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Builders

Dr Brahm Prakash helped me endure this difficult period. In practice, Dr Brahm Prakash employed the front-line damage control principle: "Just get the fellow home alive. He'll recover." He drew the entire SLV team close and demonstrated to me that I was not alone in my sorrow at the SLV-3's failure. "All your comrades are standing by you," he said. This gave me vital emotional support, encouragement, and guidance.

A post-flight review conducted on 11 August 1979 was attended by more than seventy scientists. A detailed technical appraisal of the failure was completed. Later, the post-flight analysis committee headed by SK Athithan pinpointed the reasons for the malfunction of the vehicle. It was established that the mishap occurred because of the failure of the second stage control system. No control force was available during the second stage flight due to which the vehicle became aerodynamically unstable, resulting in altitude and velocity loss. This caused the vehicle to fall into the sea even before the other stages could ignite.

Further in-depth analysis of the second-stage failure identified the reason as the draining of a good amount of Red Fuming Nitric Acid (RFNA) used as the oxidizer for the fuel power at that stage. Consequently, when the control force was demanded, only fuel was injected resulting in zero force. 'A solenoid valve in the oxidizer tank

remaining open due to contamination after the first command at T-8 minutes', was identified as the reason for the draining of RFNA.

The findings were presented to Prof. Dhawan at a meeting of top ISRO scientists and were accepted. Everybody was convinced by the technical cause-and-effect sequence presented and there was a general feeling of satisfaction about the whole exercise of failure-management measures taken. I was still unconvinced though and felt restless. To me, the level of responsibility is measured by one's ability to confront the decision-making process without any delay or distraction.

On the spur of the moment, I stood up and addressed Prof. Dhawan, "Sir, even though my friends have technically justified the failure, I take the responsibility for judging the RFNA leak detected during the final phase of countdown as insignificant. As a Mission Director, I should have put the launch on hold and saved the flight if possible. In a similar situation abroad, the Mission Director would have lost his job. I therefore take responsibility for the SLV-3 failure." For quite some time there was pin-drop silence in the hall. Then Prof. Dhawan got up and said, "I am going to put Kalam in orbit!", and left the place signalling that the meeting was over.

The pursuit of science is a combination of great elation and great despair. I went over many such episodes in my mind. Johannes Kepler, whose three orbital laws form the basis of space research, took nearly 17 years after formulating the two laws about planetary motion around the sun, to enunciate his third law which gives the relation between the size of the elliptical orbit and the length of time it takes for the planet to go around the sun. How many failures and frustrations must he have gone through? The idea that man could land on the moon, developed by the Russian mathematician Konstantin Tsiolkovsky, was realised after nearly four decades—and by the United States, at that. Prof. Chandrasekhar had to wait nearly 50 years before receiving the Nobel Prize for his discovery of the 'Chandrasekhar Limit', a discovery made while he was a graduate student at Cambridge in the 1930s. If his work had been recognized then, it could have led to the discovery of the Black Hole decades earlier. How many failures must von Braun have gone through before his Saturn launch vehicle put man on the moon? These thoughts helped to give me the ability to withstand apparently irreversible setbacks.

Early in November 1979, Dr Brahm Prakash retired. He had always been my sheet-anchor in the turbulent waters of VSSC. His belief in team spirit had inspired the management pattern for the SLV project, which later became a blueprint for all scientific projects in the country. Dr Brahm Prakash was a very wise counsellor who gave me valuable guidance whenever I deviated from my mission objectives.

Dr Brahm Prakash not only reinforced the traits which I had acquired from Prof. Sarabhai, but also helped me give them new dimensions. He always cautioned me against haste. "Big scientific projects are like mountains, which should be climbed with as little effort as possible and without urgency. The reality of your own nature should determine your speed. If you become restless, speed up. If you become tense and high-strung, slow down. You should climb the mountain in a state of equilibrium. When each task of your project is not just a means to an end but a unique event in itself, then you are doing it well," he would tell me. The echo of Dr Brahm Prakash's advice could be heard in Emerson's poem on Brahma:

If the red slayer think he slays,
Or, if the slain think he is slain,
They know not well, the subtle ways
I keep, and pass, and turn again.

