MANNED-UNMANNED TEAMING: ENHANCING LETHALITY

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Abstract

Manned-Unmanned Teaming (MUM-T) is a revolutionary strategy in the military domain that synchronizes the manned and unmanned platforms to support the operations. MUM-T gives the amalgamated features of both platforms, with enhanced awareness of battle scenes, enhanced lethality, and better chances of survival. MUM-T slightly makes employment of soldiers, manned and unmanned air and ground vehicles, robotics and sensors synchronised to provide a multi-domain, ever changing battleground action plan. MUM-T leverages AI to enhance the collaboration between manned and unmanned systems, significantly improving mission effectiveness and safety. The study focuses on how the MUM-T concept facilitates the immediate exchange of data, enhancement of force, and reduction of risk. They can conduct dangerous reconnaissance and surveillance operations and pass information to manned systems. As technology is evolving at a rapid pace, the functions of the MUM-T are going to increase in the future in various dimensions, and enhance modern warfare even more, making it even more unconventional.

When manned and unmanned systems jointly operate to perform a mission, this process is called as “manned-unmanned teaming" (MUMT). People can do the tasking for MUMT, and various unmanned systems (robots) will do the work for them. When manned and unmanned platforms join together to use

their own skills, they might be able to do many things better and faster. For example, military activities in hazardous areas, search and rescue tasks, and efforts to protect the environment are just a few examples.

MUMT involves a human pilot and an unmanned robotic platform working together on land, sea, and air. The goal of this cooperation is to do the tasks and chores that have been given to them in military operations. On land, sea, and air tests, MUMT systems show that they can be used in a variety of situations. Nevertheless, the air domain has exhibited the highest enthusiasm in advocating for the MUMT concept.

Introduction

The extensive utilisation and accomplishments of unmanned aerial vehicles (UAVs) have prompted concerns over the future relevance of human aviation systems. An idea was conceived to join both elements to achieve what was tedious or not easily feasible.

Existing technology is insufficient to allow unmanned aircraft to make complex judgements in an unknown environment independently. However, in practical terms, they must be linked to human perception. Data connections are susceptible to being obstructed or altered. The current threat of cyberattacks is more formidable than any before. Commanded guidance delays can result in severe, potentially lethal outcomes. Human analysts are tasked with assessing and interpreting the data collected by UAVs.

Although, utilising manned aircraft for data collection offers ISR capabilities in typical scenarios, unmanned platforms with latest software are able to accomplish intended military objectives in most of cases. The Russia-Ukraine conflict has illustrated that to operate in contested environment is too challenging. However, the characteristics of the mission will dictate the appropriate kind of aircraft platform to be employed.

MUMT in the Russia-Ukraine Conflict

The cooperation with unmanned equipment, known as Manned-Unmanned Teaming (MUM-T), has become the subject of a provocative gambit between Russia and Ukraine that sheds light on the capabilities in the current conflict. Both Russia and Ukraine, have undertaken MUMT operations. The details are:

(a) MUMT by The Russian forces:

By using UAVs like Eleron-3SV and Orlan-10, Russian forces determined the coordinates of the Ukrainian artillery, which Russians further shelled.

The Forpost-R, that is, the armoured personnel carrier, designed on the basis of the Israeli Searcher Mk II, was specifically intended for reconnaissance operations and operations against the Ukrainian forces.

UAV have been employed integrated with manned aircraft such as the Su-34 to improve engagement efficiency, primarily in regards to the overall awareness and target acquisition.

(b) MUMT by Ukrainian Forces:

The UAV, from Turkey, known as Bayraktar TB2, supported the Ukrainian side in targeting and eliminating Russian gun batteries, logistics, convoys and command positions.

The Ukrainian forces engaged unmanned aerial vehicles or drones, known as PD-1 and PD-2, that are manufactured in Ukraine for reconnaissance and attacking Russian forces.

