



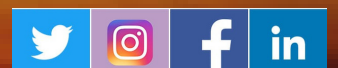
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ISSUE BRIEF

ASSESSMENT OF CONTEMPORARY UCAVS IN FUTURISTIC CONTESTED ZONES

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Abstract

Unmanned Combat Aerial Vehicles (UCAVs) are often termed as Revolutionary. While their use in Afghanistan and Iraq has helped the US to gain advantage through 'Over the Horizon' missions, we must not forget the fact that those missions were largely uncontested or unopposed. On the other hand, the performance of UCAVs are seriously challenged through various small incidents which have largely been overlooked by the world, which stems from the fact that nations are exporting or importing UCAVs without keeping in mind the challenges which may arise in near future, making the contemporary UCAVs obsolete in their roles. The UCAVs will only be termed Revolutionary if they survive in the futuristic contested battle space. This article will hence examine the role & performance of UCAVs for future contested zones based on past or present incidents.

Keywords -UCAVs, Contested, Uncontested, Reapers, Combat, Operations

Introduction

In the last few decades, the Unmanned Combat Aerial Vehicles (UCAVs) has been used consistently in the 'War On Terror' (WOT) operations by the US. It helped the USA to successfully eliminate their key targets in battle zones unopposed. This led various western military experts to declare that UCAVs are revolutionary and can also prove their mettle in battle zones apart from counterterrorism operations. In recent years, we have seen how these drones performed in the Armenia-Azerbaijan conflict in the year 2020, in the Syrian civil war or the war in Libya. Now the critical questions in front of us is whether these examples cement the fact that UCAVs are indeed revolutionary in nature or is their actual mettle still to be tested in contested environments.

No doubt during Iraq-Afghanistan war, US drones conducted a lot of Over the Horizon operations to achieve their goals, but will this be feasible in upcoming contested environment where militaries all over the world may have to deal with Nation states with military might, 'Private Military Companies' (PMC like Wagner Group with access to modern arms) or Non-State actors backed and supported by the state? On the other hand till the time Science and Technology will be evolving, nothing can be termed as revolutionary. This article briefly touches upon the different contested environments that may build up in the near future, threat analysis of contemporary UCAVs like Reaper, Predator, Global Hawk, Bayraktar etc in use and some deliberations from an Indian perspective.

Contested Environment Performance

In the Iraq-Afghanistan war, the UCAV performance was based on the fact that the entire battle was a one sided affair where the enemy state was weaker in all aspects, via economically, diplomatically, militarily, politically, socially etc. But this may not be the case when a state is stronger in all the above aspects. There the effects of the contested environment come into picture. In the future, the UCAVs will have to operate in unfavourable weather and climatic conditions, deal with fighter jets, cyber attacks, EW threats, DEW threats, limitations of international laws etc. The performance of UCAVs in contested zones will depend a lot on their roles & operations.

A) UCAVs in ISR Operations:

(I) Land Based ISR operations:

Historically the role of modern drones like MQ-9 Reaper or MQ-1 Predator has been proven to be effective in ISR operations. But those were proven in zones where the flight altitude of the UCAVs was relatively lower due to absence of effective air defence systems (ADS). The survivability of UAVs is a critical issue. Certain losses of this low cost technology may be acceptable for some countries, but loss of cost effectiveness may not be acceptable to the operators in other countries.¹ In areas containing air

defence systems (ADS), the UCAVs will need to fly at a higher altitude and which will make it challenging because some cameras used in UCAVs have a low resolution. Most of the thermal cameras are of resolution from 640 pixels by 480 pixels. Thermal aerial imaging suffers from several factors including emitted/reflected thermal radiations, shooting distance and atmospheric moisture.²

In case of adverse weather conditions like Typhoons, Storms, etc, the operation time, path elevation, UAV altitude and flight direction is also affected.³ On 5 June 2011 in Afghanistan, an Abbreviated Accident Investigation Board president found by clear and convincing evidence that hazardous weather and, specifically, a lightning strike during a MQ-1B Predator's sortie, caused the loss of communications and subsequent crash.⁴ In the Middle East operations, the US UCAVs mostly didn't face any such weather conditions. Besides effective surveillance requires clear view from sky, air dominance and control over air space which is not possible in territory having modern ADS.⁵

According to a Pentagon report, ice and extreme wind can limit UAS operations. Ice accretion is the process by which a layer of ice builds up on solid objects that are exposed to freezing precipitation, fog, or cloud droplets. The effectiveness of the mission and protection of the aircraft require that UAS operations be planned with an accurate understanding of ice accretion. The MQ-9 was designed and built with limited weather support capabilities, which include analog sensors to measure outside air temperature and wind speed in near real-time, and a sensor calibrated to detect ice buildup (accretion) once the ice exceeds a preset level. The existing sensors were found to be ineffective for in-condition sensing.⁶ This can affect its performance, for example in cold Himalayan regions.