To live only for some unknown future is superficial. It is like climbing a mountain to reach the peak without experiencing its sides. The sides of the mountain sustain life, not the peak. This is where things grow, experience is gained, and technologies are mastered. The importance of the peak lies only in the fact that it defines the sides. So I went on towards the top, but always experiencing the sides. I had a long way to go but I was in no hurry. I went in little steps—just one step after another—but each step towards the top.

At every stage, the SLV-3 team was blessed with some extraordinarily courageous people. Along with Sudhakar and Sivaramakrishnan, there was also Sivakaminathan. He was entrusted with bringing

the C-Band transponder from Trivandrum to SHAR for integration with the SLV-3. The transponder is a device fitted with the rocket system to give the radar signals which are powerful enough to help it track the vehicle from the take-off site to the final impact point. The SLV-3 launch schedule was dependent on the arrival and integration of this equipment. On landing at the Madras airport, the aircraft which Sivakami was travelling in skidded and overshot the runway. Dense smoke engulfed the aircraft. Everyone jumped out of the aircraft through emergency exits, and desperately fought to save themselves—all except Sivakami, who stayed in the aircraft till he removed the transponder from his baggage. He was among the last few persons, the others being mostly aircraft crew, to emerge from the smoke and he was hugging the transponder close to his chest.

Another incident from those days that I recall clearly relates to Prof. Dhawan's visit to the SLV-3 assembly building. Prof. Dhawan, Madhavan Nair and I were discussing some finer aspects of the SLV-3 integration. The vehicle was kept on the launcher in a horizontal position. When we were moving around and examining the readiness of the integrated hardware, I noticed the presence of big water-ports for extinguishing fire in case of an accident. For some reason, I felt uncomfortable at the sight of the ports facing the SLV-3 on the launcher. I suggested to Madhavan Nair that we could rotate the port so that they were apart by a full 180o. This would prevent the freak possibility of water gushing out and damaging the rocket. To our surprise, within minutes of Madhavan Nair getting the ports reversed, powerful water jets gushed out of the ports. The Vehicle Safety Officer had ensured the functioning of the fire-fighting system without realising that it could have wrecked the entire rocket. This was a lesson in foresight. Or did we have divine protection?

On 17 July 1980, 30 hours before the launch of the second SLV-3, the newspapers were filled with all kinds of predictions. One of the newspapers reported, "The Project Director is missing and could not be contacted." Many reports preferred to trace the history of the first SLV-3 flight, and recalled how the third stage had failed to ignite because of lack of fuel and the rocket had nosedived into the ocean. Some highlighted SLV-3's possible military implications in terms of acquiring the capability for building IRBMs. Some were a general prognosis of all that ailed our country and related it to the SLV-3. I knew that the next day's launch was going to decide the future of the Indian space programme. In fact, to put it simply, the eyes of the whole nation were on us.

In the early hours of the next day, 18 July 1980—at 0803 hrs to be precise, India's first Satellite Launch Vehicle, SLV-3 lifted off from SHAR. At 600 seconds before take-off, I saw the computer displaying data about stage IV giving the required velocity to the Rohini Satellite (carried as payload) to enter its orbit. Within the next two minutes, Rohini was set into motion in a low earth orbit. I spoke, in the midst of screeching decibels, the most important words I had ever uttered in my life, "Mission Director calling all stations. Stand by for an important announcement. All stages performed to mission requirements. The fourth stage apogee motor has given the required velocity to put Rohini Satellite into orbit". There were happy cries everywhere. When I came out of the Block House, I was lifted onto the shoulders of my jubilant colleagues and carried in a procession.

