

Missile shield

Missile development in India is a saga of self-reliance and sustained struggle.

BY T. S. SUBRAMANIAN

After the launch of Agni in 1989, **the U.S. declined to give India the phase shifters for the phased array radars for Akash.** Germany refused to give the magnesium alloy used in Prithvi's wings.

SOMETIME in February, a modified version of Dhanush, India's surface-to-surface missile, will take off from a naval ship in the Bay of Bengal. As the powerful missile, simulating the terminal conditions of a ballistic missile of a range of 1,500 kilometres, heads towards the Wheeler Island, off the Orissa coast, an interceptor missile will take off from the island and waylay the incoming "enemy" missile at an altitude of 80 km and pulverise it. The interception will take place in the last few seconds of the flight of the "enemy" missile.

If the interception is a success, it will be a hat-trick for the Defence Research and Development Organisation (DRDO) in its quest to establish a credible missile shield against incoming ballistic missiles from adversarial countries. The advantage in this mission, in which the interception takes place at an altitude of 80 km, is that the debris of the "enemy" missile will take longer to fall through the atmosphere and will become cinders. DRDO scored a spectacular success on December 6, 2007, when its interceptor missile Advanced Air Defence (AAD-02) smashed into an incoming Prithvi missile in a "hit to kill" mode. It propelled India into an elite group of three countries – the United States, Russia and Israel – that have the ability to intercept ballistic missiles. On November 27, 2006, India's first interceptor missile, Prithvi Air De-



THE ADVANCED AIR
Defence interceptor missile being launched from Wheeler Island, off the Dhamra coast in Orissa, on December 6, 2007.

fence, “ambushed” an incoming Prithvi-II missile at an altitude of 50 km.

Today, India has an inventory of powerful missiles, which include Agni, Agni II, Agni III, and Prithvi with its naval and air force versions, Akash, Nag, Astra, BrahMos, underwater-launched K-15 (Sagarika) and land version Shourya. Missile development in India is a saga of self-reliance and sustained struggle, with the pioneers learning by reverse engineering and battling technology-denial regimes such as the Missile Technology Control Regime (MTCR).

V.K. Saraswat, Chief Controller, Missiles and Strategic Systems, DRDO, said: “Today, we are confident that any time the West switches off the complete flow of technology or components, we will be in a position to build these missiles.”

The emphasis in DRDO’s missile programme, in future, will be on systems that are reliable, robust and cost-effective. Each missile can attack multiple targets. The missiles will have precision-guided ammunition to pick out areas of interest such as military facilities and radar installations. “This means you need a very accurate weapon system. Precision is going to be the buzzword,” Saraswat said. The technologies that will help in achieving such miniaturised but highly accurate systems are micro-electro mechanical systems (MEMS), nano-sensors, nano-materials, advanced computers with sophisticated software, and so on.

Saraswat, who is Programme Director, Air Defence, said: “So DRDO has embarked on a major programme of development of MEMS, nano-materials and nano-sensors to enable it to enter this particular area. In terms of speed, since the time available to reach the target will be short, the future work will be in the area of hypersonic missiles. We are already working on scram-jet technology. Our project on Hypersonic Technology Demonstrator Vehicle (HSTDV), where we want to demonstrate the performance of a scram-jet engine at an altitude of 15 km to 20 km, is already on.”

DRDO’s missile programme dates

back to 1959-60 when Dr. D.S. Kothari was Scientific Adviser to the Defence Minister. A group of young scientists including S.L. Bansal, K.C. Chaturvedi and B.N. Singh, motivated by the international scenario at that time and the 1962 Chinese aggression, set about thinking of missile technology development in India. Work began at the Metcalfe House in New Delhi at a conceptual level. Soon the missile establishment shifted to Hyderabad, where the State government gave it the army barracks of the erstwhile Nizam. This was the genesis of the Defence Research and Development Laboratory (DRDL), Hyderabad. DRDO started with building anti-tank missiles.

Its first anti-tank missile was a totally indigenous product – propulsion, control, guidance, power supply and the materials. There were no computers, and electronic circuits were used to make calculations. The missile was test-fired near Imarat, a village on the outskirts of Hyderabad. Its reliability proved to be good.

The project laid the foundation of India’s missile programme and it helped to train many technologists including A.V. Ranga Rao, S. Krishnan, K. Rama Rao, Z.P. Marshal, H.S. Rama Rao and J.C. Bhattacharya, who later contributed to the Integrated Guided Missile Development Programme (IGMDP).

Many from this group of more than 50 people, who were involved in the development of India’s anti-tank missile, went on to set up the Bharat Dynamics Limited (BDL), Hyderabad, which became the production agency of missiles. And, in the late 1960s, the Government of India decided on licensed production of SS-11B anti-tank missile of France at the BDL.

However, on the international scene, work on missile development had started before the First World War. During the Second World War, Germany could boast the brilliant missile technologist Werner von Braun. By the end of the Second World War, Germany had built the formidable V-2 rocket, signalling that Germany had arrived. After the defeat of Germany,

the U.S. and the Soviet Union captured Germany’s top missile technologists and used their expertise to build their missile programmes. A missile race began between the U.S. and the Soviet Union, leading to a proliferation of Intermediate Range Ballistic Missiles (IRBMs) and Intercontinental Ballistic Missiles (ICBMs).

REVERSE ENGINEERING

All this motivated DRDO to somehow bridge the gap and it initiated a major project for developing a surface-to-air missile (SAM). It did this by reverse engineering the Russian SAM-2, which Russia had supplied to India. India busied itself with this project from 1970 to 1979.

