Manned Fighter and Unmanned Systems
Future is Collaborative

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The application of unmanned systems during recent conflicts has stimulated an alternative thought in military capability. While these systems have accrued reasonable tactical and operational successes, their ability to do so independently is a matter of debate. The operational imperatives indicate a necessity to invest in these capabilities, but in collaboration with the manned fighters. Unmanned systems exhibit some fundamental flaws when evaluated through the prism of 'Nature', and 'Morals and Ethics' of War. Since war fundamentally is a means of human conflict resolution, a human element would have to remain as the chief protagonist at all the levels of war. Similarly, in the Indian context that is characterised as No War No Peace (NWNP), complete military solutions to various security scenarios are possible only through the complementary application of manned and unmanned aircraft. At the operational level, when assessed through the seminal concepts of OODA (Observe, Orient, Decide and Act) loop as well as combat effectiveness, risk, and cost, the capabilities of unmanned systems can be maximised through their application in conjunction with manned fighters. Globally, to harness this potential, there is an impetus

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on 6th generation fighter aircraft, which are inherently MUM-T capable. These programmes foster human–machine teaming in which humans would be responsible for the higher cognitive functions [combat strategy design, command and control (C2), etc.], while less demanding cognitive functions (tactical manoeuvres, observation, etc.) would be left to UAVs/UCAVs. At the current pace, in this field, India will remain at least one generation behind all major powers, including China. Therefore, to curtail this trend, and to boost indigenous ecosystem and make it export-worthy, in short-term (till 2030), for stabilisation of LCA and realisation of AMCA and CATS, primary focus should be on manned fighters with a proportional focus on unmanned systems as per their identified complementary roles (ISR, limited strike, high-risk, etc.). In the long-term (beyond 2030), the focus should shift to a collaborative approach to achieve the 'Collaborative Peak' of manned–unmanned teaming by 2047 (Amrit Kaal).

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'No one can defeat a powerful mind.'[1] – Chanakya
'Technology should aid the mind-set and not replace it.'

On new military technology, noted airpower theorist Colin Gray stated that the emerging technologies must be assessed on the merit of each case and through the prism of historical insights, rationality, and their demonstrated operational efficacy.[2] Unmanned aerial systems are an emerging technology that is dominating the discourse on the pretext of these being relatively cost-effective and risk-free in contemporary warfare. Holistically, it may not be true, and a balanced perspective on the same is needed. The key question that needs examination is—'Are unmanned systems credible military capabilities independently; or, is there a better approach to maximise their potential?'. Unmanned systems as a preferable choice to conduct warfare is premised on developments in Artificial Intelligence (AI), communication, and weapon technology, and their envisaged ability to outmanoeuvre the complexities of the contemporary op environment. While dissecting this notion and fostering a rational perspective, this article argues that, 'In the context of war, India's security situation and capability development prospects, and operational imperatives, development profile of air combat systems must be collaborative, led by high-tech manned fighter and complemented by unmanned systems.'

While following a capability assessment approach, the first section would delve into the efficacy of manned and unmanned AC capabilities within the strategic, operational and tactical realms of war. The next section, while

substantiating the preceding deductions with the global trends, will suggest a balanced approach to capture 'Best of both Worlds'.

Capability Trajectory in the Context of Evolving Warfare

'The real issue is how much "quality" across what performance spectrum, in what force mix, numerical strength, and sustainability, do we need, to ensure desired mission efficacy for most plausible scenarios at an affordable cost.'[3]

Every new technology, like unmanned systems in the aerial domain, which challenges the existing dominant system is considered 'disruptive'. 'Disruptive or not', in a military context, the foremost question is, 'What is the most appropriate methodology to fuse unmanned aerial systems into operational schemata?' The following approaches may offer pragmatic answers to this question:

1. *Approach 1*: Primary focus on manned fighters with upgradations of existing fleet and development of next-gen fighters to be capable of all combat (air-to-air and air-to-surface kinetic and non-kinetic firepower) as well as combat-enabling roles. A proportional focus on unmanned systems to be capable of primarily combat-enabling (ISR, EW, etc.) and limited combat roles (complementary/high-risk strike, deception, etc). Command and control retained with manned fighter.
2. *Approach 2*: Leapfrog to unmanned systems and a secondary focus on manned fighter.
3. *Approach 3*: Concurrent impetus on next-gen fighters and unmanned systems to make these capable of all combat and combat-enabling roles, and network these to enable collaborative application. Command and control are still retained with manned fighters.

