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Dreamers

During his frequent visits to Thumba, Prof. Sarabhai would openly review the progress of work with the entire team. He never gave directions. Rather, through a free exchange of views, he led us forward into new terrain which often revealed an unforeseen solution. Perhaps he was aware that though a particular goal might be clear to himself, and he could give adequate directions for its accomplishment, his team members might have resisted working towards a goal that made no sense to them. He considered the collective understanding of the problem the main attribute of effective leadership. He once told me, "Look, my job is to make decisions; but it is equally important to see to it that these decisions are accepted by my team members."

In fact, Prof. Sarabhai took a series of decisions that were to become the life-mission of many. We would make our own rockets, our own Satellite Launch Vehicles (SLVs) and our own satellites. And this would not be done one-by-one but concurrently, in a multi-dimensional fashion. In the development of payloads for the sounding rockets, instead of getting a certain payload and then engineering it to fit into the rocket, we discussed the matter threadbare with the payload scientists working in different organ-izations and at different locations. I may even say that the most significant achievement of the sounding rocket programme was to establish and maintain nation-wide mutual trust.

Perhaps realising that I preferred to persuade people to do as they were told rather than use my legitimate authority, Prof. Sarabhai assigned me the task of providing interface support to payload scientists. Almost all physical laboratories in India were involved in the sounding rocket programme, each having its own mission, its own objective and its own payload. These payloads were required to be integrated to the rocket structure so as to ensure their proper functioning and endurance under flight conditions. We had X-ray payloads to look at stars; payloads fitted with radio frequency mass spectrometers to analyse the gas composition of the upper atmosphere; sodium payloads to find out wind conditions, its direction and velocity. We also had ionospheric payloads to explore different layers of the atmosphere. I not only had to interact with scientists from TIFR, National Physical Laboratory (NPL), and Physical Research Laboratory (PRL), but also with payload scientists from USA, USSR, France, Germany and Japan.

I often read Khalil Gibran, and always find his words full of wisdom. "Bread baked without love is a bitter bread that feeds but half a man's hunger,"—those who cannot work with their hearts achieve but a hollow, half-hearted success that breeds bitterness all around. If you are a writer who would secretly prefer to be a lawyer or a doctor, your written words will feed but half the hunger of your readers; if you are a teacher who would rather be a businessman, your instructions will meet but half the need for knowledge of your students; if you are a scientist who hates science, your performance will satisfy but half the needs of your mission. The personal unhappiness and failure to achieve results that comes from being a round peg in a square hole is not, by any means, new. But there are exceptions to this like Prof. Oda and Sudhakar, who bring to their work a personal touch of magic based upon their individual character, personality, inner motives, and perhaps the dreams crystallized within their hearts. They become so emotionally involved with their work that any dilution of the success of their effort fills them with grief.

Prof. Oda was an X-ray payload scientist from the Institute of Space and Aeronautical Sciences (ISAS), Japan. I remember him as a diminutive man with a towering personality and eyes that radiated intelligence. His dedication to his work was exemplary. He would bring X-ray payloads from ISAS, which along with the X-ray payloads made by Prof. UR Rao, would be engineered by my team to fit into the nose cone of the Rohini Rocket. At an altitude of 150 km, the nose cone would be separated by explosion of pyros triggered by an electronic timer. With this, the X-ray sensors would be exposed to space for collecting the required information about the emissions from stars. Together, Prof. Oda and Prof. Rao were a unique blend of intellect and dedication, which one rarely sees. One day, when I was working on the integration for Prof. Oda's payload with my timer devices, he insisted on using the timers he had brought from Japan. To me they looked flimsy, but Prof. Oda stuck to his stand that the Indian timers be replaced by the Japanese ones. I yielded to his suggestion and replaced the timers. The rocket took off elegantly and attained the intended altitude. But the telemetry signal reported mission failure on account of timer malfunction. Prof. Oda was so upset that tears welled up in his eyes. I was stunned by the emotional intensity of Prof. Oda's response. He had clearly put his heart and soul into his work.

