participants in the R&D programmes. Their special essays inserted in the relevant sections of Chapter 5 are sure to add value and some nostalgic flavour.

Difficulties abound in gathering and collating information of historical interest in a large and busy organisation such as DRDO, engaged over a vast front of science and technology. Some major programmes in the strategic weapons sector cannot be included in this volume which is meant to be circulated widely nor can we describe detailed technical capabilities of many of the weapons and systems developed. There is also the challenge of being selective in the inclusions. We are conscious that we might have missed many notable achievements which are worthy of mention in this historical account. There might also be some misreporting, owing to our editorial limitations. We apologise for such inadvertent lapses.

The contents of this history include the actions, thoughts and impressions of the “Labs”, “DRDO Headquarters” and several eminent persons who had been participants in the great venture. All do not think alike nor do they recall past events similarly. They also do not express themselves in similar language or style. We have let the organisations and the people come through and speak in their own “language and style” as far as possible. We hope the readers will appreciate the spontaneity.

This is not a “coffee table glossy” dedicated to extolling the virtues of DRDO. Nor is it an auditors’ report focussing on the shortfalls and lapses exclusively. The scope of coverage of the science and technology domains in Defence R&D in India has few parallels in the world. The volume seeks to present a balanced picture of a national effort of truly Himalayan proportions. Results recorded here speak for themselves. Splendid successes, accomplishments with scope for improvements as Mk-II, deferred decisions, opportunities lost and some plain technical failures are all part of the historical account. We have endeavoured to be objective and to ensure that our analyses rest on the bedrock of validated data. The aim is to understand the progress made and examine how much of the objectives have been achieved, “to examine through the eyes of a friend-
मित्रस्य चक्षुषा समीक्षामहे। (यजुर्वेद 36/18)”.

Speaking personally, I recognise the crucial role played by my own professional experience in a career of 37 years in DRDO, in compiling this edition of history. Shared experiences and old comradeships helped me enormously. I am most grateful to DRDO for having provided me with rich and varied opportunities during my career earlier and for giving me the privilege of recording its luminous history now.

Bengaluru, October 2021



(KG Narayanan)

Principal Editor

Grateful Acknowledgements

When I accepted the assignment of editing the history of DRDO, I was aware that I would have to count on the co-operation of numerous participants from the Laboratories and Headquarters for inputs. I also knew that it would not be easy for these busy persons to take time away from their current pre-occupations to contribute to the recalling of history. Many of them showed great enthusiasm for the project, provided copious and timely inputs and offered helpful suggestions. Others were patient with my proddings as they struggled with the incessant demands of the present and to help me in telling the story of the past. I am most grateful to all the Directors and senior scientists of the DRDO Laboratories, Establishments and Centres for generating so much information about the years gone by. My mind goes back to my personal experience at the turn of the century when Dr RP Shenoy was editing the earlier volume of DRDO History, entreating and cajoling the Directors of laboratories to write their stories. Well, history did repeat itself!

The impulse for the preparation of this edition of DRDO's history was given in 2016 by Dr S Christopher, Chairman DRDO. He was generous with his time and support to see the project completed early. The proposal was exciting to me. However, as I had been off DRDO's radar for nearly 15 years, I had some reservations on how to approach the mission. Conversations with former colleagues in DRDO helped me to see that I would be making a worthwhile contribution. It was also fortunate that Dr VS Arunachalam, Dr VK Aatre, Shri M Natarajan and Dr S Christopher readily agreed to record their recollections of events and personal impressions. Their reminiscences help in placing many major decisions and events of those days in proper perspective. My sincere thanks are due to all of them. I am very grateful to Dr G Satheesh Reddy, Chairman DRDO and Secretary of Department of Defence R&D for reviewing the progress of the project and providing valuable suggestions.

My thanks are due to everyone in the DRDO Headquarters who helped. I must make a special mention of the inputs provided by Smt Nabanita Radhakrishnan, Director General, on the topics of economic impact of indigenous production and forward planning. She also reviewed the draft text in June 2021 and made several valuable suggestions for improvement. I am especially thankful to her.

One of the important features of this volume is the inclusion of personalised accounts by those who played important roles during their respective careers in DRDO, Academia, Armed Forces, Defence Production and Administration & Finance wings. I was somewhat surprised and truly gratified at the enthusiastic response from all of them with distinguished records of accomplishments of their own. Their readiness to co-operate clearly demonstrated the high regard they have for DRDO's work. The list of these Special Contributors is long because the canvas is vast. I must, however, include their names here and thank them individually for their contributions which help transform this volume from a mere account of events into readable history.