At the first glance, *Approach 3* seems most viable, yet it is the most ambitious. Hence, the following sections, through a prism of war and warfare, will attempt to establish a rational trajectory of manned and unmanned aerial platforms and ascertain a more practical approach. Analysis is carried out at two levels. First, at the fundamental level of war, and second, at the operational level of conduct of war.

Assumptions: The analysis factors certain important assumptions, and these are:

1. Artificial Intelligence (AI) and networks will continue to accelerate developments in both manned and unmanned systems. Unmanned

systems would continue to gain a greater level of autonomy, from *human-in-the-loop* to *human-out-of-the-loop*.

2. For clarity, Unmanned Aerial Systems (UAS), Unmanned Aerial Vehicle (UAV), Unmanned Combat Aerial Vehicle (UCAV), and Remotely Piloted Aircraft (RPA) are placed in the same category.
3. *Humans will be the chief protagonists in war*. Concerns over AI/Machine Learning (ML) and Lethal Autonomous Weapon Systems (LAWS) underpin the chief role of humans in the conduct of 'Human Affairs', most importantly in 'conflict and warfare'.

Analysis—Fundamental Level of War

At the fundamental level, manned and unmanned aircraft are best appraised through the 'Nature of War' as articulated in Clausevitzean trinity—Primordial Violence & Hatred (People), Play of Chance & Probability (Commander/ Military), and Subordination to Political Objective (Govt),[4] and thence through an evaluation within the 'Morals and Ethics of War' and 'Indian Context'. With regard to the response to realities of violence, hatred and enmity, high-tech manned fighters are abreast of the moral forces of war, but these are typically extraneous to unmanned systems operating from a relatively risk-free and virtual environment. This disconnect of unmanned systems could be seen as a symbol of progress; however, 'complete replacement of human systems by the unmanned, renders the whole activity [of warfare] a point-less waste that fails to resolve the human needs that triggered it in the first place'.[5] Operating drones remotely is like a computer game that, by its very nature, is disconnected and artificial.[6] On the yardstick of chance, probability, and chaos of war, a high-tech manned fighter with fused sensors, networking and man–machine interface is a proven capability. Likewise, the unmanned systems, due to better data processing, faster learning, and an unbiased approach, could match manned fighters. However, the proficiency of unmanned systems in the appreciation of context (*a combination of intellectual and intuitive awareness*) and hence, respond independently and aptly, is debatable. War fighting is a combination of man and machine, and history has numerous examples of technologically superior forces being defeated or stalemated by smaller and poorly equipped forces; Vietnam, Korea, Afghanistan, and the ongoing Russia–Ukraine as well as conflicts in West Asia, are a few instances that substantiate the same. Hence, the intangibles of human cognition can never be discounted in war. Human beings by far have proved more competent at coming up with innovative and dynamic solutions to problems that may not have been thought of before, in nutshell,

superior at 'being Creative', at least until, autonomous algorithms (AI) get anywhere competent at thinking 'outside the box'.[7] With manned fighters, the coherence and subordination of military objectives to the political ones are mostly assured. With increasing autonomy in unmanned systems and greater permissibility in decision-making in the kill chain, the allegiance of their tactical action to military and political objectives is arguable. For preserving coherence to political objectives, 'an assurance that humans are the moral agent and fail-safe, ultimately responsible for all decisions on lethality'[8], is indelible. Hence, to remain coherent with 'Nature of War', unmanned systems will take considerable time to display all-encompassing cognitive abilities that are essential in warfare.

