6

Movers

The future satellite launch vehicle (SLV) had also been conceived by this time. Recognising the immense socio- economic benefits of space technology, Prof. Sarabhai decided in 1969, to go full-steam ahead with the task of establishing indigenous capability in building and launching our own satellites. He personally participated in an aerial survey of the east coast for a possible site for launching satellite launch vehicles and large rockets.

Prof. Sarabhai was concentrating on the east coast in order to let the launch vehicle take full advantage of the earth's west to east rotation. He finally selected the Sriharikota island, 100 km north of Madras (now Chennai), and thus the SHAR Rocket Launch Station was born. The crescent-shaped island has a maximum width of 8 km and lies alongside the coastline. The island is as big as Madras city. The Buckingham Canal and the Pulicat lake form its western boundary.

In 1968, we had formed the Indian Rocket Society. Soon after, the INCOSPAR was reconstituted as an advisory body under the Indian National Science Academy (INSA) and the Indian Space Research Organization (ISRO) was created under the Department of Atomic Energy (DAE) to conduct space research in the country.

By this time, Prof. Sarabhai had already hand-picked a team to give form to his dream of an Indian SLV. I consider myself fortunate to have

been chosen to be a project leader. Prof. Sarabhai gave me the additional responsibility of designing the fourth stage of the SLV. Dr VR Gowarikar, MR Kurup and AE Muthunayagam were given the tasks of designing the other three stages.

What made Prof. Sarabhai pick a few of us for this great mission? One reason seemed to be our professional background. Dr Gowarikar was doing outstanding work in the field of composite propellants. MR Kurup had established an excellent laboratory for propellants, propulsion and pyrotechnics. Muthunayagam had proved himself in the field of high energy propellants. The fourth stage was to be a composite structure and called for a large number of innovations in fabrication technology; perhaps that was why I was brought in.

I laid the foundation for Stage IV on two rocks—sensible approximation and unawed support. I have always considered the price of perfection prohibitive and allowed mistakes as a part of the learning process. I prefer a dash of daring and persistence to perfection. I have always supported learning on the part of my team members by paying vigilant attention to each of their attempts, be they successful or unsuccessful.

In my group, progress was recognized and reinforced at every tiny step. Although I provided access to all the information that my co-workers in Stage IV needed, I found I could not spend enough time to be a useful facilitator and a source of support. I wondered if there was something wrong with the way in which I managed my time. At this stage, Prof. Sarabhai brought a French visitor to our work centre to point out the problem to me. This gentleman was Prof. Curien, President of CNES (Centre Nationale de Etudes Spatiales), our counterpart in France. They were then developing the Diamont launch vehicles. Prof. Curien was a thorough professional. Together, Prof. Sarabhai and Prof. Curien helped me set a target. While they discussed the means by which I could reach it, they also cautioned me about the possibilities of failure. While I arrived at a better awareness of Stage IV problems through the supportive counselling of Prof. Curien, Prof. Sarabhai's catalytic intervention led Prof. Curien to reinterpret his own progress in the Diamont programme.

Prof. Curien advised Prof. Sarabhai to relieve me of all the minor jobs which posed little challenge and to give me more opportunities for achievement. He was so impressed by our well-planned efforts that he inquired if we could make the Diamont's fourth stage. I recall how this brought a subtle smile to Prof. Sarabhai's face.

As a matter of fact, the Diamont and SLV airframes were incompatible. The diameters were quite different and to attain interchangeability, some radical innovations were required. I wondered where I should start. I decided to look around for solutions among my own colleagues. I used to carefully observe my colleagues to see if their daily routine reflected their desire to constantly experiment. I also started asking and listening to anyone who showed the slightest promise. Some of my friends cautioned me about what they termed as my naivete. I made it an unfailing routine to make notes on individual suggestions and gave handwritten notes to colleagues in engineering and design, requesting concrete follow-up action within five or ten days.