Special Contributors (in the order of inclusion of the essays in Chapter 5)

Lt Gen (Dr) VJ Sundaram, Dr Prahlada Ramarao, Smt Rohini Devi, Dr S Saikumar, Dr A Sivathanu Pillai, Shri MV Kotwal, Prof R Narasimha, Dr Kota Harinarayana, Wg Cdr R Kothiyal, Shri PS Subramanyam, Shri M Subba Rao, Cmde CD Balaji, Dr K Ramchand, Dr CG Krishnadas Nair, Air Chief Marshal AY Tipnis, Maj Gen D Kapil, Shri Dharendra Singh, Shri S Sundaresh, Shri P Sivakumar, Dr K Aprameyan, Maj Gen SS Sharma, General S Roychowdhury, Prof A Paulraj, Dr R Krishnan, Dr J Narayana Das, Admiral Arun Prakash, Shri S Varadarajan, Shri N Divakar, Shri S Bimal Khedkar, Gp Capt D Venkateshwarlu, Air Cmde VB Goley, Shri J Shanker Rao, Shri SK Kaura, Capt S Prabhala,

Shri M Gopal Rao, Dr Vikram Kumar, Dr Ramesh Gulati, Dr R Muralidharan, Dr SS Rana, Prof D Banerjee, Dr Rugmini Sankaran, Dr SS Murthy, Shri Jnan Prakash, Maj Gen Umang Kapoor, Shri R Balakrishnan and Col. Kamal Nain Rai.

DESIDOC is an exceptional asset in Information Science and Technology in DRDO. It is a privilege for authors and editors to be associated with this institution as publishers. Shri Gopal Bhushan, as the Director got the project moving with great promptitude in 2016. Dr Alka Suri followed it up with consistent support until August 2021. Smt Alka Bansal, Smt Gunjan Bakshi, Shri NK Chawla and their colleagues carried the project through to its successful conclusion by their professional skills and enthusiasm. The contributions of DESIDOC personnel to this project are more remarkable in view of the personal adversities faced by them during the difficult times of the pandemic. My sincere thanks are due to all of them.

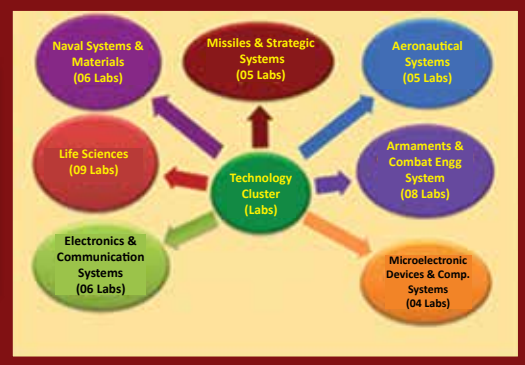
Editing this volume has been a mammoth task which took a significant portion of my time during the last few years. I express my sincere thanks to my wife Revathi and members of my immediate family for their constant support. They overlooked my “virtual” absence from the domestic environment, long after formal retirement, most indulgently!

KG Narayanan
Principal Editor

Defence R&D Laboratories & Programmes

ADA	Aeronautical Development Agency
ADE	Aeronautical Development Establishment
ADRDE	Aerial Delivery Research and Development Establishment
ARDE	Armament Research & Development Establishment
ASL	Advanced Systems Laboratory
BrahMos-JV	BrahMos Aerospace India-Russia JV
CABS	Centre for Airborne Systems
CAIR	Centre for Artificial Intelligence & Robotics
CEMILAC	Centre for Military Airworthiness and Certification
CEPTAM	Centre for Personnel Talent Management
CFEES	Centre for Fire, Explosive and Environment Safety
CHES	Centre for High Energy Systems and Sciences
CVRDE	Combat Vehicles Research & Development Establishment
DARE	Defence Avionics Research Establishment
DEAL	Defence Electronics Application Laboratory
DEBEL	Defence Bio-Engineering & Electro Medical Laboratory
DESIDOC	Defence Scientific Information & Documentation Centre
DFRL	Defence Food Research Laboratory
DGRE	Defence Geoinformatics Research Establishment
DIBER	Defence Institute of Bio-Energy Research
DIHAR	Defence Institute of High Altitude Research
DIPAS	Defence Institute of Physiology & Allied Sciences
DIPR	Defence Institute of Psychological Research
DLJ	Defence Laboratory Jodhpur
DLRL	Defence Electronics Research Laboratory
DMRL	Defence Metallurgical Research Laboratory
DMSRDE	Defence Materials and Stores Research and Development Establishment
DRDE	Defence Research Development Establishment
DRDL	Defence Research & Development Laboratory
DRL	Defence Research Laboratory
DTRL	Defence Terrain Research Laboratory
DYSC	DRDO Young Scientists Centre
GAETEC	Gallium Arsenide Enabling Technology Centre
GTRE	Gas Turbine Research Establishment
HEMRL	High Energy Materials Research Laboratory
INMAS	Institute of Nuclear Medicine & Allied Sciences
IRDE	Instruments Research & Development Establishment