In the context of Morals and Ethics, India's strategic culture is consistent with principles of *Jus ad bellum* (Just Cause of War) and *Jus in bello* (Just in Conduct of War). *Dharma Yudha,* a unique and enduring teaching of *Bhagavad Gita* that professes just war with a strict code of conduct, underlines the nature of India's strategic culture concerning the use of force for statecraft.[9] Accordingly, the use of military force as a last resort, and with restraint, calibration and proportionality[10] are a manifestation of the same. Various instances of use of force or conflict in the Indian context, from 1947–48 conflict to the Balakot strike in 2019 adequately validate these key tenets of the Indian way of warfare. Conduct of war is the primary responsibility of military officers, and they are expected to adhere to 'Morals and Ethics' of war.[11] Semi-autonomous unmanned systems, as well as autonomy in weapons, disrupt this principle. Visuals of battlefield and bloodshed in high definition alter the experience of war, as well as its psychological and emotional effects.[12] Semi-autonomous application of unmanned systems that have a human-in-the-loop, albeit at larger distances from the theatre of operation and far from realities of war, divorces the operator from the usual pressures of war and could enable an operator to suspend their ethical decision-making. With unmanned systems, war is becoming 'cheaper' and may lead to unnecessary kinetic actions.[13] At the strategic level, 'lack of human pilots can make airstrikes more appealing, and eventually make conflicts more attractive'.[14] Notwithstanding, while the physical distance from the target and a risk-free environment (long-range non-contact combat capabilities) might cause a similar detachment in a manned fighter, *a human physically in and around the battlefield would ensure the minimum desired level of ethical standards of warfare*. An autonomous weapon system conducting the complete kill cycle independently without any human intervention is a dangerous consequence that defies the principles of ethics. That is why war needs to be conducted

by 'highly trained, educated and introspective individuals, with necessary mental and technical skill required to properly and justly employ force with the intent and consequence of destroying human life'.[15] Hence, to remain consistent with *Jus in bello* and India's strategic culture, 'employment of cooperative manned and unmanned aerial systems with C2 being retained by the manned platforms'[16] is a necessity.

In the Indian context, with a highly volatile neighbourhood, the distinction between peace and war has blurred with an intermediate continuum of No War No Peace (NWNP). The actions and responses in an NWNP scenario exhibit Grey Zone characteristics of non-attribution and low threshold. Correct and timely identification of threat, followed by calibration in response, are key imperatives in NWNP. This would be difficult to achieve through unmanned systems, rather in the worst case these may cause a strategic vulnerability. An unmanned platform hacked by the enemy and made to crash land either in his territory or on a critical friendly location will have serious strategic implications. In contrast, manned fighters offer calibration, control, flexibility, as well as responsiveness in most of the NWNP situations, as was evident during the Balakot (2019) and the Eastern Ladakh (EL) crisis (2020). Nonetheless, unmanned systems play a key role in NWNP in ISR tasks, high-risk missions, battle damage assessment (BDA), and in sacrificial tactical missions. Therefore, a collaborative approach with roles/tasks rationally distributed between manned and unmanned platforms, but C2 with the manned platform will provide the most appropriate solutions to any NWNP situation by enabling a dynamic response and retention of initiative while precluding escalation.

Hence, at the fundamental level, where 'political, social, and moral context of war and warfare is as important as conflict',[17] manned fighters and unmanned systems maximise as a strategic capability only through complementary application, with manned fighters retaining the C2.

Analysis—Operational Level: Through the Prism of OODA Loop

The aerospace domain provides the most suitable environment for the growth of unmanned capabilities. Hence, this section carries out operational evaluation of manned fighter and unmanned systems through the established concepts of the aerospace domain. The assessment is carried out at two intertwined levels, through the OODA (Observe, Orient, Decide and Act) loop at the conceptual level and operational nuances at the application level. The OODA loop, a seminal design by a famous airpower theorist, John Boyd, is a simplistic yet holistic framework for the conceptual assessment

of manned fighter and unmanned systems. It premises on 'relative ability to comprehend, shape, adapt to, and in turn be shaped by an unfolding, evolving reality that is ever-changing and unpredictable'.[18]