(II) Maritime Surveillance:

Role of UCAVs in maritime surveillance has been lesser compared to land. This mainly stems from the fact that nations prefer their naval assets to provide the ISR capabilities and also since most navies like the Indian Navy operate sea based helicopters (MH-60 Romeo), the role of UCAVs has been limited. But with the increasing Chinese presence in the IOR, the role of UCAVs will increase in future. In the event the ISR operations are required to be conducted in a zone full of rival ships or near an enemy's naval base, what will be challenges for UCAVs? In future, naval ships or bases will be equipped with Directed Energy Weapons (DEW).

In May 2018, the Pentagon reported that military-grade laser weapons injured two U.S. pilots from a Chinese Navy base.⁷ China's 'Guorong' Anti-Drone System is a short-range, ground-to-air laser weapon system designed with a "detecting radar, electro-optical interference device, and high-power laser ejector," and it is reported that the system is capable of firing down a UAV in seconds from hundreds of meters away.⁸ Another system 'The Silent Hunter' is a vehicle-based laser system of power output 30-100 kW and has a maximum range of 4 km. It's reported that this weapon's beams can cut through a 5 mm thick steel sheet from 1 km away or five layers of 2 mm thick steel sheets from 800 m away.⁹

Modern UCAVs are generally made of thinner, lighter materials, and their missions place them in forward-deployed environments. This indicates UCAVs will be specifically susceptible to these types of DEW threats in maritime ISR operations in future. The UCAV characteristics which make them vulnerable to DEW weapons are its size, mission, operating altitude, operational range, speed, endurance, body material, maneuverability, and fuel type. The UCAVs which are largest in size, fly at low observable altitude, having low range and speed will be the most vulnerable to be attacked by ship or shore based DEW weapons. The examples of such UCAVs are MQ-4C Triton, X-47B Pegasus, and MQ-8C Fire Scout etc.

B) UCAVs in Military Operations:

(I) Offensive Air to Land Combat Operations:

Offensive military operations can be categorized as Airborne interdiction (AI), Offensive counter air (OCA), Close air support (CAS), Battlefield air interdiction (BAI), Suppression of enemy air defence (SEAD). The offensive targets can be categorized as

Air-to-ground fixed targets, short dwell time targets, mobile targets, SEAD targets.¹⁰ In modern times, the roles involving weapons delivery to these targets are less defined because in Iraq or Afghanistan, these targets were few or absent like SEAD targets. In the present times, with advanced ADS like S-400 or S-500 which are themselves designed to shoot down UCAVs like Reaper or Predator, the operation on SEAD targets will be difficult.

Sometimes the limitations on using UAV in combat roles are more operational. The weapon direction and delivery roles are the most challenging.¹¹ The challenge of geography will make the weapon delivery more difficult. It has to be understood that local topography and geography of a place can also become a deliberate contested zone for UCAV weapon delivery. A new theory about the hider-finder competition between air penetration and air defense shows that drones are vulnerable to ADS and that they require support from other force structure assets to be effective. This competition imposes high costs on those who fail to master the set of tactics, techniques, procedures, technologies, and capabilities necessary to limit exposure to enemy fire and to detect enemy targets.¹²

Take for example, the situation of Indo-China relations. Due to past battles and conflicts, the situation of the Indo-China border always remains tense. Most international disputes arise from border disagreements. Some experts are of the view that modern UCAVs have significant technological limitations and are just another platform. In any future interstate conflict, they will have limited utility in contested airspace.¹³ If during any conflict, India decides to take the battle into China, the air penetration will happen over the Himalayas. The thing to ponder is whether that air penetration is over China or Tibet, because historically Tibet was an independent nation. Now, when any UCAV tries to conduct offensive operations over Tibet, that will

be a tricky situation, because by default it may be Chinese territory, but in reality it's Tibet.

Tibet has many historical sites, Buddhist monasteries, natural glaciers etc. If Indian UCAV operators decide to go for BAI or SEAD operations, and by chance, the Chinese PLA installs or hides their ADS and other countermeasures like DEWs in close vicinity of those Tibetan sites, then the risk of collateral damage will be very high. This can upset the local Tibetan population in China as well as in India or the world. Sometimes many targets of drone strikes have been in residential areas, increasing the chances of civilian casualties.¹⁴ This can endanger lives of local Tibetan civilians which the Indian government can't afford. We must also not forget the fact that states have a policy of shooting down unannounced drones over their airspace, which can itself quickly escalate the situation.¹⁵

The first American MQ-1B Predator was reported to be shot down in Latakia in Syria in 2015. This broke the myth that UCAVs are revolutionary in every terrain. In the recent Armenia-Azerbaijan conflict of 2020, the inability of Armenian ADS to identify and shoot down Turkish made Bayraktar TB2 UCAVs signaled the turning point of the conflict. Still, it also reinforced the assumptions concerning the role of the UCAVs in attacking roles, that drones are only effective when operating against targets with no ADS capabilities, and still, success largely depends on the organization of the enemy, and in this aspect, the Armenian side had shown itself rather weak.¹⁶

It was reported that Armenia's air-defence systems, consisting mostly of Russian-made S-300, OSA and TOR surface-to-air missile (SAM) systems have repeatedly proved to be glaringly vulnerable.¹⁷ As per sources, only 2 Bayraktar drones were shot down each on 19 October 2020¹⁸ and on 8 November 2020¹⁹ respectively. But sometimes in general, not all of these systems are defeated due to inherent technical shortcomings. For example, in the Syrian war, personnel operating newly-acquired advanced Russian ADS lack the training time that is needed to effectively operate these complex systems.²⁰ On the other hand, one can also think what would have been the outcome of the Nagorno-Karabakh conflict, if Armenia had S-400 or Patriot ADS in its arsenal, alongwith the option to arm the mountain tops with other small and medium size ADS not easily visible.

