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NEXT GENERATION AEROSPACE POWER: THINKING UNMANNED SYSTEMS

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NEXT GENERATION AEROSPACE POWER: THINKING UNMANNED SYSTEMS

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Abstract

The period of 2019-22 is a turning point in the use of unmanned aerial systems in battlespace that itself has metamorphosed into its hybrid incarnation. The evolution of UAVs is following the same trajectory as of manned aircraft only at a faster pace and with greater accuracy. UAVs have practically pushed out manned aircraft from the reconnaissance and surveillance role and are increasing their share in the strike role. It will still take a while for a UAV to undertake an air defence mission effectively. In the foreseeable future, an optimal solution is a mix of manned and unmanned systems until technology can support a better appreciation of situational awareness and command and control aspects.

The human brain has an unmatched capability – imagination. Humans are endowed with an ability to think ahead and plan and many imaginations have been realised in the past. With a keen sense of observation and the ability to use available material, the human race has mastered our planet and made forays in other heavenly bodies albeit with limited success as yet. But this race to explore the uncharted areas has had a dark side too -a greed for more resources to stay ahead of others. While the planet

Earth has adequate resources to fulfil all needs, it cannot account for all greed. Arguments, conflicts and wars are natural outcomes of this attribute. And to stay ahead of likely adversaries in any kinetic conflict, a large number of resources, material and human, are directed to focus on winning this race. Every discovery or invention is looked upon as a new opportunity to bolster war-waging capability – from being a benign device to solving mathematical problems, computers today have graduated to play a vital role in war-waging efforts. The next era of transformation in computing in terms of artificial intelligence, machine learning and big data analysis is already taking shape and, naturally, these functionalities will be part of next-generation war systems.

War orchestration often sees a turning point that changes the way various systems in battlespace redefine their roles. In that sense, the period of 2019-22 is a turning point in the use of unmanned aerial systems in battlespace that itself has metamorphosed into its hybrid incarnation. On September 14, 2019, drones were used to attack the state-owned Saudi Aramco oil processing facilities at Abqaiq and Khurais in Saudi Arabia hitting 5% of world oil production. A few months later on January 3, 2020, outside Bagdad International Airport Iranian General Qasem Solemani was assassinated by a weapon launched by a US Unmanned Aerial Vehicle (UAV). These two recent examples of the effective use of unmanned combat systems in West Asia indicate the extent of mission effectiveness and its strategic significance with global implications. In the second half of 2020, the Nagorno-Karabakh war between Azerbaijan with Armenia saw extensive use of unmanned systems to overpower a potent land force. Closer home, India saw the first-ever attack by a UAV on an Indian armed forces establishment in Jammu. And multiple UAV attacks on US troops in Iraq and extensive use of UAVs in the Russia- Ukraine war testify arrival of UAVs as a key combat element although UAVs have been used sporadically in conflict zones for the last four decades.

Evolving Military Aviation

Looking at the freedom the birds enjoyed in three dimensions, the man was keen to replicate that. Centuries of effort and thousands of failed attempts later, the man did master the third dimension beginning with balloons and kites. But it was heavier than air machine in 1903 by Wright Brothers, that set this field for a take-off. Within a decade of that breakthrough, aircraft were part of military machinery. And a century later, aircraft practically define the battle space and control the outcome like no other military system could. Although human forays into space started over seven decades back, its impact on warfighting is still not as profound as an aircraft. The prime difference between these two mediums has been the use of weapons. With an international treaty to prohibit weaponisation of space, air power retains the edge albeit with the help of space-based systems.

Aviation, in general, and military aviation in particular, progressed rapidly with the expansion of fixed-wing and rotary-wing aircraft in the last century. The race in the combat platforms was to have more powerful engines and better airframes to outrun and outclimb the adversary. Both better speed and higher altitudes gave unmatched advantages in aerial combat or for using aircraft for targeting surface-based systems. Weapon ranges and their accuracy too improved with the induction of better systems in aviation. But exploitation of aircraft and its onboard weapon systems remained dependent on the pilot(s). The human aspect of aviation was the X-factor and was often seen to make the difference between victory and defeat. Pilots' ability to comprehend the air situation based on visual cues and control over manoeuvring aircraft often defined the combat outcome or the result of an attack on a surface target. As technology in computation and sensors improved, the strongest element of the combat platform, a human being, lost his place of pride. Now, a combat platform was a system that needed an efficient systems operator, to manage all sensors to generate a situational awareness paradigm and thereafter use that to optimise attack solutions from a plethora of weapons on board. While the combat aircraft was trying to decode all the inputs, a range of sensors and weapons were attempting to target this platform. The battlespace was contested and the undue advantage that speed and altitude provided to combat aircraft had diminished. Surface-based sensors and weapons systems with enhanced potency, range and accuracy posed a real threat. The threat magnified as gradually human element from surface-based defensive systems was replaced by automated systems that could work ceaselessly and simultaneously in multiple domains tracking and engaging multiple targets. The balance is tilting back in favour of surface-based systems.

