CIVIL-MILITARY FUSION FOR EMERGING TECHNOLOGIES IN INDIA

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Introduction

The character of warfare has undergone a major change since the end of the Cold War with Armed Forces across the globe transitioning from platforms to capabilities. Here, the Cold War is taken as an inflexion point since it marks the high point of use of conventional weaponry and role of the defence ecosystem in fostering innovation in the civilian sector, creating "spin-offs"[1] such as the global positioning system (GPS) and the Internet. Today, the situation is reversed and the defence industrial base lags behind the civilian sector in developing and using emerging technologies. Civil-military fusion (CMF) is a strategy that optimises complementarities across the civil and military domains to counter threats to an expanding ambit of national security which now encompasses food, environmental, cyber, human, economic and physical security. China did it in the form of creating "Military-civil fusion (MCF) with Chinese characteristics" during the 17th Party Congress of 2007, elevating it to a national-level strategy in 2015 and 20162. The US has a much more diffused model in place which involves the Defence Advanced Research Projects Agency (DARPA), various universities and private industry[3]. Israel has a revolving-door system between the military and the private industry[4] while Turkey's Bayraktar TB2 drone, a successful use case of CMF, has been used to further the country's national interests around the globe[5]. Can there be a CMF model for India? This paper looks at the utility of the CMF model in the Indian context by using emerging technologies as a case study.

Why is CMF Needed?

A traditional view of warfighting links the military inventory with the threat. For militaries equipped with conventional platforms, the visible threat is the military buildup of the adversary. As a result, the adversary's use of new and emerging technologies in new domains is neither acknowledged nor responded to in a befitting manner. Instead, most of these threats are clubbed under the rubric of the so-called grey zone warfare. This places the target country at a disadvantage since the response through conventional platforms is considered disproportionate to the deemed offensive action. As a result, the only measures available are either inaction or escalatory actions using the available platforms and hence, crossing into the domain of warfighting.

There is, therefore, a need to search for options that do not escalate into full-scale war, at the same time ensuring that the other side is forced to respond - at the cost of initiating hostilities. It is equally necessary to involve other organs of the state, as well as the private sector since in India's case, national security threats have expanded to include pandemics, cyber-attacks, human and drug trafficking, climate change, religious fundamentalism, terrorism and insurgencies, among others. State agencies and private actors have equally been at the receiving end of several attacks by a diffused group of actors. A majority of the cyber attacks on the Mumbai power grid[6], All India Institute of Medical Sciences (AIIMS) and other critical institutions have been traced back to the Chinese state[7]. Similarly, state and non-state actors have waged consistent information warfare (IW) against the country using social media platforms and other forms of media[8]. China's entire approach to economics has become securitised to an extent that the MCF model is considered predatory towards its private sector[9]. India's national security challenges, therefore, require a whole-of-nation approach when dealing with threats of such nature and amorphous form. In such a scenario, emerging technologies especially Big Data analysis, artificial intelligence (AI), unmanned systems and advanced semiconductors will play a huge role requiring the involvement of private players.

CMF has to be viewed from three perspectives. First, the "multi-level consumerisation of technology" ensures that more and more technology and tech-enabled platforms and systems are visible and used on the

battlefield leading to a higher expense of fighting wars. This means that the cost of using this technology in the military domain is diffused across the civil-military domain so that wars can be fought affordably. Second, CMF has traditionally been defined as the military use of civilian technology, talent and facilities which is a very constrictive view. While a majority of CMF projects look at militarising the technological lead of their civilian counterparts, the reciprocal view ie the use of military facilities by the private sector to hone their products for commercial purposes, as a way to increase the country's GDP is seldom considered. Third, use of technology on the battlefield requires that the private sector be involved more intimately in the national security matrix. It is to innovation, particularly military innovation, that we turn to since innovation forms the pivot on which the entire structure of CMF revolves.

CMF and Innovation

While several definitions exist for military innovation, they differ on whether innovation is a process[10] or an outcome[11], whether it completely changes the military[12], incrementally changes structures[13] or introduces new technologies or uses existing technologies and structures[14]. There are also differences on which component to be changed in militaries - organisation, doctrine, strategy/tactics or technology.[15] However, despite these divergent definitions, the common thread is change. Military innovation denotes a change in how militaries plan to fight or conduct military operations. For this paper, military innovation is defined as change involving a thorough understanding of technology and its potential and applying it so that the output produced in terms of military effectiveness far outstrips the input in terms of time, money and resources. Understanding technology and its application to produce military effectiveness are where the first phase of CMF comes in ie the military use of civilian expertise in industry and academia to increase effectiveness. The second phase ie the civilian use of military facilities and expertise needs to be emphasised as well since the weaponisation of trade interdependence between countries means that economic security will also have to be considered under the expanded national security threat perception.

