UAVs Unveiled: HALE, UCAV, and the Future

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Abstract— The document titled "UAV Unveiled :HALE ,UCAV and the Future " discusses the various aspects of Unmanned Aerial Vehicles (UAVs) and their application in military and intelligence operations. The paper covers different classes of UAVs, including HALE (High Altitude Long Endurance), UCAV (Unmanned Combat Aerial Vehicles), highlighting their operational capabilities and strategic importance. The authors delve into the key technological components such as control systems, sensors, and power management systems, which are critical for enhancing UAV performance in diverse mission profiles. Furthermore, it identifies research gaps in areas like system integration, cybersecurity, and data management, emphasizing the need for continued innovation to improve UAV efficiency and survivability. The document concludes by proposing methodologies for addressing these challenges, including stealth technology advancements and energy-efficient solutions like the integration of monocrystalline silicon solar cells.

Keywords—Unmanned Aerial Vehicles (UAVs),High Altitude Long Endurance (HALE),Unmanned Combat Aerial Vehicles (UCAV), Stealth Technology, Sensor Systems, Power Management, Cybersecurity in UAVs.

I. INTRODUCTION

Drones or also known as Unmanned Aerial System(UAVs) are widely discussed topic around the globe not only with effectiveness in daily life applications but it also provide a whole new perspective in there military application .The variety of drones that exist today for military applications helps to not only to gather information safely through surveillance but also give them a way to attack important assert of the enemy force and can resupply our forward forces without risking human life. Through these vast and unmatched roles that the drones can perform in much cheaper and effectively from any other platforms currently present in the military aresnal , they play vital role in a nation's army. Drones are of variety of types that are used in military-

- Micro Drones - Small,portable and used for short range for reconnaissance and surveillance,usually used for close combat and urban environments.Example-Black Hornet,RQ-11 Raven.

- Tactical Drones - Medium Sized drones ,launched by catapult or from ground .Weights around from 25 kg -200kg.[1]
- MALE(Medium Altitude Long endurance)- Usually operates between 10,000 feet -30,000 feet ,have an endurance of 15 hours and more ,used for surveillance ,and can also carry out strike missions when bombs and missile is integrated.Ex-MQ-9 Reaper ,Tapas-BH-201.
- HALE(High Altitude Long Endurance) - Operates above 30,000 feet used for strategic reconnaissance.Ex-RQ-4 Global,MQ-4C Triton.[4]
- UCAV(Unmanned Combat Aerial Vehicle)- Drones with the purpose of offensive roles.Specialized in deep penetration in enemy space due to lower radar cross section ,providing a stealthy way to perform mission.Ex- X-47B, Taranis.
- Kamikaze drones - Suicide drones that are used to overwhelm air defenses by there sheer number and attack enemies first line of air defence in order to create uncontested airspace for the ally aircraft. Ex-Harop ,Switchblade.

A. Construction of MALE,HALE,UCAV Drone

1. Airframe and Propulsion system
2. Control Systems and Sensors
3. Power,Data Management and Support system

***Airframe and Propulsion system*:**Airframe of these drones usually consist of fixed wings which help them to glide at high altitude and reduce the fuel consumption.The material that these are made up of are composite materials such as carbon fibre to reduce weight of the drone and titanium is also used to give them structural strength.Most of the drones in the categories of MALE,HALE,UCAV require a runway to takeoff due to there fixed wings.Surveillance drones can have an endurance of typically 24-48 hours while the combat or striker drones can have 8-10 hours with payload.They can have a retractable or fixed landing gear ,the later one create more drag and is less efficient. Sharp angles are present specifically on UCAV to reduce RCS and have Radar Absorbing Materials coating to have stealth throughout the mission.[2]

For the propulsion system in these drones they use turboprop or turbofan engines which can create peak thrust of 71kN in X-47b and the fuel used by them are usually JET A-1 fuel or JET B type fuel.They try to minimize the sound and heat signature to avoid getting noticed while doing surveillance, reconnaissance mission or while performing deep strike mission.