This method worked wonderfully well. Prof. Curien testified, while reviewing our progress, that we had achieved in a year's time what our counterparts in Europe could barely manage in three years. Our plus point, he noted, was that each of us worked with those below and above in the hierarchy. I made it a point to have the team meet at least once every week. Though it took up time and energy, I considered it essential.

How good is a leader? No better than his people and their commitment and participation in the project as full partners! The fact that I got them all together to share whatever little development had been achieved—results, experiences, small successes, and the like—seemed to me worth putting all my energy and time into. It was a very small price to pay for that commitment and sense of teamwork, which could in fact be called trust. Within my own small group of people I found leaders, and learned that leaders exist at every level. This was another important aspect of management that I learned.

We had modified the existing SLV-IV Stage design to suit the Diamont airframe. It was reconfigured and upgraded from a 250 kg, 400 mm diameter stage to a 600 kg, 650 mm diameter stage. After two years' effort, when we were about to deliver it to CNES, the French suddenly cancelled their Diamont BC programme. They told us that they did not need our Stage IV anymore. It was a great shock, making me re-live the earlier disappointments at Dehra Dun, when I failed to get into the Air Force, and at Bangalore, when the Nandi project was aborted at ADE.

I had invested great hope and effort in the fourth stage, so that it could be flown with a Diamont rocket. The other three stages of SLV, involving enormous work in the area of rocket propulsion were at least five years away. However, it did not take me long to shelve the disappointment of Diamont BC Stage IV. After all, I had thoroughly enjoyed working on this project. In time, RATO filled the vacuum created in me by the Diamont BC Stage.

When the RATO project was underway, the SLV project slowly started taking shape. Competence for all major systems of a launch vehicle had been established in Thumba by now. Through their outstanding efforts, Vasant Gowarikar, MR Kurup and Muthunayagam prepared TERLS for a big leap in rocketry.

Prof. Sarabhai was an exemplar in the art of team-building. On one occasion, he had to identify a person who could be given the responsibility for developing a telecommand system for the SLV. Two men were competent to carry out this task—one was the seasoned and sophisticated UR Rao and the other was a relatively unknown experimenter, G Madhavan Nair. Although I was deeply impressed by Madhavan Nair's dedication and abilities, I did not rate his chances as very good. During one of Prof. Sarabhai's routine visits, Madhavan Nair boldly demonstrated his improvised but highly reliable telecommand system. Prof. Sarabhai did not take much time to back the young experimenter in preference to an established expert. Madhavan Nair not only lived up to the expectations of his leader but even went beyond them. He was to later become the project director of the Polar Satellite Launch Vehicle (PSLV).

SLVs and missiles can be called first cousins: they are different in concept and purpose, but come from the same bloodline of rocketry. A massive missile development project had been taken up by DRDO at the Defence Research & Development Laboratory (DRDL), Hyderabad. As the pace of this surface-to-air missile development project increased,

the frequency of the Missile Panel meetings and my interaction with Gp Capt Narayanan also increased.

In 1968, Prof. Sarabhai came to Thumba on one of his routine visits. He was shown the operation of the nose-cone jettisoning mechanism. As always, we were all anxious to share the results of our work with Prof. Sarabhai. We requested Prof. Sarabhai to formally activate the pyro system through a timer circuit. Prof. Sarabhai smiled, and pressed the button. To our horror, nothing happened. We were dumbstruck. I looked at Pramod Kale, who had designed and integrated the timer circuit. In a flash each of us mentally went through an anlysis of the failure. We requested Prof. Sarabhai to wait for a few minutes, then we detached the timer device, giving direct connection to the pyros. Prof. Sarabhai pressed the button again. The pyros were fired and the nose cone was jettisoned. Prof. Sarabhai congratulated Kale and me; but his expression suggested that his thoughts were elsewhere. We could not guess what was on his mind. The suspense did not last for long and I got a call from Prof. Sarabhai's secretary to meet him after dinner for an important discussion.

