

Foreword

Satish Dhawan

It is somewhat unusual for a daughter to be writing a Foreword to a collection of tributes to her father, a situation brought about by exigent circumstances involving both extreme over-work and ill health of the original editors of this Special Section on Satish Dhawan. Roddam Narasimha and K. Kasturirangan were responsible for conceptualizing this Special Section and selecting the contributors. I have attempted to fill the last-minute editorial vacuum, deriving support from past discussions with both Narasimha and Kasturirangan who knew Dhawan deeply, over the course of decades.

Following a brief overview of Dhawan's life and career, this collection of tributes in his centenary year is loosely organized based on the affiliation of the author, and where their paths crossed with Dhawan: the Indian Institute of Science, the Indian Space Research Organization, other organizations such as the National Aerospace Laboratories, the Raman Research Institute, the Indian Academy of Sciences, and the Karnataka State Council for Science and Technology. Interested readers are also referred to the collection of online talks organized by the Indian Academy of Sciences and ISRO in September 2020 that are available on YouTube, the format of these symposia being yet another reminder of this unusual pandemic period.

In the years just before Independence, among the more central plans for governance were ideas for how independent India would build and strengthen its capabilities, including modern scientific institutions and industry. Far-sighted individuals formulated a programme for educating young Indians in the best centres for technical and scientific education in the UK and USA based on recommendations such as those by Nobel Laureate A. V. Hill, whose influential report also sparked the creation of the CSIR. A thousand scholarships were awarded to aspiring young Indians who became part of the generation that built modern India. They came of age in an era of new nationhood and were held in thrall by the manner in which the freedom fighters committed not only their reason and emotion, but also their entire beings to the cause of freedom, and an idea of egalitarianism and self-determination. These young people built with ambition and hard work, ideals and imagination. Satish Dhawan was one of them.

With the benefit of hindsight, an observer can find early signs of greatness in individuals, but for most people, there is little clarity or time in the rush of life to contemplate what one might be remembered for. Satish Dhawan is remembered not just because he transformed every institution with which he was associated, leaving a legacy of rigour, creativity and excellence in scientific endeav-

our, but also because he worked to ensure transparency, fairness and accountability in decision-making, and to create humane administrative systems that recognize that institutions are built of individuals whose aspirations must be valued.

Satish Dhawan was born in Srinagar on 25 September 1920 to a progressive middle-class family. His father, Devidayal Dhawan, was a judge, whose family came from the North-west Frontier Province town of Dera Ismail Khan, and his mother Lakshmi Khosla Dhawan, grew up in Srinagar where her father was the chief medical officer. Dhawan's boyhood in the towns all around pre-Independence Punjab – Multan, Sargodha, Ludhiana, Amritsar and Lahore – was a comfortable existence marked by close-knit family relationships, frequent visits to his maternal grandfather's house in Srinagar, but set against the backdrop of the growing freedom movement, and the powerful moral influences of Gandhi and Nehru.

Because of the transferrable nature of a judge's appointments, Dhawan's early education was informal, being imparted by a series of local Masterjis, and took a backseat to his obsession with cricket – he had to be hauled off the playing field to give his Matriculation exams as a private student in Ludhiana in 1934. After an Intermediate degree in Science in Ludhiana in 1936, Devidayal's transfer to Lahore meant that Satish spent the next few years at Government College, Lahore obtaining a BA in mathematics and physics in 1938, followed by an MA in English Literature in 1941 (perhaps because it was thought that English language proficiency would boost any career in British-ruled India). At this stage, he could have looked for a position in the Railways (as he was advised by well-wishers), but Dhawan opted to get a degree in Engineering at the MacLagan Engineering College in Lahore. While all his previous degrees were obtained in the second division, Dhawan appears to have hit his stride in studying engineering and he thrived, topping the university and winning the MacLagan Gold Medal. These were the years of the World War II, and a formative experience during his engineering degree was the year and a half of internship spent at HAL in Bangalore in 1944–45, where he worked on the shop-floor learning the nuts and bolts of aeronautical engineering while fixing Allied war planes flown in from the Pacific Theatre. The department of Aeronautical Engineering (now Aerospace Engineering) at the IISc had been started by V. M. Ghatage in 1942, and the intersections with HAL were many, sparking deep interest in Dhawan's mind, and inspiring him to apply for the newly announced Government scholarships for graduate education in the US.

