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MUMT v/s A2/AD: EXPLORING TO DOMINATE IN A CONTESTED ENVIRONMENT

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The United States Army Aviation Centre (USAACE) defined MUMT in the 2013 MUMT Strategy Brief' as "the synchronised employment of soldier, manned and unmanned air and ground vehicles, robotics, and sensors" for "achieving enhanced situational awareness, increased lethality, and improved survivability."[1]

'Manned-Unmanned Teaming' (MUMT), defined by the IEEE, is the "coordinated use of manned and unmanned systems to achieve a common goal". The armed forces consistently employ this concept for accomplishments of various missions. Combining human judgement with automated machine processes is central to the MUMT approach. Search and rescue missions, environmental monitoring projects, and military operations are areas where humans and robots can work together to achieve greater efficiency and effectiveness.[2]

In recent years, the MUMT has garnered a great deal of attention to improve the security and efficiency of military operations. Missions that would be impossible for either system to complete alone can be accomplished with MUMT thanks to the synergistic collaboration between manned and unmanned systems through information sharing and the division of labour.

MUMT describes the cooperation between human operators on land, sea, and air and unmanned vehicles on land, sea, and air within the context of tactical operations to carry out missions and tasks. The MUMT system's adaptability is fully displayed over land, sea, and philosophy. However, the air domain has shown the most support for the MUMT concept.

In the early 2020s, software complexity increased significantly, allowing algorithms to perform an increasing number of mundane and repetitive activities that were previously the purview of humans. Significant improvements in unmanned technology have been made possible by developing relevant technologies. Though the changes have occurred since World War II's end, their notable momentum has been chiefly seen after the beginning of the 21st century.[3]

Growth Drivers for MUMT. Diverse foundations have contributed to the growth of combined human and robotic military capacities. Some of them are:

- Advances in sensor technology have made it possible for remote systems to collect more precise and up-to-date information, improving their situational awareness and capacity to make sound decisions.
- With the development of autonomous artificial intelligence, remote systems no longer need constant human intervention to carry out complex tasks. This allows people to focus on higher-level tasks like strategy planning and decision-making.
- Increase in real-time data transmission and decreases in latency have resulted from developments in telecommunication protocols and network topologies, paving the way for effortless cooperation between persons and distant systems.
- Easy-to-operate design techniques have impacted the evolution of Human Machine Interfaces, leading to more user-friendly and natural designs. This has allowed for more efficient information sharing between humans and remote systems.
- MUM-T ensures that manned platforms can keep their distance from the enemy's defences. It is assessed that weapons used with MUMT will be able to achieve their maximum capabilities due to the absence of ground-based obstructions. Effectively, the kill ranges are likely to get enhanced.

- As manned-unmanned teams become more prevalent, it became necessary to create programs that teach humans how to work efficiently with robots and teach robots how to communicate with humans.

The development of manned-unmanned teaming has been fuelled by technological progress, improved communication capabilities, and a commitment to user-centric design principles.

EXPLOITATION OF MUM-T IN OPERATIONS

Using a combat drone to extend the power and reach of an inhabited fighter while still keeping a human in charge of firing decisions is an increasingly common practice among militaries. The Russian S-70 Okhotnik, a UCAV, was deployed on the Ukrainian battlefield on June 27, 2023. During this operation, it targeted Ukrainian military installations located in the regions of Sumy and Kremenchuk.[4]

A prototype of the Russian S-70 Okhotnik combat drone is expected to enter military service in 2024 with the promised capability of attacking air and ground targets. The manned-unmanned teaming will be part of Russia's approach to network-centric war. The Okhotnik and the Su-57 will share their targeting and sensor data, allowing each aircraft to perceive everything the other's sensors captured. Each Okhotnik can carry up to 4,400 pounds of bombs, considerably more than an MQ-9 Reaper in US service can deliver.[5]

In the Azerbaijan-Armenia conflict, a notable development occurred when human and unmanned aircraft collaborated effectively, resulting in a swift resolution to the protracted disagreement. The recent success of the Turkish-made TB-2 UAV system, employed jointly by the Turkish and Azeri air forces, is a significant milestone.[6]

Nevertheless, most of the MUMT projects are in a nascent stage and focusing on the processes of conceptualisation, design, and validation. The use of MUMT in the Gulf War, the Nagorno-Karabakh conflict, and the Russia-Ukraine conflict (RUC) was incidental or an improvisation of various dimensions of MUMT. For example, drones were launched ahead of attack helicopters or tank columns. The credible communication link between these elements for data transfer and control was missing. The actual MUMT mission may be possible by 2024.