For India, with a limited defence budget, the need for CMF has never been felt more. CMF, once fully operationalised fulfils four key requirements: by indigenising a major portion of R&D, production and managerial processes of defence manufacturing, it ensures that the requirements of the Indian Armed Forces are not constrained by foreign policies of other countries. Dependence on imports also has a follow-on disadvantage. The operational doctrines, force structures and tactics have been tailored as per the characteristics of the imported equipment and not what may be the optimal requirement for victory in the Indian context. There is now an opportunity to design, from first principles, technologies, doctrines and concept of operations based on indigenous manufacturing capability. Second, the handholding of private firms and academic research by the Indian Armed Forces and the Ministry of Defence (MoD) may lead to the growth of these industries to "unicorn" status and increase exports, spurring increased R&D in these companies, encouraging more industries in the defence sector and finally increasing the size of the economic pie so that additional resources may be diverted to the military. Third, an expanding notion of national security means that a holistic approach needs to be taken against threats. As an example, India's G20 presidency and its emphasis on digital solutions and the success of the India Stack means that several residual cyber capabilities of institutions within the state, academia and private industry need to come together so that India's model of cyber governance and provision of digital public goods can be exported to other countries[16]. Fourth, the acquisition of military capability, either in the form of a technology or a platform or both does not end with the product itself. A support structure that includes bases, airfields, ranges, maintenance, repair and overhaul facilities (MRO) also needs to be in place. This is again where CMF can offer solutions, in terms of offering civilian facilities for military use and vice-versa. Emergency landing strips (ELFs) for fighter aircraft on highways operated by the National Highway Authority of India (NHAI), the Bharatmala project, the National Logistics Policy (NLP) and Gati-Shakti are all examples of CMF at the national level[17]. All four key requirements point to the need for innovation: at the cognitive level so that a broadened concept of national security is understood by all stakeholders; at the organisational level so that there is greater inter-

agency and interministerial coordination and finally at the structural level so that silos are broken down and a more flatter structure begins to emerge. All these changes point to greater opportunities for coordination and entrepreneurship.

Military innovation devolves around the confluence of two sets. The first set consists of actors i.e. the military as a whole, private industry (talent, know-how, R&D and managerial practices), academia and think tanks. The second set comprises military doctrines, organisation and concept of operations. The utility of CMF then flows from the defence strategy, based on acquisitions, capability development, training and educational requirements and operations. There needs to be a flow of ideas from the first to the second set and the common factor between the two i.e the Armed Forces' role, therefore, becomes crucial. For India to evolve an effective structure for CMF, there is a need to look at various CMF strategies in use by different countries around the globe. We will briefly look at five countries viz the US, the UK, Turkey, Israel and China and also analyse the challenges that may help in formulating an effective model for India in the field of emerging technologies.

Examples of CMF in Other Countries

In the China model, the PLA has annointed itself as a captive market for certain companies in fields designated critical from China's national security perspective like AI, quantum communications and advanced semiconductor devices. These companies may be globally uncompetitive but still benefit from the PLA funding due to their importance to the national security calculus. Changsha Jingjia Microelectronics Ltd and Cambricon Technologies are two examples of homegrown Chinese companies specialising respectively in graphic processing units (GPU) and specialised hardware for cutting-edge AI applications. This model is known as step-up and in China's case is state-directed[18].

The US has two sub-models. In the first sub-model, the private sector fuels innovation and the military has, over the past few years, created several organisations such as the Defence Innovation Unit (DIU) and the Army Futures Command (AFC) which looks at a mix of civilian and defence experts to position the US Army at the top in several identified

areas[19]. The second sub-model is that of DARPA which comprises Program Managers in six technical offices responsible for identifying breakthrough technologies and ensuring that concepts are converted into capabilities. Programs such as AFWERX (Air Force Work Project)[20] and SOFWERX[21] (Special Operations Forces Works) aim to create a virtual 'marketplace' of ideas similar to Uber, Airbnb and Amazon where the user (soldier), acquirer (Service) and the provider (manufacturer) are iterating continuously for rapidly testing prototypes and fielding them.

The Israeli model involves a revolving door policy where soldiers, after finishing their mandatory service in the Israeli Defence Forces (IDF) use their military expertise to create commercially successful defence companies[22]. In Israel's hi-tech Unit 8200, prospective programmers are selected from high schools and are seated next to their clients ie intelligence officers and all products are designed and produced in-house[23]. Several Unit 8200 alumni have founded companies such as Check Point, Imperva, Nice, Gilat, Waze, Trusteer, NSO and Wix[24].

The Turkish government allowed Selçuk Bayraktar, the Chief Technology Officer (CTO) of Baykar and the creator of Bayraktar TB2 to join the Turkish military in field conditions to test out his UAV models[25]. The company's exports to Ukraine and Azerbaijan created asymmetries for the side using these drones and fulfilled Turkey's foreign policy goals without the live involvement of the Turkish government.

