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FIGHTING FUTURE WARS

A ROADMAP FOR ADOPTION OF DISRUPTIVE TECHNOLOGIES IN THE INDIAN MILITARY

DISRUPTIVE INNOVATION AND INDIA'S DEFENCE PRIVATE SECTOR

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About the author

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Introduction

The Indian Government and armed forces need to come together to drive a revamp of the defence procurement and industry ecosystem, if they are to remotely succeed in their task of re-equipping the military with 'Disruptive Technologies' suited for the battlefield of the future and deliver state-of-the-art indigenously developed defence equipment. The overhaul and revamp of Indian defence procurement is the equivalent to "cleaning of the Augean stables," and must be done, if the local defence industry and procurement ecosystem is to pivot towards the military's needs for the future battlefield.

Despite the need to equip the military for future conflicts, successive Governments have proven unequal to the task of reforming Indian defence procurement and its 'Gordian Knot' of problems related to replacement of legacy eighties era military hardware at huge cost. The military too must acknowledge its part in the problem, as it has been unable to come to a conclusion on the reorganization and re-structuring needed to fight future wars, as has been done by several other militaries including China.

India's military at present is equipped to fight 'Today's War' with 'Yesterday's Technologies'. For the purposes of this discussion, we can set a timeline for any armed conflict before 2030 as today's war and defence equipment inducted before 2010 (which themselves were developed in the late eighties/early nineties), as yesterday's technologies. All three wings of the Indian armed and paramilitary forces are saddled with substantial amounts of legacy defence equipment originally procured in the eighties, followed by significant though smaller (one could even argue, piecemeal) procurements post the 1999 Kargil War. "The country's military has a most impressive heritage, legacy, and spirit. But the nation's procurement practices and industrial policy are basically a betrayal of all that is good about that military," says Richard Aboulafia Vice President of Analysis at Teal Group. in any future conflict, the Indian armed forces will largely be at a technology disadvantage and hope that a preponderance in numbers and quality of training will help turn the tide.

Future Reality

Disruptive technologies create a paradigm shift on the battlefield as they tend to change how actors compete on a battlefield and are not related to their novelty or complexity alone. They also bring in particular attributes which change how one interacts with a specific community of users in a particular environment.[1] "If you want disruptive technologies to come in, it can only happen if you have an ecosystem for technology development, which is linked to some major programmes of the company or the country," says Dr. Shyam Chetty Former, Director of CSIR National Aerospace Laboratories (NAL). The long gestation periods for Aerospace and Defence (A&D) programmes are due to their safety critical nature for the users, operating environment and aspects related to collateral damage etc. Hence developmental timelines are often protracted with the result that development of disruptive technologies often progresses slowly, requiring a very long term roadmap and hence cannot be achieved by the

[1] (i) C. ANTHONY PFAFF. *The Ethics of Acquiring Disruptive Military Technologies*. Vol 3, Issue 1 Winter 2019/202034. Texas National Security Review, 2015.

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same developmental approach taken towards delivering conventional defence technologies with incremental upgrades.

In the aerospace domain, we are witnessing a global trend towards 'Loyal Wingman' Unmanned Combat Aerial Vehicles (UCAV) and related swarm operations. Such developments show the way forward and investments in these technologies must be made now, if India is not to be left behind. This is especially the case as the continued heavy focus on traditional military platforms, runs the risk of placing India at a significant disadvantage when disruptive technologies become available to China.

Keeping in mind the present technology levels of India's armed forces and public and private sector defence industry, the nation would be better served in targeting 'Disruptive Innovation' in key areas instead. 'Disruptive Innovation' is a buzzword used to describe the way in which new entrants in a market can disrupt established businesses and first coined by Clayton Christensen in the mid 1990s. The process whereby a smaller company with fewer resources is able to successfully challenge established incumbent businesses is described as 'Disruption'. New entrants can become disruptive by starting to successfully target overlooked market segments and later gaining a foothold by delivering improved functionality and often at a lower price. Such entrants then move up the value chain, delivering better performance, while preserving advantages that drove their early success. Disruption is said to have occurred when mainstream customers start adopting the new entrant's offerings in large numbers.[2]