Further augmented by incorporating the MUM-T capabilities with the help of UAVs with manned aircraft such as the Su-24 as well as MiG-29s in order to amplify the effectiveness of these strikes.

With respect to the conduct of wars, the MUM-T operations are considered effective retaliatory tool. These have been attributed to factors such as better situational awareness of targets, real-time targeting etc.

The current conflict between Russia and Ukraine underscores need for MUM-T in the current warfare and the ability to transform military forces and alter the nature of the operations.

Advantages of Manned Platforms

Manned platforms do have numerous advantages which give them edge over UAS. The major advantageous features of manned platforms are:

Human decision-making: In this case, pilots are capable of making decisions on the same planes within the shortest time possible, regardless of the circumstance.

Real-time situational awareness: Perception and response processing depend on many factors that cause pilots to notice or respond differently to continually changing circumstances.

Capability to Adapt: Pilots aim to alter their plans depending on the progression of activities. Pilots are allowed to combine data gathered by a few types of sensors.

For instance, incidents permit aviators to act regarding failed systems in an emergency.

Aircraft relevance to both extensive and limited Operations: As for the size of the aircraft that, is to be used for data collection, depends on the dimensions and financing options of a certain project. It is imperative to mention that specific corridor mapping operations might be more advantageous when utilising vehicles with comparatively lower costs of operation. Some of the projects are meant to last for several days, while others may involve the ability to transport other complex equipment like LIDAR sensors, and metric digital cameras, which may, in turn, require larger aeroplanes. Carriage of heavier pods by HALEs, in most of the cases, may not be feasible, Using it in contested environment may be vulnerable also.

Piloted planes show flexibility in geographical mapping because they are fitted with comparatively modern mapping sensors. These advanced sensors are often considered a hassle for unmanned devices to import into their ecosystems due to the platform's payload limitations despite the necessity for accurate and wide-ranging mapping outputs they help

to produce. This is a major strength of manned aircraft in so far as flexibility in data acquisition is concerned.

Airspace-Compatible Operations: Large manned aircraft capable of flying over most missions can freely operate, subject to air traffic congestion. The other factor that makes manned aircraft preferable when it comes to flying over populated areas is that their operations are significantly limited by fewer restrictions compared to operations of Unmanned Aerial Systems (UAS).

The pilot on board may take evasive actions in case the situation (in an emergency) demands, while UAS may be on obstruction in the air for other manned or unmanned operators. Therefore, Safety-wise, human-crewed operations seem to have an edge over UAS operations. Thus, the measures that the regulations have laid down regarding operating UASs near or over populated areas are more stringent. Given that multiple fatal accidents with piloted aircraft still occur fairly rarely, such planes could be easily viewed as one of the most enticing options that can be considered when talking about ISR operations.

Limitations of Manned Aircraft

The various limitations of manned platforms are enumerated below:

This exposes pilots to a situation in which they are literally placed in a position where the risk of their lives is at stake.

This implies that pilots, like any other human being, undergo fatigue and stress and are restricted in specific ways due to the human anatomy.

Higher operating expenses: Manned aircraft consumes a lot of people and fuel and requires more frequent maintenance than most other aircraft.

Limited endurance: Manned aircraft have relatively short mission endurance due to fatigue.

The manned aircraft operations are generally expensive to conduct. Many aircraft, including the large ones, are costly to own and fully maintain. These costs are then either added to the price of the geospatial data acquisition directly or, more commonly, reflected as a part of this cost. Furthermore, the deployment of piloted aircraft to a project location might incur significant expenses as a result of the exorbitant price of aviation fuel. Typically, the collection of data from manned aircraft necessitates the presence of a sensor operator in addition to the pilot, hence increasing the overall cost of the operation.[1]

Unsuitable for Small Projects: UAS is a cost-effective choice for projects for smaller area, for instance - an area of 2 square miles or less. The significant operational expenses associated with manned aircraft, especially when smaller aircraft are employed, typically render their employment impractical for projects covering an area of 10-20 square miles.[2]

Lower-resolution photography is more productive for imagery acquisition, often done with a resolution ranging from 7.5cm to 15cm. High-resolution imagery is feasible with manned aircraft, but it is not as efficient. Due to their affordable acquisition and operational expenses, tiny unmanned aerial systems are most preferred for projects that are insufficient in scale to warrant the use of human aircraft.