But in the current Russia-Ukraine conflict, the performance of Bayraktar TB2 has been very poor. Right from the start of the conflict in 2022, around 10 Bayraktar TB2 drones have been shot down. On 27 April 2022, a Ukrainian Bayraktar TB2 was shot down near Kazinka, Belgorod Oblast right on the border with Ukraine, by Pantsir-S1 ADS.²¹ Here it's surprising that Pantsir-S1 is a legacy ADS and not as advanced as the S-400. A careful analysis of the reports of drowned drones show that most of them were shot in mid-flight, which means that they were flying in their maximum flight ceiling and still were caught by the Russian ADS radars and shot using missiles. Images of shot drones show the entire structure completely damaged, hence shows the weakness of UCAVs when hit with high kinetic force. These above incidents point to the fact that

there is enough chance of intercepting drones with legacy systems or advanced ADS in contested battle zones.

(II) UCAV & Fighter Jet Engagements:

The air-to-air combat roles are largely unreported or unknown for UCAVs because mostly the USAF UCAVs were used to operate in uncontested zones in the Middle East or Afghanistan which didn't have any modern Air-Force to challenge. So many analysts termed that phase as revolutionary. We have till now only heard about dogfights happening between two fighter jets, but for the first time in aviation history, we have recently come across engagement between UCAVs and fighter jets which heavily tilts the balance in favour of manned fighter jets to challenge and down any UCAV in WVR aerial combat. Hence, the dynamics of air-to-air combat for UCAVs like Reapers, Predators or Bayraktars will be challenged via two recent incidents.

First, during the current Russia-Ukraine conflict, on 14th March 2023, a Russian Su-27 aircraft struck a USAF MQ-9 unmanned aerial vehicle's propeller, causing U.S. forces to bring it down into international waters of the Black Sea.²² According to USAF Gen. James B. Hecker, commander, U.S. Air Forces Europe and Air Forces Africa, *"Several times before the collision, the Su-27s dumped fuel on, and flew in front of the MQ-9 in a reckless, environmentally unsound and unprofessional manner. This incident demonstrates a lack of competence in addition to being unsafe and unprofessional."* The MQ-9 aircraft was conducting routine operations in international airspace when it was intercepted and hit by a Russian aircraft, he added.²³

Secondly, on 5 July 2023, Lt Gen Alex Grynkewich, Commander, 9th AF (AFCENT) and Combined Forces Air Component Commander (CFACC) for CENTCOM stated that, *"Earlier today at approximately 10:40 A.M., Russian military aircraft engaged in unsafe and unprofessional behavior while interacting with U.S. aircraft in Syria. While three U.S. MQ-9 drones were conducting a mission against ISIS targets, three Russian fighter jets began harassing the drones. Against established norms and protocols, the Russian jets dropped multiple parachute flares in front of the drones, forcing our aircraft to conduct evasive maneuvers. Additionally, one Russian pilot positioned their aircraft in front of an MQ-9 and engaged the afterburner, thereby reducing the operator's ability to safely operate the aircraft."*²⁴

Now if we analyze these above two incidents, then it's clear that modern UCAVs like MQ-9 Reapers will become most vulnerable in engagements with manned fighter jets. The fighter jets have enough tactics and offensive capability to destroy any UCAV in WVR range, without undergoing any operational obstacles. In the first incident, the video from the MQ-9 Reaper clearly shows the aggressive posture of Su-27 fighter jets and the drone appears helpless with no self defence capability. Dumping of fuel from Su-27 fighters on the drone must have caused damage to the propeller because any liquid (jet fuel) thrown with a velocity has kinetic energy & direct collision with the fighter jets would have made the Reaper spun out of control violently which doesn't

appear from the video feeds captured.²⁵ This incident has lessons for maritime surveillance over contested waters.

In the second incident of Syria again, the modern MQ-9 Reapers appear helpless and vulnerable when Russian jets drop flares (Image 2).²⁶ This means that during any future engagements, fighter jets don't need to utilize their costly missiles to destroy any drones, the use of flares will force the UCAVs to change their mission parameters. Also if small bomblets or munitions with proximity sensors are dropped they can destroy the UCAVs similar to how depth charge works in sea. The use of afterburners to cause turbulence in front of UCAVs to disturb their flight path along with chances of damaging their critical electronics onboard is a very new and unique tactic displayed by the Russian Air-Force which will be keenly watched by American adversaries, specially China. The statement released by the Pentagon on these two incidents seems to indicate that the US government and military currently don't have any effective response in these types of engagements involving an unmanned drone with a manned fighter jet. In future, this can jeopardize ISR and military operations in contested zones. This can also affect India's policy in future because the Indian government has recently decided to purchase 31 MQ-9 Reapers from the USA.