The whole nation was excited. India had made its entry into the small group of nations which possessed satellite launch capability. Newspapers carried news of the event in their headlines. Radio and television stations aired special programmes. Parliament greeted the achievement with the thumping of desks. It was both the culmination of a national dream, and the beginning of a very important phase in our nation's history. Prof. Satish Dhawan, Chairman ISRO, threw his customary guardedness to the winds and announced that it was now well within our ability to explore space. Prime Minister Indira Gandhi cabled her congratulations. But the most important reaction was that of the Indian scientific community—everybody was proud of this hundred per cent indigenous effort.

I experienced mixed feelings. I was happy to achieve the success which had been evading me for the past two decades, but I was sad because the people who had inspired me were no longer there to share my joy—my father, my brother-in-law Jallaluddin, and Prof. Sarabhai.

The credit for the successful SLV-3 flight goes, first, to the giants of the Indian space programme, Prof. Sarabhai in particular, who had preceded this effort; next to the hundreds of VSSC personnel who had through sheer will-power proved the mettle of our countrymen and also, not least, to Prof. Dhawan and Dr Brahm Prakash, who had led the project.

We had a late dinner that evening. Gradually, the din and clatter of the celebrations calmed down. I retired to my bed with almost no energy left. Through the open window, I could see the moon among the clouds. The sea breeze seemed to reflect the buoyancy of the mood on Sriharikota island that day.

Within a month of the SLV-3 success, I visited the Nehru Science Centre in Bombay for a day, in response to an invitation to share my experiences with the SLV-3. There, I received a telephone call from Prof. Dhawan in Delhi, asking me to join him the next morning. We were to meet the Prime Minister, Mrs Indira Gandhi. My hosts at the Nehru Centre were kind enough to arrange my ticket to Delhi, but I had a small problem. It had to do with my clothes. I was dressed casually as is my wont and wearing slippers—not, by any standards of etiquette, suitable attire in which to meet the Prime Minister! When I told Prof. Dhawan about this problem, he told me not to worry about my dress. "You are beautifully clothed in your success," he quipped.

Prof. Dhawan and I arrived at the Parliament House Annexe the next morning. A meeting of the Parliamentary Panel on Science & Technology chaired by the Prime Minister was scheduled. There were about 30 Members of the Lok Sabha and Rajya Sabha in the room, which was lit by a majestic chandelier. Prof. MGK Menon and Dr Nag Chaudhuri were also present. Shrimati Gandhi spoke to the Members about the success of the SLV-3 and lauded our achievement. Prof. Dhawan thanked the gathering for the encouragement given by them to space research in the country and expressed the gratitude of the ISRO scientists and engineers. Suddenly, I saw Shrimati Gandhi smiling at me as she said, "Kalam! We would like to hear you speak." I was surprised by the request as Prof. Dhawan had already addressed the gathering.

Hesitantly, I rose and responded, "I am indeed honoured to be in this great gathering of nation-builders. I only know how to build a rocket system in our country, which would inject a satellite, built in our country, by imparting to it a velocity of 25,000 km per hour." There was thunderous applause. I thanked the members for giving us an opportunity to work on a project like the SLV-3 and prove the scientific strength of our country. The entire room was irradiated with happiness.

Now that Project SLV-3 had been successfully completed, VSSC had to re-organize its resources and redefine its goals. I wanted to be relieved of the project activities, and consequently Ved Prakash Sandlas from my team was made the Project Director for the SLV-3 Continuation Project, which aimed at making operational satellite launch vehicles of a similar class. With a view to upgrade the SLV-3 by means of certain technological innovations, the development of Augmented Satellite Launch Vehicles (ASLVs) had been on the cards for some time. The aim was to enhance the SLV-3 payload capability from 40 kg to 150 kg. MSR Dev from my team was appointed Project Director ASLV. Then, to reach the sun-synchronous orbit (900 km), a PSLV was to be made. The Geo Satellite Launch Vehicle (GSLV) was also envisaged, though as a distant dream. I took up the position of Director, Aerospace Dynamics and Design Group, so that I could configure the forthcoming launch vehicles and technology development.

