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Missiles in Indian Military's Arsenal and Their Features

New Delhi: Nestled in a hostile neighbourhood, India has to maintain a credible and potent defence force for which it has developed a series of tactical, medium and long-range missiles to deal with the threat posed by two nuclear adversaries – China in the north and Pakistan on its west. With the historic and successful test-firing of the supersonic cruise missile BrahMos from an Indian Air Force Sukhoi Su-30 MKI multirole air superiority fighter jet on November 22, India is moving towards developing the capability of launching pinpoint aerial attacks on enemy targets on land and sea, and in all weather conditions day or night.

With the IAF version of the BrahMos, India has added another lethal and potent weapons platform in its arsenal which already includes land and sea-based missiles. Apart from BrahMos, India already has the Agni, Prithvi, Nirbhay, and Dhanush series of missiles in its arsenal while submarine-launched ballistic missiles Sagarika and Shaurya along with Prahaar and Agni-V are in the development stage.

Here is a look at the deadly missiles in India's arsenal:

BrahMos: The product of an India-Russia joint venture, BrahMos is the most advanced cruise missile in the world today. Its name is a combination of Brahmaputra river in India and Moskva river in Russia. The 8-8.2 m long, 0.67 m wide BrahMos is a supersonic (Mach 2.0-2.8), short-range, ramjet-powered, single warhead anti-ship/land attack cruise missile which can carry a 200-300 kg high explosive or submunitions warhead. Its launch weight is 2,200-3,000 kg and it has a range of 300-500 km. It can be launched from land, air, submarine and ship. BrahMos has stealth features, deep-dive capabilities to hit targets hidden in mountains, and uses a solid propellant boost motor with a liquid-fueled ramjet sustainer motor. A hypersonic variant of the missile is also under development which will use a scramjet engine and use a special fuel to reach speeds of more than Mach 5.

Prithvi-I: It is India's first indigenous missile developed and operationalised under the Integrated Guided Missile Development Programme (IGMDP). Prithvi-I is a short-range, road-mobile ballistic missile, uses single-stage liquid propellant engine and entered into service in 1994. The missile is 8.56 m long, 1.1 m in diameter, weighs 4000 kg and can carry a warhead weighing up to 1000 kg. It has a minimum range of 40 km and a maximum of 150 km. It has an accuracy of 50 m Circular Error Probability (CEP). Some missiles of the Prithvi series are nuclear tipped too.

Prithvi-II: It is similar to Prithvi-I but can carry a lighter warhead of 500 kg over a longer range of 250-350 km with an accuracy of 50 m CEP. It can carry a 1,000 kg warhead but over a shorter range. The road-mobile, single-stage liquid propellant engine driven missile is 9.0 m long, 1.1 m in diameter, and weighs either 4,000 or 4,600 kg.

