LIMITATIONS OF DRONES AND THE FUTURE OF AMERICAN AIR SUPERIORITY

by
Rohith Narayan Stambamkadi

"Remember, terrain doesn't wage war. Machines don't wage war. People do and they use their mind!"
~ Col. John Boyd

In his iconic speech 'A Fear for the Future', former British Prime Minister Stanley Baldwin warned 'The Bomber will always get through' - highlighting the offensive potential of airpower and the prominence of air superiority in warfare. Today, the U.S grapples with a similar dilemma as it waits for the Trump administration to take a decision on its air superiority initiative, the Next Generation Air Dominance (NGAD). The crux of the dilemma is whether current or next generation Unmanned Aerial vehicles (UAVs) or drones yield an offensive advantage. In other words, will the drones always get through?

Despite their technological allure and affordability, drones perform under specific operational contexts for specific mission objectives and are unlikely to shift the offense-defense balance. Recent Ukrainian spoofing of Russian Shahed drones, Israel's successful drone interceptions against Hamas, high attrition rates in Syria, etc., all exemplify drone vulnerabilities to electronic warfare, air-defense systems, reliance on contested networks, and limited effective mass in contested environments. Further, advances in Integrated Air Defense Systems (IADS), anti-drone weapons, adversary interferences negate the offensive potential and survivability of next-generation drones. To sustain air superiority, the U.S must balance proven manned platforms with unmanned innovation. Leaning heavily on stand-off centric platforms, including UAVs to provide 'affordable mass' compromises 'effective mass', and cedes strategic initiative to the adversaries. Future operational success and deterrence critically depends on integrated stand-in and stand-off forces, characterized by 'manned-unmanned teaming'.

Limited Performance in Hyperdynamic Combat Zones

In his recent comments on X, Elon Musk took aim at manned fighter jets like F-35 calling them 'obsolete' while seemingly calling for development of autonomous swarm drones. He further said that not just the F-35, but all manned aircrafts are outdated. It is notable that Musk's endorsement of autonomous drones contrast with ongoing safety concerns surrounding Tesla's self-driving cars, which, despite labelled as 'Full Self-Driving,' still require 'active driver supervision.' This suggests that drones may face significant challenges in hyperdynamic environments, particularly as dynamic as warfare. While there is no denying that drones are increasingly becoming crucial on battlefields, they are only enabling but not decisive. Drones rely on data inputs through sensors and predefined algorithms based on patterns and known variables to navigate and execute tasks on the battlefield. This makes them effective in predictable environments with perfect information.

Nevertheless, combat zones are anything but predictable. In dynamic environments, sensors and algorithms struggle with unpredictable obstacles or adversary interference. This is exemplified by recent Ukrainian spoofing of Russian launched Shahed drones back to Russia and Belarus by feeding them false GPS targets to veer them off the course. In this context, drones offer limited flexibility and constrain air-superiority as they lack real-time adaptability and situational awareness like manned aircrafts. While ongoing developments in Machine-Learning can improve next-generation UAVs and enhance performance in dynamic environments, it can also enhance AI-enabled deception effectively neutralizing UAV threats.

The Myth of the Offensive

Despite their prominent role in recent conflicts, current generation drones have limited offensive advantage compared to manned fighters. Notably, drone optimists argue that small size, low altitude, and slow speed, lower the range at which drones can be detected, lessen the probability of interception, and enable offensive advantage. Nevertheless, these characteristics have a limited impact on detectability.

Firstly, some of the prominent current-generation drones have longer wingspan than jet fighters. For example, the MQ9-A has a wingspan of 20m, and Iranian Shahed-129 has a wingspan of 16m. In comparison, an F-16 has a wingspan of 9.5m and an F-18 Hornet 11.5m. Hence, UAVs (particularly Medium-Altitude Long Endurance -MALE) are not much smaller than jet fighters. Further, the range at which an object can be detected depends on its radar cross section (RCS). While the size of an object does impact its RCS, radar reflection primarily depends on the frequency of radar pulse, and the shape and orientation of the object with respect to incoming radar beams.

While one might argue that UAVs have leaner shape compared to manned aircrafts and their wingspan does not determine size, or next-generation drones might have shorter wingspans, radar systems rely on factors like shape, orientation, and specular reflections rather than exclusively on size. Even small protuberances or external components like missiles and cameras on drones increase their RCS, enabling detection. Additionally, advancement in radars enable signal processing to identify low-RCS objects effectively making drones vulnerable to next-generation air-defense systems.

Secondly, slow speed can be addressed simply by changing the filtering functions of air defenses, and modern radars, advanced signal processing can take advantage of change in frequency of waves to distinguish incoming threats from clutter and identify slow cruise objects like UAVs. Further, while flying under the radar can delay or deny detection, this feature is not novel to existing manned aircrafts. The effectiveness of low-altitude flight diminishes significantly when radars are positioned at higher elevations, such as buildings, mountains, or airborne platforms.