Enabling 'Disruptive Innovation' within the Indian defence industry is key to setting them on the path of 'Disruptive Innovation' and creating the necessary defence ecosystem for such an endeavour. It is important to note however, that the term 'disruption' is often used all too frequently in a broader concept of innovation in support of whatever organisations wish to do, and this is something one would need to guard against. We must guard against packaging current generation technologies and passing them off as disruptive technologies. Countries such as Israel, South Korea and Turkey have followed the path of disruptive innovation to create a high level of self-sufficiency in their respective defence industries and achieve sustained and significant export success. Israel as example, only got good at technologies and exports when it abandoned its dream of having a national fighter prime and sinking enormous resources into such programmes.

Despite being a late starter, India yet has to time to pick and choose its core areas for future defence technologies, as it will take a lot longer than expected for new transformational technologies to really impact warfighting. India's increasingly confident defence industry is growing in capability but in comparison with global competition and those in SE Asia and APAC, it is still in a stage of infancy. However, they can yet contribute meaningfully to technologies related to miniaturization, networking of sensors, software driven hardware, etc.

[2] CLAYTON M. CHRISTENSEN, MICHAEL E. RAYNOR, AND RORY MCDONALD. *What Is Disruptive Innovation?.* Harvard Business Review, 2015

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The recently announced indigenous Loyal Wingman concept programme from Hindustan Aeronautics Limited (HAL) could be a potential disruptor. Once the entire concept comprising of manned and unmanned assets operating in conjunction with each other, is realised along with loitering and stand-off munitions, it would certainly deliver a disruptive effect on the battlefield. HAL is following the approach of disruptive innovation here, as it has tied up with start-ups to deliver on innovative swarm munitions. However, considerable support from the Government and armed forces will be needed to guide complex programmes such as an unmanned loyal wingman aircraft, along its journey from design, development, trials, certification, series production, induction into operational service and finally product support.

Overcoming the Status Quo

In his address at a seminar on the "Impact of Disruptive Technologies on Our Fighting Philosophy in Future Conflicts" at Army War College, Mhow, in August 2020, Army Chief General MM Naravane highlighted the impact of disruptive technologies in warfare and war fighting but emphasized that the current modernization drive was focused on upgrading existing weapon systems and platforms. General Naravane said that while adequate emphasis must be given to available dual use disruptive technologies, he also recommended an overarching national mission to identify the needs and congruence of products into military applications be formed as part of the armed forces modernization strategy. This is an area of concern as development of disruptive technologies like Cloud Computing, Artificial Intelligence (AI), Augmented Reality/ Virtual Reality (AR / VR), Robotics, Big Data Analytics, Cyber, Small Satellite, 5G/6G, Quantum Computing and cyber warfare is already well advanced and such a national mission should have already been setup by now.

One could go as far as to say that if India is to have any realistic hope of introducing cutting-edge defence equipment into operational service in the latter half of this decade, and homegrown disruptive technologies' by the end of this decade, it would require much greater participation from the nation's defence private sector. However, it is also quite evident that the emergence of such disruptive technologies from India's current defence ecosystem will be challenged not only by high technological and cost barriers but also a strong aversion from private sector defence industry in investing in the research and time needed to develop genuine high technology products. This dichotomy can only be addressed with a strong commitment from the Government and armed forces to provide the defence private sector with realistic technology development milestones and firm development timelines coupled with a level playing against Defence Public Sector Units (DPSU) and steady orders for equipment.

It is now clear that that the defence ecosystem created with much sweat and toil between 1990 – 2010; as a result of the Integrated Guided Missiles Development Programme (IGMDP), Light Combat Aircraft (LCA) and Advanced Light Helicopter (ALH) programmes, Arjun Main Battle Tank (MBT) and numerous other projects handled by the Defence Research Development Organisation (DRDO), Hindustan Aeronautics Limited (HAL) and other DPSUs, requires a reboot to meet the demands related to development of current state-of-the-art in

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military technology, let alone seed the development of disruptive technologies for the Indian armed forces.

India's policy makers also need to decide between acquiring effective weapons systems at reasonable prices or driving acquisitions to deliver in-country capabilities and jobs as the two goals are not compatible.[3] The former approach could be better suited to drive growth of the private sector defence industry as compared to the latter, which often ends up in the hands of DPSUs. Few would quibble on the fact that India has been unable to leverage its import of costly defence equipment into acquisitions and enhancing its defence industrial base.