Observation as a 'combination of sensing outside information, processed through implicit guidance, and interaction with unfolding circumstances'[19] is a factor of aircraft (manned or unmanned) sensor, interface, and operator ability. Sensing, data processing and user interface are similar in both unmanned as well as manned fighters. The operator's ability is a factor of training in manned aircraft, and of data, algorithms, and Machine Learning in unmanned aircraft. Thus, an unmanned aircraft outperforming a manned system in 'Observation' would be a factor of the quality and resilience of algorithms employed. Unmanned systems with stealth and long loiter capabilities like the RQ-170 provide a better option for ISR missions with a high level of autonomy in take-off, landing and flying pre-determined observation profiles.[20]

Since orientation is more of a contextual feature as compared to observation, a manned fighter is envisaged to be better oriented than an unmanned aircraft. *While an unmanned system could achieve a faster analysis and synthesis of information, it cannot yet develop a contextual appreciation of the same* (*Easily synthesises 'What' and 'How', but poor in 'Why'*). Human instincts (and thus orientation to any situation) are an evolutionary development and will mostly work even to a newer stimulus never encountered before, thus preserving the required orientation. Autonomous systems will not be able to assimilate and thus react to new stimuli or variables (which it observes), which it has never encountered before,[21] while also being a complete slave to datasets and learning algorithms driving these systems. This distinctive human ability, in the words of Richard M. Restak, is due to 'the interaction with the environment that exert tremendous influence on the way the human brain works and how it has evolved, and is able to make dynamic connections leading to contextual eliminations and selections'.[22]

Decision and Action are a logical sequence that is largely driven by internal and group feedback.[23] A high-tech manned fighter has all the means to decide and act as promptly as possible, but the intricacies of human nature (inhibitions, biases, abilities) may prevent it from being equivalent to an unmanned aircraft. However, the decision and action of manned aircraft would mostly be right or at least perceived as right (*Jus in bello*). This is especially 'true in a life-and-death situation'[24] and when 'the passionate desire is pursuit of military victory and protection of comrades',[25] while mostly being conscious of the ethics of war. Various UCAV development programmes,

such as X-45 and XQ-58A Valkyrie programmes, are aimed at AI-enabled high degree of autonomy not just in terms of flying but also to decide on and execute tactical options.[26] The highest level of autonomy in decision-making and action is considered to be LAWS, 'due to its serious consequences from ethical, legal, and political concerns, it is facing serious hurdles.[27]

It emerges that a collaborative development with a high level of autonomy in non-kinetic missions (like ISR), and human-in-the-loop autonomy in kinetic missions (like in Loyal Wingman concept) is more acceptable as well as a viable solution. Various 6th generation programmes like Future Combat Air Systems (FCAS) and Next Generation Air Dominance (NGAD) will achieve the same.[28] The essentiality of manned fighters leading the collaboration of manned and unmanned systems is succinctly summarised by Boyd himself as he stated that 'Though, speed is the most important element of the (OODA) cycle but it is just not simply cycling through the Loop, if that was the case, military can make computer models. *But computer models do not take into account the single most important part of the cycle—the Orientation phase. Moreover, machines do not fight wars, humans fight wars, one must get into the minds of humans, that is where the battles are won*.'[29]An unmanned platform is driven by the mind of the designer, who either might not consider the mental and moral premises of the user (warrior in this case) or could not replicate the same, which would mostly keep an unmanned system deficient in operating independently.

Analysis—Operational Level: Nuances

The operational nuances, primarily *combat effectiveness, risk and cost*, ascertain the tangible op potential of both manned and unmanned systems. Combat effectiveness is a combination of payload capacity, delivery effectiveness and mission versatility. A high-tech manned aircraft carries varied types of payloads, is multi-role, is highly manoeuvrable, and is capable of dynamic on-scene decision-making—one of the most important tenets of war fighting. It can carry up to an average of 3.0 Tonnes (T) of loads (though most of the modern fighters carry more than 5 T) of diverse warheads and high accuracy (<10 m). It is self-sufficient in target acquisition, tracking and neutralisation, besides being highly reliable due to extensive pre-employment testing and evaluation.[30] Moreover, the modern technology ensures kinetic and non-kinetic firepower capability in the same aircraft. In the future, it will become a credible C2 platform and dynamically control unmanned systems that are performing diverse roles (6th generation fighter will achieve the same).[31] At present, unmanned systems carry relatively lesser payload and are mostly for

a specific task (which on an average is equal to 1.0 T, though there is growth expected in this aspect). Their manoeuvrability has improved, but has not reached the levels of a manned fighter. Its signature depends on size and stealth features, and decision-making is as good as algorithms. *Their capability of independent on-scene decision-making and actions that are acceptable to humans is far-fetched and might take significant time to be proven as employment worthy*.