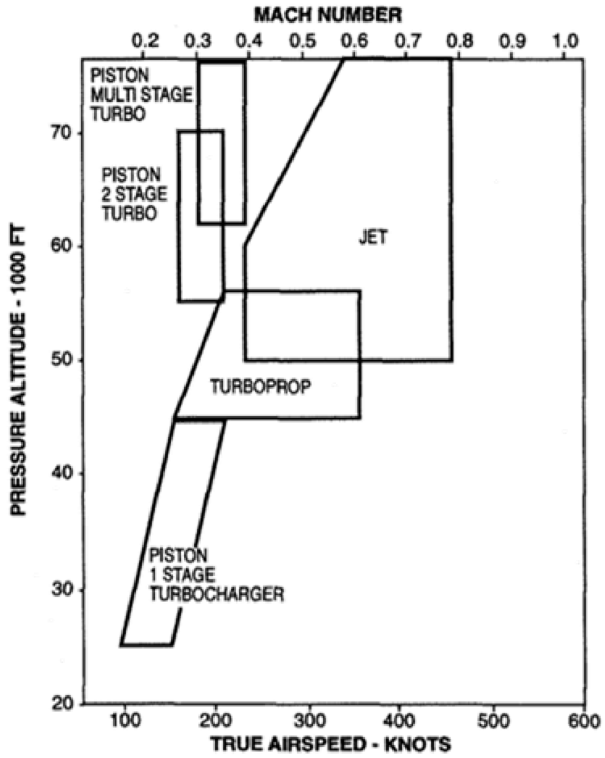

Fig-1 Air envelope of different type of engine [3]

Control Systems and Sensors: Drones are designed to handle sophisticated and complex flight conditions present in the mission requirement.To handle such situation it have **FCS , IMU, GPS ,INS ,** Data link ,Power and Weapon Management System. Sensors that are present in these drones are **EO,IR Sensor, SAR**,**LIDAR**, **EW Sensor,**Signal intelligence(Communication and electronic).

Power,Data Management and Support system: Power management systems are used to ensure fuel efficiency throughout the mission and ensuring a subtle way of powering propulsion ,avionics sensors and maintaining communication with **GCS**. It consists of **PDU,ECU,**Battery Systems,Generators and Alternators,Backup power systems.

Data Management System have Data Link system for real time transmission of data to **GCS** ,**DPU** handles data coming from the sensors to provide what action should be taken. Encryption and Telemetry systems are present to have secure connection and continuously monitors vital flight data and transmit it to ground station.

Support Systems include tools which can diagnostics, monitors health and helps to keep the drone in optimal condition for operational capabilities thus increasing availability rate of the platforms.

II. LITERATURE REVIEW

A. Origin

Drones have undergone rapid development in recent years, experiencing remarkable advancements in their relatively short history. In 1849 an unmanned combat air vehicle used by Austrians to attack the Italian city of Venice with almost numbers of these vehicles reaching about 200 ,fitted with bomb inside that detonate with the help of a timer device. With increase in technology advancements Sir Nikola Tesla in 1900 proposed concept of wirelessely controlling the balloon changing the way these aerial combat will take place in the upcoming future.[7]

In 1959, USAF officially created the plan for the birth of UAV program due to concerning losses of there pilots in hostile territories which was given the code name of 'Red Wagon'. From there to the current breeds of drone a lot of things are changed .If we look the materials by which they are built have changed from being of steel and iron to now made up of composite material making it lightweight, more durable and efficient in reducing drags ,the propulsion systems have also been more efficient, powerful and reliable ,payloads have been increased and integration of different air to air ,air to surface missiles can be integrated to a platform thus increasing the variety of missions one platform can perform also helping to achieve efficiency with logistics of that platform and increasing the availability rate of the platform.

B. Technological advancement in sensors

Before 2000s drone was consisting of basic set of sensors which include an optical camera which were usually analog cameras with basic **IMUs** using RF waves to control and early GPS for navigation systems. But due to importance they play and how they can change the modern warfare huge technological advancements have been seen , thus creating a race between nations to create the most lethal drone, with diverse operationability. Current drones consist of digital camera with stabilization system ,and specialized camera for thermal imaging ,multispectral and hyperspectral.Advanced IMUs which can have gyroscope,accelerometer and even magnetometer. Usage of LIDAR and RTK GPS to improve target detection and navigational system.Implementation of AI with all these sensors help to drone to be autonomous and can take decisions on based on different sensor readings.