In late 1945, travelling to the US on an American troopship were several students destined to return and serve India with their technical and creative skills. On

board the M/S Torrens, with Dhawan were Brahm Prakash, later a close colleague at IISc and ISRO, and Indar Kapila, a fellow Punjab University graduate who was instrumental in the design and construction of Bhakra-Nangal dam. Reaching New York with the expectation of heading to California, Dhawan found that Caltech had not re-started its educational programme after its wartime efforts in aviation, and he was assigned to the Aeronautics programme at the University of Minnesota in Minneapolis. The year spent at Minneapolis yielded a Master's in Aeronautical Engineering, but also permitted Dhawan to explore second-hand bookshops acquiring a range of books that cemented his love of literature. Second-hand bookshops became a favourite haunt when he finally settled in Bangalore.

GALCIT (then the Guggenheim Aeronautical Laboratories at the California Institute of Technology, but where the G now simply stands for Graduate), founded by the brilliant Theodore Von Karman, was already a thriving centre for aeronautical research. Arriving at Caltech in 1947, Dhawan found the mentor, colleagues and friends who would change the arc of his life. Hans Liepmann, his PhD guide, and Anatol Roshko, a fellow student were both drawn to America from elsewhere – Hans from Germany via Istanbul, and Anatol, from Ukraine, after a childhood spent in a small mining town in Canada. The three immigrants formed a firm professional and personal friendship. Their scientific and personal connection was deep, based on respect, excitement and appreciation of scientific ideas, egalitarian ideals, and humour, and lasted a lifetime.

Hans, Anatol and Satish had a shared dislike of bombast and self-importance. Typified by Roshko in his acceptance speech for the Timoshenko Medal of the American Society for Mechanical Engineering is their shared feeling about the abundant honours that all three received over their careers. Roshko's joke is set in the former Soviet Union – Two friends are at a grand reception sipping cocktails when one notices a man with his chest almost completely covered with medals. Says one to the other, 'Do you have any idea what those medals are for?' and the other replies, 'Well, you see that one at the top left? That one was a mistake; and the others followed automatically.' This joke was their typical response to the numerous awards that all three earned over their lives. The experiences at Caltech left a strong impression on Satish and in many ways were defining for the self-reliant and hands-on engineer he became, reinforcing his strong sense of democratic values.

Returning to India in 1951, Dhawan joined the Department of Aeronautical Engineering at the IISc as a Senior Scientific Officer. He was soon promoted to Assistant Professor, and because of his whole-hearted engagement with teaching and research was asked to head the department in 1955. In 1956, Dhawan married Nalini Nirody, a cytogeneticist who had just returned from her

doctoral studies in Washington University, St Louis. Nalini's family hailed originally from South Canara, but she had grown up in Madras where her father B. S. Nirody was a translator. Mr Nirody was a self-taught horticultural enthusiast who had won a scholarship to study in the US in 1920, and was subsequently responsible for introducing many plant varieties to India – he was a familiar figure at IISc, having started the plant nursery there in 1949, presaging the green loveliness of the sprawling campus. Together, Satish and Nalini embarked on a life in IISc marked by their complete identification with the institute and the progress and welfare of its faculty, staff and students.

The year 1956 was also important to Dhawan as he was invited to address the meeting of the World Federation of Scientific Workers at Beijing, the President at the time being Frederic Joliot-Curie. Back at IISc, a group of like-minded scientists and university professors used to meet regularly to discuss Indian history (initiated by D. D. Kosambi, the polymath), socialist values and the importance of ensuring that the benefits of science and education were available to the common man. In addition to their scientific contributions, from this group emerged highly impactful work in appropriate technology, spearheaded by A. K. N. Reddy, and in science education and outreach at the state level – with M. A. Sethu Rao, A. R. Vasudeva Murthy and others creating the Karnataka State Council for Science and Technology. Dhawan's instinctive ideals of social justice, and his focus on enabling fair and open dialogue between management and workers at all levels in both IISc and later at ISRO, were influenced and honed by the discussions initiated during those formative early friendships, and continued throughout his life.