In a network denied environment, a manned fighter with rigorous training provides an assured redundancy and, as a result reasonable guarantee of operational success. *In contrast, the unmanned systems are highly susceptible to a network denied/compromised environment, leading to a substantial reduction in op effectiveness*. Thus, an unmanned system would need to be 'designed to operate in a unified framework that addresses both air combat as well as network defence concerns'.[32] The more complex the operating environment for an autonomous unmanned system, the more complex the AI will need to be. Yet, for an autonomous unmanned system, errors will be inevitable.[33] These errors will reflect in the operational efficacy of these systems, and without human feedback or control, will magnify. No amount of testing, software verification and validation will be able to prevent the likelihood of errors in such complex systems.[34] Also, adversaries will seek to hack/spoof the systems to exploit these vulnerabilities.[35] Russia has successfully interfered with various types of drones in Ukraine and Syria using advanced EW systems.[36]

Considering risk as a combination of 'Risk to Objective' and 'Risk to Resource', the unmanned systems are not that risk-free. Russia–Ukraine conflict highlights the high risk to unmanned assets in a contested environment. The losses to unmanned systems are nearly tenfold compared to manned aircraft (nearly 3,000 as compared to 300). Similarly, there was a significant reduction in the employment of TB-2s, due to a large number of losses in a contested environment. Low weight of attack, poor manoeuvrability and unprecedented growth in AD and EW environment make these systems highly vulnerable,[37] thus risking both 'the objective' and 'the resource'. Further, a strategic level assessment of Russia–Ukraine war reveals that despite increasing the use of drones by both countries 'Ukraine has not dislodged Russia from Donbas, and Russia has not broken Ukraine's will to resist'.[38] Manned fighter and the crew behind the system are rigorously trained, employ sound tactics and enabled by technology, achieve the objective as well as make all efforts to preserve the resource. Innovative tactics employed by fighters have ensured that even in a complex air defence environment, the 'rates of attrition' were kept low.[39] For instance, 'with sound tactics employed

alongside, and suppression of air defences, *impressive loss rates of <0.5 percent were achieved during Bekka Valley conflict, Yom Kippur War, Falklands War, and Desert Storm (in Desert Storm it was 0.1 percent)* despite formidable air defences'.[40] It was realised that, 'first, the attacker was able to implement loss reducing improvements much faster than defender; second, manned fighter, properly maintained, equipped, and operated with defence suppression, was able to penetrate sophisticated defences'.[41]

A2AD (Anti Access Area Denial), which denies access and freedom of operation in the operational area, is often considered a major detriment to manned fighters, but it has solutions that can be evaluated through pre-launch survivability and the ability of defence penetration. Aircraft, though, are vulnerable due to predictable locations within the airbases, and can survive strikes by housing them in hardened aircraft shelters and dispersing them across airfields.[42] Pre-launch survivability is further enhanced through resilience and redundancy of launch bases by rapid airfield recuperation measures and use of ELFs (Emergency Landing Fields) and JUAs (Joint User Airbases). Moreover, to destroy a significant number of aircraft on the ground would require coordinated surprise attacks on airfields involving many sorties with precision munitions.[43] It is possibly due to all these factors that the Ukrainian Air Force was able to survive despite extensive barrages of Russian attacks.[44] Towards defence penetration, firstly, the complex terrain (*especially the mountainous one*) provides an automatic protection from all types of SAMs due to gaps in surveillance and communication. Secondly, innovative tactics and technology, along with active and passive countermeasures, and embedded suppression of air defence reduce the effectiveness of any sophisticated system.[45] Thirdly, a complementary application of different types of weapon systems that include fighters, unmanned and SSMs, as a composite package, would overwhelm A2AD and enable firepower penetration. Fourthly, most of the air-launched weapons being employed from stand-off distances, followed by dynamic post-launch evasive manoeuvres, further mitigate the vulnerability to SAMs. To exemplify, the Russian Air Force was able to greatly reduce losses of its assets by employing similar tactical innovations after learning from initial setbacks.[46]