Lastly, a plethora of contemporary air-defense mechanisms like advance communication and networking, jamming, spoofing, anti-drone weapon systems, or birds-of-prey negate offensive advantages of drones. While current-generation drones have capabilities that may be effective against certain air defense systems, they are not consistently capable of overcoming advanced IADS. The performance of TB2 drones in the initial stages of Ukraine conflict underscore these observations. TB2s supplemented manned jets providing limited precision ground-attack capability, but their success was entirely contingent on Russia's decision not to operate its air defenses. About 10 days into the war, the aircraft's large radar signatures were vulnerable to Russia's active EW systems and short-and medium-range air defenses. Although Ukrainian forces adjusted tactics by flying at lower altitudes before popping up for strikes to reduce detection, most of the drones were shot. Ukrainian forces found TB2s too expensive to risk as they were not survivable in contested front lines, and were later employed only in favorable circumstances.

With respect to next-generation drones, advancements in air defense technology do not remain static while drone technology evolves to enhance offensive capabilities. Recent developments underscore several promises and advancements in air defenses, particularly against UAVs. Unlike current UAVs, even if future drones become fully stealth, advancements in sensor acuity, multi-sensory connectivity, big data and machine learning, AI-enabled multi-static radars, can enable accurate radar returns and possibly even defeat stealth technology. In this light, excessive reliance on unmanned systems to support offensive capabilities could be risky and compromise air-superiority.

Why Drones Exclusively Cannot Enable Air Superiority

The concept of air superiority embraces Col. John Boyd's dictum of 'Perception, Planning, Control' of the pilot, characterized by the iconic framework – OODA loop. Drawing a parallel between Boyd's framework for pilots and the principles underpinning autonomous drones, the analogous components translate to 'Perception, Navigation, and Communication'. Nevertheless, as detailed above, reliance on static algorithms and sensor inputs limits adaptability in dynamic combat environments. These vulnerabilities coupled with adversary interference, negate air superiority through drones.

Despite these realities, the U.S. Airforce's 2024 posture statement relies heavily on 'affordable mass' characterized by drones and stand-off capabilities, or capabilities that can strike from outside the enemy's air defense perimeter. Though affordable mass is good to have, it does not guarantee 'effective mass' and limit traditional air-superiority. Air-superiority requires sustained air-to-air combat and an ability to strike within contested and highly defended enemy areas (stand-in capabilities), a capability that drones have limited potential to achieve.

Firstly, drones typically have limited range, payload, endurance, speed and lack stealth capabilities compared to manned aircrafts. Enhancing these capabilities in future escalates costs, undermining the very advantage of drones: affordability.

Secondly, the uneven effects of stand-off munitions in Ukraine and Israel highlight that drones add to the complexity of modern warfare, but cannot replace stand-in forces like manned aircrafts, ensuring even a limited control of air.

Further, stand-off centric approaches can play into adversary's capabilities and potential planning. Tactics like 'Hellscape' swarms could only delay adversary efforts for a limited time, and recent examples suggest that drones are still vulnerable when employed in large numbers to saturate enemy air defenses. For example, between 2018 and 2020, Russian air defenses disabled more than 150 drones during the Syrian civil war and in 2019 alone, managed to neutralize around 70 multiple drone and missile attacks against its Syrian Khomeini air base.

Similarly, Israel's air-borne and ground defenses intercepted several rockets and drones by Hamas. Much recently, even lower-end defense systems and electronic warfare within Ukraine's limited air-defense umbrella managed to offset the largest ever aerial offensive of Russia against Ukraine.

Lastly, a force designed primarily to prevent losses will be brittle against anti-access and area-denial (A2/AD) defenses, as stand-in forces are critical part of attrition. Seeking to define affordable mass in terms of lower risk is inherently suggestive that stand-in forces are still necessary. Procuring survivable lethal stand-in assets that can effectively engage in highly defended areas is hence crucial for maintaining effective mass.

Conclusion

As the Trump administration considers the future of NGAD, it must balance what is timely with what is timeless. Integration of UAV technologies with the enduring value of manned platforms is crucial for enabling air dominance. While UAVs can be effective in certain operational conditions, they offer limited performance in sustained combat. As portrayed in the iconic movie Top Gun: Maverick (albeit in a different context), in modern air-combat, 'It's not about the plane, it's about the pilot'.

Human judgment, situational awareness, real-time adaptability cannot be entirely replicated by UAVs and hence, despite technological advancements, warfare requires humans in the loop. Complete air superiority against a peer adversary may be unattainable, but achieving at least mission-specific superiority requires more than relying solely on affordable mass. Effective integration of manned and unmanned systems, with an emphasis on manned-unmanned teaming, investment in both UAV capabilities and pilot training defines future American air superiority.

Rohith Narayan Stambamkadi is the founder of the Indian Forum for Public Diplomacy (IFPD), a not-for-profit advocacy forum focused on civilian-led strategic culture, based in Hyderabad, India. He is currently based in Washington DC and specializes in defense innovation, autonomous weapons and military AI.