Sudhakar was my colleague in the Payload Preparation Laboratory. As part of the pre-launch schedule, we were filling and remotely pressing the hazardous sodium and thermite mix. As usual, it was a hot and humid day at Thumba. After the sixth such operation, Sudhakar and I went into the payload room to confirm the proper filling of the mix. Suddenly, a drop of sweat from his forehead fell onto the sodium, and before we knew what was happening, there was a violent explosion which shook the room. For a few paralysed seconds, I did not know what to do. The fire was spreading, and water would not extinguish the sodium fire. Trapped in this inferno, Sudhakar, however, did not lose his presence of mind. He broke the glass window with his bare hands and literally threw me out to safety before jumping out himself. I touched Sudhakar's bleeding hands in gratitude, he was smiling through his pain. Sudhakar spent many weeks in the hospital recuperating from the severe burns he had received.

At TERLS, I was involved with rocket preparation activities, payload assembly, testing and evaluation besides building subsystems like payload housing and jettisonable nose cones. Working with the nose cones led me, as a natural consequence, into the field of composite materials.

It is interesting to know that the bows found, during archaeological excavations at different sites in the country, reveal that Indians used composite bows made of wood, sinew, and horn as early as the eleventh century, at least 500 years before such bows were made in medieval Europe. The versatility of composites, in the sense that they possess very desirable structural, thermal, electrical, chemical and mechanical properties, fascinated me. I was so enthused with these man-made materials that I was in a hurry to know everything about them almost overnight. I used to read up everything available on related topics. I was particularly interested in the glass and carbon Fibre Reinforced Plastic (FRP) composites.

An FRP composite is composed of an inorganic fibre woven into a matrix that encloses it and gives the component its bulk form. In February 1969, Prime Minister Indira Gandhi visited Thumba to dedicate TERLS to the International Space Science Community. On this occasion, she commissioned the country's first filament winding machine in our laboratory. This event brought my team, which included CR Satya, PN Subramanian and MN Satyanara-yana, great satisfaction. We made high-strength glass cloth laminates to build non-magnetic payload housings and flew them in two-stage sounding rockets. We also wound and test flew rocket motor casings of up to 360 mm diameter.

Slowly, but surely, two Indian rockets were born at Thumba. They were christened Rohini and Menaka, after the two mythological dancers in the court of Indra, the king of the sky. The Indian payloads no longer needed to be launched by French rockets. Could this have been done but for the atmosphere of trust and commitment which Prof. Sarabhai had created at INCOSPAR? He brought into use each person's knowledge and skills. He made every man feel directly involved in problem solving. By the very fact of the team members' participation, the solutions became genuine and earned the trust of the entire team resulting in total commitment towards implementation.

Prof. Sarabhai was matter-of-fact and never tried to hide his disappointment. He used to talk with us in an honest and objective manner. Sometimes I found him making things look more positive than they actually were, and then charming us by his almost magical powers of persuasion.

When we were at the drawing board, he would bring someone from the developed world for a technical collaboration. That was his subtle way of challenging each one of us to stretch our capabilities.

At the same time, even if we failed to meet certain objectives, he would praise whatever we had accomplished. Whenever he found any one of us going over his head and attempting a task for which he did not have the capability or skill, Prof. Sarabhai would reassign activity in such a way so as to lower pressure and permit better quality work to be performed. By the time the first Rohini-75 rocket was launched from TERLS on 20 November 1967, almost each one of us was in his own groove.

Early next year, Prof. Sarabhai wanted to see me urgently in Delhi. By now I was accustomed to Prof. Sarabhai's working methods. He was always full of enthusiasm and optimism. In such a state of mind, sudden flashes of inspiration were almost natural. On reaching Delhi, I contacted Prof. Sarabhai's secretary for an appointment and was asked to meet him at 3.30 a.m. at Hotel Ashoka. Delhi being a slightly unfamiliar place, with an unfriendly climate for someone like me, conditioned to the warm and humid climate of South India, I decided to wait in the hotel lounge after finishing my dinner.