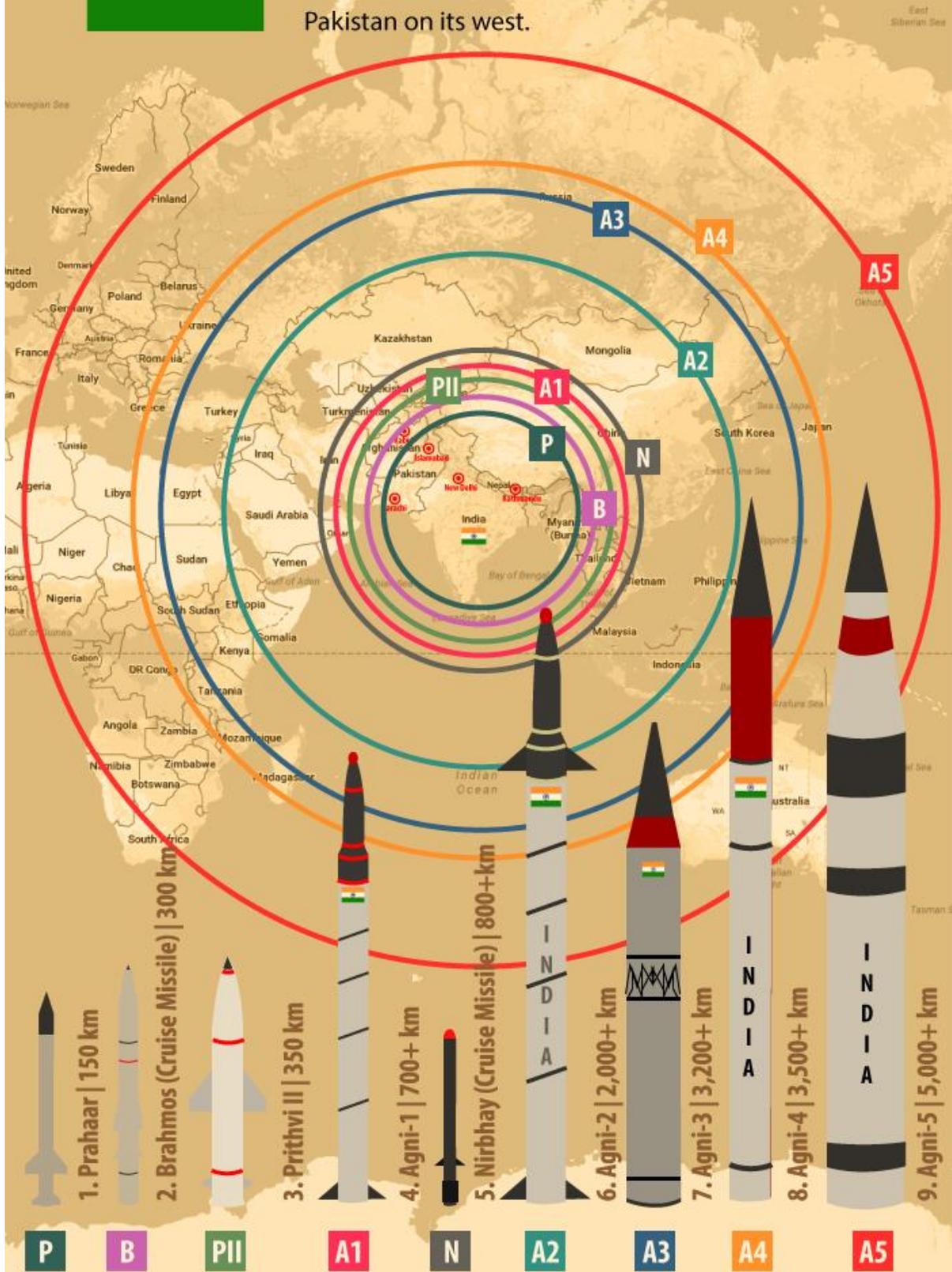
Prithvi-III: The last in the Prithvi series, this too is a short-range, road-mobile missile but uses a two-stage, solid propellant motor. Much more accurate than its predecessors with a CEP of 25m, Prithvi-III has a range of 300 to 350 km and can carry a warhead of 500 to 1000 kg. It has also been configured to carry nuclear payload of 10 to 20 kilotonne.

Dhanush: This is the naval version of Prithvi-I. It is a short-range, ship-based ballistic missile which is 8.53 m long, 1 m in diameter, launch weight 5,600 kg and can carry nuclear, high explosive, submunitions, Fuel-Air Explosive (FAE) or chemical weapons over a range of 250-400 km. It entered service in 2010. Powered by a single-stage liquid it has a CEP of 25 m.

INDIA'S MISSILES



India has developed a series of tactical, medium and long-range missiles to deal with the threat posed by two nuclear adversaries - China in the north and Pakistan on its west.



Agni-I: Aimed primarily at Pakistan, the 700km range, 14.8 m long and 1.3 m wide, the short-range Agni-I ballistic missile can carry a 2000 kg warhead. The 12,000 kg solid propellant road and rail mobile launched missile has an accuracy of 25 m CEP and can be nuclear armed with a warhead of 20 or 45 kT. Its range can be extended to 1,200 km if it carries a warhead of 1,000 kg.

Agni-II: In service since 2004, the medium range Agni-II ballistic missile is 20 m long, 2.3 m wide and has a launch weight of 16,000 kg. It is a road/rail-mobile launch missile and can carry a 1000 kg warhead which is mostly a 150 kT or 200kT nuclear bomb and has an accuracy of 40m CEP. It can also be fitted with high-explosive conventional bombs. With a reduced payload its range can be increased to 3,500 km.

Agni-III: The intermediate-range ballistic missile (IRBM) Agni-III uses a two-stage solid propellant engine, has a range of 3,000-5,000 km and is capable of hitting targets deep inside China including Beijing and Shanghai. It is 16.7 m long, 1.85 m wide, launch weight 48,000 kg and carries a single 2,000 kg warhead which is a 200-300 kT nuclear fusion bomb with an accuracy of 40m CEP.

