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Achievers

I started my work at NASA at the Langley Research Centre (LRC) in Hampton, Virginia. This is primarily an R&D centre for advanced aerospace technology. One of my most vivid memories of LRC is of a piece of sculpture depicting a charioteer driving two horses, one representing scientific research and the other technological development, metaphorically encapsulating the interconnection between research and development.

From LRC I went to the Goddard Space Flight Centre (GSFC) at Greenbelt, Maryland. This Centre develops and manages most of NASA's earth-orbiting science and applications satellites. It operates NASA's tracking networks for all space missions. Towards the end of my visit, I went to the Wallops Flight Facility at Wallops Island in East Coast, Virginia. This place was the base for NASA's sounding rocket programme. Here, I saw a painting prominently displayed in the reception lobby. It depicted a battle scene with a few rockets flying in the background. A painting with this theme should be the most commonplace thing at a Flight Facility, but the painting caught my eye because the soldiers on the side launching the rockets were not white, but dark-skinned, with the racial features of people found in South Asia. One day, my curiosity got the better of me, drawing me towards the painting. It turned out to be Tipu Sultan's army fighting the British. The painting depicted a fact forgotten in Tipu's own country but commemorated here on the other side of the planet. I was happy to see an Indian glorified by NASA as a hero of warfare rocketry.

My impression of the American people can be summarized by a quotation from Benjamin Franklin, "Those things that hurt instruct!" I realised that people in this part of the world meet their problems head on. They attempt to get out of them rather than suffer them.

My mother had once narrated an incident from the Holy Book—after God created man, he asked the angels to prostrate themselves before Adam. Everybody prostrated themselves except Iblis, or Satan, who refused. "Why did you not prostrate yourself?" Allah asked. "You created me of fire and him of clay. Does not that make me nobler than Adam?" Satan contended. God said, "Be gone from paradise! This is no place for your contemptuous pride." Satan obeyed, but not before cursing Adam with the same fate. Soon Adam followed suit by becoming a transgressor after eating the forbidden fruit. Allah said, "Go hence and may your descendants live a life of doubt and mistrust."

What makes life in Indian organizations difficult is the widespread prevalence of this very contemptuous pride. It stops us from listening to our juniors, subordinates and people down the line. You cannot expect a person to deliver results if you humiliate him, nor can you expect him to be creative if you abuse him or despise him. The line between firmness and harshness, between strong leadership and bullying, between discipline and vindictiveness is very fine, but it has to be drawn. Unfortunately, the only line prominently drawn in our country today is between the 'heroes' and the 'zeros'. On one side are a few hundred 'heroes' keeping nine hundred and fifty million people down on the other side. This situation has to be changed.

As the process of confronting and solving problems often requires hard work and is painful, we have endless procrastination. Actually, problems can be the cutting edge that actually distinguish between success and failure. They draw out innate courage and wisdom.

As soon as I returned from NASA, India's first rocket launch took place on 21 November 1963. It was a sounding rocket, called Nike-Apache, made at NASA. The rocket was assembled in the church building I have referred to earlier. The only equipment available to transport the rocket was a truck and a manually operated hydraulic

crane. The assembled rocket was to be shifted from the church building to the launch pad by truck. When the rocket was lifted by the crane and was about to be placed on the launcher, it started tilting, indicating a leak in the hydraulic system of the crane. As we were fast approaching the launch time, 6 p.m., any repairs to the crane had to be ruled out. Fortunately, the leak was not large and we managed to lift the rocket manually, using our collective muscle power and finally placing it on the launcher.

In the maiden Nike-Apache launch, I was in charge of rocket integration and safety. Two of my colleagues who played a very active and crucial role in this launch were D Easwardas and R Aravamudan. Easwardas undertook the rocket assembly and arranged the launch. Aravamudan, whom we called Dan, was in charge of radar, telemetry and ground support. The launch was smooth and problem-free. We obtained excellent flight data and returned with a sense of pride and accomplishment.

When we were relaxing the next evening at the dinner table, we received news of the assassination of President John F Kennedy in Dallas, Texas. We were appalled. The Kennedy years were a significant era in America, when young men were at the helm of affairs. I used to read with interest about Kennedy's moves in the missile crisis of late 1962. The Soviet Union built missile sites in Cuba, from which it would have been possible to launch attacks on American cities. Kennedy imposed a blockade or 'quarantine', barring the introduction of any offensive missiles to Cuba. America also threatened to respond to any Soviet nuclear attack from Cuba on any country in the Western Hemisphere by retaliating against the USSR. After fourteen days of intense drama, the crisis was resolved by the Soviet Premier Khrushchev ordering that the Cuban bases be dismantled and the missiles returned to Russia.

The next day, Prof. Sarabhai had a detailed discussion with us on future plans. He was creating a new frontier in the field of science and technology in India. A new generation, scientists and engineers in their 30s and early 40s, was being charged with an unprecedented dynamism. Our biggest qualifications at INCOSPAR were not our degrees and training, but Prof. Sarabhai's faith in our capabilities. After the successful launch of Nike-Apache, he chose to share with us his dream of an Indian Satellite Launch Vehicle.