The United Kingdom (UK) has embarked on an ambitious goal of replacing its current fleet of combat aircraft namely, the Eurofighter Typhoon with a Future Combat Air System. Team Tempest, as the designing consortium of private and government agencies is known, aims to field the system by 2035. The FCAS design starts with a computer instead of the physical aircraft design for incorporating deep learning, swarms, virtual cockpit in helmet, hypersonic weapons and directed energy weapons (DEW). The team is attempting a digital age model of procurement in a virtual collaborative environment based on non-hierarchical peer-to-peer platforms, open behaviours and agile practices for the generation of an information management system[26]. This will be done to continually upgrade and enhance the system, both virtually and in real time. This

includes creating a digital twin of the aircraft together with a digital thread to establish through-life linkage with the twin and the aircraft such that the thread runs through all organisations and contexts with which the product interacts. This will ensure that the platform is never out of sync with the latest technological developments.

Challenges Faced by Countries in Incorporating CMF

While China's model of MCF is one of the most commented on due to the opaque nature of the regime, it is also one of the least objectively analysed. In his magisterial study of the Chinese system of military innovation, Professor Tai Ming Cheung acknowledges that China's MCF is a pedestal for the operationalisation of what Chinese President Xi Jinping calls an integrated national security strategy (INSS) and without his intervention, it would have remained a "floundering mid-tier policy initiative lacking political support that would occasionally receive passing leadership attention." China's MCF project is a top-down initiative where all actions are taken based on the directions of the top leadership. While MCF has been incorporated into the Chinese constitution in 2017, there has been no major exposition of its details and a majority of Chinese works just regurgitate the Chinese president's speeches[27]. The other major challenges for China are the construction of an integrated innovation and acquisition system which is still antiquated and bureaucratised; creation of dedicated and permanent MCF personnel workforce and institutional identity; facilitating access to resources and; adapting the system to react to and pre-empt the international threat environment apart from extrinsic factors such as climate change and increasingly hostile sanctions regime.

The US also suffers from an acquisition process that prioritises legacy platforms. As of date, the US Department of Defence (DoD) is invested too much into legacy platforms and weapon systems already catered for in the defence budget at the expense of new technology that will determine whether such platforms can survive and succeed in a more contested environment[28]. This is a hangover from the end of the Cold War era where Western militaries have been habituated to conduct operations in almost uncontested environments especially poor air

defence (AD) and electronic warfare (EW) resources of the adversary which have tended to be terror and non-state groups. The UK, on the other hand, recognises that its model of acquisition i.e. CADMID (Concept, Assessment, Demonstration, Manufacture, In-Service and Disposal) is a linear one and utterly unsuited when it comes to dealing with new technologies and is looking at a spiral development model for the new range of emerging technologies[29].

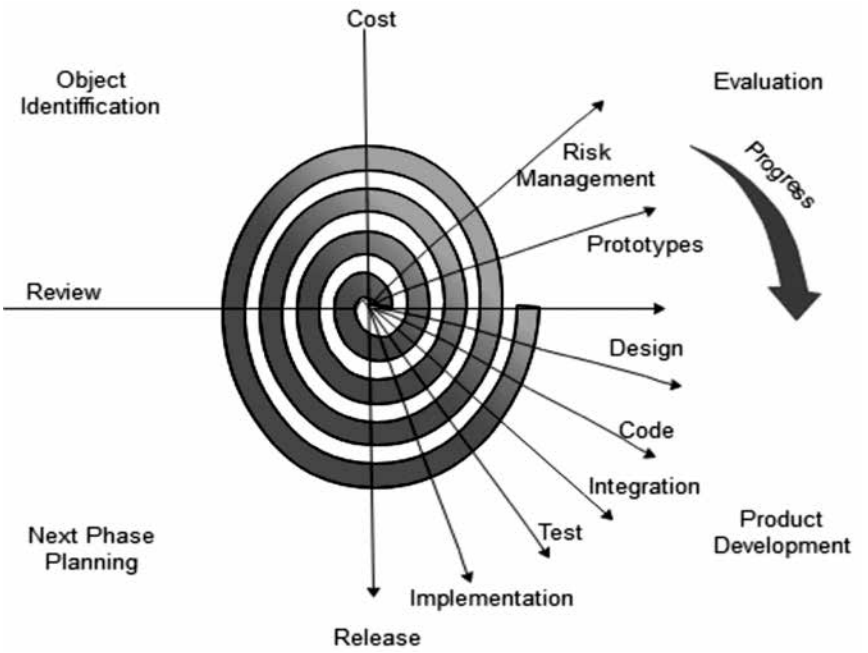

Fig 1: Details of the Spiral Model.

Reference:https://www.javatpoint.com/software-engineering-spiral-model

The spiral model is said to be one of the best when it comes to developing customised software-based solutions for high-risk and unstable projects. It is an evolutionary software process model that couples the iterative feature of prototyping with the controlled and systematic aspects of the linear sequential model. Using the spiral model, the software is developed in a series of incremental releases. During the early iterations, the additional release may be a paper model or prototype. During later iterations, more and more complete versions of the engineered system are produced[30]. This model can be used for developing moonshot prototypes which are risky yet highly innovative projects.