Advantages of Unmanned Aircraft

The advantages of MUM-T operations have dividends on war-waging capabilities. better situational awareness, more accurate hits, targeting in real-time and Battle damages assessment, and mitigating danger for manned aircraft and on-board air crew. The various reasons that make unmanned aircraft a popular choice for military and civilians are appended below:

- This reduces the risk of endangering human life since no pilot is precariously positioned.
- Extended endurance: UAS can hover and be airborne for a couple of hours or even days.

- Lower operational costs: UAS take less crew, fuel, and maintenance than conventional aircraft types.
- Improved precision: Unmanned Aerial Systems maintain their flying patterns; hence, generic models of these flying objects hold an improved flying pattern.
- The UAS can handle several operations and will not tire the pilot, even if there are many operations.

The Other Factors:

- Cost-effective Operations: UAS are the most economical means of obtaining aerial photography for small-scale project areas. Transporting UAS to the project site is cost-effective as they may be easily delivered as cargo or checked in as luggage on a trip. Unlike manned aircraft, UAS does not need the presence of a sensor operator (copilot) beside a pilot. UAS is highly appealing for gathering airborne data.
- High-resolution imagery is often gathered by UAS due to the limitation on flight altitude, namely below 400 feet above ground level (AGL). Attaining a high resolution of 2cm or less is challenging and costly when using manned aircraft.
- Optimal for Small ISR Projects: UAS is the preferred choice for projects that span a smaller area. Though UAS is capable of covering larger areas over an extended duration of operation, if the operation involves taking numerous photos during that time, the effort required to manage those photos from multiple software applications becomes a problem and slows down the completion of the project.

Limitations of Unmanned Aircraft

- UAS only has poor situational awareness because it operates depending on the sensors and data linkages.
- Delays in communication: UAS may take time or even fail to respond or communicate in a prescribed or expected time due to the above reasons.

- Openness to cyber-attacks: UAS are propelled by software as well as data communication.
- Reliance on GPS: UAS rely on GPS, so its safety is paramount for the proper functioning of the unmanned aircraft. This means that the UAS is occasioned by challenges as subsequent regulations.
- A common observation regarding UAVs is "lack of situational awareness and on-the-spot decision-making". However, MUMT operations have addressed it to a certain extent. Unmanned components may be controlled in relation to developing air situations.
- Operational Limitations: The limitations due to size, the technology architecture used, and design issues do restrict the operational exploitation of the Unmanned platforms.

Other Functional limitations are appended below:[3]

- Unsuitable for Large Projects: UAS's poor speed and endurance make it impractical for imaging projects exceeding 2 square miles or corridors longer than a few linear miles.
- Payload Incapabilities: UASs are unable to carry advanced mapping sensors that are bulky and of high quality, such as metric cameras and full-size lidar sensors, because of their restricted capacity for transporting payloads. UASs are only capable of carrying miniaturised cameras and lidar sensors. However, it is important to note that these miniaturised sensors produce products with reduced quality and accuracy when compared to their full-size counterparts.
- Operational Regulations: The degree of freedom of operations of UAS, in military operations, is unrestricted subject to the position of other friendly military aircraft. Although the degree of freedom of operations is unrestricted for combat, the drone regulations impose limitations on the use of UAS in populated areas, hence constraining its application in many non-military usages. For example, the highest-flying altitude is restricted to below 400 feet AGL under Indian Drone Regulations[4] and the regulatory rules, which hampers its efficiency in gathering aerial data.