If DRDL has today grown to be a massive complex with a huge infrastructure, the credit should go to Air Vice Marshal V.S. Narayanan. He was the one who perceived the need to build a critical mass of infrastructure. He set up solid and liquid propellant test facilities, the base for precision-manufacturing of gyroscopes, accelerometers, actuators for missiles’ control and guidance, and foundry for manufacturing light materials such as magnesium. “I am happy to say that I joined DRDO as a young scientist at that time,” said Saraswat.

Saraswat gave another instance of the sweep and amplitude of Air Vice Marshal Narayanan’s vision. Narayanan realised that academic institutions should have tailor-made courses for young men interested in missile technology. An M.Tech course in missile technology was started at the Indian Institute of Science, Bangalore, with the help of its Aeronautics Department, in the early 1970s. Many DRDO scientists who pursued that course went on to become project directors and programme directors in its laboratories.

Between 1970 and 1979, the basic technologies needed for a missile programme were in place. Yet, India was not in a position to deliver the systems. So the indigenisation of the Russian SAM-2 began. In parallel, a programme called Valiant began under

the leadership of Squadron Leader R. Gopalswamy to build a rocket engine powered by liquid propellants. Saraswat was part of the team that built the engine between 1971 and 1974. Dr. B.D. Nag Chaudhri, then Scientific Adviser to the Defence Minister, motivated the young missile technologists not only to indigenise SAM-2 but build technologies needed for the future, such as liquid engines. The engine was tested on June 10, 1974. The previous month, India had conducted a peaceful nuclear experiment at Pokhran.

DRDO simultaneously turned its attention to building a guidance package because the inertial navigation system formed an essential part of a long-range missile. A team headed by D. Burman and comprising P. Banerjee and Avinash Chander (who now heads the Advanced Systems Laboratory in Hyderabad that designs and builds the Agni series of missiles) built a platform-based inertial navigation system (INS), which was tested on board an Avro aircraft in 1974-75. This INS, based on transistor-based analog computers, weighed 50 kg. (Today, the INS weighs 9 kg.) Subsequently, said Avinash Chander, an INS was built for both missiles and an aircraft, and this was tested in 1979 on board a Canberra aircraft.

By now, DRDL had built enough infrastructure in the fields of propulsion, navigation and manufacture of materials. But it did not have its own range (launch pads), so it used the Indian Space Research Organisation's Sriharikota base or the Indian Air Force's Suryalanka air base for flight-testing its own SAM-2.

Soon, India's political and scientific leadership, which included Prime Minister Indira Gandhi, Defence Minister R. Venkataraman, and Scientific Adviser to the Defence Minister V.S. Arunachalam, decided that all these technologies should be consolidated. This led to the birth of the Integrated Guided Missile Development Programme. A.P.J. Abdul Kalam, who was project director of ISRO's successful SLV-3 flight in 1980, was inducted as the DRDL Director to shape these di-



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verse technologies into a good product. It was then decided that DRDL would pursue multiple projects simultaneously and not merely one project at a time.

Thus, four projects were born under the IGMDP: the tactical surface-to-surface missile Prithvi, the tactical surface-to-air Akash, the short-range surface-to-air Trishul, and the anti-tank missile Nag.

According to Kalam, Prithvi could not be converted into a long-range missile and so the DRDO should come up with re-entry technology. "On Kalam's insistence, a development project on re-entry technology was included in the programme [IGMDP], and he called it Agni," said Saraswat. Thus, the 1980s saw the realisation of technologies in the areas of Nag, the inertial navigation system of Prithvi, phased array radars, capability to handle multiple targets, the re-entry technology of Agni, the ram-rocket motor of Akash, and so on.

TECHNOLOGY

The first Prithvi test-firing took place in 1988 and the Agni Technology Demonstrator's flight-test took place the following year. After the launch of Agni in 1989, the U.S. declined to give India the phase shifters for the phased array radars for Akash. Germany refused to give India the magnesium alloy used in Prithvi's wings.

Servo-valves needed for the electro-hydraulic control systems of Agni and Prithvi were embargoed. France, which used to give gyroscopes and accelerators to India, said its exports were taboo. Intel said it would not give India chips for the computers used in Prithvi and Agni. "This is a very short list. The list runs into hundreds of components and materials," said a top DRDO scientist. After 1989, DRDO evolved strategies to counter the MTCR.

The missile men duly began programmes for the development of phase shifters, magnesium alloy, servo-valves, and so on. Kalam and his team formed a consortium of DRDO laboratories such as the Solid State Physics Laboratory and the Defence Metallurgical Research Laboratory (DMRL), the Defence Research and Development Establishment, industries and academic institutions to build these sub-systems, components and materials. It was an exacting path, but it yielded positive results. The public sector undertaking Mishra Dhatu Nigam Limited (MIDHANI), DMRL and private industries developed the magnesium alloy in two years. When the first plate of magnesium alloy rolled out of MIDHANI, Germany proffered India any amount of magnesium alloy. DRDO wrote back saying it was prepared to export the alloy to Germany.

The phase shifters, a critical element for radars for Akash, was jointly developed by the Indian Institute of Technology, New Delhi, the Birla Institute of Technology and Science, Pilani and the Council of Scientific and Industrial Research (CSIR) laboratories. The resins and carbon fibres used in the re-entry systems of Agni, which were denied to DRDO, were developed in India. The winding machines, also denied, were fabricated.

Saraswat said: "While this was a painful process, it laid a strong foundation for research and it stood the country in good stead because today there is a flair for doing this kind of work in industry, academic institutions and laboratories." □