In economic terms, manned and unmanned systems for similar functionality would have similar costs. An unmanned system as a functional replacement of a manned fighter would need an investment much more in technology to substitute for the competence of a pilot (due to *near zero tolerance for failure and miscalculation*).[47] This makes creation of reliable and

combat-effective unmanned systems one of the greatest challenges of design and development. It is probably due to this complexity that despite unmanned technology available for decades, commercial aviation is still manned. As a rough comparison, an MQ-9B costs approximately Rs 900 cr compared to Rs 550 cr for each LCA.[48] Likewise, the cost of UAVs, such as Global Hawk, is around US$ 130–150 mn/ unit (approx. Rs 1,000–1,200 cr at current rates of conversion),[49] which is roughly equivalent to that of an F-35.[50] Although a manned fighter may not achieve an equivalent level of persistence, the diversity of effects that can be delivered by it justifies its cost-effectiveness. While an unmanned system allows cost reduction due to no human element in the air, the incumbent costs of sophisticated technology, secure and redundant network, ground-based infrastructure, including a skilled operator, reduces the cost gap (ground operators for unmanned aircraft also face the challenges of fatigue). In addition, ground-based operation centres are vulnerable to enemy attacks.

Specifically, in terms of *cost/tonne of payload*, the cost of a high-tech manned fighter may be considered as approx. Rs 1,000 cr and *an equivalent unmanned system* may be considered at least half of this cost.[51] Considering an attrition rate of 5 per cent for both the systems (though, historically, fighter's loss rates have been <2 per c ent, lower than that of the unmanned systems), a manned/unmanned AC would be lost after every 20 missions.[52] The payload carried by a manned fighter and an unmanned AC is considered as three and one tonne, respectively [refer Para 12 (a)]. In 20 missions, cost/tonne for a fighter and an unmanned AC would be approx. Rs 16 cr/T and Rs 25 cr/T, respectively.[53] Hence, even at an attrition rate of 5 per cent, fighter AC is nearly twice as cost-effective as unmanned AC. Cost-effectiveness would increase to approximately four times in case the fighter attrition is considered as 2 per cent, and that of the unmanned AC is still kept at 5 per cent. *Though loss of crew would be invaluable, it is a difficult reality of war faced by every combatant on land, sea, and in air, and there are several mitigation strategies to limit this*. To illustrate further, Ukraine has claimed to have shot down more than 500 Shahed-136 drones (nearly 90 per cent of the total number).[54] These weapon systems, 'with less than 10% payload capacity of air launched munitions and high vulnerability display significant performance drawbacks' and, thus, are considered inadequate to accrue any noteworthy operational outcome independently.[55]

Hence, maximum combat and cost-effectiveness as well as risk mitigation are accrued by employing both the systems in a tactically sound complementary manner. Manned aircraft delivering requisite load and

employed in diverse roles, and unmanned platforms complementing in load and mitigating vulnerabilities as part of a composite package.[56] In the future, with the development of optionally manned fighters and improvements in the payload of unmanned systems, aforementioned calculations might change. However, in view of lethal autonomy, how much of the payload can be trusted to an autonomous or semi-autonomous unmanned platform will remain an important point of deliberation.[57]