The comparison table is given below to highlight the differences between Manned and Unmanned Aerial Platforms:

Comparison between Manned v/s Unmanned Aircraft		
Capabilities	***Manned ac***	***Unmanned ac***
Operational Risk (Vulnerability)	Yes	No
Lag time for Operations	More	Less
Effect of weather	More	Less
Expandability	More	Less
Autonomous Ops	Yes	Limited
Payload Limitations	Low	High
Attrition Resilience	Low	High
Easy Mobilisation	No	Yes
Capability to undertake Large Projects	Yes	No
Capability to undertake Small Projects	No	Yes
Imagery Quality	Yes	Comparatively Low

Growth of MUMT

In the early years of the 2020s, technology attained a notable degree of complexity, enabling algorithms to execute an expanding array of ordinary and repetitive tasks typically carried out by individuals. The progression of relevant technology has facilitated significant advancements in unmanned technology. These developments have occurred since the end of the Second World War, yet their noteworthy momentum has been observed primarily since the onset of the 21st century.

The utilisation of unmanned aerial vehicles (UAVs) significantly facilitated the advancement of unmanned technology by the United States and its allies to provide military assistance in Afghanistan and Iraq starting in 2001 and 2003, respectively. UAVs

have been utilised by the US and Israeli militaries, among others, since the 1960s. However, during operations Enduring Freedom and Iraqi Freedom, unmanned aircraft undertook more missions than previously carried out by manned platforms.

The scope of these operations included intelligence, surveillance, and reconnaissance (ISR) missions, such as aerial surveillance. Over time, they changed their focus to using UAVs like the General Atomics Predator series for kinetic air-to-ground attacks. These robotic aerial vehicles (UAVs) had air-to-surface weapons and guided bombs on board to ensure they could attack quickly. Unmanned Combat Aerial Vehicles, or UCAVs, are useful for two main reasons.

- First, they hit strategic targets in secret and with accuracy, usually in places where manned planes would face high air defence risks.
- Secondly, they are utilised in situations where the implementation of these platforms might potentially have negative political repercussions.

Although the ethical and practical implications of completely replacing people with robots on the battlefield are a worry, recent technological progress has made it possible to create unmanned vehicles. These vehicles are now able to accompany individuals and take on specific parts of their tasks that were previously done by humans, therefore providing support to them. In addition, this strategy is to reduce the number of troops in conflict zones, hence decreasing losses and easing the logistical challenges caused by human presence. Nevertheless, it is crucial to acknowledge that autonomous vehicles will still require fuel, spare parts, and maintenance.

The extent to which the MUMT can be exploited will depend on the intrinsic capabilities of the system. Therefore, it is imperative that the design of the MUMT possesses the capacity to accommodate all foreseeable military objectives effectively. The development of manned-unmanned joint capabilities has been influenced by various factors, such as

- The development of sensor technologies
- The progress in artificial intelligence

- Progress in communications protocols and network topologies
- User-centered design methods

The evolution of manned-unmanned teaming has been driven by technology improvement, improved communication skills, and prioritisation of user-centered design concepts. By using both human and artificial intelligence, it is quite possible to optimise work and improve the level of results of addressing various issues in several sectors and industries.

Advantages of MUMT

It might be mentioned here that the MUMT technology can be regarded as a force multiplier, offering the needed toolkit to address the increasing challenges that larger-scale, more extensive threat operations pose to provincial forces and industry. This approach also safeguards both the operator and its assets against potential challenges as hedges related thereto.