The existing VSSC infrastructure was inadequate to handle the size and weight of the future launch vehicle systems and the implementation of all these projects was going to require highly specialized facilities. New sites were identified for the expanded activities of VSSC, at Vattiyoorkavu and Valiamala. Dr Srinivasan drew up a detailed plan of the facilities. Meanwhile, I carried out an analysis of the application of SLV-3 and its variants with Sivathanu Pillai, and compared the existing launch vehicles of the world for missile applications. We established that the SLV-3 solid rocket systems would meet the national requirements of payload delivery vehicles for short and intermediate ranges (4000 km). We contended that the development of one additional solid booster of 1.8 m diameter with 36 tonnes of propellant along with SLV-3 subsystems would meet the ICBM requirement (above 5000 km for a

1000 kg payload). This proposal was, however, never considered. It nevertheless paved the way for the formulation of the Re-entry Experiment (REX) which, much later on, became Agni.

The next SLV-3 flight, SLV3-D1, took off on 31 May 1981. I witnessed this flight from the visitors' gallery. This was the first time I witnessed a launch from outside the Control Centre. The unpalatable truth I had to face was that by becoming the focus of media attention, I had aroused envy among some of my senior colleagues, all of whom had equally contributed to the success of SLV-3. Was I hurt at the coldness of the new environment? Perhaps yes, but I was willing to accept what I couldn't change.

I have never lived off the profits of others' minds. My life, in keeping with my nature, has never been that of a ruthless achiever. The SLV-3 was made not by force and manipulation, but through consistent collective effort. Then why this sense of bitterness? Was it peculiar to the VSSC top level or a universal reality? As a scientist, I was trained to reason out reality. In science, reality is that which exists. And because this bitterness was real, I had to reason it out. But can these things be reasoned out?

Were my post-SLV experiences leading me into a critical situation? Yes and no. Yes, because the glory of SLV-3 had not gone to everyone who deserved it—but hardly anything could have been done about that. No, because a situation can be considered critical for a person only when realisation of the internal necessity becomes impossible. And that certainly was not the case. In fact, the concept of conflict is built upon this basic idea. In retrospect, I can only say that I was fully aware of a great need for actualization and renewal.

In January 1981, I was invited by Dr Bhagiratha Rao of the High Altitude Laboratory (now the Defence Electronics Applications Laboratory (DEAL)), Dehra Dun to give a lecture on the SLV-3. The renowned nuclear scientist, Prof. Raja Ramanna, whom I had always admired, and who was then the Scientific Adviser to the Defence Minister, presided over the gathering. He spoke on India's efforts in generating nuclear energy and the challenge in conducting the first nuclear test for peaceful purposes. As I had been so closely involved with SLV-3, it was natural that I was soon in full spate about it. Later, Prof. Raja Ramanna invited me for a private meeting over tea.

The first thing that struck me when I met Prof. Ramanna was his genuine pleasure at meeting me. There was an eagerness in his talk, an immediate, sympathetic friendliness, accompanied by quick, graceful movements. The evening brought back memories of my first meeting with Prof. Sarabhai—as if it was yesterday. The world of Prof. Sarabhai was internally simple and externally easy. Each of us working with him was driven by a single-minded need to create, and lived under conditions which made the object of that need directly accessible. Sarabhai's world was tailor-made to our dreams. It had neither too much nor too little of anything needed by any one of us. We could divide it by our requirements without a remainder.

My world, by now, had no simplicity left in it. It had become an internally complex and externally difficult world. My efforts in rocketry and in achieving the goal of making indigenous rockets were impeded by external obstacles and complicated by internal wavering. I was aware that it required a special effort of the will to sustain my trajectory. The coordination of my present with my past had already been jeopardised. The coordination of my present with my future was uppermost in my mind when I went to have tea with Prof. Ramanna.