Trends, Prospects and Recommendations

While the military discourse on recent conflicts has focussed on unmanned systems, the actual developments underscore the requirement of a collaborative approach led by a manned fighter. Globally, aerospace and next-generation manned fighter programmes are a key element of military development. NGAD programme of the US, FCAS of Europe, Tempest of the UK, J-20/ FC 31 and development of J-X sixth generation aircraft of China,[58] and joint programme by Türkiye and Pakistan to develop 5th generation fighter 'KAAN/ TF-X'[59] emphasise impetus of major military powers on a collaborative manned fighter. Most of these programmes are a combination of manned fifth/sixth generation fighter with the unmanned system as 'Loyal Wingman'. Skyborg is an AI system capable of piloting UCAVs autonomously, yet it is developed to operate in tandem with manned fighter aircraft.[60] The entire concept is based on a fine balance between mission control and risk-cost balance, with unmanned systems stated for high-risk mission activities and the manned system exercising operational and tactical control.[61] In terms of roles, the manned platform is envisaged as an advanced command post operating through a robust network.[62] Unmanned systems will perform combat-enabling missions, such as ISTAR or deception and sacrificial missions like kamikaze drones.[63] DARPA's Air Combat Evaluation (ACE) programme summarises this development approach that 'fosters human–machine teaming through a hierarchical system in which the highest level of cognitive functions (combat strategy design, target selection and prioritisation etc.) would be the responsibility of humans, while less demanding cognitive functions (tactical manoeuvres etc.) would be left to UCAVs.'[64] *Therefore, it is reasonable to deduce that despite evolution in unmanned capability, manned fighter AC accrues significant operational value, thus leading to a collaborative approach for the employment of both systems.*

The situation across our borders exhibits similar trends and needs to be viewed critically. It is assessed that by 2035, the entire fighter inventory of

PLAAF would be 4th (J-10 class), 5th (J-20 class), and 6th (J-X) generation aircraft, and at least 4–5 times that of the IAF in terms of numbers. With the rapid pace of inductions of J-10C (*close to 100 x J-10C by 2030*) and JF-17, and a collaboration in the KAAN project with Türkiye,[65] the advantage of Indian Air Force (IAF) over Pakistan Air Force (PAF) is rapidly waning. By 2035, PAF might achieve near parity with IAF. The situation in unmanned as well as collaborative projects is equally alarming. As per the SIPRI report, China has exported more than 250 combat UAVs to various countries, including Pakistan, in the past decade in comparison to US's export of just 12 combat, which supposedly manufactures the most advanced of these platforms.[66] It is already pursuing multiple projects in CH (Rainbow), WL (Wing Loong), and GJ (Stealth UCAVs) series unmanned combat platforms while simultaneously working on 'Loyal Wingman' concepts. Pakistan, similarly, is taking full advantage of its all-weather ally China, and it has more than 25 unmanned combat platforms, and there is no doubt that with its collaboration with Türkiye, man–unmanned teaming is not far.[67] *There is a definite realisation among both adversaries that high-tech fighters collaborating with unmanned aerial systems are a major source of combat power to enable operational edge over the Indian military*.

In the backdrop of these trends, the following are the key prospects of manned fighter and unmanned systems collaboration in the Indian context:

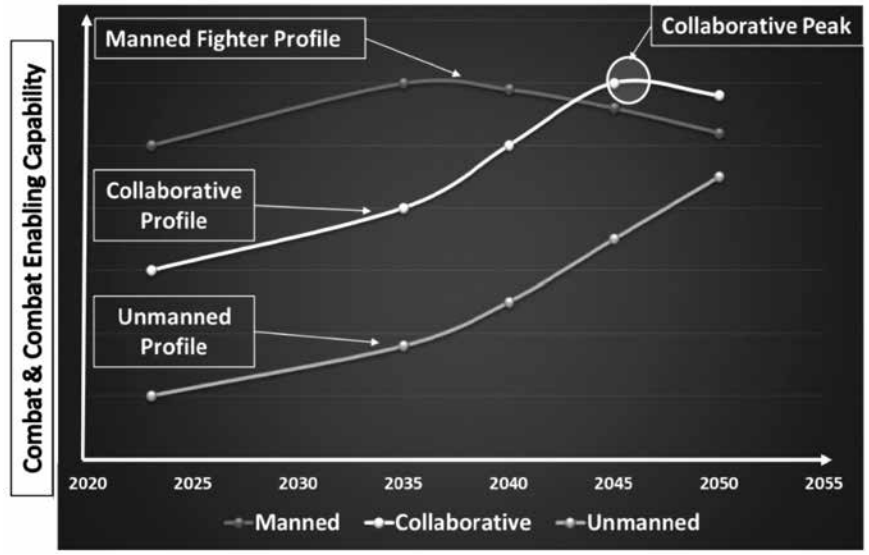
1. First and foremost, both to our west and north, strong air forces will prevail in all future battlespaces unless the IAF's present asymmetric advantage is bolstered on priority.
2. India is likely to field 5th generation fighter and MUM-T capability by 2035, by when most of the modern air forces (including China) would have fielded 6th generation fighter.[68] This implies a clear gap of one generation. Similarly, an optionally manned fighter could be anticipated on 15–20 years' timelines. *These realities would need to be factored in our developmental profiles*. In addition, 'Atmanirbharta' is a long-term strategy and how this strategy will bridge the inventory slide in next two decades would need a thorough deliberation.
3. With a surge in aerospace and aviation industry, commercial application of unmanned systems is witnessing an unprecedented growth. Simultaneously, the threat of unmanned systems as well as their management problem is growing at an equal pace. Hence, their development would need to be pursued with concurrent focus on *dual-use techs, air space management* and *air defence*.