Prof. Sarabhai's optimism was highly contagious. The very news of his coming to Thumba would electrify people and all laboratories, workshops and design offices would hum with unceasing activity. People would work virtually round the clock because of their enthusiasm to show Prof. Sarabhai something new, something that had not been done before in our country—be it a new design or a new method of fabrication or even an out-of-the-way administrative procedure. Prof. Sarabhai would often assign multiple tasks to a single person or a group. Though some of those tasks would appear totally unrelated in the beginning, they would, at a later stage, emerge as deeply interconnected. When Prof. Sarabhai was talking to us about the Satellite Launch Vehicle (SLV), he asked me, almost in the same breath, to take up studies on a rocket-assisted take-off system (RATO) for military aircraft. The two things had no apparent connection except in the mind of this great visionary. I knew that all I had to do was to remain alert and focussed on my purpose, and sooner or later, an opportunity to do a challenging job would enter my laboratory.

Prof. Sarabhai was ever-willing to try out novel approaches and liked to draw in young people. He had the wisdom and judgement which enabled him to realise not only if something was well done, but also when it was time to stop. In my opinion, he was an ideal experimenter and innovator. When there were alternative courses of action before us, whose outcome was difficult to predict, or to reconcile varying perspectives, Prof. Sarabhai would resort to experimentation to resolve the issue. This was precisely the situation at INCOSPAR in 1963. A bunch of young, inexperienced, but nevertheless energetic and enthusiastic persons were given the task of fleshing out the spirit of self-reliance in the field of science and technology in general, and of space research in particular. It was a great example of leadership by trust.

The rocket launch site later blossomed into the Thumba Equatorial Rocket Launch Station (TERLS). TERLS was established through active collaboration with France, USA and USSR. The leader of the Indian

space programme—Prof. Vikram Sarabhai—had comprehended the full implications of the challenge and had not balked at taking it on. Right from the day INCOSPAR was formed, he was aware of the need to organize an integrated national space programme, with the equipment for the manufacture of rockets and launch facilities developed and produced indigenously.

With this in view, a wide-ranging programme for scientific and technological development in rocket fuels, propulsion systems, aeronautics, aerospace materials, advanced fabrication techniques, rocket motor instrumentation, control and guidance systems, telemetry, tracking systems and scientific instruments for experimentation in space were launched at the Space Science and Technology Centre and the Physical Research Laboratory at Ahmedabad. Incidentally, this laboratory has produced a large number of Indian space scientists of extremely high calibre over the years.

The real journey of the Indian aerospace programme, however, had begun with the Rohini Sounding Rocket (RSR) Programme. What is it that distinguishes a sounding rocket from a Satellite Launch Vehicle (SLV) and from a missile? In fact, they are three different kinds of rockets. Sounding rockets are normally used for probing the near-earth environment, including the upper regions of the atmosphere. While they can carry a variety of scientific payloads to a range of altitudes, they cannot impart the final velocity needed to orbit the payload. On the other hand, a launch vehicle is designed to inject into orbit a technological payload or satellite. The final stage of a launch vehicle provides the necessary velocity for a satellite to enter an orbit. This is a complex operation requiring on-board guidance and control systems. A missile, though belonging to the same family, is a still more complex system. In addition to the large terminal velocity and onboard guidance and control, it must have the capability to home onto targets. When the targets are fast-moving and capable of manoeuvring, a missile is also required to carry out target-tracking functions.

The RSR programme was responsible for the development and fabrication of sounding rockets and their associated on-board systems for scientific investigations in India. Under this programme, a family of operational sounding rockets were developed. These rockets had wide ranging capabilities, and to date several hundreds of these rockets have been launched for various scientific and technological studies.

I still remember that the first Rohini rocket consisted of a single solid propulsion motor weighing a mere 32 kg. It lifted a nominal 7 kg payload to an altitude of about 10 km. It was soon followed by another, to which one more solid propellant stage was added to dispatch multi-experiment payloads weighing nearly 100 kg to an altitude of over 350 km.

The development of these rockets had resulted in a fully indigenous capability in the production of sounding rockets as well as their propellants. This programme had brought into the country technology for the production of very high-performance solid propellants, like those based on polyurethane and polybutane polymer. It later resulted in the setting up of a Propellant Fuel Complex (PFC) to manufacture strategic chemicals required for rocket engines, and a Rocket Propellant Plant (RPP) to produce propellants.

The development of Indian rockets in the twentieth century can be seen as a revival of the eighteenth century dream of Tipu Sultan. When Tipu Sultan was killed, the British captured more than 700 rockets and subsystems of 900 rockets in the battle of Turukhanahally in 1799. His army had 27 brigades, called Kushoons, and each brigade had a company of rocket men, called Jourks. These rockets had been taken to England by William Congreve and were subjected by the British to what we call ‘reverse engineering’ today. There were, of course, no GATT, IPR Act, or patent regime. With the death of Tipu, Indian rocketry also met its demise—at least for 150 years.

Meanwhile, rocket technology made great strides abroad. Konstantin Tsiolkovsky in Russia (1903), Robert Goddard in USA (1914) and Hermann Oberth in Germany (1923) gave rocketry new dimensions. In Nazi Germany, Wernher von Braun’s group produced V-2 short range ballistic missiles and showered fire on the Allied Forces. After the war, both the USA and the USSR captured their share of German rocket technology and rocket engineers. With this booty, they started to run their deadly arms race with missiles and warheads.

Rocketry was reborn in India thanks to the technological vision of Prime Minister Jawaharlal Nehru. Prof. Sarabhai took the challenge of giving physical dimensions to this dream. Very many individuals with myopic vision questioned the relevance of space activities in a newly independent nation which was finding it difficult to feed its population. But neither Prime Minister Nehru nor Prof. Sarabhai had any ambiguity of purpose. Their vision was very clear: if Indians were to play a meaningful role in the community of nations, they must be second to none in the application of advanced technologies to their real-life problems. They had no intention of using it merely as a means to display our might.

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