India's Model of Acquisition of Emerging Technologies

The Indian Armed Forces have focused on micro, small and medium-sized enterprises (MSMEs) and startups in the defence sector since they have the intellectual capital and energy to design unique systems and technologies. There has been a multi-agency and multi-pronged approach to attracting and handholding selected startups in certain selected technology segments. Broadly the effort to encourage defence startups, individual R&D, MSMEs and academia has been in two directions. The first and the most exhaustive is by the Department of Defence Production (DDP) in MoD.

A Defence Innovation Fund (DIF) has been established along with a Defence Innovation Organisation (DIO) which will act as a corporate venture capital firm for handholding enterprising startups[31]. While the DIO has been envisaged as a high-level policy guidance body, the executive functions are being performed by the Innovations for Defence Excellence (iDEX) with functional autonomy. The CEO of iDEX and DIO will be the same, in theory providing the linkage between executive action and policy guidance. DIO comprises the Secretary (Defence Production) as the Chairman, the Chief Managing Director (CMD) of Hindustan Aeronautics Limited (HAL) and the CMD of Bharat Electronics Limited (BEL) as members, apart from a member from the Atal Innovation Mission/ Niti Aayog and the CEO iDEX. There is also an advisory council constituted of the vice-chiefs of the three Services, the Chief of Integrated Defence Staff to the Chiefs of Staff Committee (CISC), Additional Secretary (Defence), Secretary (Defence Finance), Secretary (R&D) and representatives from other Defence Public Sector Undertakings (DPSUs), Department of Science and Technology (DST) and Department for Industrial Policy and Promotion (DIPP)[32]. The idea is that the Services Headquarters (SHQs) and the DPSUs will play the primary role in identifying potential topics through the promulgation of problem statements and the Technology Perspective and Capability Roadmap (TPCR). iDEX will act as the translating layer between the SHQs and DPSUs and the Indian innovation ecosystem based on the principles of co-creation and open innovation[33]. iDEX will coordinate with partner incubators (PIs) based on the Silicon Valley model such

as CODISSIA, T-Hub (Hyderabad), FORGE (Coimbatore), SINE IIT Bombay, IIM Ahmedabad's CIIE, IIT Delhi FIIT and IITM Incubation cell (IITMIC) and defence innovation hubs (DIHs), two of which are likely to be set up in Nashik and Chennai respectively, to nurture them. This will include advice, guidance, funding, and assistance in the expansion of markets. Since the funding of DIO and thereby iDEX is through the corporate social responsibility (CSR) and non-CSR funds of the various DPSUs and MoD and in India, DPSUs still get the first option for accepting or rejecting a project, the DPSUs will be entrusted with 'productising' of the innovations of the startups. This also assumes that the DPSU has the technical know-how of completing the project, scaling it in requisite quantities.

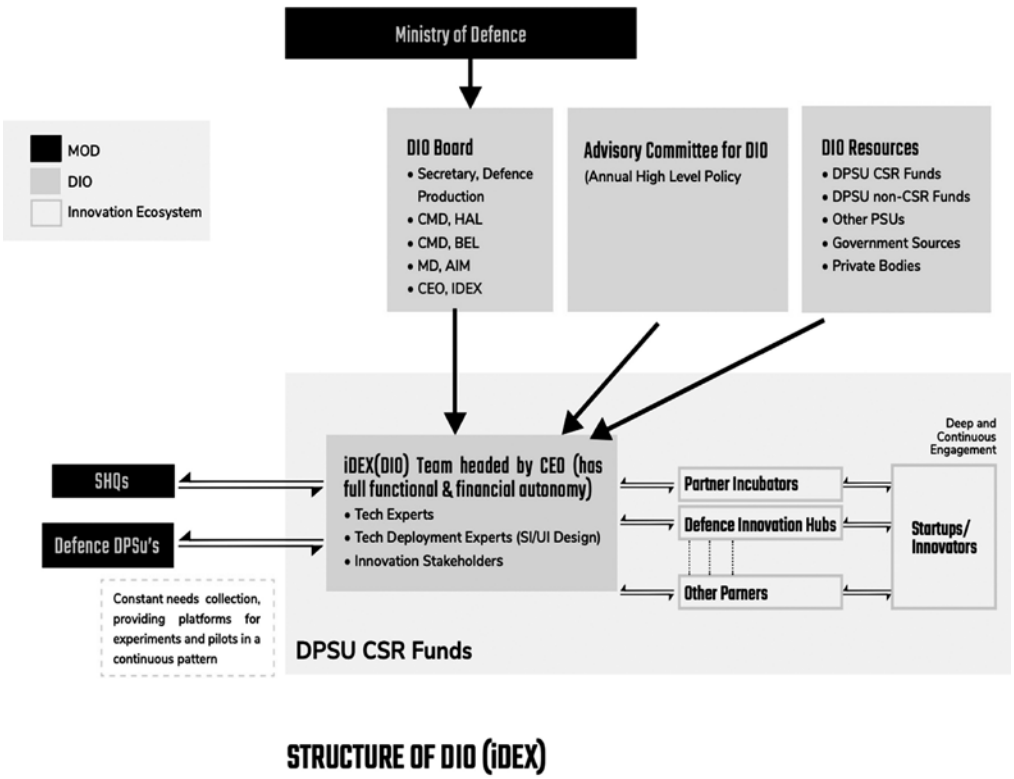

Fig 2: Structure of the Defence Innovation Organisation (DIO)