Sensors	**Applications**	**Advantages**	**Disadvantages**
Thermal Infrared Sensor	Used in drone and fighter jet	Accurate monitoring, more accurate data,low power	Sunlight interference,impressionable to distance
Hyperspectral sensor	Used for detection against difficult to detect target	Accurate analysis of classification of the image	Cost ,Complexity and Data Storage Capacity
LiDAR	Used for battlefield mapping ,determining line of sight	3D Tactical Mapping,spatial classification	Calibration errors,Sensors noise , affect by atmospheric conditions

Table 1 - Comparison of different sensors

C. Legal Implications

There are many Legal Implications while operating these platforms as such ad for India currently foreigners are not allowed to fly UAVs as per by DGCA. Except Nano drones all others have to acquire a Unique Identifcation Number(UIN) during registration.While flight restrictions include no more than 120m above ground level and restricted over no fly zones.

Similar legal implications are present in United States of America that one must be register their device with Federal Aviation Authority if the weight of the UAV exceeds 250g.There drones are allowed to fly in Class G airspace which is 325m from ground which is often referred to as uncontrolled airspace.[12]

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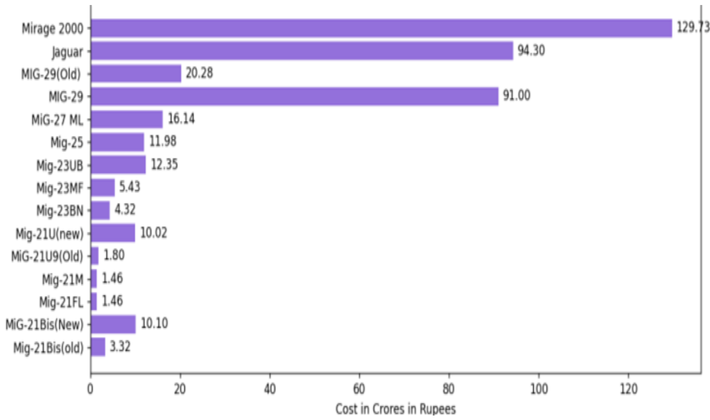
III. RESEARCH GAPS AND PROBLEM FOUNDATION

In this modern warfare problems faced by the MALE,HALE & UCAVs are :

- System Integration: Developing standardized protocols and communication systems to ensure seamless interoperability between UAVs and existing defense infrastructure.
- Cybersecurity: Strengthening cybersecurity measures to protect drones from cyber-attacks and electronic warfare, ensuring the integrity and security of UAV operations.
- Data Management: Enhancing data processing capabilities to handle the large volumes of data generated by UAVs, enabling real-time analysis and actionable insights.
- Energy Efficiency: Innovating in power systems and energy management to extend the operational range and endurance of UAVs for longer missions.
- Swarm Technology: Overcoming technical challenges in swarm technology to deploy multiple UAVs in coordinated and effective military operations.
- Stealthy platform : Not being detected by radars which can be ground based or early airborne and control systems (AWACS) warning systems.[9]As most of the drones get detected by radars and hit by the air defenses or nearby SAMs.

Since these drones are pretty expensive and need a country fortune to acquire them ,as MQ-9A Reaper which is a very popular drone and more than 300 units have been made and the approx cost is around 30$ million for one unit. While developing nations such as India which currently have its own indegious aircraft program and its one unit cost for aircraft- Tejas is around 43$ million.Moreover, the loss of such expensive drones presents not just a financial burden but also a strategic setback in terms of lost intelligence and capability gaps.The development of more resilient UAV platforms, alongside advancements in autonomous recovery systems, will be essential to mitigate these risks in future operations.

If we compare how much the current IAFs aircraft cost compare to these drones then we can see how much of an important assert they are for the countries .



` Fig 2.Cost comparison of different aircraft in India

As per official reports from the US Air force the total number of crashes of UAV was around 17 from 2016 to 2024.Out of which 14 was MALE Drone MQ-9A and the other 3 was of HALE drone RQ-4 Globalhawk.While other reports such as from dronewars net data has been shown in Table 2.

Drones	**Cost per Unit**	**Number of crashes**	**Total cost**
MQ-9A	$32 million	14	$448 million
RQ-4	$220 million	3	$660 million
Hermes 900	$10 million	5	$50 million
Hermes 450	$2 million	3	$6 million
Gray Eagle	$21 million	3	$63 million
MQ-8Fire scout	$27.5 million	3	$82.5 million

Table 2 - Comparison of Cost of different MALE Drones.

While many of these faced technical failures ,there were few which was shoot down by Houthis,Hezbollah to bringing these Hale, Male Uavs of Israel and US forces.These sophisticated drones brought down by firing SAMs thus bringing out the major flaw of getting detected and tracked by these air defences system.