Indian MUMT Project 'HAL CATS'. Indian aerospace firm Hindustan Aeronautics Limited (HAL) is developing a MUM-T system it calls the "HAL Combat Air Teaming System (CATS)" in partnership with the private sector. CATS is an overarching system whose central node is an LCA. "Mothership for Air teaming exploitation" (MAX) refers to the two-seater Tejas Mk1 Trainer. For the Tejas Mk-1A to serve as a MAX in CATS, its command-and-control infrastructure is now undergoing modifications. The operator of each LCA's weapon system in Tejas MAX will operate the UAS/swarm drones. A network of highly sophisticated autonomous drones will be linked to a fighter plane through the CATS, which may employ them in air-to-air, sea-to-air, and ground-to-ground combat. The Tejas two-seat trainer is being fine-tuned as part of an effort to combine human and robotic flight.[7]

MUMT Projects for Other Nations. Various MUMT projects of various countries, which are still to be inducted in warfare operations

- The US Army has implemented MUM-T tactics on the AH-64D Longbow Apache helicopter gunship. The Apache Block II effectively showcased the capability of transmitting video to the One System Remote Video Terminal (OSRVT) by utilising the Efficient Tactical Common Data Link (TCDL). Teaming of MQ-9 Reaper and F-35 Lightning II for MUM operations is also under progress.[8]
- Russia is involved in a joint flying venture encompassing a stealth fighter aircraft called the Su-57 and an attack UAV known as the Okhotnik. Israel's Elbit Systems has developed UAS swarms using Remote Autonomous Systems (RAS) technology. Israeli MUMT project involves Heron TP and F-16. Turkey has successfully demonstrated an autonomous taxi and take-off roll for its Kizilelma Fighter UAV. The Chinese project is with Wing Loong UAV and J-20 Fighter MUMT, while the United Kingdom's MUMT project is teaming with Protector

UAV with Typhoon. France's 'Système de Drone Aérien' (SDA) is the experimentation of MQ-9 Reaper and Rafale MUM teaming projects. Europe's Future Combat Air System (FCAS) programme is in progress, where France, in collaboration with the UK, is facilitating the advancement of a series of interconnected aerial vehicles. South Korea is now engaged in a project to develop a stealth UATV.[9]

ANTI-ACCESS/AREA DENIAL (A2/AD)

The concept of A2/AD entails implementing a military approach to obstructing or hindering an opponent's capacity to gain access to or conduct operations within a particular geographical region. Western strategic planners widely use the term "A2/AD" to refer to a strategic approach involving utilising a range of interconnected technologies, such as missile sensor guidance systems, to impede the freedom of operations. The primary objective of 'A2/AD' is to deter potential adversaries from deploying military forces 'in close proximity' to or within the defined region.[10]

A2/AD consists of two components – 'A2' and 'AD'. 'The Anti-Access (A2)' concept is employed 'to deter or restrict hostile forces from gaining access to a designated conflict zone or operational area'. 'The area denial (AD)' component of the A2/AD strategy aims to' impede or restrict the enemy's ability to manoeuvre within a designated operational area freely'. In its fundamental essence, A2AD refers to a defensive instrument or strategic approach employed to impede an adversary's ability to obtain entry into various domains or move unrestrictedly within the realms of land, sea, space, cyber, electromagnetic warfare, maritime, and air. The concept of A2AD has been employed throughout history. Nations like China and Russia have successfully established and fortified a comprehensive A2AD network to safeguard their territorial boundaries. However, it is common practice for all major military forces to employ a variant of A2AD strategies to protect their personnel and assets.[11] Numerous countries, including the United States, Russia, and Israel, widely operate the concept. As technology progresses, so do A2/AD domain capabilities.

WEAPONS DEPLOYED IN A2/AD

Any weapon or technology can be utilised for A2AD purposes if it effectively impairs or limits the movement of entities through a given area. The product is designed with multiple layers to enhance its effects. Some examples of A2AD capabilities include layered coastal defence systems designed to counter threats from ships, anti-tank systems to deter armoured vehicles, and layered air defence systems to protect against airborne threats.