Satish Dhawan was many things to many people. The articles in this Special Section cover different elements of Dhawan's contributions, and more importantly, the influence he had on the authors' way of thinking or the ideas he opened their minds to or encouraged, by his actions and his example. Several contributors have raised multiple aspects, so the articles are grouped by the spaces where the contributor and Dhawan intersected. Thus, Roddam Narasimha, P. Balaram and C. N. R. Rao represent his IISc days, T. Prahlad, B. L. Deekshatulu represent the intersection of IISc and ISRO and NAL, K. Radhakrishnan, R. Aravamudan, V. Siddharth and Y. S. Rajan, B. N. Suresh and P. Kale reflect on the ISRO days, G. Srinivasan and U. Shrinivasa recount his association with RRI, the Indian Academy of Sciences, ASTRA and KSCST and finally, I provide a personal account on Dhawan's relationship with his brother Ranjit and their shared obsession with flight.

In the opening article, Roddam Narasimha (**page 1422**), Dhawan's student, colleague, and lifelong friend, recalls his association with Dhawan for over half a century. Narasimha's and Dhawan's lives and careers were intertwined from the early fifties onwards. Narasimha's

recollections begin with Dhawan's refreshingly simple and straightforward approach to teaching, and his low-cost experimental approach to performing exciting research on problems faced by the needs of the aircraft industry. In an article imbued with a deep understanding of not just Dhawan as a scientist but also as an idealist with immensely practical instincts, Narasimha takes us through his own experience in fluid dynamics research at IISc and Caltech, which was so intimately connected with Dhawan's journey. Narasimha recalls how Dhawan was quick to assign credit and refused to have his name on papers where the key observations and experiments were contributed by the student. He highlights how Dhawan had enormous faith in Indian talent, and worked both at IISc and at ISRO to convey that confidence to young people, so that they were themselves convinced of their worth. He calls Dhawan a silent socialist, ascribing his values to beliefs that placed social justice at the core of his motivations.

In his article 'Satish Dhawan: The transforming of the Indian Institute of Science' P. Balaram (page 1427), the quintessential raconteur of science and scientific personalities gives us a short history of how the winds of change came to sweep IISc from a stately and slow-moving vessel to an adaptive research organization, and Dhawan's role in that transformation. With his characteristic style which readers of his *Current Science* editorials value for its wit and insights, Balaram also focuses on Dhawan's love of Bangalore, the spirit of enabling others, the scientific and managerial rigour, his attention to attracting talented and now legendary scientists to the Molecular Biophysics Unit, the Solid-State and Structural Chemistry Unit, and the Centre for Theoretical Studies, among others. The box item on the Raman letter adds a bit of mystery to the piece, and should foster a wider interest in maintaining better archives than we currently have in most scientific organizations.

T. S. Prahlad (page 1433) interacted with Dhawan at all stages of his own career, from IISc Aero student to VSSC engineer, from experiments in wind tunnels, through the early days of SLV3, to his Directorship of NAL. In his article, 'A privileged association with Prof. Satish Dhawan', Prahlad shares his technical appreciation of the scientific problems tackled with the aircraft industry in mind, speaks of the precision of Dhawan's instrument design and the skilled ability of the Aero department mechanics to execute them. He also highlights the importance of the external review system at ISRO for keeping a project on track and honest, with clearly documented progress, which is the core of ISRO's culture. This is a recurring theme in many of the pieces by other colleagues. In addition, he speaks of how Dhawan enabled smooth transitions by identifying and grooming people into leadership roles, and the clarity of Dhawan's philosophy of international collaborations when needed, but with indigenization and self-reliance as a core objective.

C. N. R. Rao (page 1439), one of the brightest stars attracted to IISc by Dhawan and who himself led IISc for a decade, writes a brief tribute from the heart focusing on what Dhawan meant to him in 'Satish Dhawan (25 September 1920–3 January 2002)'.

Another IISc student turned colleague, B. L. Deekshatulu (page 1440) in his article 'Prof. Satish Dhawan: Visionary, humanitarian and unparalleled administrator' shares his recollections as an MSc, PhD student then Professor of Computer Science and Digital Technology in the newly formed School of Automation. After a period spent at IBM, Deekshatulu was deeply involved in remote sensing using aerial surveys, and has a humorous metaphor for how Dhawan changed the somewhat dictatorial single Professor system to the rotating heads of departments. Deekshatulu writes about the first-ever forest cover survey using remote sensing, and along with other articles later in the section speaks of Dhawan's role in catalysing the National Natural Resources Management System (NNRMS), presaging the IRS satellites with the focus on the big picture, as well as immediate action to achieve objectives. He also speaks with feeling about Dhawan's defense of Nambinarayanan as an example of his willingness to speak out against injustice.