ISSA	Institute for Systems Studies & Analyses
ITM	Institute of Technology Management
ITR	Integrated Test Range
LASTEC	Laser Science & Technology Centre
LRDE	Electronics & Radar Development Establishment
MTRDC	Microwave Tube Research & Development Centre
NMRL	Naval Materials Research Laboratory
NPOL	Naval Physical & Oceanographic Laboratory
NSTL	Naval Science & Technological Laboratory
PXE	Proof & Experimental Establishment
R&DE(Engrs.)	Research & Development Establishment(Engrs)
RCI	Research Centre Imarat
SAG	Scientific Analysis Group
SSPL	Solid State Physics Laboratory
TBRL	Terminal Ballistics Research Laboratory
VRDE	Vehicles Research Development Establishment



1. Defence Technologies and Self-Reliance

1.1 Preparedness

Conflicts arise among nations over political ideologies, economic interests or differing perceptions of historical factors. Quite often, they escalate over short periods of time. A nation dedicated to the well-being and safety of her citizens must necessarily pay constant attention to national security which encompasses territorial integrity and the security of her citizens—ensuring that national territories and resources are not encroached upon by adversaries, through war or through covert hostile action. A wise nation “keeps its powder dry” even while dedicating herself sincerely to the ideals of human development and global peace. To balance and manage the demands placed on available resources by development and by security needs simultaneously is a serious and constant challenge.

India’s journey in defence preparedness started almost immediately after she attained independence. Daunting challenges to her territorial integrity and security were thrown at her—in the form of armed intrusions into Jammu & Kashmir and three major wars in the first 25 years of her existence as an independent nation. These wars came upon India even as she was making heroic efforts to rebuild economic capacities that had been plundered and shattered by centuries of colonial rule and to provide citizens with basic needs of food, shelter, healthcare, education and human dignity. How well the Indian people weathered the storms and forged ahead with unwavering commitment to the democratic constitution, is a saga unparalleled in world history.

Unfortunately, the benefits of the ending of the global Cold War in 1989—so called “peace dividend”—resulting in reduced demands for war fighting capabilities in many Western countries did not reach India. As global political and ideological scenarios changed, new threats of proxy war and hostilities by non-state actors emerged and intensified in our neighbourhood in the 1990s. Indian concerns on national security remain unabated.

Eternal vigilance is the widely recognised price of liberty. India is determined to meet these security challenges fully and effectively. At the same time, India remains committed to safeguard its independent posture in national and international affairs. As an essential component of this posture, India has a vision and a road map for attaining self-reliance in technologies. Department of Defence Research and Development of the Government of India is mandated to help transform this vision into reality.

1.2 Technology in War

Successive generations of the human race have handed down legendary accounts of astonishing feats performed in war—such as the use of thunderbolts and lightning, weapons which released enormous energy to achieve mass destruction and space & time travel. Some of these accounts may appear to foretell the arrival of the high technology weapons of today. How much of these legends are based on evidence and how much on fertile imagination are conjectures which we can leave conveniently alone.

There is no doubt, however, that modern wars are technological to a great extent. Highly sophisticated multirole military aircraft, intercontinental ballistic missiles, battle tanks with unprecedented mobility, fire power and immunity, ships and submarines with very low observable signatures, guided weapons, unmanned platforms for surveillance and attack and other such systems have become common in operational use now. Sensors, communication networks and electronic warfare dominate the scene in battle and in preparation for it. 21st century war fighting concepts emphasise the role of space platforms, network-centric operations, information warfare and robotics. Significant roles for non-lethal warfare are envisaged. Management of the physiology and psychology of the war fighters is likely to be highly technology based. It is evident that the scope of interaction of application of scientific principles with the conduct of war and defence preparedness has indeed become very wide.