Image 1. Source: Pentagon

(III) Drone-to-Drone Combat Engagements:

Just like the engagement between UCAVs & fighter jets, the current Russia-Ukraine war has also given rise to a new phenomenon, which are drone to drone engagements. Some Quadcopters simply ram each other in a crude aerial demolition derby. In other encounters, highly sophisticated craft use advanced radar backed by AI and the latest aerospace engineering technology to precision fire nets that snag other drones (Image.1). "*This is something we haven't seen before,*" says Caitlin Lee, who leads the Center for Unmanned Aerial Vehicles and Autonomy Studies at the Mitchell Institute for

Aerospace Studies in Arlington, Virginia. "This is the first time we're seeing drone-on-drone conflict."²⁷

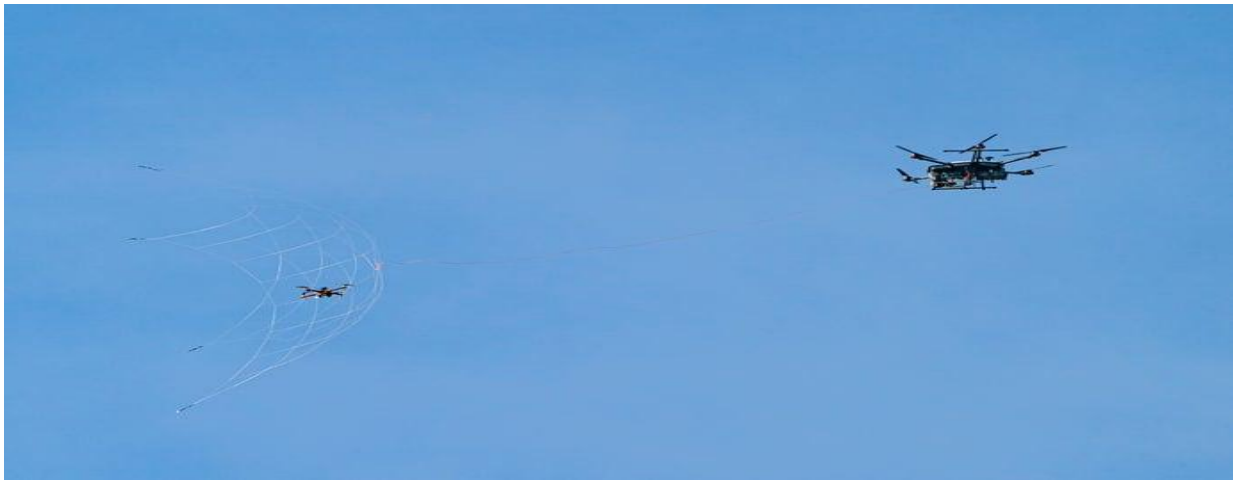


Image 2. Source: Scientific American

Fortem Technologies, a start-up based in Pleasant Grove, Utah, USA, has vaulted into the drone wars through its product named DroneHunter F700. Ukraine first deployed DroneHunter last May to chase down the Group 1 and 2 drones that Russia was using to spy on frontline Ukrainian troops. When Russia began launching the Iranian-built UAV Shahed, a Group 3 drone, as a kamikaze weapon, Fortem began modifying DroneHunter to intercept these armed drones and ensnare them in nets.²⁸

In prospective futuristic contested zones, the engagement of a single UCAV with a counter swarm of UCAVs or drones also can't be denied. These swarm drones could revive, for example, the concept of encirclement. Encirclement creates a perception in the target's mind that the battle is not going well.²⁹ In the Black sea collision of Su-27 with MQ-9 predator drone, it's realized that the fighter jet had an upper advantage and just destruction of the UCAV propeller is enough to bring it down. The propeller has been identified here as the vulnerable spot. Hence, UCAVs in swarms will try to fire wired mesh made of metal to entangle the drone propellers to bring them down. Additionally, if such UCAV swarms are fitted with DEW weapons, just designed like the MQ-9 Reaper underbelly movable EO/IR camera sensors, then the firing of DEW Lasers or High Powered Microwaves (HPM) can damage the rival UCAV's vital electronics components.³⁰ Already the world is progressing towards 6th generation fighter jets with DEW capability.

C) Counter-Terrorism Operations:

(I) Engagement with Terrorists:

The 9/11 terror attacks revealed one thing, that terrorists can be highly educated, smart, tech savvy, able to fly a complex flight to ram it directly in the WTC Towers.