A2/AD plans usually use various weaponry to deny access to their enemies and create rigorous operational conditions. The following is a list of some examples of weapons that are often used in A2/AD systems, along with the essential attributes of each weapon:

- **Integrated Air Defense Systems (IADS)**. IADS use SAMs, radar systems, and command and control networks to defend against airborne threats. These systems have multiple levels of defence combat targets at varying altitudes and ranges. The well-known IADS encompass the Russian S-400 and S-300, the U.S. Aegis Combat System, and the Israeli Iron Dome.
- **Surface-to-Air Missiles (SAMs).** SAMs can target aircraft, drones, and other airborne threats. They are usually used in land-based missile batteries or naval boats. SAM systems use radar and may engage at various ranges and heights Prominent surface-to-air missile (SAM) systems encompass the Russian S-400, U.S. Patriot, and Chinese HQ-9.
- **Ballistic Missiles**. A2/AD plans can use short-range (SRBMs), medium-range (MRBMs), and intercontinental ballistic missiles (ICBMs). These land-based missiles can carry conventional or nuclear bombs. They threaten enemy forces and infrastructure with long-range strikes. Illustrative instances encompass the Russian Iskander, Chinese DF-21, and North Korean Hwasong series.
- **Anti-Ship Missiles (ASMs)**. These are employed to destroy navy vessels. Land-based launchers, aircraft, submarines, and surface ships

launch them. ASMs can engage ships at sea due to their long ranges, rapid speeds, and robust guidance systems. Some examples of Anti-Ship Missiles (ASMs) are the Chinese YJ-18, Russian Kalibr, and Iranian Noor missiles.

- **Anti-Access Mines**. These mines prevent enemy naval or amphibious forces from approaching, landing on a coast, or entering a canal. These mines can be launched from ships, aircraft, or submarines and have sensors that engage nearby targets. Illustrative instances encompass the U.S. Mark 60 CAPTOR and the Russian PMK-2.

It is essential to consider that the exact weapons used in A2/AD can differ from country to country, region to region, and even with the progression of technology.

THE VULNERABILITIES OF A2/AD

The A2/AD strategy, as it refers to a military system to prevent or impede an adversary's ability to enter or operate within a contested region, usually relies on the utilisation of long-range precision-guided weaponry, air defence systems, and various other capabilities. Although the A2/AD technique represents the defensive approach, it has flaws. The following are several potential vulnerabilities that are related to A2/AD strategies:

- The sensors, command and control, and weapons systems that make up A2/AD are all vulnerable to the opponent's compromise. The A2/AD force's situational awareness and response capabilities can be hampered by the enemy's employment of cyberattacks, jamming, or kinetic strikes against the network's communication nodes, radars, or launchers. The adversary can also deploy stealthy or decoy platforms to avoid or trick the A2/AD network's sensors and missiles.
- The enemy's ability to take advantage of A2/AD's assets and resources depends on their quantity and quality. For instance, A2/AD can employ many low-end, inexpensive, and susceptible assets or a small number

of high-end, premium, and capable weapons. The A2/AD force's low-end assets can be overwhelmed or flooded by a barrage of enemy SWARM drones or missiles, while the force's high-end assets can be whittled down or rendered useless by attrition or deceit.

- Coordinating and synchronising A2/AD's actions and capabilities is a difficulty the adversary can exploit. The A2/AD framework, for instance, can be governed centrally, in a coherent but inflexible fashion, or decentralised, in a flexible but chaotic manner. The A2/AD force's command and control structure can be brought into turmoil if the enemy employs a combination of tactics, such as Muti-mode multi-directional attacks at once or using a wide variety of domains and ranges, or if the adversary is quick to exploit weaknesses in the A2/AD force's operations and capabilities.

As an illustration, Anti-Access/Area Denial (A2/AD) can be implemented through two distinct approaches: a centralised method characterised by coherence but rigidity or a decentralised approach characterised by flexibility but potential chaos.

COUNTERMEASURES AGAINST A2/AD SYSTEMS

Various countermeasures can be implemented to mitigate the effectiveness of A2/AD systems. The primary objective of these countermeasures is to diminish the efficacy of A2/AD methods and enhance the capacity of an opposing force to infiltrate or deactivate defensive capabilities. The following are several illustrations:-

- **Stealth Technology**. Stealth aircraft and warships refrain from radar detection. Stealth systems can attack targets or gather intelligence by drastically reducing their radar signature through shape, materials, and coatings.
- **Electronic Warfare (EW)**. Jamming radar signals, spoofing enemy sensors, or disrupting communication networks can deceive A2/AD systems. EW can allow friendly troops to exploit or negate A2/

AD defences by reducing the adversary's situational awareness and command and control.