He did not take long to come to the point. The Devil Missile programme had been shelved in spite of tremendous achievements made by Narayanan and his team at DRDL. The entire programme of military rockets was reeling under a persistent apathy. The DRDO needed somebody to take command of their missile programmes which had been stuck at the drawing board and static test bed stages for quite a while. Prof. Ramanna asked me if I would like to join DRDL and shoulder the responsibility of shaping their Guided Missile Development Programme (GMDP). Prof. Ramanna's proposal evoked a mixture of emotions in me.

When again would I have such an opportunity to consolidate all our knowledge of rocketry and apply it?

I felt honoured by the esteem in which Prof. Ramanna held me. He had been the guiding spirit behind the Pokharan nuclear test, and I was thrilled by the impact he had helped create on the outside world about India's technical competence. I knew I would not be able to refuse him. Prof. Ramanna advised me to talk to Prof. Dhawan on this issue so that he could work out the modalities of my transfer from ISRO to DRDL.

I met Prof. Dhawan on 14 January 1981. He gave me a patient hearing, with his typical penchant for weighing everything carefully to make sure he didn't miss a point. A markedly pleasant expression came to his face. He said, "I am pleased with their appraisal of my man's work". He then smiled. I have never met anyone with a smile quite like Prof. Dhawan's—a soft white cloud—you could picture it in any shape you wanted to.

I wondered how I should proceed. "Should I formally apply for the post so that DRDL could send the appointment order?" I enquired of Prof. Dhawan. "No. Don't pressurise them. Let me talk to the top-level management during my next visit to New Delhi," Prof. Dhawan said. "I know you have always had one foot in DRDO, now your whole centre of gravity seems to have shifted towards them." Perhaps what Prof. Dhawan was telling me had an element of truth in it, but my heart had always been at ISRO. Was he really unaware of that?

Republic Day, 1981 brought with it a pleasant surprise. On the evening of 25 January, Mahadevan, Secretary to Prof. UR Rao, rang up from Delhi to inform me about the Home Ministry announcement about the conferment of the Padma Bhushan award on me. The next important call was from Prof. Dhawan to congrat-ulate me. I felt blissfully elated as it was from my guru. I rejoiced with Prof. Dhawan at his receiving the Padma Vibhushan and I congratulated him wholeheartedly. I then rang up Dr Brahm Prakash and thanked him. Dr Brahm Prakash chided me for the formality and said, "I feel as if my son has got the award." I was so deeply touched by Dr Brahm Prakash's affection that I could no longer keep my emotions in check.

I filled my room with the music of Bismillah Khan's shehnai. The music took me to another time, another place. I visited Rameswaram and hugged my mother. My father ran his caring fingers through my hair. My mentor, Jallaluddin, announced the news to the crowd gathered on Mosque Street. My sister, Zohara, prepared special sweets for me. Pakshi Lakshmana Sastry put a tilak on my forehead. Fr. Solomon blessed me holding the holy cross. I saw Prof. Sarabhai smiling with a sense of achievement— the sapling which he had planted twenty years ago had finally grown into a tree whose fruits were being appreciated by the people of India.

My Padma Bhushan evoked mixed reactions at VSSC. While there were some who shared my happiness, there were others who felt I was being unduly singled out for recognition. Some of my close associates turned envious. Why do some people fail to see the great values of life because of sadly twisted thought processes? Happiness, satisfaction, and success in life depend on making the right choices, the winning choices. There are forces in life working for you and against you. One must distinguish the beneficial forces from the malevolent ones and choose correctly between them.

An inner voice told me that the time had come for a long felt, but ignored, need for renewal. Let me clean my slate and write new 'sums'. Were the earlier sums done correctly? Evaluating one's own progress in life is not an easy task. Here the student has to set his own questions, seek his own answers and evaluate them to his own satisfaction. Judgement aside, eighteen years at ISRO was too long a stay to leave without pain. As for my afflicted friends, the lines by Lewis Carroll seemed very appropriate:

You may charge me with murder –
Or want of sense
(We are all of us weak at times):
But the slightest approach to a false pretence
Was never among my crimes!

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