Prof. Sarabhai was staying at the Kovalam Palace Hotel, his usual home whenever he was in Trivandrum. I was slightly perplexed by the summons. Prof. Sarabhai greeted me with his customary warmth. He talked of the rocket launching station, envisaging facilities like launch pads, block houses, radar, telemetry and so on—things which are taken for granted in Indian space research today. Then he brought up the incident that had occurred that morning. This was exactly what I had feared. My apprehension of a reproach from my leader, however, was unfounded. Prof. Sarabhai did not conclude that the failure of the pyro timer circuit was the outcome of insufficient knowledge and lack of skill on the part of his people or of faulty understanding at the direction stage. He asked me instead, if we were unenthused by a job that did not pose sufficient challenge. He also asked me to consider if my work was possibly being affected by any problem of which I was hitherto unaware. He finally put his finger on the key issue. We lacked a single roof to carry out system integration of all our rocket stages and rocket systems. Electrical and mechanical integration work was going on with a significant phase difference—both in time and in space. There was little effort to bring together the disparate work on electrical and mechanical integration. Prof. Sarabhai spent the next hour in re-defining our tasks, and, in the small hours of the morning, the decision to set up a Rocket Engineering Section was taken.

Mistakes can delay or prevent the proper achievement of the objectives of individuals and organizations, but a visionary like Prof. Sarabhai can use errors as opportunities to promote innovation and the development of new ideas. He was not especially concerned with the mistake in the timer circuit, least of all with pinning the blame for it. Prof. Sarabhai's approach to mistakes rested on the assumption that they were inevitable but generally manageable. It was in the handling of the crises that arose as a consequence that talent could often be revealed. I later realised by experience, that the best way to prevent errors was to anticipate them. But this time, by a strange twist of fate, the failure of the timer circuit led to the birth of a rocket engineering laboratory.

It was my usual practice to brief Prof. Sarabhai after every Missile Panel Meeting. After attending one such meeting in Delhi on 30 December 1971, I was returning to Trivandrum. Prof. Sarabhai was visiting Thumba that very day to review the SLV design. I spoke to him on the telephone from the airport lounge about the salient points that had emerged at the panel meeting. He instructed me to wait at Trivandrum Airport after disembarking from the Delhi flight, and to meet him there before his departure for Bombay the same night.

When I reached Trivandrum, a pall of gloom hung in the air. The aircraft ladder operator Kutty told me in a choked voice that Prof. Sarabhai was no more. He had passed away a few hours ago, following a cardiac arrest. I was shocked to the core; it had happened within an hour of our conversation. It was a great blow to me and a huge loss to Indian science. That night passed in preparations for airlifting Prof. Sarabhai's body for the cremation in Ahmedabad.

For five years, between 1966 to 1971, about 22 scientists and engineers had worked closely with Prof. Sarabhai. All of them were later to take charge of important scientific projects. Not only was Prof. Sarabhai a great scientist, but also a great leader. I still remember him reviewing the bi-monthly progress of the design projects of SLV-3 in June 1970.

Presentations on Stages I to IV were arranged. The first three presentations went through smoothly. Mine was the last presentation. I introduced five of my team members who had contributed in various ways to the design. To everybody's surprise, each of them presented his portion of the work with authority and confidence. The presentations were discussed at length and the conclusion was that satisfactory progress had been made.

Suddenly, a senior scientist who worked closely with Prof. Sarabhai turned to me and enquired, "Well, the presentations for your project were made by your team members based on their work. But what did you do for the project?" That was the first time I saw Prof. Sarabhai really annoyed. He told his colleague, "You ought to know what project management is all about. We just witnessed an excellent example. It was an outstanding demonstration of team work. I have always seen a project leader as an integrator of people and that is precisely what Kalam is." I consider Prof. Sarabhai as the Mahatma Gandhi of Indian science —generating leadership qualities in his team and inspiring them through both ideas and example.