The scale of the challenge is enormous indeed and belies the token efforts made thus far to overhaul not only the nation's defence procurement but also its defence industrial base. This is largely due to the fact that design and development of major defence platforms (and the attendant investments) yet remains the preserve of Defence Public Sector Units (PSU), as successive Government appear loath to changing the status-quo. India's disastrous mistake has been to focus on a single national champion (DRDO, DPSUs) with no international or domestic competition. "The problem with a largely state-run defence establishment, like India's, is that it favours manufacturing jobs, rather than transformational technologies. Platforms, particularly traditional ones, tend to stick around a lot longer than they should," says Aboulafia.

At the end of the day it boils down to what India needs with regards to achieving her military aims and how it will be supported by indigenous capability. if the focus is solely on platforms for national prestige, then these will be accomplished over the next few decades with a lot of money, as is currently being done for nuclear submarines, missile programmes, aircraft carriers and 4/4.5 gen fighter aircraft programmes. Evidently, these platforms need to be developed to meet strategic priorities, but they are hardly likely to feature disruptive technologies. Be it a tank, warship or aircraft, technologically, almost all of the innovative new technologies on these platforms today are largely related to their subsystems and not the chassis, hull or airframe respectively. While the government could mandate local content to ensure maximum technology development, it compromises on the essential goal of giving engineers freedom to source globally and develop the best product. Keeping Disruptive Innovation in mind, and if the private sector industry is to benefit and thrive, then it would be better to focus on specific niche areas.

The ability of the Ministry of Defence (MoD) to run complex defence programmes has also proven less convincing, given the large number of stakeholders, general bureaucracy, vested and often competing interests of different DPSU/DRDO labs and a general lack of accountability. Programmes often meander along for decades until they die a quiet death or overcome enormous odds or in some cases find favour with the ruling dispensation of the day. Of course, India is not alone in facing this challenge, many developed nations also face this issue to some extent but then our security challenges are far more immediate and hence this is an area that needs greater introspection.

[3] ATUL CHANDRA, *"India's Fighters Battle for Relevance",* Flight International, February 2015

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Innovating to Disrupt

The U.S. Army's Enhanced Night Vision Goggle – Binocular (ENVG-B) is an example of disruptive technology that dramatically enhances the combat effectiveness and survivability of a soldier with a Heads-Up Display (HUD) that integrates wirelessly with weapon optics, providing the soldier with real-time combat information and navigation assistance in addition to using AR technologies that deliver see-through map overlays and a compass,. However, integrating some of these systems for an indigenous system would certainly not be out of the realm of possibility as the Indian private sector is ideally suited for disruptive innovation in such niche areas. Night Vision Devices / Night Vision Goggles (NVD/NVG) technology is now transitioning from being hardware heavy and dependent on legacy processing platforms to software driven hardware. These NVDs/NVGs are harnessing the ever growing processing power available on new computing platforms and bringing the latest and greatest of consumer electronics right into the hands. In earlier times it took years for military hardware to catch up with the advancements in consumer electronics.

"Today however, the situation is reversed, allowing companies to enable an Electro Optics (EO) device with edge video processing, have real time auto target recognition capabilities using deep learning models making them smart NVDs and reducing reaction time, in turn saving lives of a jawan on ground," says Ankit Kumar, CTO and Co-Founder, Tonbo Imaging. Tonbo is making use of the tremendous advances taking place in the consumer electronics ecosystem, to deliver systems that are much more powerful and designed to solve challenges such as scalability, wireless coexistence, future-proofing and support for third-party hardware/software architecture. The company has been using Android software for its night vision systems as it provides all the required interfaces to transmit video and communications data to command and control centres.

Many armed forces worldwide have their own wireless and wired networks across the country to enable communication to EO devices. The communication interface options available on consumer electronics provide all possibilities of communication like LTE in an urban setting, wireless with their point to point connections on borders and Bluetooth type network for short range communication to personal devices like their rugged wrist / handheld computers. EO systems are now being fitted on nearly everything from helmets, to small arms and land vehicles, manned / unmanned aircrafts and naval vessels they are now the eyes and brains everywhere improving situational awareness and intelligence gathering capabilities of a nation. It is one such domain where disruptive innovation could deliver tangible benefits to the armed forces and Indian private sector defence firms due to the large order volumes.