I have always been a religious person in the sense that I maintain a working partnership with God. I was aware that the best work required more ability than I possessed and therefore I needed help that only God could give me. I made a true estimate of my own ability, then raised it by 50 per cent and put myself in God's hands. In this partnership, I have always received all the power I needed, and in fact have actually felt it flowing through me. Today, I can affirm that the kingdom of God is within you in the form of this power, to help achieve your goals and realise your dreams.

There are many different types and levels of experience that turn this internal power reaction critical. Sometimes, when we are ready, the gentlest of contacts with Him fills us with insight and wisdom. This could come from an encounter with another person, from a word, a question, a gesture or even a look. Many a time, it could come even through a book, a conversation, some phrase, even a line from a poem

or the mere sight of a picture. Without the slightest warning, something new breaks into your life and a secret decision is taken, a decision that you may be completely unconscious of, to start with.

I looked around the elegant lounge. Somebody had left a book on a nearby sofa. As if to fill the small hours of that cold night with some warm thoughts, I picked up the book and started browsing. I must have turned only a few pages of the book, about which I do not remember a thing today.

It was some popular book related to business management. I was not really reading it, only skimming over paragraphs and turning pages. Suddenly, my eyes fell on a passage in the book, it was a quotation from George Bernard Shaw. The gist of the quote was that all reasonable men adapt themselves to the world. Only a few unreasonable ones persist in trying to adapt the world to themselves. All progress in the world depends on these unreasonable men and their innovative and often non-conformist actions.

I started reading the book from the Bernard Shaw passage onwards. The author was describing certain myths woven around the concept and the process of innovation in industry and business. I read about the myth of strategic planning. It is generally believed that substantial strategic and technological planning greatly increases the odds of a 'no surprises' outcome. The author was of the opinion that it is essential for a project manager to learn to live with uncertainty and ambiguity. He felt that it was a myth to hold that the key to economic success is computability. A quotation from General George Patton was given as a counterpoint to this myth—that a good plan violently executed right now is far better than a perfect plan executed next week. It is a myth that to win big one must strive to optimize, the author felt. Optimization wins only on paper, but would invariably lose later in the real world, the book said.

Waiting in the hotel lobby at 1 a.m. for an appointment two hours later was certainly not a reasonable proposition, neither for me nor for Prof. Sarabhai. But then, Prof. Sarabhai had always exhibited a strong component of unorthodoxy in his character. He was running the show of space research in the country—under-staffed, overworked—

nevertheless in a successful manner.

Suddenly, I became aware of another man who came and sat down on the sofa opposite mine. He was a well-built person with an intelligent look and refined posture. Unlike me—always disorderly in my dress—this man was wearing elegant clothes. Notwithstanding the odd hours, he was alert and vivacious.

There was a strange magnetism about him which derailed the train of my thoughts on innovation. And before I could get back to the book, I was informed that Prof. Sarabhai was ready to receive me. I left the book on the nearby sofa from where I had picked it up. I was surprised when the man sitting on the opposite sofa was also asked to come inside. Who was he? It was not long before my question was answered. Even before we sat down, Prof. Sarabhai introduced us to each other. He was Group Captain VS Narayanan from Air Headquarters.

Prof. Sarabhai ordered coffee for both of us and unfolded his plan of developing a rocket-assisted take-off system (RATO) for military aircraft. This would help our warplanes to take off from short runways in the Himalayas. Hot coffee was served over small talk. It was totally uncharacteristic of Prof. Sarabhai. But as soon as we finished the coffee, Prof. Sarabhai rose and asked us to accompany him to Tilpat Range on the outskirts of Delhi. As we were passing through the lobby, I threw a cursory glance at the sofa where I had left the book. It was not there.