4. The modelling of unmanned systems for artificial combat solutions depends on data and a suitable intelligent architecture to enable set-piece manoeuvres/tasks. *It is a long-term proposition*; however, it is a mandate of ongoing indigenous programmes.

Development profile of manned fighters and unmanned systems must capture 'Best of both Worlds'. Accordingly, following recommendations merit consideration:

1. *In short-term (till 2030)*, to stabilise LCA programme and realise AMCA and CATS, *Approach I* (mentioned earlier) is suggested. *In long-term (beyond 2030)*, to capitalise on gains made in preceding years, a shift over to *Approach III*, to achieve *'Collaborative Peak' by 2047 (end of Amrit Kaal)*, as depicted below (Figure 1) is suggested:

Figure 1 Collaborative Profile



Source: Author's creation

2. Indigenous manned fighter programme, i.e., LCA and AMCA, and integration of indigenous kinetic and non-kinetic capability on fighters is vital to retain combat edge over our adversaries as well as foster an export-capable defence ecosystem. It is even more important in view of IAF's commitment to procure a substantial number of indigenous

LCAs,[69] as also the interests shown in LCA by various middle-income countries like Argentina and Malaysia.

3. To overcome shortfalls in niche capability and compress timelines of indigenous development, complementing the indigenous fleet with COTS aircraft (in limited numbers and ToT options) is required. Hence, the collaboration with FFCs would be essential on a case-by-case basis. Likewise, internally, the production lines need to be extended to private partners to meet qualitative and quantitative requirements within the desired timeframe.
4. To ensure a progressive and realistic path of development in this field, IAF should become the nodal service to spearhead manned and unmanned platform development in the air domain. It would also include dual-use aerospace tech for civil aviation and commercial use. This has been concisely expressed by Air Marshal (Dr) Diptendu Choudhury as he states that 'The pace of technological advancements can only increase if the IAF and the industry synergistically short circuit the synapses between the development of future operational concepts, identifying operational requirements, industrial research, development, and production and, finally, operational testing and evaluation.'[70]

Conclusion

Manned fighter and unmanned platforms have their benefits as well as limitations that can only be harnessed and overcome through complementary application. The progress in aerospace technologies tends to tilt the balance towards unmanned systems. However, a holistic view through the context of war, warfare and Indian conditions, as well as strategic culture, suggests otherwise and offers a more balanced perspective. Hence, till the time war is a clash of opposing human wills with 'justice expected in cause and conduct', and there is a realistic assessment of every system as well as the Indian context, a collaborative approach that fuses manned fighter and unmanned systems is the most rational option. It will seamlessly combine the indomitable human will, spirit, and resolve, and technological advancements in military aviation. Accordingly, the essence of the argument of this article can be summarised through Boyd's trinity of prioritisation as an assured formula of success in any form of competition, and that is, 'People First, Ideas Second, Things Third'.[71] The science-oriented group will place 'Things (Technology)' first, a commerce-oriented will probably place 'Ideas and Things' first, but an art-oriented group will

definitely place 'People' first—and *war, predominantly is an art; an incisive, violent, and unforgiving human interaction*.

'*Not only have aerospace technology costs, like those of the Armies and Navies, continued to grow, but the very complexity and extent of this technology will compel very difficult choices on even the most well-endowed governments and defence staffs*.'

Tony Mason, 1994.[72]

NOTES

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