Reference: Operationalisation Plan for Defence Innovation Organization (DIO) And Defence Innovation Fund (DIF)

While this framework looks at creating commercially viable companies out of MSMEs and defence startups, there is an alternate pathway called the Support for Prototype and Research Kickstart (in Defence) (SPARK) which provides an amount of Rs 1.5 crores each to selected projects that help "create functional prototypes of products/technologies relevant for national security" and help new technologies find markets in the Indian defence establishment[34]. The innovators eligible for the SPARK grant will be based on the Defence Innovation Startup Challenge (DISC), which has entered its eighth iteration. A newer version of SPARK, known as SPARK II envisages the selection of projects by startups if they have received interest from any of the three Services, discovered through open challenges, pitch events or Technology Watch of iDEX or if it has received any interest, work order or investment from any friendly foreign country (FFC)[35]. The evaluation of the company will be based on four parameters viz technology advantage, product advantage, commercial advantage and finally, integration advantage. Similarly, risks will also be evaluated and finally, a risk matrix will be created. Those companies which cross a laid down opportunity score will be eligible for the grant. The latest DISC 8 challenge emphasises electro-optical (EO) and synthetic aperture radar (SAR) payloads for mini-satellites of up to 150 kg, high-speed onboard data processing for low earth orbit (LEO) imaging satellites, AI-based change detection for multi-payload fused imagery data, conversion of an Android phone to a satellite phone, autonomous CubeSat swarms in LEO and development of nano and micro-imaging satellites. The main area for funding research is space-based technologies supplemented by AI and imaging[36]. iDEX has also evolved into iDEX (Prime) which selected two challenges each by the three Services for resolution by innovators, iDEX Prime (Space)[37] and iDEX Prime (Sprint)[38] and even an Open Challenge.

The next process is the Technology Development Fund (TDF) sponsored by the Defence Research and Development Organisation (DRDO). It provides funding of up to Rs 50 crores to MSMEs and startups[39], with the caveat being that the industry must be owned and controlled by a resident Indian citizen with a minimum of 51% ownership. TDF also allows collaboration with academia and research institutions and

industry consortiums with the development period being a maximum of four years[40]. The development agency is evaluated under 4 heads:

- **Design capability (60 points)**: Proposed configuration and approach to meet functionalities; indigenous design capability; infrastructure.
- **Fabrication and manufacturing capability (25 points)**: indigenous manufacturing capability especially plant and machinery.
- **Maintainability and life cycle support (10 points): a** methodology for life cycle support.
- **Commercial Criteria (05 points):** nature of the company; net profit and turnover.

The passing points are 60. Here commercial viability, maintainability and life cycle support have been given the lowest qualifying marks. Out of 100, even if a company hypothetically scores zero on these two and gets 60 in the first two, it can get the funds. DRDO being a government organisation looks only at the design capability and not the long-term sustainability of the commercial enterprise which is a lacuna that needs to be rectified. DRDO has also launched a Dare To Dream program which envisions the sponsoring of individual R&D and then handholding to ensure that the individual is able to create a company[41].

Challenges. The system is undoubtedly a major step for unlocking the entrepreneurial spirit of the Indian technological ecosystem, mutually benefitting the Armed Forces as well as the private companies involved in designing, creating and incubating new technologies. If conceptualised and executed properly, it has the potential to nearly double or triple India's current defence exports. In its current form, the scheme suffers from being overly complex, concentrated and biased towards the public sector. It needs to be reiterated that the challenges being analysed and measures suggested are for emerging technologies and the same can be applied, albeit with minor modifications, to the wider defence industry and the national security calculus.

The challenges and their recommended solutions are:-

- **Concentration within Public Sector**. Though the idea of the DIO and a corporate VC fund i.e. iDEX are conceptually sound, they suffer from being concentrated in the hands of government officials, serving and retired. There is no representation from the private industry or academia, either in the advisory council or the main body. The translator layer between the Services and the private industry is, therefore, wholly bureaucratic. Instead of a collaborative or a co-creator approach, provision of grants is followed, where companies and startups compete with each other for limited funds. This is unlike the US model of DIU where the US Armed Forces have stationed program managers and project officers in Silicon Valley in order to actively seek out the best R&D and researchers in eight priority areas[42]. The DPSUs have been designated for productising the prototypes selected by iDEX. This implies that inefficient managerial practices of DPSUs, which have no experience in handling or producing technologically sophisticated weapon systems, will be used to produce high-technology systems.