Hence in future, counter terror operations can be difficult if these smart terrorists are backed by the State itself like Pakistan. Obtaining accurate intelligence is the holy grail of the counterterrorism mission because it is extremely hard to discover the identity and pinpoint the location of terrorists. Adversaries have become increasingly sophisticated in learning how to outmaneuver drones. Al-Qaeda in the Islamic Maghreb and al-Qaeda in the Arabian Peninsula have both disseminated detailed instructions to extremist fighters on evasion, cover and communications techniques.³¹ Without adequate and consistent ground presence, drone strikes are inspired by lousy intelligence, resulting in the deaths of innocent civilians.³² This is explained by the hider-finder theory in the earlier section.

But counterterrorism operations will become contested when the terrorists acquire the capability of engagingUCAVs via Electronic Warfare (EW) or Cyber Warfare (CW). Since military software is vulnerable to the same cyberattacks as commercial software, military supply chains have many of the same risks.³³ As per a NATO report, MALE and HALE drones system network and software are vulnerable to cyber attacks. Radio transmissions can reveal operators' whereabouts, and ground control stations, satellites and satellite ground segments can be potential targets. In future asymmetric responses could see terrorists attacking operators rather than the drone itself.³⁴

In 2009 Iraqi insurgents had intercepted live video feeds from unmanned Predator drones. They were able to view raw satellite feeds of live video shot by cameras on theUCAV.³⁵ In 2010, a hacker used a basic security vulnerability to access highly sensitive files relating to the USAF MQ-9 Reaper drone and tanks.³⁶ In 2011 a CIA drone was captured by Iranian hackers who managed to force the drone to land inside hostile territory so they could seize it and reverse-engineer its technology.³⁷ It occurred either by jamming the satellite communication and spoofing the GPS-signal or a technical malfunction.³⁸ In 2011, Wired.com reported that a keylogging malware was detected inside the operating cockpits used to send commands to the Predator and Reaper drones at Creech Air Force Base in Nevada.³⁹ A Risk assessment of MQ-9 Reaper and RQ-170 Sentinel was done. It shows information flow vulnerabilities, chances of virus attack to Ground Control Station (GCS), attack at communication links, Ku band communication limitations, Wi-Fi susceptible to eavesdropping etc.⁴⁰

UCAV Mishaps Assessment

Drone Wars UK began compiling details of military drone crashes in 2010.⁴¹ Their findings from the year 2015 till now are tabulated below:

UCAV Origin Year	USA Made	Iranian Made	Turkish Made	Israeli Made	Chinese Made
2015	26	2	0	2	1
2016	7	1	1	1	1
2017	7	2	0	1	0
2018	9	0	2	1	1
2019	11	1	2	0	4
2020	15	1	21	3	12
2021	7	3	0	1	1
2022	5	1	8	2	1
2023	4	2	5	2	0

Table 1.

Further, the below images indicate the crash details of different modern UCAVs in operation -