- Enhanced Situational awareness: It is as follows: It is evident that the frequent use of MUMT may enhance the assurance of situation awareness of both manned and unmanned systems. For instance, to reduce the risk factors associated with traffic or any activities that involve human interaction with the environment, autonomous systems integrated with up-to-date data on the environment could assist human systems in making better decisions when controls have been enhanced by augmented situational awareness. Machines and individuals if they would use MUMT, there is a possibility that they would also become more perceptive with regards to their environment.
- Enhancing Intelligence, Surveillance, and Reconnaissance (ISR) Capabilities: Above all, the present study found that MUMT is a more effective communication strategy for escalating ISR, more so in stressing operations. In naval endeavours, the bobbing may be more of observation, spying, and intelligence collecting (ISR) that is often done by helicopters manned from one ship hence enabling exploration.[5]

- Increased Probability of Survival: Since these shooter platforms are drones then they are easier and more efficient to operate and cheaper to replace than manned platforms, which in turn minimises technical failure risks and the loss of personnel.

- Adaptability: MUMT can be beneficial when it comes to the ability to change and scale up the flow of military functions. Often, it can be done where manned operation is not safe or feasible or where manned vehicles are unavailable, for example, performing scouting in front of a convoy or close air support. Such a configuration enables manned systems to conduct activities that are directly related to mission aims, while unmanned systems can effectively handle risky or intricate tasks.

With respect to efficiency, the following have been observed:

  - Better and shorter time cycle for completion of projects

  - High productivity in project development in relation to time

- Cost-Effectivity: It has been pinpointed that employing MUMT may substantially help to reduce the cost burden on a country's budget associated with managing military activities. Thus, when it is compared to human systems, unmanned systems are relatively less costly and are capable of working in risky environments. Modern and technologically advanced manned fighter aircraft have a heuristic value of cost in the range of one hundred million US dollars. On the other hand, the approximate cost of each unmanned wingman as predicted is believed to be less than five million US dollars. MUMT strategy has the potential of leading to the realisation of some expenses while at the same time decreasing the chances of conception of casualties.

However, MUMT is still in its infancy, though once well-developed it can radically alter, in the near future, the very conduct of war. The progress made in the technology would facilitate the integration to boost its role as a weapon system.

The realisation of these possible advantages infers the replacement of traditional human methods with MUMT systems. In order to prevent the improper usage of MUMT systems from becoming the norm, it is important to identify and prevent security risks within them.

Limitations of MUMT Operations

Unmanned Military Systems have advantages. MUMT systems have the same risks as human operators; they can be targeted by enemy fire and IEDs. The enemy may not know much about unmanned systems but they can strike fast. Unmanned systems can also increase the risk of collateral damage as there is a higher chance of hitting unintended targets.

MUMT has many challenges. Communication and synchronisation are key for MUMT systems, but achieving that environment can be tough, especially in complex and dynamic situations.

The probable weaknesses in MUMT systems are appended below:

- **Communication and Coordination failures.** The problem of exchanging info and coordinating between human and unmanned systems is due to different communication protocols and data formats used by both.
- **Vulnerability to Cyber Attacks.** Unmanned systems are connected to the internet, so they are vulnerable to hackers.
- **Exposure to enemy fire and IEDs.** MUMT does have potential risks to hard-kill.
- **Task overload.** Too much workload can be a big challenge for pilots who are operating manned platforms and unmanned aircraft (UA) during MUMT. According to the United States Army Aeromedical Research Laboratory (USAARL) study, pilots will face several challenges of heightened workload in MUMT operations.[6]

Countering the Vulnerabilities of MUMT

MUMT systems must operate autonomously and talk to each other. A contingency plan is needed in case of system failure or loss. However, maintaining the autonomy of communication and control systems while keeping them efficient can be tough.

- Resilient communication and control systems with standardised communication protocols and data formats will enable seamless info exchange and task synchronisation between manned and unmanned devices.
- Cybersecurity can harden unmanned systems against cyber-attacks. Implementing strict security protocols and using techniques that are less hackable will enable operations to continue.
- There are ways to prevent brutal killings. To reduce the risk of collateral damage, we must use advanced precision weapons and improve target identification and avoidance mechanisms.

Recognising and addressing MUMT vulnerabilities is key to improving military effectiveness, safety and resilience.