With regards to munitions, while India has had success in the development of cruise missiles, air-to-air missiles, precision guided weapons, etc., it needs to quickly transition towards developing networked collaborative weapons capable of sharing data, interacting, and developing and executing coordinated actions to improve effectiveness of the weapons. Such a programme is already underway in America under the U.S Air Force's (USAF) Golden Horde programme being run by the USAF Research Laboratory. This new generation of smart weapons can communicate between themselves to locate, self-assign, track and strike multiple ground targets in a synchronized manner. Indigenous development of such weapons,

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will have a multiplier effect on the battlefield and can also be designed to be platform independent further enhancing their usability.

Reality Check

"In my opinion, the *Technology Readiness Level (TRL)* of some of the Indian private sector companies on an average is around 4 to 5. A number of them are below this level," says Commodore C.D. Balaji (Retd), Outstanding Scientist, who retired as Director of the Aeronautical Development Agency (ADA). While a TRL designation is provided to indicate the readiness level of a particular technology or system, Balaji uses it in this case to identify the technological status of companies. Private sector players in India are more associated with building items / systems after they have been developed, barring a few who have taken up ab-initio development. "The only way that this scenario can change is for them to be participative rather than reactive." There is obviously a need for the same to be borne in mind by private sector players. There are no quick fix and readymade solutions. The timeline could also be distributed amongst varying levels of readiness and requirement, for e.g., prototype and production. TRLs could be lower during technology development stages, improving in prototype stage and further building up as confidence and experience grows towards pre-production and thence production.

The LCA Tejas programme originally resulted in development of several disruptive technologies, such as composite flight structures, Unstable Flight Control Systems as also the implementation of disruptive technologies such as the technology leap from drawing board to 3-Dimensional Computer Aided Design (3-D CAD), Computer Aided Engineering (CAE) and Computer Aided Manufacturing (CAM). The use of composite structures was a technology leap for India is the late 90s/early 2000s, as the country went from licence built metallic structural aircraft to an indigenously developed aircraft featuring extensive use of composite materials. Composites are used in Tejas' primary load bearing structures and the aircraft features 90% composite usage by surface area and 45% by weight. The introduction and maturation of composite technology in India entailed learning on a large scale, design challenges to be surmounted, simulation and inspection techniques to be evolved, and tooling technologies and fabrication processes to be evolved.

From existing Indian experience in conventional flight controls, with cables and push-pull rods, the Unstable Flight Control Systems resulted in a leap in technology to an unstable Fly-By-Wire (FBW) flight control system. This needed understanding of control theory, writing algorithms, developing control laws, simulation in engineer-in-loop simulators, writing of software codes, validation in hardware-in-loop simulators, flight level evaluation in real time simulators, etc., prior to clearance to flight. It is instructive to note that the time taken to develop the above disruptive technologies for the LCA Tejas had timelines varying between a few years to as much as 10 to 12 years, due to the varying levels of complexity. Hence private sector players will need utmost patience, perseverance and understanding to remain invested and have promise of committed business at the end.

Specifically related to aircraft development, Balaji lists several areas where the private sector can come forward to partner with the development agencies: composites raw material

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indigenisation; development of composite manufacturing as more and more usage of structural composites are being made in aircraft; Avionics and Flight Control System Hardware development and build, together with chip development; software for the various flight and mission critical computers on the aircraft, together with a robust software quality process; modelling and simulation technologies with adaptation of Model Based Systems Engineering; development of efficient Ground Support and Ground Handling Equipment (GSE/GHE); development of innovative learning tools for aircraft maintenance staff and development of technologies for low-observable aircraft.

Indigenisation a Precursor to Innovation?