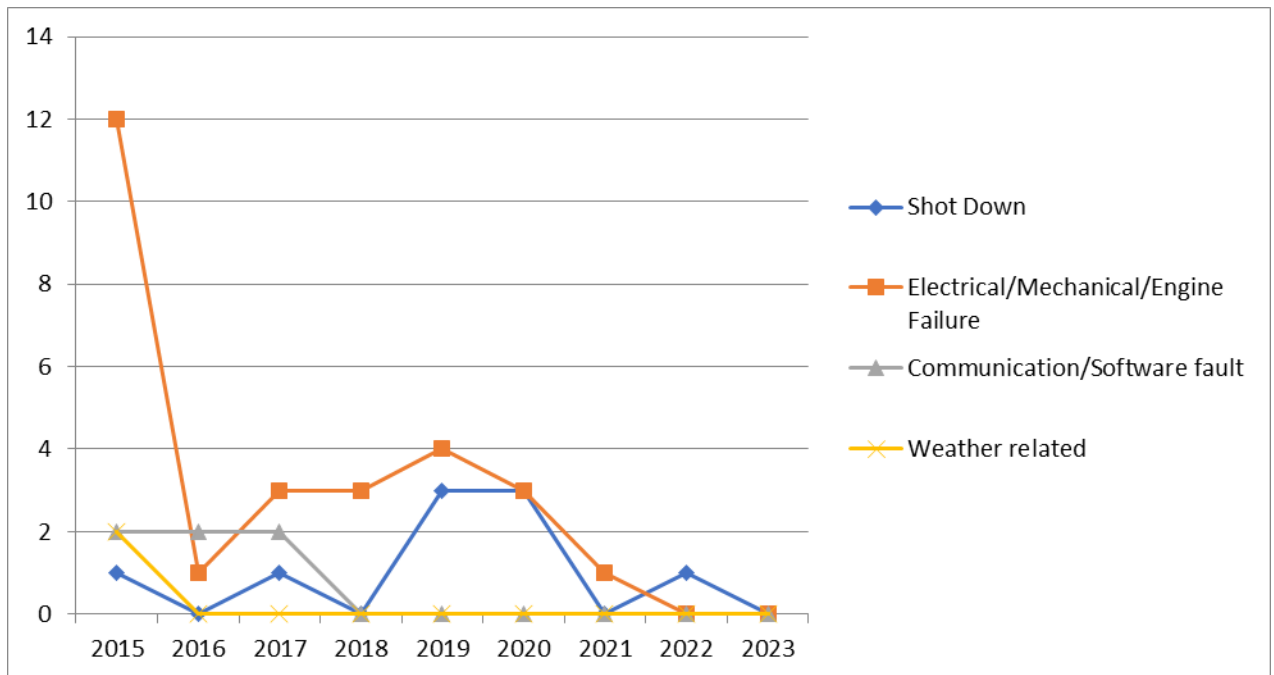


Image 3. MQ Family Mishaps. **Source:** Author

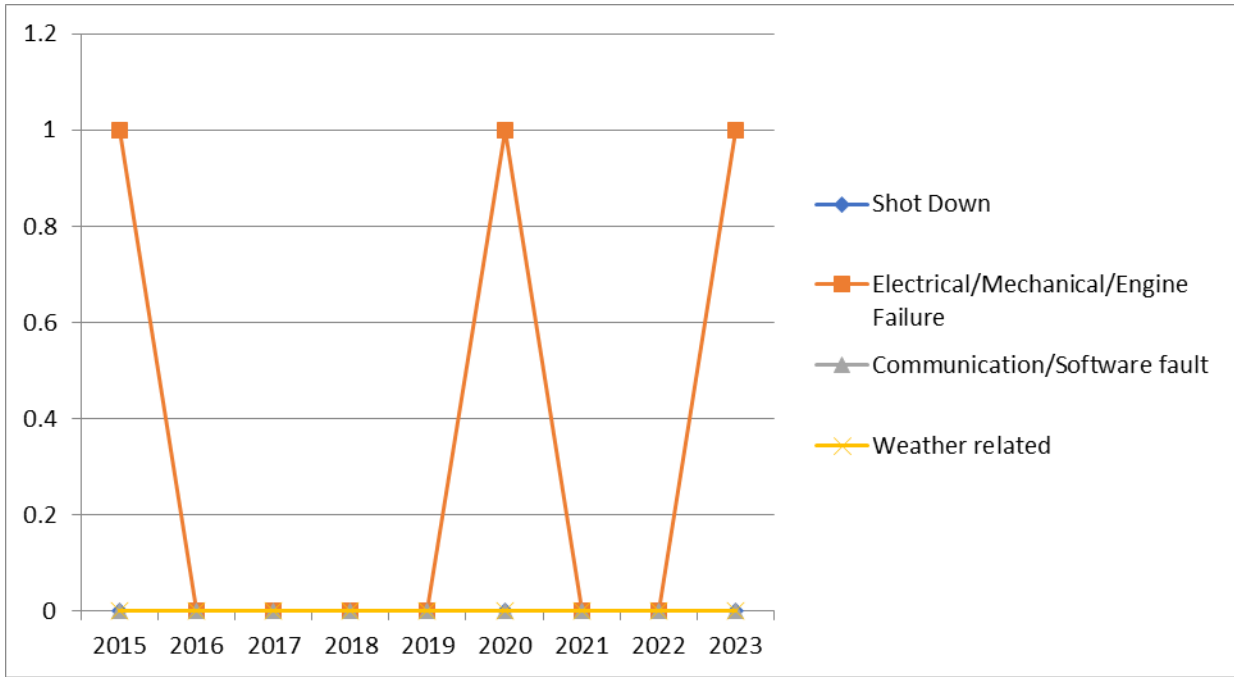


Image 4. Heron/Hermes-900 mishaps Source: Author

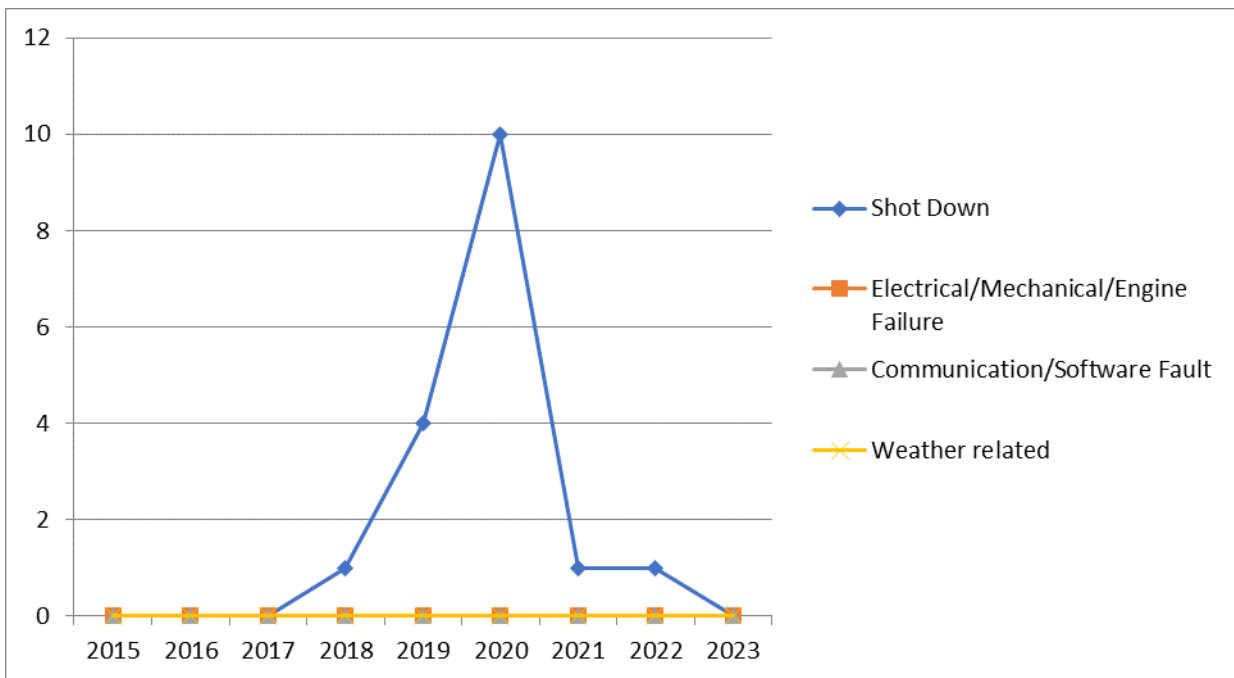


Image 5. WingLoong/CH-4 mishaps Source: Author

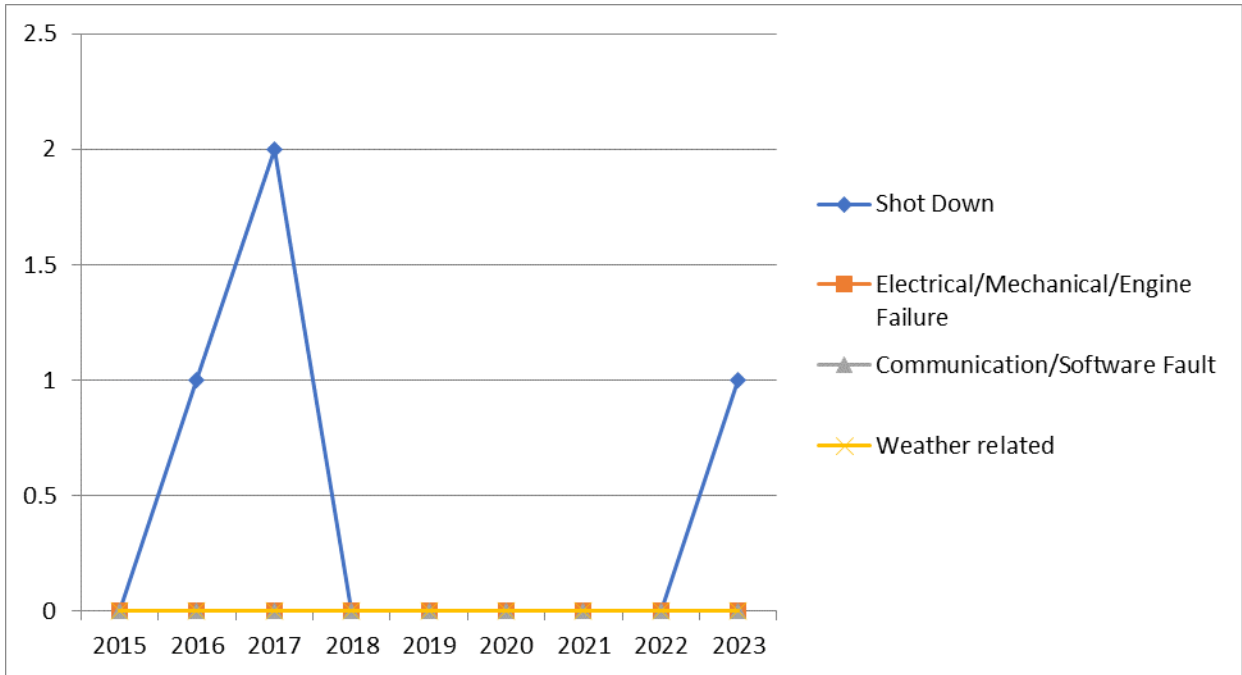


Image 6. Shahed/Mohajer mishaps Source: Author

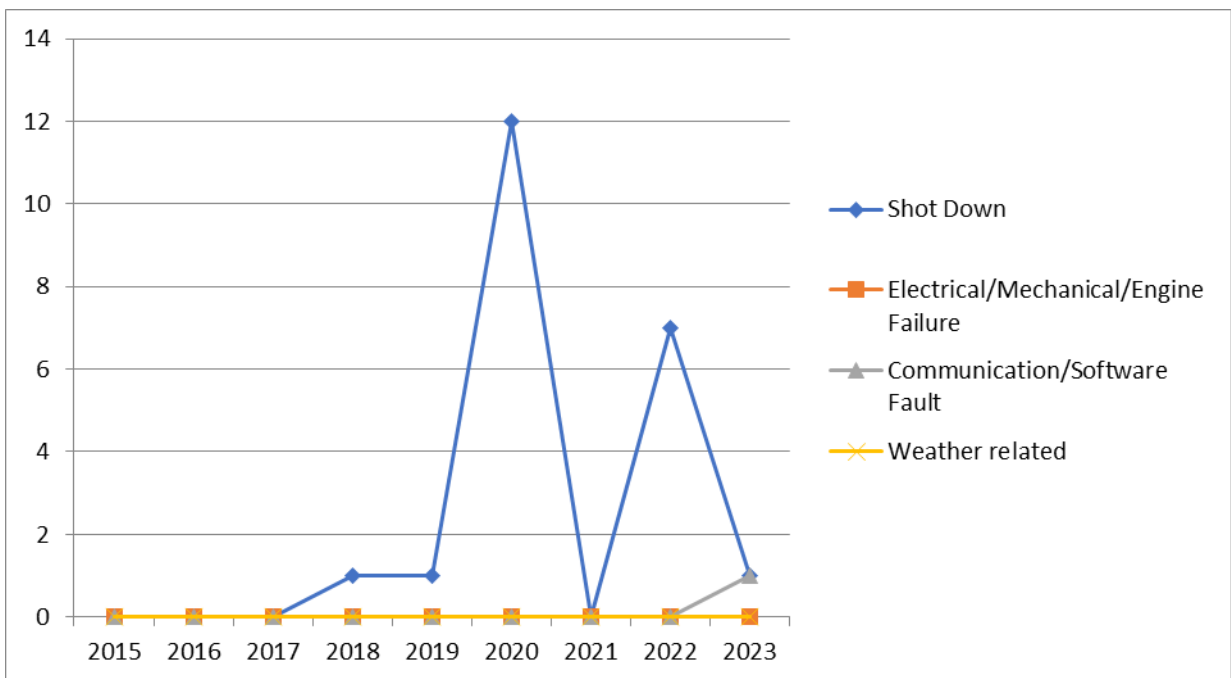


Image 7. Bayraktar mishaps Source: Author

As per Table 1. The largest UCAV mishaps have been reported to be from US manufacturers, followed by Turkey and China. These have occurred in partially contested zones. Most US UCAVs have crashed in the year 2015 where the first report of MQ-9 Reaper to be shot in Syria was reported. Image 3 depicts the high amount of MQ-9 type UCAV crashes due to Electrical/Mechanical/Engine failure incidents. This has significantly reduced but a 2016 report on MQ-9 shows that the MQ-9 Block 5 RPA

is subject to overheating problems in operationally relevant environments.⁴² Also Many MQ-9 Reapers have crashed due to lost satellite links or communication faults. If such UCAVs crash in contested zones, then there is always danger of reverse engineering by the enemy.