Some missiles have multiple independently targetable reentry vehicles (MIRV), which means they can annihilate several targets simultaneously.

Agni-IV: In service since 2013, Agni-IV is an IRBM with a range of 3,500-4,000 km and a warhead capacity of 800 kg which will be a nuclear fission bomb of 20 or 45 kT or fusion bomb of 200-300 kT. It is 20 m long, a two-stage solid propellant missile with a launch weight of 17,000 kg.

Agni-V: India's only Intercontinental Ballistic Missile (ICBM), Agni-V is still in the development stage. Although Agni-V's officially announced range is 5,500-5,800 km, defence experts are of the view that its range can be easily extended to at least 8,000 km.

The missile is three-stage solid fueled missile and is configured to carry up to 10 MIRVs. The missile is 17.5-20 m long, 2-2.2 m wide with a launch weight of 49,000-55,000 kg. While there has been no official word on the kind of warhead Agni-V will carry, all such weapons with other countries are nuclear tipped.

Sagarika: It is a submarine-launched short-range ballistic missile (SLBM) and is also known as K-15/B-05. The two-stage solid propellant driven 700-750 km range Sagarika is 10.8 m long, 0.8 m wide, and has a launch weight of 5,500 to 6,300 kg. It can carry both conventional or nuclear warhead weighing 500 to 800 kg.

Shaurya: Sagarika's advanced version, Shaurya is a submarine-launched medium-range ballistic missile which is 12 m long, 0.8 m wide, uses a two-stage solid propellant and has a range of 3,000-3,500 km. Its launch weight is 17,000 kg and it can carry a 2,000 kg warhead which is likely to be a nuclear bomb. With Sagarika and Shaurya, India has completed its nuclear triad.

Prahaar: The indigenous Prahaar is another short-range, solid propellant, road-mobile ballistic missile. It has been developed to target enemy armoured formations, bunkers, command and control centres. The road-mobile 150 km range Prahaar is 7.3 m long, 0.42 m wide and has a launch weight of 1,280 kg. It can carry a single nuclear, high explosive or submunitions warhead weighing 200 kg.

Nirbhay: This is India's first indigenously produced cruise missile which can be fired from land and submarine. It is 6.0 m long, 0.5 m wide with a launch weight of 1,500-1,600 kg. It can be used to carry both conventional and nuclear warhead.

While the conventional warhead can be 450 kg of high explosive or submunitions, the nuclear warhead can be of 12 kT. Powered by a turbojet, Nirbhay's range will be 800-1,000 km.

Sat, 25 Nov, 2017
(Online)

DRDO to Test New Propellant Booster on BrahMos Missile in December

The High Energy Materials Research Laboratory (HEMRL) of India's state-run Defence Research and Development Organisation (DRDO) will conduct a mechanical vibration test of a solid propellant booster for the BrahMos supersonic cruise missile sometime in December.

"A solid propellant booster, which is an important component of the BrahMos, is in its final stages of development. The requisites, which have been conducted in the recent past, have shown positive results and a final test, called a mechanical vibration test, will be carried out next month. The propellant will thereafter be put to use in the missile," HEMRL Director KPS Murthy, who was speaking to reporters on the sidelines of the inauguration of the 11th International High Energy Materials Conference and Exhibits (HEMCE-2017) said Thursday.

The solid propellant booster is soon going to be introduced for future launches of BrahMos. The two-stage missile system uses a solid propellant booster to achieve supersonic speed in the first stage while at the second stage the liquid ramjet takes the missile closer to Mach 3 speed in cruise phase.

The booster trial results have been evaluated by Russian experts and the final test is expected to be conducted sometime in December.

The BrahMos missile has been jointly developed by Russian and Indian scientists and is the world's first and only supersonic cruise missile. It is a precision strike weapon for the Indian armed forces and can be fitted in ships, mobile launchers, submarines and aircraft against land and sea targets.

HEMRL is responsible for the design and development of ignition systems for all classes of solid rocket propellants used in the tactical and strategic missile programs of DRDO such as the Pinaka Mk I & Mk-II, Akash, Nirbhay, AAD, Agni program.