The Era of Unmanned Aerial Vehicles

Two distinct things appear in the current operating environment. One - to defeat a system that relies on fast computations to achieve weapon solutions, there is a requirement to outthink the systems. It is humanly difficult to outthink computers in this era and going forward, it will be nearly impossible. So the panacea of combat aviation- a human being needs assistance to survive. The second issue is about economics. The cost of training a pilot to operate in the current operational environment is very expensive and time-consuming. Even after all the training, it may not be possible to ensure a favourable combat outcome when pitted against high-power computed systems. Well, pilots will not go into oblivion immediately but will have a redefined role. Rather than manning combat aircraft to operations, they will be required to understand evolving combat aviation aspects and help in developing systems that can be deployed in the combat zone. The transition of pilots from 'knights' to 'scientists' is almost over.[1]

As soon as man could fly, aviation found its way into the military domain. The first task for military aviation, whether in a hot air balloon or with heavier-than-air machines. was to see on the other side of the line - reconnaissance. Initially observations by the pilots and later with the help of still cameras. as higher observation posts gave a good picture of enemy disposition. The next task for military aviation was the use of a platform to drop weapons – the strike role. And later the aircraft was assigned an air defence role to shoot enemy aircraft. The evolution of UAVs is following the same trajectory. Only at a faster pace and with greater accuracy. These refined attributes are an outcome of technological advances in computation, communication, and sensor fidelity. UAVs have practically pushed out manned aircraft from the reconnaissance and surveillance role because of their low cost of operation and low risk. Gradually UAVs are increasing their share in the strike role. It will still take a while for a UAV to undertake an air defence mission effectively.

So the next generation of aerospace power will revolve around unmanned systems that could contemplate possible scenarios based on inputs from multiple sensors and can think of an optimum solution. The battle will be in the computation domain with information providing the needed ammunition to guide the onboard weapons to the desired target and evading the weapons that are aimed to hit it. Like a manned aircraft, the platform will have to have multiple redundancies and operate in conjunction with other platforms in a synchronised manner.

Unmanned Aerial Vehicles in Hybrid War

> *As the brutal fighting continues in the Ukraine War, it seems likely to fundamentally upend the way we wage war in the 21st century. From new tactics to equipment, the Russian invasion of Ukraine may presage fundamental changes in how war is conducted. A new tactical triad is emerging in the 21st-century battlefield—special forces, unmanned systems, and cyber will be far more important going forward. While legacy systems from tanks to destroyers to close air support aircraft will retain utility, we need to rethink our way of war.* [2]

This section has three subsections. First, the characteristics of hybrid war follow up with attributes of UAVs and thereafter intertwining of hybrid war and UAVs and their security implications.

Operational Environment in Hybrid War

What is hybrid War? Two issues are related to this –the term hybrid war and a phenomenon called a hybrid war. The term 'hybrid war' indeed is a new one and has gained prominence in the current century. This is often used interchangeably with grey zone, nonlinear, unrestricted war, no war no peace, new war, mutating war etc. Primarily it means that there are multiple prongs of wars and all of these do not necessarily use kinetic capability. In short, a mix of kinetic and non-kinetic means for waging war. But in case we look at the history of warfare, hybridity has always been there. From Kautilya’s Arthashastra to Kamandaka’s Nitisar tenets of war hybridity are annunciated. Although the term hybrid war is a new one the phenomenon is not.

How is hybrid war different from the wars of the last century? Essentially there are no differences as all wars have the same violent nature. But war characteristics have transformed. Earlier a 'force on force' well-defined conflict with a specified beginning and often a well-marked end took place every so often in a geographically bound area. That has changed. While force-on-force conflict still retains a sizeable portion in the current context of hybrid warfare, its salience has reduced significantly. Other facets of warfare have gained prominence and the most distinct feature of these facets is the absence of an announced beginning or an end and the area of operations. War declarations are passe. Time and space of conflict are limitless. The aggressor can strike wherever it can reach. Technology has played a major part in this aspect. This has brought in three basic changes in the conflict scenario.