Like Kasturirangan, as someone who occupied the same position later, K. Radhakrishnan (page 1444), had a ringside seat to the daily workings, as well as the legacy of Dhawan in ISRO. As Chairman ISRO, he obtained a deep sense of the management and delivery of programmes set in place earlier, which he recounts, in his article 'Satish Dhawan: A transformational leader of Indian Space Programme'. He points out how, as early recruits to space programme in the Sarabhai days, there were many idealists, highly committed and motivated, so there was great energy in the initial structure. However, as time progressed, the organizational aspects needed cohesion for the larger role envisaged, which Dhawan brought in. Radhakrishnan also underscores the importance of the separation and identities of different elements – (policy) Space Commission, (governance) DoS, (executive) ISRO. He speaks of seminal decisions in ISRO that gave it its character and backbone, the democratic and de-centralized techno-managerial decision-making. He highlights the key concept that expertise is valued more than seniority, and that open discussion allows the tension between democratic functioning and organizational cohesion to be constructive.

A unique perspective is provided in the candid account by R. Aravamudan (page 1448) in 'Satish Dhawan, the academic who professionalized space research in India'. Aravamudan has a deep understanding of the space programme, having joined as an impressionable young engineer when the charismatic and brilliant Sarabhai was laying the foundation. He grew with the organization to serve as the Director of the Sriharikota Launch Centre now named after Dhawan, as well as of the U. R. Rao

Satellite Centre in Bangalore. Aravamudan provides an interesting sociological perspective of the response of ISRO staff to the new chairman in describing the first visit of Dhawan to Thumba, an honest response to the change in leadership style, and ultimate appreciation of both styles and their appropriateness in very different phases of the programme. He acknowledges the need for change to a system where accountability to parliament was critical to justify the large outlays of public spending, Dhawan's introduction of a highly structured process for seeking and deploying programmes, and appreciates the non-hierarchical reviews and input sought. He also details the focus on partnering with industry yet sustained academic involvement, and the transparent mechanism of failure analysis for which ISRO has become well known. Importantly, he covers issues of personnel management and parity in a growing organization, resulting in a great improvement in job satisfaction, and highlights Dhawan's ability to deal with labour issues, where his commitment to social justice was evident. He appreciates Dhawan's intellectual honesty, and his ability to quickly recognize merit.

V. Siddhartha and Y. S. Rajan (**page 1452**) were members of a tight-knit group of four young whizz-kids inducted by Dhawan at ISRO HQ (the other two were K. S. Prabhu and Jai Singh). In 'Satish Dhawan: Refractions from another time', Siddhartha and Rajan tell of their unique insight into Dhawan as they spent long hours with him, discussing, disagreeing, executing, providing backup, travelling with him everywhere, preparing for meetings and policy discussions, troubleshooting, and ultimately, being inspired. Each of these four men went on to have stellar careers in different arenas. What shines through in the subtext of this piece is the camaraderie and idealism of their formative years. There are also some insights into the history of science policy, insider views and Dhawan's views on various decisions that have had a significant impact.

Now Chancellor Indian Institute of Space Science and Technology, B. N. Suresh (**page 1457**) like R. Aravamudan grew up in ISRO, watched, experienced and participated in the evolution of the band of enthusiastic scientists to a highly structured but open work environment, very focused on its national relevance and social obligations. In 'Satish Dhawan: Provider of a firm structure to ISRO and a major contributor to "ISRO Culture"', Suresh appreciates how the 'catchment area' for ISRO engineers and scientists was not confined to the elite institutes or those with foreign degrees, but how they were mostly drawn from Indian institutions: the faith that Dhawan placed in people's ability encouraged them to give their training and commitment to the programme. He also speaks of the culture of participatory management.