Much of the capability available within the defence private sector is tailored towards supporting current generation programmes which were developed over the last two decades. This means that they are essentially geared towards supporting yesterday's war, hardly a conducive environment towards a forward looking mindset. It is a damning indictment of the powers that be, that India's defence private sector remains largely restricted to supplying raw materials, semi-finished products, parts and components, sub-assemblies and sub-systems etc. to DPSUs and Ordnance Factories.[4]

Efforts to involve the private sector for strategic Research & Development (R&D), following the Kelkar Committee's 2005 report, have not made the progress envisaged. Three Projects, the Tactical Communication System (TCS), Battlefield Management System (BMS) and Futuristic Infantry Combat Vehicle (FICV) reached selection by 2013, but have yet to result in usable equipment for the Army. The Indian system needs to sustain a Production Supply Chain first, before thinking about a Development Supply Chain. "We were part of Akash and Pinaka systems that went into serial production and developed over 12,000 certified sub assembly with over 1,400 vendors. A break in order flow of 5-8 years and supply chains are back to drawing board", says Rahul Chaudhry, Ex CEO Tata Power SED says. Sustaining the procurement chain is essential, once technologies mature into an operational product.

While there has proven to be adequate synergy between Military and Government industry / development agencies for programmes such as LCA Tejas, tripartite arrangements with the private sector players who should be included as risk sharing partners will test our current processes. The Development Entity needs to take the potential private sector participant along ab-initio, so that there is a gradual infusion of technology during the process of working and developing new and disruptive technologies. In this way, the TRL of the private sector player will improve. This will have the benefit of building up a robust development eco-system in the country. The private sector player needs to be made more willing to enter risk-sharing partnerships with the Development Entity in the larger national interest and the capital

[4] December 2008 of the Parliamentary Standing Committee on Defence titled 'Indigenisation Of Defence Production-Public-Private Partnership'.

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infusion that needs to be provided, maybe a smaller percentage of the total development cost, is essential for obtaining the necessary commitment from the private sector player.

To truly enable disruptive innovation the Government must ensure that it goes side by side with indigenisation efforts. Indeed, much of the technology and value added components for those platforms—engines, radars, weapons, etc.—would necessarily still need to be imported. Should this focus shift towards disruptive innovation and development of specific capabilities, then it could help create several niche technology areas, where Indian industry will be quite competitive not only at home but also abroad. This would also help in securing better terms while negotiating technology transfer/technology infusion programmes from foreign vendors during purchase of equipment / systems / aircraft. "The only way, in my experience, is if we have the necessary knowledge in a particular area, we have a bargaining chip to seek technologies. Obviously, our Technology Readiness Levels may be lower, but if the vendor sees a potential for internal development of those technologies, then they may be forthcoming in sharing the same. This is an essential 'point of strength' approach," Cmde Balaji says.

Certification is another area where the concerned Indian agencies concerned are spread far too thin, have staffing issues and a challenge to be at various places. This is an unacceptable situation considering the number of defence programmes underway and India's geographical diversity, which makes it imperative for certification staff to travel to various parts of the country for timely completion of certification tasks. At present Military Airworthiness Certification is with Centre for Military Airworthiness and Certification (CEMILAC) and the Aviation Quality Assurance is with Directorate General Aeronautical Quality Assurance (DGAQA). While CEMILAC certifies the design, DGAQA ensures that production standards are adhered to. When mixing military technologies, certification remains a major challenge and adds to expense and risk and a more benevolent approach towards Commercial Off The Shelf (COTS) could help hasten the process. Moving towards self-certification for Govt and private sector firms overseen by both CEMILAC and DGAQA in their respective areas could again speed up the process. For realization of next generation defence technology, testing is also a time consuming process and time and labour intensive. Steps taken now to ensure that sufficient trained manpower is available to complete these tasks on time will yield manifold benefits in the future.

Collaborative Approach

To harness the potential of the Indian defence ecosystem, greater and deeper collaboration between industry, top-level academia and DPSUs is a must. This is an area that the Indian Software Industry is already working on; though most of these technologies are for civilian and industrial applications. However, in last five years, several Indian organisations are undertaking pilot and Proof of Concept (PoC) engagements on experimenting these technologies for defence and military requirements in partnership with DPSUs and with assistance from IIT/IISc. India needs to take a leaf on how such collaboration has been working in other countries, especially the US. Creation of top quality training infrastructure on these advanced systems will be another crucial part of this effort.