MUMT in India

India is looking at MUMT for its Air Force and focusing on its Tejas light combat aircraft. India wants to integrate UAVs with its manned aircraft and ground stations to enhance its ISR capabilities.[7]

The Indian MUMT project is the 'Hindustan Aeronautics Limited (HAL) Combat Air Teaming System (CATS'. It is an ongoing project to develop a manned and unmanned aircraft system that can work together in various operational scenarios. HAL is the main agency involved, along with agencies like Newspace Research and Technologies, DRDO, and NAL.[8]

The CATS Warrior project was launched in 2018. Showcased at the Aero India 2021 expo. Currently, the CATS Warrior is undergoing wind tunnel tests, with the rollout planned for 2024 2025. Flight testing of the CATS Warrior is expected to take place in 2024.[9]

The CATS system integrates an LCA-based mothership with the Tejas Mk1 Trainer serving as the MAX (Mothership, for Air Teaming eXploitation). The development of the Tejas twin-seat trainer aims to enhance its capabilities for manned teaming as a Multirole Aircraft for Tactical Support within the CATS framework. The weapon system operator of

the Tejas MAX aircraft will oversee the UAS or SWARM (Smart War Fighting Array of Reconfigured Modules)[10], which is a drone associated with each Light Combat Aircraft (LCA). The goal of the CATS system is to establish a network of drones integrated with fighter aircraft.

The plan, which requires an investment of Rs 400 crore, includes an aircraft called the Tejas Mk1 Light Combat Aircraft (LCA) and various unmanned platforms such as the CATS Warrior, CATS Hunter and CATS Air Launched Flexible Asset (ALFA). These unmanned units can be activated individually or simultaneously. They are designed to be controlled from a fighter aircraft (LCA) known as the 'mothership' which releases them from a safe distance, under the supervision of its pilot. This innovative concept will effectively optimise firepower against enemy targets while effectively safeguarding the pilot and fighter aircraft from enemy fire.[11]

The prototypes of various integrated unmanned vehicles and their corresponding capabilities were unveiled in mid-2018 as part of the ongoing development process.[12] The vital elements of CATS are:

CATS Warrior: The CATS Warrior UAV can be coupled with the CATS MAX and is simply a small wingman that can be operated remotely from the ground. Its armament would consist of the Chamundi missile system, which forms the basis of the CATS Warrior's weaponry. The HAL PTAE-7 would be upgraded twin turbojet engines used in the DRDO Lakshya. This kind of element can still be applied in conditions where there is rivalry. This is done by allowing the CATS Warrior to work concurrently with or preceding the LCA or even independently. The Warrior vehicle has a lot of other technologies, and some of them include the following: Electro-Optic/Infrared (EO/IR) Payload, Active Electronically Scanned Array (AESA) Radar, Inertial Navigational Unit and a Jammer. These enhanced technologies enhance the Warrior's capabilities with regard to ISR operations and engagement in combat. The aircraft has the capability to carry 2 advanced and sophisticated air-to-air missiles neatly externally – these maybe short-range or beyond visual range. Besides, it is incorporating internal accommodation to accommodate the Smart Anti-Airfield Weapon (SAAW).[13]

CATS Hunter: As part of the HAL CATS project, the HAL is in the developmental stage of an air-launched cruise missile that is named the CATS Hunter and has low observability while remaining at stand-off range. Thus, the CATS Hunter can be launched from fighter aircraft such as LCA Tejas, Jaguar, Sukhoi-30 MKI etc., for deep penetration strikes. HAL boasts of asserting that it is capable of flying 700 miles, locating a target and releasing hellfire missiles or 350 km, deploying its Brimstone attack drones before it has to go back to base.[14]

CATS ALFA-S: Consequently, Swarm's efficiency has improved due to the application of AI technologies. The recent advancements in air-launched swarm technology have given impetus to the development of the CATS ALFA-S project. HAL is collaborating with New Space Research & Technologies, a startup located in Bengaluru, to develop a UAV known as "Air Launched Flexible Asset-Swarm" (ALFA-S). The Alpha-S, which the Warrior can carry and release, is a swarm of up to 24 drones that can individually carry roughly 5-8kg of explosives and concurrently target numerous enemy positions.[15]