After an interim arrangement with Prof. MGK Menon at the helm, Prof. Satish Dhawan was given the responsibility of heading ISRO. The whole complex at Thumba, which included TERLS, the Space Science and Technology Centre (SSTC), the RPP, the Rocket Fabrication Facility (RFF), and the Propellant Fuel Complex (PFC) were merged together to form an integrated space centre and christened the Vikram Sarabhai Space Centre (VSSC) as a tribute to the man to whom it owed its existence. The renowned metallurgist, Dr Brahm Prakash, took over as the first Director of VSSC.

The RATO system was successfully tested on 8 October 1972 at Bareilly Air Force station in Uttar Pradesh, when a high performance Sukhoi-16 jet aircraft became airborne after a short run of 1200 m, as against its usual run of 2 km. We used the 66th RATO motor in the test. The demonstration was watched by Air Marshal Shivdev Singh and Dr BD Nag Chaudhury, then the Scientific Adviser to the Defence Minister. This effort was said to have saved approximately Rs 4 crores in foreign exchange. The vision of the industrialist scientist had finally borne fruit.

Before taking up the responsibility of organizing space research in India and becoming the chairman of INCOSPAR, Prof. Sarabhai had established a number of successful industrial enterprises. He was aware that scientific research could not survive in isolation, away from industry. Prof. Sarabhai founded Sarabhai Chemicals, Sarabhai Glass, Sarabhai Geigy Limited, Sarabhai Merck Limited, and the Sarabhai Engineering Group. His Swastik Oil Mills did pioneering work in the extraction of oil from oilseeds, manufacture of synthetic detergents and of cosmetics. He geared Standard Pharmaceuticals Limited to enable large-scale manufacture of penicillin, which was imported from abroad at astronomical costs at that time. Now with the indigenization of RATO, his mission had acquired a new dimension—independence in the manufacture of military hardware and the potential saving of crores of rupees in foreign exchange. I recalled this on the day of the successful trial of the RATO system. Including trial expenses, we spent less than Rs. 25 lakhs on the entire project. The Indian RATO could be produced at Rs.17,000 apiece, and it replaced the imported RATO, which cost Rs. 33,000.

At the Vikram Sarabhai Space Centre, work on the SLV went on at full swing. All the subsystems had been designed, technologies identified, processes established, work centres selected, manpower earmarked and schedules drawn. The only hitch was the lack of a management structure to effectively handle this mega-project and coordinate activities which were spread over a large number of work centres with their own ways of working and management.

Prof. Dhawan, in consultation with Dr Brahm Prakash, picked me for this job. I was appointed the Project Manager—SLV, and reported directly to the Director, VSSC. My first task was to work out a project management plan. I wondered why I was selected for this task when there were stalwarts like Gowarikar, Muthunayagam, and Kurup around. With organizers like Easwardas, Aravamudan, and SC Gupta available, how would I do better? I articulated my doubts to Dr Brahm Prakash. He told me not to focus on what I saw as other people's strengths compared to my own, but instead, to attempt to expand their abilities.

Dr Brahm Prakash advised me to take care of the performance degraders and cautioned me against outrightly seeking optimal performance from the participating work centres. "Everyone will work to create their bit of SLV; your problem is going to be your dependency on others in accomplishing the total SLV. The SLV mission will be accomplished with, and through, a large number of people. You will require a tremendous amount of tolerance and patience," he said. It reminded me of what my father used to read to me from the Holy Qur'an on the distinction between right and wrong: "We have sent no apostle before you who did not eat or walk about the market squares. We test you by means of one another. Will you not have patience?"

I was aware of the contradiction that often occurred in such situations. People heading teams often have one of the following two orientations: for some, work is the most important motivation; for others, their workers are the all-consuming interest. There are many others who fall either between these two positions or outside them. My job was going to be to avoid those who were interested neither in the work nor in the workers. I was determined to prevent people from taking either extreme, and to promote conditions where work and workers went together. I visualized my team as a group in which each member worked to enrich the others in the team and experience the enjoyment of working together.

The primary objectives of the SLV Project were design, development and operation of a standard SLV system, SLV-3, capable of reliably and expeditiously fulfilling the specified mission of launching a 40 kg satellite into a 400 km circular orbit around the earth.