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Sat, 25 Nov, 2017
(Online)

Arjun battle tanks to get homegrown missile next year

The indigenous missile is under trials and would be able to meet the army's requirement of engaging targets at ranges less than 1,200 metres.

India's homegrown Arjun Mk-2 tanks may finally get missile firing capability next year.

The Defence Research and Development Organisation (DRDO) will be ready with a new indigenous missile that can be fired from the tank, a top government official told Hindustan Times on Saturday. The upgrade of Arjun Mk-2 tank suffered a major setback in 2013 after the Israeli missile to be fitted on it failed to meet the army's requirements, delaying the programme by several years.

The indigenous missile is under trials and would be able to meet the army's requirement of engaging targets at ranges less than 1,200 metres.

The army rejected the Israeli LAHAT (laser homing anti tank) missile, manufactured by the Israeli Aerospace Industries, because it could engage targets only at ranges beyond 1,500 metres. The LAHAT missiles tested by the army and the DRDO cost nearly Rs 20 crore, an expenditure dubbed unfruitful by the national auditor in a recent report.

The army initially wanted a missile that could engage targets between 500 metres and 5km, but later revised the requirement to 1,200 metres and 5 km.

Missile firing capability is one of the most significant upgrades proposed in the tank. The defence ministry cleared the purchase of 118 Arjun Mk-2 tanks at a cost of more than Rs 6,600 crore in 2014.

The DRDO-developed tank is an upgraded version of the Mk-1 variant, 119 of which have been inducted in the army. The Mk-2 variant is supposed to have nearly 80 improved features over the previous version, including more than 15 major technology upgrades.

The major improvements on the new tank include better firepower, integrated explosive reactive armour, advanced laser warning and countermeasure system, a mine plough, a remotely-operable anti-aircraft weapon, advanced land navigation system and enhanced night vision capabilities.

The army raised its maiden armoured regiment equipped with Arjun Mk-1 tanks in May 2009, more than 35 years after the project was conceived.



Mon, 27 Nov, 2017

IAF banks on Tejas, new fighter to bolster fleet

By Dinakar Peri

It has a sanctioned strength of 42 squadrons and a projected requirement of 45 to face the threat of a two-front war

As the deal with the French government for 36 Rafale jets lands in the middle of political maelstrom, the Indian Air Force (IAF) is looking at Tejas, the indigenously developed light combat aircraft, and a single-engine fighter to be procured soon to arrest the dramatic fall in its squadron strength.

“The rate of decommissioning of aircraft is way higher than the planned and even proposed inductions. Tejas is a good aircraft, and 123 of them will be inducted in the force as planned. But the numbers are not coming fast enough, and the requirement is much beyond that in other categories,” a Defence Ministry source said.

The IAF has a sanctioned strength of 42 squadrons and a projected requirement of 45 to face the anticipated threat of a two-front war. Now, the force has 33 squadrons and by December-end, it will be down to 31. With the planned induction of 36 Rafales between 2019 and 2022, the remaining Sukhoi-30MKIs and some Tejas jets, the strength will be 30 till 2027. In the subsequent five-year term, it will fall to 27. If there are no new inductions, it will slide further to 19 by 2042.

“The IAF is upgrading most of the aircraft in its inventory. But from 2025, most of those aircraft such as the Jaguars and the MiG-29s will start going out,” the source said.

In a month, the IAF is expected to issue the Request for Information (RFI) for over a 100 single-engine fighter aircraft under the Strategic Partnership model. Lockheed F-16 and Saab Gripen are in the race for the order and have already tied up with the Tatas and the Adani group, respectively, to build the jets locally with technology transfer. The IAF has placed orders for 40 jets in two batches of which the first 20 are in the initial operational configuration and the remaining 20 in the final operational configuration.

The order for 83 Tejas Mk-1A jets is expected soon.

Apt move by def min to purchase Spike missiles

APROPOS ‘Spike likely in India’s missile armoury’ news. It seems to be a good move on the part of defence ministry to immediately procure spike missiles from Israel in order to meet the urgent requirement of the force. At the moment, the army needs third generation ATGMS, with a strike range of at least 2.5 km and with fire and forget capabilities in order to equip all its 382 infantry battalions and 44 mechanised infantry units, which at the moment are depending on Russian IBMP combat vehicles. In fact, this buying from Israel and manufacturing indigenous at the same time will balance the need for taking care of internal security requirements along with promoting of ‘Make in India’.