- The composition of both DIO and iDEX reflects a hierarchical view of CMF. The recommendation is to drastically change the composition of the translator layer and break it into a set of clusters. While the top governing body i.e. DIO can have an industry veteran as the Chairman, members may be from DDP, SIDM, DPSUs, the Design branches of the three Services and selected academia and think tanks. This will provide a more non-hierarchical policy-making structure with increased collaboration between the industry, MoD and the Services. The practice of DPSUs getting the first choice for productising the MSME/ startup design needs to be rethought and startups must have the option of either feeding to bigger industries which can act as integrators or starting their own production lines, based on commonalities with requirements of other ministries.

- **Clusterisation**. Currently, the model followed by iDEX is to coordinate with SHQs who release their requirements in the form of technological problem statements. iDEX then organises its own

challenge apart from the DISC and open challenges to select startups for funding through SPARK/ SPARK II and/ or further nurturing through PIs and DIHs. However, being solely government guided and funded, this is not an ideal model either for a private-public partnership model (PPP) or CMF. The iDEX competitions have started to evolve. Initially, they were a mix of problem statements by the three Services. Now they have their categories such as iDEX Prime (Space). But a number of major ministries are missing. For example, the requirement for a counter UAV (C-UAV) system affects not only the MoD but also the Ministry of Home Affairs (MHA), the State Police and the Ministry of Civil Aviation (MoCA). Similarly, UAVs are required by the MoD, MHA, State Police, Ministry of Agriculture and Farmers Welfare, Archaeological Survey of India (ASI) and other agencies.

- There is therefore a need for clustering together the representatives of various user bodies along with the necessary makers of components which belong to different industries. The Prime Minister's Office (PMO) can constitute a coordinating body, focused on national security, comprising representatives from all ministries and top manufacturing houses and decide on five priority clusters where CMF can be effectively implemented. These can be autonomous systems, information management systems, advanced semiconductors, intelligence, surveillance and reconnaissance (ISR) and logistics. These clusters can be geographically co-located in areas with the maximum R&D and educational institutions in that particular field and can also act as centres of excellence (CsOE) as well as standard-setting bodies, in line with the best practices in the world. The process of CMF has to be top-down and a constantly monitored initiative for effective coordination between the various ministries and agencies. Once the clusters have been decided, the Gati Shakti platform can be used for virtual collaboration, open innovation and creating integrated solutions for national security. Within the clusters, a new form of iDEX, let's call it iMCFX (Innovations for MCF Excellence) may be instituted in the form of open challenges, sponsored by all affected ministries and agencies. This will also serve to increase

the prize amount. The difference from the previous model will be the encouragement for joint ventures (JVs) and consortiums. The mantra to be followed is to collaborate and compete. The role of the government ministries will be two-fold: assured funding for crossing over from the Valley of Death and adequate orders for scalability. A report by Ernst and Young (EY) and the Federation of Indian Chambers of Commerce and Industry (FICCI) has found that in major components such as motor and propeller, autopilot, batteries, high-end navigation, camera payloads, sensors and communication systems in UAVs, the imported component ranges from 50 to 75%. The major countries of import are China, Taiwan, the US, the EU and Japan[43]. A host of Indian companies can collaborate in UAVs by competing for modular systems in propulsion, airframe, battery packs, and payloads and make them within the country rather than competing piecemeal for the entire UAV which leads to the import of a majority of systems.

- **Financing and IP Rights**. The current model of financing is based on grants and loans to promising startups and MSMEs which acts as seed money. Once the prototype is built, a model of no cost no commitment (NCNC) demonstrations follow post which the longer process of the acquisition comes into play. Sometimes the same startup may be catering to the piecemeal requirement of all three Services apart from other ministries. This leads to duplication of efforts. The cluster system aims to remove these redundancies. Effective ways of testing and failing fast will ensure that the companies can discard unworkable models to innovate along different lines. For this, effective bankruptcy laws, reduced cost of borrowing capital and protection of IP rights is critical. The system of L1 may need a relook as repetitive competition depletes the resources of cash-strapped startups and there may be a need for a longer engagement period with the industry as well as assured orders. L1 also forces the companies to cut costs in terms of imports, indirectly benefiting adversaries resorting to dumping steel and other materials onto Indian shores.

- **Two Way Sharing of Data and Infrastructure**. There are a number of ranges, facilities and labs available with the Services, DRDO and various DPSUs which can be commoditised and shared with MSMEs and startups on a nominal cost basis. Furthermore, some inventors can also be taken to field conditions in Eastern Ladakh or Kashmir for testing out their products in actual field conditions, similar to the Bayraktar model. This will help improve the ruggedisation of the equipment, apart from providing real-time feedback from the actual users i.e. the troops on the ground. For developing AI systems for reading satellite imagery or parsing intelligence reports for possible predictive results, it is important that the training set be composed of actual data and not the synthetic training data generated by algorithms. For this, data has to be unshackled from the clutches of archaic classification rules which prevent classified information to be shared with the private industry. The advent of open-source intelligence (OSINT) and commercial satellite imagery firms such as Maxar[44] have rendered these notions obsolete and a new policy directive needs to be promulgated that relooks at the way information is classified. Safety nets such as non-disclosure agreements (NDA) may be insisted on. On the other hand, academia and private industry have a big role to play in encouraging innovation within the Armed Forces. The iDEX4Fauji initiative which looks at the tapping of the potential of personnel from the Armed Forces needs to be given a foundational basis in science and technology and the incubators within academia and startups may lease labs and facilities for selected Armed Forces personnel to intern with them and use their equipment for honing their products and testing the prototypes.