It was about an hour's drive to the Range. Prof. Sarabhai showed us a Russian RATO. "If I get you the motors of this system from Russia, could you do it in eighteen months time?" Prof. Sarabhai asked us. "Yes, we can!" Both Gp Capt VS Narayanan and I spoke almost simultaneously. Prof. Sarabhai's face beamed, reflecting our fascination. I recalled what I had read, "He will bestow on you a light to walk in."

After dropping us back at the Hotel Ashoka, Prof. Sarabhai went to the Prime Minister's house for a breakfast meeting. By that evening, the news of India taking up the indigenous development of a device to help short run take-offs by high performance military aircraft, with myself heading the project, was made public. I was filled with many emotions—happiness, gratitude, a sense of fulfilment and these lines from a little-known poet of the nineteenth-century crossed my mind:

For all your days prepare
And meet them ever alike
When you are the anvil, bear –
When you are the hammer, strike.

RATO motors were mounted on aircraft to provide the additional thrust required during the take-off run under certain adverse operating conditions like partially bombed-out runways, high altitude airfields, more than the prescribed load, or very high ambient temperatures. The Air Force was in dire need of a large number of RATO motors for their S-22 and HF-24 aircraft.

The Russian RATO motor shown to us at the Tilpat Range was capable of generating a 3000 kg thrust with a total impulse of 24500 kg-seconds. It weighed 220 kg and had a double base propellant encased in steel. The development work was to be carried out at the Space Science and Technology Centre with the assistance of the Defence Research and Development Organization (DRDO), HAL, DTD&P(Air) and Air Headquarters.

After a detailed analysis of the available options, I chose a fibreglass motor casing. We decided in favour of a composite propellant which gives a higher specific impulse and aimed at a longer burning time to utilize it completely. I also decided to take additional safety measures by incorporating a diaphragm which would rupture if the chamber pressure for some reason exceeded twice the operating pressure. Two significant developments occurred during the work on RATO. The first was the release of a ten-year profile for space research in the country, prepared by Prof. Sarabhai. This profile was not merely an activity plan laid down by the top man for his team to comply with, it was a theme paper meant for open discussions, to be later transformed into a programme. In fact, I found it was the romantic manifesto of a person deeply in love with the space research programme in his country.

The plan mainly centred around the early ideas which had been born at INCOSPAR; it included utilization of satellites for television and developmental education, meteorological observations and remote sensing for management of natural resources. To this had been added the development and launch of satellite launch vehicles.

The active international cooperation dominant in the early years was virtually eased out in this plan and the emphasis was on self-reliance and indigenous technologies. The plan talked about the realisation of a SLV for injecting lightweight satellites into a low earth orbit, upgrading of Indian satellites from laboratory models to space entities and development of a wide range of spacecraft subsystems like the apogee and booster motors, momentum wheel, and solar panel deployment mechanism. It also promised a wide range of technological spin-offs like the gyros, various types of transducers, telemetry, adhesives, and polymers for non-space applications. Over and above, there was the dream of an adequate infrastructure that would be capable of supporting R&D in a variety of engineering and scientific disciplines.

The second development was the formation of a Missile Panel in the Ministry of Defence. Both Narayanan and I were inducted as members. The idea of making missiles in our own country was exciting, and we spent hours on end studying the missiles of various advanced countries.

The distinction between a tactical missile and a strategic missile is often a fine one. Generally, by 'strategic', it is understood that the missile will fly thousands of kilometres. However, in warfare, this term is used to denote the kind of target rather than its distance from missile launch. Strategic missiles are those that strike at the enemy's heartland, either in counter-force attacks on their strategic forces or in counter-value attacks on the society, which in essence means his cities. Tactical weapons are those that influence a battle, and the battle may be by land, sea or air, or on all three together. This categorization now appears nonsensical, as the US Air Force's ground-launched Tomahawk is used in a tactical role, notwithstanding its range of some 3000 km. In those days, however, strategic missiles were synonymous with intermediate range ballistic missiles (IRBMs) with ranges in the order of 1500 nautical miles or 2780 km and inter-continental ballistic missiles (ICBMs) with a capability of going even further.