The Defense ministry, which was talking to both US and Israel for purchasing of these missiles, has ultimately decided to procure it from Israel at the cost of around Rs. 3000 crore. Nevertheless, the army is still facing shortage of missiles and in order to build up stocks to last for at least 10 days in case of intense fighting, sufficient procurement is immediately required and here it is seen that the Defense minister is very quick to take decision and buying of Spike missiles from Israel is one such prompt and better decision.

*Mon, 27 Nov, 2017*

Mi-17 to get advanced navigation system

By Vijay Mohan

The Indian Air Force has approached Hindustan Aeronautics Limited (HAL) for retrofitting part of its Soviet-origin Mi-17 medium lift helicopter fleet with advanced navigational aids.

Under the project, to be executed at No.3 Base Repair Depot in Chandigarh, nearly 60 helicopters will be retrofitted with the Tactical Air Navigation System (TACAN) as well as the VHF Omni-directional Radio Range (VOR) equipment and instrument landing system, IAF sources said.

HAL has traditionally been associated with the licence manufacture and repair of western-origin helicopters such as the French Alouette III and the SA-315 Lama, known locally as Chetak and Cheetah, as well as the Dhruv, advanced light helicopter and the proposed Indian Multi-Role Helicopter that envisions to replace older Mi-17 variants in a few years. HAL is not known to have been associated earlier with modifications or upgrades related to Mi-8/17 and Mi-25/35 fleet.

TACAN provides the aircrew the exact bearing and distance to a ground station and is primarily meant for military aircraft. Equipped aircraft can use this system for route navigation as well as non-precision approaches to landing fields. On ground, TACAN receivers can be placed on top of a building or in a truck. It is a smaller and more accurate version of VOR that is now the standard air navigational system in the world where aircraft determine their position and stay on course by receiving radio signals transmitted by a network of fixed ground radio beacons.

Besides supplying the navigation equipment along with associated accessories and technical support, HAL will also be required to train IAF personnel in the operation and maintenance of the equipment in Chandigarh. Sources said that the project is expected to commence in January 2018, with three helicopters being initially retrofitted and evaluated by the IAF. The remaining choppers will be upgraded in batches within two years.

Sukhoi plant can roll out 5th- gen fighter jet: HAL

The facility at Nasik is set to fall idle after it delivers the last batch of 35 aircraft out of the total order of 222 to the IAF

New Delhi, Nov. 26: The manufacturing facility of the Hindustan Aeronautics Ltd producing Sukhoi fighter jets can be used to build the fifth generation fighter aircraft if the government decides to go ahead with the proposed Indo-Russian joint venture, T Suvarna Raju, the chief of the aerospace behemoth, has said.

Mr Raju said the state-of-the-art facility in Nasik will not require any major investment to reconfigure it to produce the fifth generation fighter aircraft.

He said there was much in common between the FGFA and the Sukhoi 30MKI jet as both had structural similarities and the plant was well equipped to produce the new generation stealth fighter for which India and Russia have been in negotiations for nearly a decade.

“Definitely, it can be used for the FGFA. It will need a little bit of augmentation. We will not need major investment,” Mr Raju, the chairman and managing director of HAL, said.

The facility set to fall idle after it delivers the last batch of 35 aircraft out of the total order of 222 to the Indian Air Force.

In 2007, India and Russia had inked an inter-governmental pact for the FGFA project but no concrete decision has yet been taken on it.

Pitching for the FGFA project, Mr Raju said it would be an opportunity for India to acquire high technology which has not been offered to it by any other country except Russia. “I will not comment on the justification on expenditure on the project. But, as a country, if we are looking for fifth generation technology,” Mr Raju said.

Mahindra Defence, Shapoorji Pallonji May Bid for Troubled Bharati Defence

The two companies evaluating deal that values the target company at \$350 million

By Sneha Shah & Baiju Kalesh

Mumbai: Mahindra Defence and Shapoorji Pallonji Group may independently bid for the troubled Bharati Defence and Infrastructure (formerly Bharati Shipyard) in the first such bankruptcy resolution attempt under the Insolvency and Bankruptcy Code for the security industry.

The two companies are currently evaluating the deal that values the target company at \$350 million, said three people with direct knowledge of the development. Bharati has also seen interest from other suitors such as German Dry Docks and other companies seeking to control individual docks along India's eastern and western water margins.