IV. PURPOSED METHODOLOGY

In this section we will discuss about the possible theories that can be used in order to resolve the problems and research gaps of how these drones can improvised and tackle these problems.

There are different types of radars that are deployed in an ongoing war to counter the incoming aerial threats of enemy forces.[8]These radar have an operational range from 220MHz to 35GHz. For Range determination of these radars we have this Radar Range equation:

$$P_r = \frac{P_1 G_1 G_2 \sigma \lambda^2}{(4\pi)^3 R^4}$$

σ = RADAR cross section (m^2)
λ= wavelength of a RADAR signal
G1 = transmission antenna gain
G2 = reception antenna gain
Pt = transmission power (W)
Pr = reception power (W)
R = Range of RADAR

Radars are of two types :- Primary and Secondary and then also divided in ranges of frequencies in which they are operated and if see the types of radars which are mainly responsible for these detection are :[9]

Band Designation	Frequency Range	Usage
VHF	30-300MHz	Very-long-range surveillance
UHF	300-1000MHz	Very-long-range surveillance
L	1-2GHz	Long-range surveillance
S	2-4GHz	Moderate-range
C	4-8GHz	Long-range Tracking
X	8-12GHz	Short Range tracking Missile
Millimeter	40-100GHz	

Table 3 - Different type of radars

To counter the drone detection from these radars and especially from the x bands radar which guide missile to the UAV to destroy it ,we can have different methods for its countermeasure

A. *Stealth Technology*

Stealth is used to have a silent entry of aircraft without getting detected by the enemy defenses or radars thus making a surprising attack on enemy forces installation ,important asserts and air defenses.There are different parameters for creating Stealth:

- Shape of an Aircraft
- Stealth materials used
- RCS element
- Infrared radiation reduction
- Visual detection reduction
- Active stealth monitoring

For the shape of the aircraft having radar absorbant surface ,this can be made having sharper angles which can reduce the frontal rcs of the aerial vehicle making it close to invisible for some angles for the radar to detect it .Then about the materials which are used to make a aerial vehicle stealth are usually made up of nano-materials that are made up of Gas Phase synthesis using different types of Chemical Vapour Deposition. These materials have reduced imperfections which are usually present in the bulk materials,these nano coatings are generally used for protecting the structure and surface of the aircraft from harsh conditions and environment.[6]

B. *Endurance and Energy Efficiency*

Since these drones cost a lot ,a more endurance hours are needed as it can give edge in providing the information,so to have an edge these drones propulsion systems are made to ounce every Joule of Energy from these but ultimately these IC engines have there limits.So incoperating this engines with Solar cells provide us with hybrid system of energy which help it to be airborne. Since these drones already operate at such an high altitude they are exposed to strong solar radiation which can help them to retain energy and charge there batteries which can further increase there range and endurance of these platforms.The type of solar cells that can be used are

- GaAs (Gallium Arsenide)
- Monocrystalline Silicon Solar Cells
- Multi-Junction Solar Cells

These cells have an efficiency of around 20-30% ,this energy can be stored in battery and delievered when required by the propellers and rotors.

C. Cybersecurity Measures

Cyberattacks on these drones have been a major issue providing a soft kill opportunities to the enemy forces .There are many types of cyberattacks that can happen such as 1)Hardware 2)Software 3)Sensor 4)Network 5)Communication attacks on these drones .These categories have there subcategories of attacks ranging from backdoor malware to GPS spoofing. Some of them are passive attacks such as eaves-drooping and modification so in order to resolve this issue and ensure a safely operating drones we have to use both detection and prevention methods. Firewall methods working both as IDP and IDS .These include Signature based , Behavior Based ,Heuristics based having an hybrid model.Enhance routing protocols can be used which prioritize security and are efficient so they can stop the malicious data entering into CAN.Some of the protocols that can be used are DSDV ,SEAD ,SRP,ZHLS. In addition to this port,protocol and applications can themselves handle abnormally.Use of cryptographic analysis inorder to support the authentication process.

V. RESULTS AND DISCUSSION

A. Stealth Technology

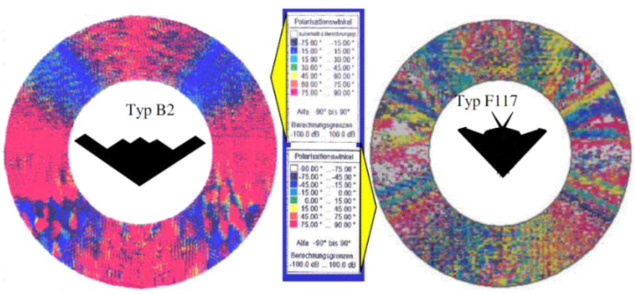


Fig.3.Distribution for the optimum polarization angle for different stealth aircrafts.