As a first step, I translated the primary project objectives into some major tasks. One such task was the development of a rocket motor system for the four stages of the vehicle. The critical problems in the completion of this task were: making an 8.6 tonne propellant grain and a high mass ratio apogee rocket motor system which would use high-energy propellants. Another task was vehicle control and guidance. Three types of control systems were involved in this task—aerodynamic surface control, thrust vector control and reaction control for the first, second and third stages and the spin-up mechanism for the fourth stage. Inertial reference for control systems and guidance through inertial measurement was also imperative. Yet another major task was the augmentation of launch facilities at SHAR with systems integration and checkout facilities and development of launch support systems such as launchers and vehicle assembly fixtures. A target of 'all line' flight test within 64 months was set in March 1973.

I took up the executive responsibility of implementing the project within the framework of policy decisions taken, the approved management plan, and the project report; and also within the budget and through the powers delegated to me by the Director, VSSC. Dr Brahm Prakash formed four Project Advisory Committees to advise me on specialized areas like rocket motors, materials and fabrication, control and guidance, electronics, and mission and launching. I was assured of the guidance of outstanding scientists like DS Rane, Muthunayagam, TS Prahlad, AR Acharya, SC Gupta, and CL Amba Rao, to name a few.

The Holy Qur'an says: "We have sent down to you revelations showing you an account of those who have gone before you and an admonition to righteous men." I sought to share the wisdom of these extremely brilliant people. "Light upon light. Allah guides to His light whom He will. He has knowledge of all things."

We made three groups to carry out the project activities—a Programme Management Group, an Integration and Flight Testing Group and a Subsystems Development Group. The first Group was made responsible for looking after the overall executive aspects of SLV-3: project management, including administration, planning and evaluation, subsystems specifications, materials, fabrication, quality assurance and control. The Integration and Flight Testing Group was assigned the tasks of generation of facilities required for integration and flight testing of SLV-3. They were also asked to carry out the analysis of the vehicle, including mechanical and aerodynamic interface problems. The Subsystems Development Group was given the job of interacting with various divisions of VSSC and was made responsible for ensuring that all technological problems in the development of various subsystems were overcome by creating a synergy amongst the available talent in these divisions.

I projected a requirement of 275 engineers and scientists for SLV-3 but could get only about 50. If it had not been for synergistic efforts, the whole project would have remained a non-starter. Some young engineers like MSR Dev, G Madhavan Nair, S Srinivasan, US Singh, Sunderrajan, Abdul Majeed, Ved Prakash Sandlas, Namboodiri, Sasi Kumar, and Sivathanu Pillai developed their own ground rules designed to help them work efficiently as a project team, and produced outstanding individual and team results. These men were in the habit of celebrating their successes together—in a sort of mutual appreciation club. This boosted morale, and helped them a great deal to accept setbacks and to revitalize themselves after periods of intense work.

Each member of the SLV-3 project team was a specialist in his own field. It was natural therefore that each one of them valued his independence. To manage the performance of such specialists the team leader has to adopt a delicate balance between the hands-on and the hands-off approach. The hands-on approach takes an active interest on a very regular basis in the members' work. The hands-off approach trusts team members and recognizes their need for autonomy to carry out their roles, as they see fit. It hinges on their self-motivation. When the leader goes too far with the hands-on approach, he is seen as an anxious and interfering type. If he goes too far hands-off, he is seen as abdicating his responsibility or not being interested. Today, the members of the SLV-3 team have grown to lead some of the country's most prestigious programmes. MSR Dev heads the Augmented Satellite Launch Vehicle (ASLV) project, Madhavan Nair is the chief of the Polar Satellite Launch Vehicle (PSLV) project and Sandlas and Sivathanu Pillai are Chief Controllers in DRDO Headquarters. Each one of these men rose to his present position through consistent hard work and rock-like will power. It was indeed an exceptionally talented team.

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