Gp Capt Narayanan had an ineffable enthusiasm for indigenous guided missiles. He was a great admirer of the strong arm approach of the Russian Missile Development Programme. "When it could be done there, why not here, where space research has already prepared the soil for a bonanza of missile technology?" Narayanan used to needle me.

The bitter lessons of the two wars in 1962 and 1965 had left the Indian leadership with little choice in the matter of achieving self-reliance in military hardware and weapon systems. A large number of Surface-to-Air Missiles (SAMs) were obtained from the USSR to guard strategic locations. Gp Capt Narayanan passionately advocated the development of these missiles in the country.

While working together on RATO motors and on the Missile Panel, Narayanan and I played the roles of student and teacher interchangeably wherever required. He was very eager to learn about rocketry and I was very curious to know about airborne weapon systems. The depth of Narayanan's conviction and his force of application were inspiring. Right from the day of our pre-dawn visit to the Tilpat Range with Prof. Sarabhai, Narayanan was always busy with his RATO motor. He had arranged everything that was required before being asked. He obtained funding of Rs 75 lakhs with a further commitment towards any unforeseen costs. "You name the thing and I will get it for you, but do not ask for time," he said. At times, I often laughed at his impatience, and read for him these lines from T.S. Eliot's Hollow Men:

Between the conception
And the creation
Between the emotion
And the response
Falls the Shadow.

Defence R&D at that time was heavily dependent on imported equipment. Virtually nothing indigenous was available. Together, we made a long shopping list and drew up an import plan. But this made me unhappy—was there no remedy or alternative? Was this nation doomed to live with screwdriver technology? Could a poor country like India afford this kind of development?

One day, while working late in the office, which was quite routine after I took up the RATO projects, I saw a young colleague, Jaya Chandra Babu going home. Babu had joined us a few months ago and the only thing I knew about him was that he had a very positive attitude and was articulate. I called him into my office and did a bit of loud thinking. "Do you have any suggestions?" I then asked him. Babu remained silent for a while, and then asked for time until the next evening to do some homework before answering my question.

The next evening, Babu came to me before the appointed time. His face was beaming with promise. "We can do it, sir! The RATO system can be made without imports. The only hurdle is the inherent inelasticity in the approach of the organization towards procurement and sub-contracting, which would be the two major thrust areas to avoid imports." He gave me seven points, or, rather, asked for seven liberties—financial approval by a single person instead of an entire hierarchy, air travel for all people on work irrespective of their entitlement, accountability to only one person, lifting of goods by air-cargo, sub-contracting to the private sector, placement of orders on the basis of technical competence, and expeditious accounting procedures.

These demands were unheard of in government establishments, which tend to be conservative, yet I could see the soundness of his proposition. The RATO project was a new game and there was nothing wrong if it was to be played with a new set of rules. I weighed all the pros and cons of Babu's suggestions for a whole night and finally decided to present them to Prof. Sarabhai. Hearing my plea for administrative liberalization and seeing the merits behind it, Prof. Sarabhai approved the proposals without a second thought.

Through his suggestions, Babu had highlighted the importance of business acumen in developmental work with high stakes. To make things move faster within existing work parameters, you have to pump in more people, more material and more money. If you can't do that, change your parameters! Instinctive businessman that he was, Babu did not remain long with us and left ISRO for greener pastures in Nigeria. I could never forget Babu's common sense in financial matters.

We had opted for a composite structure for the RATO motor casing using filament fibre glass/epoxy. We had also gone in for a high energy composite propellant and an event-based ignition and jettisoning system in real-time. A canted nozzle was designed to deflect the jet away from the aircraft. We conducted the first static test of RATO in the twelfth month of the project initiation. Within the next four months, we conducted 64 static tests. And we were just about 20 engineers working on the project!

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