First, the actors in conflict are states, non-state actors, state-sponsored non-state actors, regular combatants and irregulars and non-combatants, conventional weapons and unconventional systems. Non-state actors, hitherto fore, came into being and fought against a specific state but now these actors have an international footprint. States too find it easier to use non-state actors as hybrid war tools.

Second, technology has expanded kinetic capability in terms of range and precision. This has expanded the battlespace that was normally restricted to land borders or coastal areas. Now, all assets that an entity holds anywhere on land, water or aerospace or cyberspace can be targeted. So, a defender’s task is enormous.

The third aspect is time compression. No longer months and weeks are available to plan and take kinetic action. The situation changes rapidly as mobility and communication speed have grown exponentially in this century. Reaction time available is in terms of hours and at best days. So, everyone must be ready always and every time. The cost of defensive operations has gone up substantially.

Combat in the prevailing operational environment is heavily dependent on technological changes. On one hand, technological developments are resulting in sensors with greater sensitivity and range and, on the other hand, higher speed and volume of communication are permitting dispersal, diffusion and expansion of battlespace. The balance is gradually, but definitely, tilting in favour of the aggressor and first-mover advantage is increasing. In such a scenario, Artificial Intelligence, high-speed weapons (hypersonic) and space-based sensors and tools will have a significant impact on the combat environment. These aspects will also redefine the role played by combat forces and their mix of manned and unmanned systems. This is the summation of the current genre of hybrid war that has changed from force-on-force to system-on-system contests. Although the current Russia- Ukraine war showcases limited advantage to the aggressor as Ukraine succeeded in stalling and repulsing large-scale Russian military aggression. The phenomenal attrition of Russian offensive teams using armoured vehicles and helicopters has been because of Ukrainian better battlespace orientation with real-time intelligence inputs and usage of portable weapons and unmanned aerial systems.

Expanding Role of UAVs in Operations

It is important to understand how and why the UAVs come at the forefront of the kinetic force application. There are three critical components involved in the employment of unmanned systems instead of manned systems in combat, viz., basic navigation (on a pre-defined route), tactical operations (situation appreciation and changing the plan midway) and weapon or load delivery (correct and timely targeting). While progress has been made in all three verticals, it is yet to reach a level that would enable the complete replacement of manned systems. Factors that need to be considered in this debate are Sensors and Dynamic Situation Processing[3], Speed and Manoeuvrability [4] Weapon Carrying Capacity[5] Quantity and Costs[6] Endurance and Risks [7]*:*

How are UAVs playing a role in the hybrid war? First of all the battlespace expansion has put a premium on the information. A better-informed one will be better prepared. And there is no better way to gather information than a UAV. Ongoing Russia- Ukraine war has showcased this again. With sensitive sensors and long reach and endurance, UAVs can keep a vast area under surveillance and help decipher the plan on the ground or in the maritime domain. Yes, there is a threat to the UAV should it transgress into hostile aerospace. But its relatively small radar cross-section and small visual, audio and thermal signature act as its natural defence. In case, it is engaged by the air-to-air or surface-to-air missiles, the cost implications are invariably against the defender unless the UAV shot is a top-end model. So for a defender, it seems a lose-lose situation. More importantly, being unmanned, there are no personnel at risk. That becomes a defining parameter for pushing the envelope outward in the usage of UAVs for recce and surveillance.

Precision targeting that came to the forefront after Gulf War I has changed the battlespace dynamics. With manned aircraft, there were only a handful of states that could undertake precision targeting. But now, a commercially available UAV equipped with a GPS can deliver a packet at a predefined location with precision. It is not difficult to replicate the packet with an explosive. So, UAVs practically give precision targeting capability to anyone who can spend a few thousand rupees. While the range of such UAVs at present is limited to a few kilometres and the payload is also restricted because of low-capacity batteries but a small explosion of a couple of kilograms delivered precisely can be devastating. IAF was lucky to escape major damage while the Jammu base was attacked by a couple of such UAVs.