- **Cross-Pollination**. The need for inter posting of personnel from different ministries to MoD and vice-versa has been mooted for long. For effective CMF, it is not only necessary to post personnel from different agencies and ministries at the level of Directors and below, but also allow service personnel to be posted in various ministries, in order to understand the requirements and commonalities within different branches of the government. The study leave provisions for the Armed Forces may include a new vertical of industrial internship

(II) which may involve deputing industrious officers and men from the Services to different industries, MSMEs and startups. The follow-up of these actions is equally important. Specialisation needs to be built in within the Services. Once done with the study leave, the personnel need to be utilised in the procurement and acquisition branches where their experience and expertise will ensure practicable General Staff Qualitative Requirements (GSQR). Slowly, this will lead to a core group of officers proficient in interfacing between the industry and the Services and also other ministries.

Conclusion

The main reason why CMF is critical for India is the expanding notion of national security and India's rising clout in the comity of nations. CMF has to be a top-down policy-oriented approach that utilises the Indian entrepreneurial spirit rather than being supported and hand-held by the government at all times. The Indian Armed Forces will play a crucial role in CMF but need to be sufficiently equipped, educated and trained to take on this role. Finally, CMF will ensure that India attracts a significant chunk of orders from the developing world, and act as the net security provider for the Third World.

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Endnotes

1 Jong-Tsiong Chiang, "Technological spin-off: Its mechanisms and national contexts", Technological Forecasting and Social Change 41, No 4 (June 1992): 365-390, https://doi.org/10.1016/0040-1625(92)90044-T

2 Tai Ming Cheung, Innovate to Dominate: The Rise of the Chinese Techno-Security State (Ithaca: Cornell University Press, 2022), 83-142

3 Erica RH Fuchs, "Rethinking the role of the state in technology development: DARPA and the case for embedded network governance", Research Policy 39, No 9 (November 2010): 1133-1147, https://doi.org/10.1016/j.respol.2010.07.003

4 Rubin, Eliran. "Tiny IDF Unit Is Brains Behind Israeli Army Artificial Intelligence." Haaretz, Aug 15, 2017. https://www.haaretz.com/israel-news/2017-08-15/ty-article/tiny-idf-unit-is-brains-behind-israeli-army-artificial-intelligence/0000017f-e35b-d7b2-a77f-e35fc8f40000

5 Nicholas Danforth, "How much Multipolarity does a Strongman Need?: Why Erdogan has benefited from Russia's Failure in Ukraine", War On The Rocks, 09 September 2022. https://warontherocks.com/2022/09/how-much-multipolarity-does-a-strongman-need-why-erdogan-has-benefited-from-russias-failure-in-ukraine/

6 Sanger and Schmall. "China Appears to Warn India: Push Too Hard and the Lights Could Go Out." New York Times, Feb 28, 2021. https://www.nytimes.com/2021/02/28/us/politics/china-india-hacking-electricity.html

7 Manral and Sheriff. "The AIIMS cyberattack and its China links: What we know so far." The Indian Express, December 16, 2022. https://indianexpress.com/article/explained/the-aiims-cyberattack-and-its-china-links-8324982/

8 Namita Barthwal, "Information Warfare and India's Level of Preparedness", Centre for Land Warfare Studies, Feb 11, 2022. https://www.claws.in/information-warfare-and-indias-level-of-preparedness/

9 Margaret M. Pearson, Meg Rithmire and Kellee S. Tsai, "China's Party-State Capitalism and International Backlash: From Interdependence to Insecurity", International Security 47, No 2, Fall 2022, 135-176. https://doi.org/10.1162/isec_a_00447

10 Thomas G Mahnken, 'China's anti-access strategy in historical and theoretical perspective', The Journal of Strategic Studies 34, no. 3 (2011), 303. https://doi.org/10.1080/01402390.2011.574971

11 Stephen Peter Rosen, 'New ways of war: understanding military innovation', International Security 13, no. 1 (1988), 134. https://doi.org/10.2307/2538898

12 Chad C Serena, A revolution in military adaptation: the US Army in the Iraq War (Washington, DC: Georgetown University Press, 2011), 9.

13 Tai Ming Cheung, 'The Chinese defense economy's long march from imitation to innovation,' The Journal of Strategic Studies 34, No. 3 (2011), 326.