The Israeli made Herons/Hermes-900 have performed well with no incident of being shot down & only 3 incidents of having technical failure. (Image 4). The Chinese WingLoong/CH-4 UCAVs have the highest rate of being shot down in the year 2020. Their performance was below par in the Saudi led war in Yemen (Image 5). The Iranian Shahed/Mohajers are recently being used in Russia-Ukraine war but they are used as Kamikaze drones, rather than a UCAV. Still they have a low rate of being shot down compared to their economical cost (Image 6). The Turkish Bayraktars are on the other hand also prone to being shot down in large numbers. (Image 7)

Recommendations

1. Further research on weather compatibility of UCAVs is required.
2. Protection from DEWs to be devised in land, sea and air domains.
3. UCAVs are still vulnerable to ADS & hence they shouldn't be sent in contested zones before neutralizing ADS.
4. UCAV to manned jet encounters currently is not in favour of UCAVs, hence all ISR operations to be accompanied with jets near Enemy state boundaries.
5. Cyber security of UCAVs is a reality & should be upgraded regularly.
6. Stealth features of UCAVs to be researched upon.
7. UCAV operators undergo mental stress regularly. Their mental well-being will guarantee reliable mission performance.

Lessons for India & Conclusion

The above statistics point to the fact that no modern UCAV is perfect in any partially contested zone. So their performance in any futuristic fully contested combat zone will be highly different and challenging from the current scenario. As we are seeing militaries are evolving war fighting techniques and capabilities to counter UCAVs, it will be apt to rethink the purpose of utilizing UCAVs in their traditional ISR roles & move beyond a step further to deeply study how different contested zones are born everyday across the world, even if it's a small incident.

Finally uncertain Geopolitics will also come into picture, since nations are guided by their national interests. Since India is planning to procure 31 MQ-9 Reapers, we must not forget the fact that US platforms also retain a part of their control with the US, just like the F-16 fighter jets of Pakistan. Hence going indigenous is the way forward since UCAVs aren't a platform to be imported for a nation like India.

DISCLAIMER

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