In the 2019 unveiling of the 'Jaguar Max' update package, the ALFA-S swarm drone system was introduced, showcasing its ability to target multiple entities effectively. The reliable companion can be equipped with both aerial and terrestrial missiles. The ALFA-S drones are contained within the CATS ALFA carrier. The LCA can transport a maximum of five CATS ALFA variant glide pods. The initial prototypes of the ALFA-S drones will be anticipated to be deployed utilising the Hawk Advanced Jet Trainers.[16]

CATS Infinity (CI): The MUMT package needs to be well connected through communication links. This connectivity is accomplished by the help of CI. The 'CI' is an aerial control vehicle developed as a High-altitude platform satellite (HAPS). It is designed to operate at elevated altitudes (65000 ft), predominantly within the stratosphere, and serves as a communication relay system. It can maintain a prolonged orbital presence, typically three to six months. The CI system is classified as a solar-powered pseudo-satellite. The wings of the CI can unfold, thereby exposing solar panels. This technology is an interface for transmitting visual data from the battlefield to satellites, thereby enhancing communication between UAVs. The initial prototype is expected to be finished by 2025.

Recommendations

The successful execution of the MUMT concept will rely on the inherent capabilities and functionalities of the system in consideration. The mission has been allocated specific objectives in accordance with the specified criteria. Hence, the progress of MUMT necessitates the incorporation of comprehensive strategies to address all anticipated military objectives.

To address the operational and maintenance issues, the following processes should be executed.

- **Analysing the Performance.** It is crucial to evaluate MUMT operations to address any operational gaps. Formulating strategies to accomplish the required mission objectives should be allocated to an 'expert' agency.
- **Challenges in Coordinating Airspace.** Collaboration among aviation authorities, air traffic management organisations, and industry stakeholders is necessary to ensure the secure and efficient integration of MUMT operations inside the airspace.
- **Maintenance and Logistical Assistance.** To keep operations going, various steps may be taken to ensure that both – human and unmanned resources for maintaining, repairing, and providing logistical support are timely met.
- **Training and Skill Development.** Allocate essential resources to provide relevant training and education for team members engaged in the operations and integration of manned and unmanned systems, enabling them to do so with expertise.
- **Research and Development (R&D).** Depending on the strategic goals and objectives of MUMT, there is requisite importance in maintaining the FGCP, followed by consistent prioritisation and investment in R&D to improve the efficacy and efficiency of the operations.

Freeware improvements, increased autonomy capabilities, and advancements in interoperability will continue to bring higher integration between MUMT and manned vehicles in the future.

Conclusion

The idea behind MUM-T surpasses modern thought regarding a mission's capacity to reach elevated levels of autonomy and delivers a considerable improvement in situation awareness and decision-making, boosting the probabilities of success in military operations.

The MUMT is defined as the ability to combine manpower, manned, and unmanned systems to achieve particular objectives. It is rapidly becoming the most significant technological revolution with an alarming impact on the future of aerial combat.

Low waypoint platforms will be incorporated into a constellation of intelligent ground nodes to improve crewed vehicle performance. These devices will work as 'force multipliers', will make the team stronger, and establish order and authority to safeguard the driver.

Addressing the issues with MUMT systems may offer solutions that would enhance the efficiency and safety of military processes and make these activities more robust. HAL has been developing CATS to be integrated into existing aircraft with an anticipation that will revolutionise aerial combat. In addition, the growth of the IAF's Operational Capability, with induced firepower, shall improve the Indian defence and Aerospace sector globally. It clearly depicts that the innovative and productive participation of private sector enterprises is capable of contributing to developing a competitive aerospace environment in the country. It must be looked after.

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