Does technology win wars? Most certainly it does, other things remaining the same. Does superior technology always determine the winner? The answer to this question is less certain, going by the outcomes of conflicts in the 20th and 21st centuries. Application of technology might be a necessary but not a sufficient condition to ensure victory in war. Several other factors such as strategy, tactics, morale, costs and availability of industrial base to sustain the technologies enter the calculation. Certainly, availability of an uninterrupted domestic design and manufacturing base is seen to be an essential condition for the application of high technology to win wars.

1.3 National Goal of Self-Reliance

National leadership has emphasised consistently the goal of self-reliance for the full development of independent India. Prime Minister Shri Jawaharlal Nehru wrote in the

3rd Five Year Plan, referring to the economic and industrial development of India “The only viable meaning of self-reliance in an increasingly interdependent world is that we should be able to pay our way in our international transactions through our exports and normal inflow of capital, that we should do away with reliance on official aid which is never free of strings.” Addressing the DRDO scientists in 1992, Prime Minister Shri PV Narasimha Rao referred to the climate of international sanctions and trade embargos and stated “we have to depend on ourselves.... you have to depend on your own resources, resources not necessarily in monetary sense but resources of all kind ... so this taboo (embargo) which is going to be slapped on you, you will have to face this for a long time”.

Prime Minister Dr Manmohan Singh said in his speech in the special session of the Parliament in 1997, “Self-reliance must remain the cardinal principle of our economic and social policies. But it has to be interpreted in a dynamic world” and suggested that “we can pursue greater self-reliance by creating inter-relationships and inter-dependence that enhance our bargaining power.” The inspirational goal of आत्मनिर्भर भारत, “Atmanirbhar Bharat” established by Prime Minister Shri Narendra Modi in 2020 spells out the major goals for the defence sector-FDI limit in defence manufacturing to be increased, Make in India initiative to be promoted.

India’s quest for self-reliance in defence technologies started early and is based on several strong reasons related to strategic policy considerations and practical realism. The need was elaborated in the detailed analysis made by Prof PMS Blackett in his report to the Prime Minister in 1948 thus: “On the other hand, a long and continued dependence on imported weapons might not be acceptable militarily and politically. Firstly, difficulties could be experienced in getting the latest weapons from abroad without accepting military and political obligations, which might

About the Book

A historical account of Defence Research and Development in India is presented covering the period 1983 – 2018 which were decades of explosive growth and achievements, expectations and challenges. Annual budget grew from Rs. 300 crores to Rs. 17,000 crores. Output of the defence R&D efforts measured by financial value of indigenous production achieved went up steeply to Rs. 300,000 crores. Hundreds of development projects were completed covering every aspect of defence requirement. Through the efforts of a single generation of scientists, soldiers, managers and policy makers, the indigenous capabilities in nuclear weapons, guided missiles, fighter aircraft, aerial early warning system, UAVs, battle tanks, artillery guns, rocket launchers, strategic submarines, underwater sensors, torpedoes, radars, communications, electronic warfare and other domains including life support measures for the warfighters were inducted in service use. This chronicle describes the huge efforts made by the establishments under the aegis of the Department of Defence Research and Development, as succinctly and spontaneously as possible, based on the reports and descriptions rendered by the laboratories and by major contributors who participated in the vast national endeavour.

About the Author



Dr KG Narayanan, Principal Editor of this volume completed his career in DRDO as the Chief Advisor at DRDO Headquarters after having been a member of its scientific workforce from 1965 to 2002. He contributed to several of the development programmes described here. He led two of the major laboratories—Aeronautical Development Establishment (ADE) and Defence Avionics Research Establishment (DARE) during the years 1986-2001. He also worked in the Solid State Physics Laboratory (SSPL) earlier and at DRDO Headquarters, thus acquiring a breadth of professional experience.

Dr Narayanan is a BSc of Madras University, BTech. (Hons.) of IIT, Kharagpur and PhD of IISc, Bangalore. He is a Fellow of the Indian National Academy of Engineering, a Distinguished Alumnus of IIT, Kharagpur and a recipient of several honours including the Systems Society Gold medal and DS Kothari Award of the Indian Science Congress Association. His current interests include history of Indian science and society.

Price: INR ₹ 2100
US \$ 75
UK £ 65

978-93-94166-06-6



**DEFENCE RESEARCH & DEVELOPMENT ORGANISATION
MINISTRY OF DEFENCE, INDIA**