- **Long-range Stand-off Weapons.** Cruise or hypersonic missiles allow the enemy to engage A2/AD systems outside the defended area. These weapons may incapacitate crucial nodes, infrastructure, and sensors, weakening A2/AD systems and defensive posture.
- **Cyber Operations**. Cyberattacks against command-and-control networks, communication infrastructure, or computers can impair A2/AD systems. Infiltrating or manipulating these networks might damage A2/AD defences, disrupt coordination, or trigger false alarms or misdirection.
- **Saturation Strikes**. Overloading A2/AD systems with simultaneous or successive attacks might exploit their weaknesses and boost penetration. Adversaries try to overwhelm interceptors, sensors, and other defensive systems to penetrate and engage targets.
- **Special Operations Forces (SOF)**. SOF can covertly deactivate or sabotage important A2/AD assets. Targeted strikes, reconnaissance missions, and sabotage operations against important A2/AD network nodes can reduce their effectiveness and defensive capabilities.

MUMT AGAINST A2/AD

The concept of A2/AD encompasses a range of operations and capabilities, including but not limited to air defence systems, radar technologies, missile systems, naval minefields, electronic warfare tactics, cyber offensive measures, and space-based weaponry. Nevertheless, the A2/AD system is neither invincible nor impenetrable and possesses some flaws that adversaries can exploit.

A2/AD uses defensive measures to prevent an enemy from entering or moving through a given area. To solve such challenges, MUM-T integrates manned and unmanned strengths. MUM-T improves situational awareness, operational flexibility, and operator-unmanned system coordination by merging manned and unmanned platforms. Manned platforms offer cognitive capacities, experience, and decision-making, while unmanned systems offer reach, persistence, and high-risk operations. Unmanned systems to carry out operations that would be too hazardous or challenging for manned platforms; MUM-T can fight back against A2/AD. When in action with manned platforms, unmanned systems can perform reconnaissance, surveillance, and target acquisition in real-time, judgements may be made, and threats can be engaged more securely.

Unmanned systems can saturate the enemy's defences and divert their focus with multiple drone attacks. Exploitation of Loitering Munition Drones may also be resorted to enhance the lethality. They can boost the manned platforms' efficacy and overwhelm A2/AD systems with electronic warfare, decoy operations, and weapons platforms.

Human operators on manned platforms can be protected from A2/AD attacks by relying on unmanned equipment to conduct preliminary surveillance and target acquisition.

By consistently Monitoring enemy activities and detecting developments or changing threats, Unmanned systems can provide persistent surveillance over an assigned region. Man-operated platforms can get this data in real time to better adjust their tactics and responses against A2/AD weapons.

MUM-T allows for distributed operations, which is the simultaneous use of manned and unmanned platforms across a large geographical area. As it becomes more difficult for an enemy to single out and destroy a dispersed force, this distributed strategy can help counter the threats A2/AD systems pose.

The weaknesses of the A2/AD approach could be targeted and exploited to diminish or nullify its effectiveness. Disruptive technologies represent a highly productive approach that should be implemented carefully and carefully. The utilisation of MUMT operations has the potential to achieve the desired objectives effectively.

MUM-T enables mission planners and operators more versatility and adaptability. Unmanned systems are flexible in deployment and positioning, allowing them to adapt to changing operational requirements and take advantage of openings in the enemy's A2/AD defences.

Unmanned devices can be used as a force multiplier, overwhelming the enemy's defences, and drawing their focus elsewhere. They are exploiting Stealth with Disruptive Technology. Their usage in electronic warfare, decoy operations, and weapon platforms can boost the performance of human-operated systems and render A2/AD defences useless.

THE VULNERABILITIES OF MUMT

MUM-T's success in combating the A2/AD methods depends on unmanned system capabilities, command and control system integration, and strategy adaptability. Adversaries may also create MUM-T countermeasures. Therefore, continual research, development, and innovation are essential to staying ahead in this field. To achieve the highest degree of equipment preparedness, pre-emptive measures must be initiated to check the adverse effects of likely vulnerabilities that manifest within MUMT systems. These are:

- **Communication and the Need for Coordination**. Communication and coordination failures are MUMT systems' most significant vulnerabilities due to their variations in communication protocols and data formats; manned and unmanned systems face challenges in sharing information and coordinating. In conflict zones, manned-unmanned equipment communication delays might be problematic.
- **Cyber-Attacks**. Continuous internet access makes unmanned systems vulnerable to cyberattacks. Cyberattacks might turn off unmanned systems or take control, putting manned-unmanned teams at risk.
- **Exposure to Hard Kill**. MUMT systems are exposed to Risks from hostile fire and IEDs. Safety issues exist in unmanned systems. Using unmanned devices may also increase collateral damage due to hitting unwanted targets.
- **Aeromedical Problems**. During a MUMT mission, pilots flying manned platforms alongside an unmanned aircraft (UA) may face aeronautical

challenges like task saturation and excessive workload. In 2015, the US Army Aeromedical Research Laboratory (USAARL) studied the Human Factors (HF) and aeromedical challenges of using MUMT applications. MUMT pilots may face many problems, according to the USAARL. These issues include visual overload, increased workload, task saturation, distraction, decreased flying situational awareness, and motion sickness. USAARL also warns that processing contradictory sensory information, such as aerial platform motion cues and unmanned aircraft (UA) orientation, and other potential outcomes from enhanced cockpit UA compatibility may increase the risk of Spatial Disorientation (SD).[12]

RECOMMENDATIONS

The efficacy of MUM-T in fighting A2/AD strategies is contingent on several elements, including the sophistication of the unmanned systems, the cohesiveness of the command-and-control structures, and the flexibility of the tactics employed. It's also possible that MUM-T's foes will figure out how to counteract it. Thus, continuous research, development, and invention are required to preserve competitive advantage in this field.

To accomplish all envisaged military objectives to counter A2/AD, these may be factored into the design of MUMT. The following measures need to be considered to address the operational and maintenance limitations of MUMT:

- **Exploring the Tactics**. Validation/testing and revaluation of techniques are essential for improving MUMT procedures. One organisation should be tasked with devising strategies for carrying out the various components of the objective.
- 'The Tactical Air Combat Development Establishment (TACDE)' is a specialised unit within the Indian Air Force dedicated to advancing and refining aerial combat capabilities. This institution can potentially be assigned the responsibility of developing MUMT tactics.
- **Managing Airspace Management Challenges**. New procedures, tools, and regulations must be created to manage airspace for manned and

unmanned teaming operations. All stakeholders must cooperate to ensure no fratricide and the safe integration of manned and unmanned aircraft inside the targeted airspace.

- **Maintenance and Logistical Operations**. Maintenance and logistical operations can prevent unplanned downtime and boost operational availability by planning and providing replacement parts, technical assistance, and experienced people. The demand for MRO and logistics support for manned and unmanned assets needs to be addressed.
- **Training and Skill Development**. The smooth operation of MUMT requires a skilled crew. Develop essential team members' education and training to effectively combine human and unmanned systems. Exercise will help operators manage unmanned assets and comprehend human and platform constraints.
- **Research and development (R&D).** Regular R&D enhances the MUMT's productivity and efficiency. This requires cutting-edge research, realistic experimentation, and hypothesis testing. Focus on improving sensors, data processing infrastructure, and real-time data fusion algorithms to strengthen the ability to counter A2/AD.

Future research in MUMT will likely yield improvements in autonomy and interoperability, ultimately leading to deeper levels of manned and unmanned system integration.

Even though MUM-T has several benefits, it's crucial to consider that A2/AD approaches are constantly developing. The effectiveness of MUM-T could be reduced if adversaries devise countermeasures or modify their strategies. Therefore, maintaining an efficient counter to A2/AD requires a holistic approach that integrates MUM-T with other operational concepts like electronic warfare and cyber capabilities.

CONCLUSION

The MUMT uses both human and robotic resources to complete a task. It's becoming increasingly clear that this is one of the most transformative technology developments for aerial combat in decades. Adaptable unmanned gadgets, as part of an extensively used intelligence network, will act as a "force multiplier" for crewed aircraft, boosting the team's efficiency and protecting the pilot from harm while maintaining command.

A2/AD refers to using defensive measures to deny an adversary access to a specific area or their freedom of movement. The A2/AD strategy encounters a significant obstacle in effectively coordinating and synchronising its manoeuvres and capabilities, which may be susceptible to exploitation by adversaries. MUMT combines the strengths of both manned and unmanned systems to overcome these challenges. MUMT can indeed be an effective strategy. Exploring potential strategies for incorporating the MUMT into alternative missions warrants additional consideration. Furthermore, it is imperative to acknowledge that the relentless progression of technology will persistently enhance diverse platforms and sub-systems with the ultimate objective of optimising the operator's workload.

However, MUM-T's success in combating A2/AD methods depends on unmanned system capabilities, command and control system integration, and strategy adaptability. Adversaries may also create MUM-T countermeasures. Therefore, continual research, development, and innovation are essential to staying ahead in this field.

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