UAVs have many weaknesses that include low speed, low manoeuvrability, low reliability and high reaction time because of the time taken for communication from UAV sensors to the ground control station and back. Despite these shortfalls, UAVs that can attack precisely pose a considerable threat. More so as such capability is available commercially with no effective counter. This has tilted the balance in favour of the aggressor. While several systems are available to counter UAVs, to shoot them, to disable them using electromagnetic or kinetic systems but it is practically impossible to win this contest by using defensive systems. A UAV swarm is a real threat with no easy answers. Once artificial intelligence develops further and finds its way into UAVs, security challenges will escalate multifold. The only possible solution will be to develop AI enable counter UAVs. That will be at least a decade from now. The security establishment will have to live with this threat till then.

Will Unmanned Combat Systems Compel Force Restructuring?

War is unforgiving. Threat matrices continuously change. Geopolitics, economics and technology play critical roles in defining these matrices. Therefore, armed forces across the world continuously attempt to re-equip, re-organise, re-structure and re-define their force structures to enhance their operational capabilities. The focus of these processes invariably is to build proficiency in the relevant domains for present and future conflict scenarios. With finite financial resources, there is a perpetual debate between domains, quality and quantity. Where do unmanned systems fit in this matrix at the current technological level?

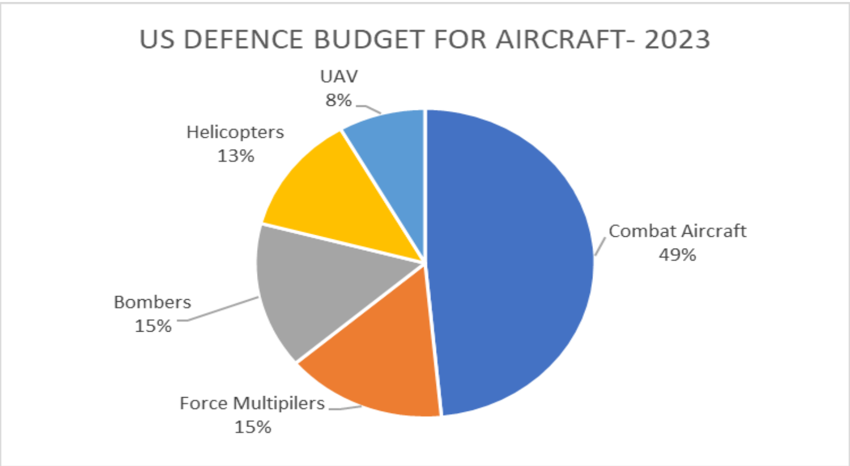
While most space-based systems are unmanned and have played a significant role in supporting combat operations, unmanned combat systems are carving out a niche space in underwater, surface and aerial domains. The expansion of the role of unmanned combat operations has been one of the defining features of the contemporary operational environment. These are indicative of the transforming character of conflict and force application methods in ongoing hybrid wars. Under this changing operational environment, the role of combat forces and their profile has to alter. Therefore, the upward trajectory of the role and scope of unmanned combat systems and its implication for combat force structures is a foregone conclusion. Gradually unmanned systems will undertake a majority of combat support missions. The entire human resource matrix and training will undergo major change to cope with this transformation in combat support forces.

For decades, the long-term trend in unmanned systems has been clear as indicated in the US Congressional Research Service Report which noted that 'DOD spending on Unmanned Aerial System (UAS) has increased from $284 million in FY2000 to $3.3 billion in FY2010.[8]With effect from 2010, the induction of UAVs has outnumbered the induction of manned aircraft in the US armed forces. And since 2011, the US Air Force has trained more UAV pilots than fighter/bomber pilots. The Unmanned Systems Integrated Roadmap of the United States Armed Forces till the year 2034 gives a glimpse of the operational role the unmanned systems will play in the future battlespace. [9] As per US Congressional Research Service Report:

> *"Conventional wisdom states that UAS offer two main advantages over manned aircraft: they are considered more cost-effective, and they minimize the risk to a pilot's life. For these reasons and others, DOD's unmanned aircraft inventory increased more than 40-fold from 2002 to 2010. "*[10]

But most of the financial allocations the world over, including in the US, are still being made for manned aircraft development and procurement (Figure 1). This will change once better processing capacities; artificial intelligence and communication equipment are developed and incorporated into UAVs.