In 'Professor Satish Dhawan – A gentle integrator' Pramod Kale (**page 1461**) who served as Director, Space Applications Centre, Ahmedabad, and Director, Vikram

Sarabhai Space Centre, Thiruvananthapuram focuses on how Dhawan integrated diverse elements of the space programme to build a strong self-reliant organization. Both Kale and Aravamudan indicate how critical it was to have IAS officers of the calibre, energy and integrity of M. A. Vellodi and T. N. Seshan on board. From his long association with the programme for utilization of satellites for rural education, Kale speaks of how Dhawan sought from scientists their personal views about what Satellite Instructional Television Experiment (SITE) should be used for. He provides some very interesting observations about prevailing ideas using satellite-based methods to engineer social issues, and how Dhawan was opposed to pushing such an agenda, his attitude being that ISRO should provide information and opportunities, and leave people to decide how to use them. He gives a telling example of Dhawan's interactions with members of the Planning Commission in an INSAT task force meeting – some apparently expressed the view that awareness created by TV programmes and ads would lead to dissatisfaction resulting in revolution. Dhawan's response recalled by Kale is interesting 'Revolution caused by rising expectations should be always preferred and welcomed compared to revolution caused by rising frustrations'. He recounts how Dhawan had very clear views about trade unions and their importance, appreciating that workers were partners in nation-building, and therefore created mechanisms for non-confrontational dialogue between management and labour.

Among the host of other institutions with which Dhawan was associated, the closest to his heart were the Raman Research Institute, where he chaired the Council for many years, and the Indian Academy of Sciences (IASc), of which he was an active member and served for a while as President. Proposed for membership to the Academy by Raman himself, Dhawan invested substantial energy and passion into serving both the RRI and the IASc. Ganesan Srinivasan (**page 1469**) not only worked closely with Dhawan in both these organizations, he became a friend and has a unique perspective. In his piece, 'The spirit of a giant', Srinivasan gives an account of the structures Dhawan put in place in defining and managing the RRI-DST relationship to protect the scientific autonomy of the RRI and preserve its excellence. He also recounts Dhawan's efforts in IASc to define the role of the academy with respect to the public understanding of science, its relevance to citizens' concerns, the importance of public access, especially the declassification of scientific data for citizens to promote understanding and engagement with contemporary issues. Two other aspects Srinivasan touches on are Dhawan's willingness to use his access to the PM to bring about change not just for ISRO or scientific enterprise, but as a concerned citizen, for example in the creation of the Bangalore Planetarium, and the preservation of the unique ecology of Silent Valley. Finally, Srinivasan details the influence Dhawan

brought to bear as a man of conscience, to ensure that the wrongful accusation of an outstanding aircraft designer Raj Mahindra, was publicly corrected.

In his piece 'Vegetable oils for transportation fuels, the bus we missed', Shrinivasa Udipi (**page 1474**), who was associated with Dhawan in a number of scientific enterprises aimed at social relevance talks about Dhawan's interest in disseminating the fruits of research. He details Dhawan's promotion of appropriate technology spear-headed by A. K. N. Reddy at ASTRA, and in livelihood projects that could be assisted by participation in large national programmes such as SuTRA. He also gives an account of the creation of another organization mentioned by Balaram in his piece, the Karnataka State Council for Science and Technology, which has had a considerable impact at the state level, in sustaining a focus of scientific research on the development needs of society. The insights into these aspects of Dhawan are embedded in an account of the development of an unrealized project for converting biofuels into a viable alternative for diesel.

The final piece in this collection of memoirs and tributes to Dhawan the scientist and organizational leader, is a personal account (**page 1479**). 'Devidayal's sons: Satish and Ranjit Dhawan and the Fellowship of Flight' is not a straightforward historical description. Starting with

the brothers' shared fascination with all things aeronautical, I build on the connection between the theory and practice of flight, which presented itself in the lives of Satish, an aeronautical engineer and his brother Jit, a fighter pilot. This story itself is embedded in the backdrop of the post-independence development of aeronautical research and the aircraft industry in Bangalore, and the decisive role of the IAF in '65 and '71. I also reflect on what borders mean to a people torn apart by larger forces yet connected by culture and history, as a means of reflecting the experiences of the family, which in turn is the experience of many who lived through Partition. The form is non-linear narrative, aimed, like an impressionist painting, to create an assemblage that readers could complete for themselves in the context of all the other pieces in this collection.

The recurring threads that run through all these pieces are not just the esteem of the contributors for Satish Dhawan's scientific abilities and human qualities, but also a recognition of the ideals that he held dear, ideals that he worked hard to incorporate into administrative structures that enabled fair and effective work environments.

Jyotsna Dhawan