“Mahindra Defence and Shapoorji Pallonji group have been approached and they are currently carrying out due diligence on the company,” said one of the persons with direct knowledge of the development. EY is acting as advisor to the lenders.

Bankers now have to take a call on liquidating the company that has been taken to the National Company Law Tribunal (NCLT) by the asset reconstruction arm of Edelweiss, which has a controlling stake in it through pledged shares.

“This opportunity has been presented to us. However, we have not put in any formal bid as of date for Bharati Shipyard,” a Shapoorji Pallonji Group spokesperson said in an e-mailed response to queries from **ET**. “Given our significant presence and strengths in the infrastructure sector, our strategy and business development teams are regularly evaluating opportunities.”

Bharati Defence: The Sinking Ship

2017

Edelweiss ARC acquires 85% of the outstanding ₹10,000-CRORE debt of the company

Flies for resolution at NCLT under the new Indian Bankruptcy Code, seeks bidders

Some suitors interested in location specific docks

Many suitors including German Dry Docks approach them

Mahindra Defence and Shapoorji Pallonji Group approached

COMPANY BEING VALUED AT \$300-350 MILLION

Edelweiss declined to comment, and Bharati couldn't be immediately contacted. Mahindra spokespersons were traveling and could not be reached.

Mahindra Defence considered acquiring Pipavav Defence in a ₹3,000-crore deal in 2015. However, the Anil Ambani-led ADAG bought the company in a slump sale. “Mahindra Defence has been actively looking at acquisition opportunities and this could be an ideal fit,” said another person with knowledge of the development.

Earlier this year, creditors led by Edelweiss, which owns 85% of the ₹10,000-crore debt of the company, filed a case at NCLT seeking permission to turn around the company under new management. Creditors have proposed a revival package for the ailing company under the Insolvency and Bankruptcy Code. This will require infusion of ₹400 crore initially.

The new code requires lenders to approach NCLT with a concrete revival plan, which, if approved, has to be set in motion within 180 days.

Edelweiss has appointed former naval officer Narendra Kumar as CEO of the company.

“Edelweiss has approached the court and got a restraining order for the promoters from coming to the office,” said another person. The fund is now looking at giving the company a fresh infusion of capital to ensure some orders are delivered to the Coast Guard and the Indian Navy.

Edelweiss's Distressed Assets Resolution Business could play a role in the revival. It is unclear whether CDPQ of Canada, which has an agreement with Edelweiss, will invest in the company, **ET** reported in August.

THE ASIAN AGE

Mon, 27 Nov, 2017

‘Pakistan nukes surest route to nuclear war’

In the last four decades, the Pakistani deep state’s pursuit of low intensity conflict in Afghanistan and India.

Washington: Pakistan’s tactical nuclear-weapons programme is not only dangerous for safety and security of the region, but also it is the surest route to escalating conventional war to the nuclear level, according to a report by an American think-tank.

In its report “Asia in the Second Nuclear Age”, the Atlantic Council, however, said Pakistan does not appear to have operationalised its tactical nuclear-warfare plans yet. “Pakistan’s tactical nuclear-weapons programme is dangerous for safety and security reasons, and also because it is the surest route to escalating conventional war to the nuclear level. However, Pakistan does not appear to have operationalised its tactical nuclear-warfare plans yet,” said the report released this month.

The greatest threat in the region comes not from the development of large, sophisticated, and diversified nuclear arsenals, but from the continued stability of the institutions guarding them. “In this regard, the future stability of Pakistan remains a wild card,” said the report.

In the last four decades, the Pakistani deep state’s pursuit of low intensity conflict in Afghanistan and India, via the vehicles of radical jihadi non-state actors, has produced terrible blow back effects on Pakistan itself. Noting that both the Pakistani state and civil society have become the targets of terror attacks, it said some attacks have occurred, with insider help, on sensitive military bases where nuclear weapons are likely stored. “The possibility that Pakistan’s nuclear weapons could be stolen — or that schisms in Pakistan’s military might cause nuclear command-and-control failures — is not as fantastic as it once seemed,” report said.

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Mon, 27 Nov, 2017

Iran: Will increase missile range if Europe threatens

London: The deputy head of Iran’s Revolutionary Guards warned Europe that if it threatens Tehran, the Guards will increase the range of missiles to above 2,000 km, Fars news agency reported.