Figure 1: 2023 USA Defence Budget Demand for Aircraft



Source: Based on data in the FY 2023 Program Acquisition Costs by Weapon System of United Stated Department of Defence Fiscal Year 2023 Budget Request by the Office of the Undersecretary of Defence (Comptroller)/ Chief Financial Officer, April 2022

Gestalt

The hybrid nature of current conflicts by no means indicates that force-on-force conflicts are passé. While the armed forces are redefining their configuration to tackle various facets of hybrid threats but the same time is also gearing up for a force-on-force conflict. So the focus of capability expansion of current armed forces the world over is moving in two directions, not necessarily mutually exclusive. On one hand, the capability of combat platforms is being enhanced technologically to meet threats from advanced defence systems and opposing combat elements. On the other hand, the role of combat power is being refined to tackle hybrid threats from a diffused enemy. In this, the emphasis is on surveillance technology and precision low-calibre attack capability. In this domain, space assets and unmanned vehicles are considered the most suitable. While these capabilities can be augmented by manned combat systems but the converse is not true. This is evident from the USAF expansion plan over the next decade that envisages 62 combat aircraft squadrons and only 27 UAV squadrons.[11]

In the foreseeable future, an optimal solution is a mix of manned and unmanned systems until technology can support a better appreciation of situational awareness and command and control aspects. Currently, the most suitable missions for unmanned systems are the five Ds – Detect, Designate, Dirty, Destructive and Dangerous. With the current state of technology, unmanned systems are the best bet for operations in an uncontested space for surveillance and search and strike missions with low calibre high accuracy guided weapons. However, operations in a moderate to dense defence environment will need manned systems to react appropriately. Unmanned Systems can be of great value though to reduce the risk to manned systems by saturating the space and attacking deployed defensive systems, thus compelling an adversary to expend his missiles. Unmanned Systems are essential ingredients of a combat force and their role will continue to increase along with their capability. A quantum jump in the operational role of unmanned systems can be expected only with a breakthrough in AI. Until that happens, however, the role of unmanned systems will increase gradually to reach about 50 per cent of combat operations over the next three decades.[12]

[1] Stephen Fino, Tiger Check: Automating the US Air Force Fighter Pilot in Air-to-Air Combat, 1950–1980, Johns Hopkins University Press; USA, 2017.

[2] James Stavridis, What the U.S. Military Needs to Learn from the Ukraine War,TIME, April 11, 2022.

[3] In a benign defence environment and uncontested space, unmanned systems are efficient in mission accomplishment. When decision-making autonomy is required or there are rules of engagement or a developing tactical situation that cannot be explicitly expressed mathematically, human interface is essential. The current generation of sensors do not have the capacity to replicate the appreciation by a human and pose a limitation in operations because the unmanned system operator is not fully aware of the situation in real time. The major drawback of the current generation systems is their inability to capture high fidelity data, process, encrypt and transmit it and, based on directions from the control station, receive, decrypt and process it to execute a command. Based on the type of processor and communication systems, this process may take anywhere from 600 milliseconds to three seconds – a very long duration in combat operations. Communication capabilities form the backbone of operations and more so for unmanned systems. The USAF with the launch of fourth Advanced Extremely High Frequency (AEHF) satellite on October 17, 2018, completed the constellation requirements for global Extended Data Rate (XDR) connectivity online. This enhanced the communications throughput 10 times over the existing Milstar. The goal of such a satellite constellation is to provide survivable, global, secure, protected and jam-resistant communications for high-priority military ground, sea and air assets. Increased speed allows the transmission of real-time video, battlefield maps and targeting data to help combatant commanders and national leaders make optimal tactical and strategic decisions. The development of Artificial Intelligence will reduce dependency on communication from base station and enhance the level of autonomy to the unmanned systems.

[4] Unmanned systems are generally characterised by their low speed and consequent low manoeuvrability as compared to manned platforms and this makes them vulnerable. At the same time, however, a low size and observability and greater endurance are design features that assist unmanned systems in mission accomplishment. Some unmanned systems manufactures like Kratos, USA involved in making target drones, are also dwelling into tactical UAVs that are manoeuvrable to more than 9*g*.