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"Trained technical manpower is going to be a key differentiator in meeting the future requirements of our Armed Forces. Already the forces are grappling with shortage of such high-end talent and hence Government of India has encouraged the cooperation between Defence PSUs /Forces and the Indian IT Industry," says Aloke Palsikar, Senior Vice President, IES Growth & Strategic Initiatives at Tech Mahindra. "All these equipment are based on sophisticated technologies and rely on high end Software systems. Hence the role of Indian IT in maintenance of these systems will soon be a necessity." Indian IT firms are already running large scale programs in developing and supporting backend systems like ERP, HR, supply chain etc. and other systems for the armed forces.

Change is Inevitable

There is yet time to incorporate the thinking followed by some of the countries with regards to developing next generation and future disruptive technologies. The UK is already starting to derive greater benefit from greater commercial innovation and stronger partnerships between Ministry of Defence (MOD) and the defence industry. This includes ways in which the agility of small and medium enterprises can be harnessed by the MOD. In the case of the UK, this is being done through partnerships with companies like QinetiQ, which help incubate innovation to the benefit of the MOD. QinetiQ was formed when elements of the UK's Gov research and development labs were privatised. It brings a strong understanding of government processes and thinking along with some 20 years of operating as a private company. QinetiQ does something similar with the UK MOD's procurement agency (DE&S), where it has won a contract to manage the procurement of all engineering services to DE&S, another example of MOD partnership with private industry to commercially innovate.

The experience in the UK has been that if the MoD can find a way of harnessing the innovation from small and medium enterprises then it can be of tremendous benefit. If the Indian MOD can find a way of harnessing the spirit and innovation from small companies and combine it with the technical expertise of the DRDO labs then the industry would flourish. India will also needs to guard against the comfort of Foreign Military Sales (FMS) procurements with the USA . Despite the many positive attributes of such acquisitions, there are downsides to FMS procurements, an obvious downside being the lack of technology transfer when procuring through FMS. Rather than a specific partnership, India could benefit from reform of its commercial processes. There is a depth of technical understanding in India, including DRDO, which should allow it to be an intelligent customer, balancing the needs of indigenous development with pure military requirements. It would be educative to study the UK home Office's "Accelerated Capability Environment", for which QinetiQ is the prime contractor bringing its technical and programme knowledge to rapidly bring the expertise of some 180 different organisations to solve real-time problems. This is a great example of how a large defence company like QinetiQ can enable innovation.

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Conclusion

Decades of investment in government led research and development have allowed Indian state dominated defence labs and DRDO to deliver on numerous strategic technologies, but have fallen short in delivering on the innovation needed for the future warfighting needs of the Indian military. The DRDO, as an example, has been hampered by its ability to manage cutting-edge technical developments, often delivering incremental improvements in technology already dated by global standards. While technical innovation is an apparent strength of the DRDO, commercial innovation is not and this is a crucial aspect that needs to be remedied if the enormous costs of developing defence technology need to be recouped or reduced.

Probably the most important change over the last decade is the end of the era of defence technology eventually filtering down into commercial technology. Today, it is the innovative commercial sector, driven by the consumer market, which has been leading much of the innovation at the technology level, and for some time now. The mandarins tasked with guiding India's defence ecosystem for the future must realise that today it is commercial innovation that unlocks access to real technical innovation and not the other way around. There is no doubt that India's private sector would not only be more successful in delivering on disruptive innovations for future defence technologies, but also find a more meaningful way to market or raise funding for them.

India's defence industry stands at the crossroads as its traditional DPSU dependent heavy manufacturing driven approach is at odds with the rapid emergence of digital technologies in the defence domain, more suited to the agile private sector firms. Whilst there is comfort in technologies already mastered, if India's defence private sector is to seize the opportunity from emerging defence technologies and grow to master disruptive innovation, then it has to be provided with the right ecosystem to nurture its growth. At the present moment, there remain pockets of excellence around the nation that have the potential to grow into disruptive firms in the future. However, for disruption to thrive, there must be a step change in how the Government looks at India's private sector defence industry. While DPSUs can continue with their manufacturing intensive activities, it is time to create an ecosystem within the nation that encourages disruptive innovation in the defence domain

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