France has called for an “uncompromising” dialogue with Iran about its ballistic missile programme and a possible negotiation over the issue separate from Tehran’s 2015 nuclear deal with world powers.

“So far we have felt that Europe is not a threat, so we did not increase the range of our missiles. But if Europe wants to turn into a threat, we will increase the range of our missiles,” Brig Gen Hossein Salami said.

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Mon, 27 Nov, 2017

Low-cost launches will put Isro in a new orbit

By Prakash Chandra

Outsourcing manufacture to private players can stimulate R&D and bring innovation to its missions

The 2008 Chandrayaan 1 Mission and the 2014 Mars Orbiter Mission Have Established ISRO’S Credentials as a Lowcost, Hightechnology Service Provider

The Indian Space Research Organisation (Isro)’s loud thinking on outsourcing the manufacture of satellite launch vehicles is not surprising. “Work is in progress to put the mechanism (for outsourcing) in place,” Isro chairman AS Kiran Kumar told mediapersons in New Delhi last Tuesday. This, he said, has been done to balance the growing demand for satellites with the need for adequate numbers of launch vehicles. While a roadmap for the extent and scope of private participation in Isro’s new scheme of things may take a while to unfold, the basic idea seems to be for the agency to provide training for industry at its centres and allow private players wider access to its design, drawings, and testing facilities.

Isro uses industry manpower and facilities to build small to mid-sized satellites — ranging from 300 kg to 2,000 kg — for domestic use and export. The latest move gives the agency room to focus on its primary goal of becoming a leader in the highly competitive global satellite launch market, particularly for nano- and micro-satellites. The international market for these satellites is expected to touch \$3 billion in the next couple of years, as thousands of satellites for space-based applications like navigation and surveillance line up for launch by 2025. This is unlike the heavier (plus 2.5 tonne) communication satellite market where Isro’s Geosynchronous Satellite Launch Vehicle (GSLV) seeks to make a mark.

Isro is keen on private operators like Godrej & Boyce taking over its workhorse Polar Satellite Launch Vehicle (PSLV) programme altogether. The PSLV has recorded more successful missions, 39, than any other space agency with comparable launchers and Isro is now developing a 'compact' booster along the lines of the PSLV. This new avatar can be assembled in just 72 hours as against the 40 day-turnaround time a standard PSLV would take, and can launch payloads up to 700 kg into a near-Earth orbit of 700 km.

While energising Isro's partnership with private players in satellite fabrication is one thing, subcontracting private industry to build launchers is a potential game changer that could stimulate R&D and help absorb enterprise and innovation into Isro's missions. This has been proven by Nasa and the European Space Agency where private players like SpaceX and aerospace majors like Boeing play key roles in launches. In any case, corporate giants like Godrej, Tatas, L&T, Mahindras and the state-run Hindustan Aeronautics Limited (HAL) have been supplying critical systems and spacecraft parts to Isro's launch vehicles. So opening the door wider to private participation would encourage more big players to join in the effort to bolster India's launch capability. Private companies are not hamstrung by bureaucratic tangles that often stall government projects, and they are magnets for funding from various sources since high-tech companies automatically attract investment.

This could not happen sooner as India's current launch rate of three satellites a year for domestic use is set to jump to 20 satellites from 2018. As satellites get smaller and cheaper, there is a corresponding need to develop more cost-effective launch vehicles to keep the number of launches higher and costs lower. India currently boasts 30 to 35% cheaper launches than other countries. The 2008 Chandrayaan 1 mission (which helped scientists confirm the presence of water on the Moon) and the 2014 Mars Orbiter Mission (carried out on a ridiculously low budget) have established Isro's credentials as a low-cost, high-technology service provider par excellence in the satellite launch market.

As Isro wades deeper into the fiercely competitive global launch market dominated by the American, Russian, European, and Chinese launchers, it is imperative to have another cost-effective space transportation system like the Reusable Launch Vehicle (RLV) for smaller satellites. The RLV's booster and upper stage are reusable, so it would bring down launch costs dramatically with a corresponding increase in launch capability. Having successfully test-flown the RLV's technology demonstrator version last year, Isro should try to realise the technology as soon as possible. Along with a small-scale version of the PSLV, this could provide an ideal launch configuration for Isro to find its place in the sun.

Prakash Chandra is a science writer. The views expressed are personal