[5] Owing to their power, unmanned systems are capable of carrying low calibre/low weight weapons in limited numbers as compared to manned platforms. But this limitation can be overcome by converting manned platforms into unmanned systems or through the use of special weapons with high accuracy to reduce Over Target Requirement (OTR)[5] in terms of number and size of weapons. The conversion of fighter aircraft to UAVs for undertaking training missions has been tried and tested in the cases of the F4 and F16 in the US Air Force and the F6 in the People's Liberation Army Air Force (PLAAF). The same could be developed further for undertaking high risk operational missions. Technology involving a swarm of UAVs operating in a group and being mutually supportive is at an advanced stage of development and will assist UAVs in garnering a greater share of operational missions. A critical component of such programme is development of autonomous flight controls, to allow a single operator, on the ground or in another aircraft – such as the pilot of a combat aircraft – to manage the missions of several UAVs at once. The mission could be controlled from the ground, through direct line-of-sight, through a relay, through a satellite relay, through another aircraft.[5] This technology will expand the operational applicability of the UAVs.

[6] Unmanned systems do not need some of the safety and operating systems that manned systems need and thus enjoy better cost efficiency. This normally translates into greater numbers of unmanned systems for the same cost as compared to a manned system. The Valkyrie, a tactical UAV under development, could be built for less than $2 million. The low-cost nature of these tactical systems means that it would be cheaper to finance an air war against an adversary. The air defence system is expensive and advanced air defence missiles may cost upto $5 million. Such missile engagement for a relatively cheap UAV of $500,000 is a good barter. The cost equation for employing tactical UAVs in high threat zones becomes very effective. However, autonomous aviation technology is yet to mature, which can be assessed from the fact that UAV accident rates are four to five times higher than that of manned aircraft. This negates the cost-effectiveness partially as of now but is likely to improve with better technology. As compared to manned aircraft the major factor in the cost matrix is the safety features for the pilot. Safety

of pilot is a critical function in combat aircraft design. This aspect can be clearly understood from the design configuration for a Flight Control Systems (FCS). To enhance combat capability, the aircraft are designed with relaxed stability. The X-29 was designed with a thin, supercritical wing for improved supersonic performance, a form of variable wing camber and canard fore planes. Trimmed so that the fore plane and wing would almost equally loaded at high speed for the lowest possible supersonic drag. The platform was very unstable at very low speed. To counter the chances of failure of FCS, the digital flight control system had three independent channels with each monitoring the other two for possible failures and as a standby to these three, a fourth analogous FCS should the digital system fail. So practically, four layers of redundancy to ensure that the pilot had a reasonable chance of ejecting should things go wrong. This is where a UAV scores over the manned aircraft.

[7] Unmanned Systems practically eliminate human endurance as a factor for mission duration. Autonomous in-flight refuelling could keep the UAV in the air for days. In July 2018, Zephyr set the world record for flight endurance after staying aloft using solar cells for 25 days, 23 hours, 57minutes. The aircraft flew as high as 74,000ft during the daytime. Similarly unmanned submergible systems can undertake long duration missions without the need to surface. Risk to life and risk of capture of operators is fully eliminated. However, the control of unmanned systems is heavily dependent on electromagnetic waves, which are susceptible to interference/jamming/technical malfunctions. Any delay in the transmission of critical commands could be lethal. Another aspect of the absence of an operator in the unmanned system is the limited ability of on-board systems to diagnose any system malfunction, especially owing to an external factor. An aircrew can diagnose an instrument failure and react to save the aircraft, but a UAV with instrument failure will most probably be lost.

[8] Jeremiah Gertler, US Unmanned Aerial Systems, Congressional Research Service Report for Congress, January 3, 2012, 7-57—www.crs.gov R42136 available on *https://fas.org/sgp/crs/natsec/R42136.pdf accessed on August 2, 2018.*

[9] Department of Defecne, USA, FY2009–2034 Unmanned Systems Integrated Roadmap, April 6, 2009, p xiii.

[10] Jeremiah Gertler, US Unmanned Aerial Systems, Congressional Research Service Report for Congress, January 3, 2012, 7-57—www.crs.gov R42136 available on *https://fas.org/sgp/crs/natsec/R42136.pdf accessed on August 2, 2018.*

[11]Stephen Losey, "New Air Force secretary: 'We are too small for what the nation expects of us'," *Air Force Times*, June 6, 2017, available at https://www.airforcetimes.com/news/your-air-force/2017/06/06/new-air-force-secretary-we-are-too-small-for-what-the-nation-expects-of-us/ accessed on march 25, 2019.

[12] Kishore Kumar Khera, *Has the Time Come to Replace Manned Combat Aircraft With Armed Unmanned Aerial Vehicles?* IDSA Comment available on www.idsa.in accessed on December 01,2017.