14 Michael Horowitz and Shira Pindyck, "What is a military innovation and why it matters", The Journal of Strategic Studies, March 2022, 1-30. https://doi.org/10.1080/01402390.2022.2038572

15 Martin Van Creveld, Technology and war: from 2000 BC to the present (New York: The Free Press, 1989), 219

16 "Panel: Digital Identities: Foundational Architectures for a Digital Society The Road to G20 | Global Technology Summit 2022," YouTube video, 54:55, "Carnegie India," 01 December 2022, https://www.youtube.com/watch?v=DyGc7V2j0WQ&list=PLeXQMWQXRkJUgzoJROMgNCE5T5C3qORJz&index=7

17 Lieutenant General Anil Puri, "Role of the Department of Military Affairs in Enhancing Civil-Military Integration," Seminar on Civil-Military Integration: The Way Forward (Panel Discussion, Centre for Land Warfare Studies, Manekshaw Centre, New Delhi, December 26, 2022)

18 Bradford Waldie, "How Military-Civil Fusion Steps Up China's Semiconductor Industry", DigiChina, April 01, 2022. https://digichina.stanford.edu/work/how-military-civil-fusion-helps-chinas-semiconductor-industry-step-up/

19 Kathleen Hicks, "Getting to Less: The Truth About Defense Spending", Foreign Affairs, March/April 2020. https://www.foreignaffairs.com/united-states/getting-less

20 Milligan and Tresslar (2022), "Air, Space Forces transition to AFWERX 3.0", US Air Force Website, November 25, 2022. https://www.af.mil/News/Article-Display/Article/3225640/air-space-forces-transition-to-afwerx-30/

21 Bottoms (2018), “SOFWERX: A smart factory of innovation helping the warfighter”, US Special Operations Command (USSOCCOM) Website, February 02, 2018. https://www.socom.mil/sofwerx-a-smart-factory-of-innovation-helping-the-warfighter

22 Eliran. “Tiny IDF Unit Is Brains Behind Israeli Army Artificial Intelligence.” Haaretz.

23 Tendler, Idan. “From The Israeli Army Unit 8200 To Silicon Valley.” TechCrunch, March 21, 2015. https://techcrunch.com/2015/03/20/from-the-8200-to-silicon-valley/

24 Tendler. “From The Israeli Army Unit 8200 to Silicon Valley.” TechCrunch

25 Stephen Witt, “The Turkish Drone That Changed the Nature of Warfare”, The New Yorker Magazine, May 09, 2022. https://www.newyorker.com/magazine/2022/05/16/the-turkish-drone-that-changed-the-nature-of-warfare

26 John Louth and Adrian Spragg, “UK Future Combat Air: A Programme Management Imperative”, The RUSI Journal 164, No 4, September 25, 2019, 46-59. https://doi.org/10.1080/03071847.2019.1666509

27 Tai Ming Cheung, Innovate to Dominate: The Rise of the Chinese Techno-Security State, 83-142.

28 Kathleen Hicks, “Getting to Less: The Truth About Defense Spending”.

29 John Louth and Adrian Spragg, “UK Future Combat Air: A Programme Management Imperative”, 46-59.

30 Java T Point, https://www.javatpoint.com/software-engineering-spiral-model. Date: Unknown, Author: Unknown

31 Department of Defence Production (2018), “Operationalization Plan for Defence Innovation Organization (DIO) And Defence Innovation Fund (DIF)”, Ministry of Defence (MoD)

32 Ibid.

33 Ibid.

34 “Operationalisation Plan for Defence Innovation Organization (DIO) And Defence Innovation Fund (DIF)”

35 Ibid.

36 Department of Defence Production (2022), “Challenges under DISC 8”, Ministry of Defence (MoD). https://idex.gov.in/disc-category/31

37 Department of Defence Production (2022), “Challenges under DISC 8”, Ministry of Defence (MoD). https://idex.gov.in/disc-category/33

38 Department of Defence Production (2022), “iDEX Prime Sprint Challenges”, Ministry of Defence (MoD). https://idex.gov.in/disc-category/30

39 Ministry of Defence. “Funding under Technology Development Fund scheme of DRDO enhanced to Rs 50 crore per project from Rs 10 crore.” MoD Press Release, June 08, 2022.

40 Defence Research and Development Organisation (DRDO), Technology Development Fund (TDF), https://tdf.drdo.gov.in/

41 Defence Research and Development Organisation (DRDO), Dare to Dream 3.0, https://www.drdo.gov.in/dare-dream-30

42 Sean Carberry, “Reined-In Army Futures Command Moves Out Under New Leadership”, National Defense, November 29, 2022. https://www.nationaldefensemagazine.org/articles/2022/11/29/reined-in-army-futures-command-moves-out-under-new-leadership

43 Ashish Rajvanshi, Ankit Mehta and Neel Mehta. “Making India the drone hub of the World”, EY and FICCI Report, Aug 2022. https://assets.ey.com/content/dam/ey-sites/ey-com/en_in/news/2022/09/ey-ficci-drones-report.pdf

44 Thomas D Taverney. “The Evolution of Space-Based ISR”, Air and Space Forces Magazine, Aug 10, 2022. https://www.airandspaceforces.com/article/the-evolution-of-space-based-isr/