In Fig.3 Elliptical polarization of two stealth air surfaces of US military aircraft correctly depicting how the different angles of incident of radiation can have different range of polarization for frequencies which varies from 450MHz and 800MHz.Elliptical polarization can be considered as the variation of Circular Polarization where waves are generated from CP Waves when they are mutually perpendicular and with an unequal amplitude. These are helpful to us as it make it difficult for undesired receiver to capture the useful signal. Elliptical Polarization can reflected waves and distribute them among different polarization components into linear,circular or other elliptical forms making it harder for the radar to analyze the signal.[14]

B. Active Stealth Monitoring

- Detection of the Radar Signal:The stealth system of the object deploys sensors to detect radar signals impinging from the host of enemy radar systems. These sensors decide the frequency and polarization, among other characteristics of radar waves utilized. This, in turn, finds out the nature of radar and the level of threat associated with the radar signals in real-time. It would calculate the most appropriate manner to reduce the detectable radar return coming out from the aircraft through the enemy configuration.Once the radar signals are analyzed, a range of various countermeasures may be used by the active stealth system to reduce the signature It can create a signal in the system that is 180 degrees out of phase from the coming radar wave. When this artificially generated wave is transmitted back, it destructively interferes with the coming wave and cancels it out, thereby reducing or nullifying any radar return which may go back to enemy radar. The system radiates false radar signals with the intention of confusing enemy radar as it tries to discriminate the object from the false echoes. The system dynamically changes the radar signature from the object by adjusting the materials, coatings, or surface features that better absorb or scatter radar waves in a manner to minimize detection.Unlike a reactive approach, active stealth systems make adjustments continuously in strategy as conditions of the radar environment change. That is to say, if the enemy radar decides to shift its frequency or polarization, the dynamically changing countermeasure would be done by the stealth system itself to maintain low detectability.Other Integration:Active stealth monitoring is very often integrated with other EW systems-namely, jammers and decoys-with the purpose of comprehensive defense against radar detection.

C. Endurance and Efficiency

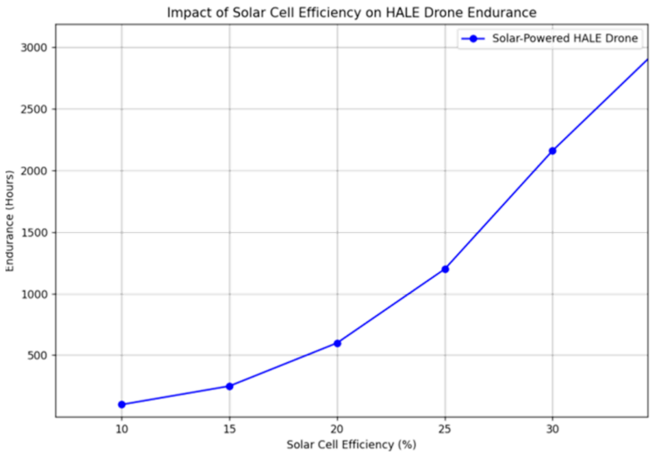


Fig -4 Solar Efficiency on Hale drones.

The following graph is showing a positive correlation: the greater the solar cell efficiency, the longer the drone endurance. In other words, it means that by increasing the efficiency of the solar cells, the endurance of the drone also increases. An example would be that at 10% efficiency, the drone might have an endurance of approximately 100 hours.

This would be able to reach up to 3000 hours at 35% efficiency.

Non-linear Growth: The graph does seem to show that growth in endurance is not fully linear. By this, I mean the increased efficiencies at higher percentages yield an ever-increasing benefit to their endurance. This is due to greater energy storage during daylight hours, which increases along with reducing losses in energy conversion, to provide this non-linear trend.[5]

Significance in HALE Drones: HALE drones fly at high altitudes where there is almost no interruption in sunlight during daylight hours, making them very apt platforms for the application of solar power. The capability for staying aloft for considerable periods of time, even days, weeks, or even months, hugely enhances these drones as being hugely useful in such applications as surveillance, communication. This effectively means that better efficiency in solar cells would equate to longer missions independent of refueling or changes in batteries, an aspect that becomes important in settings that are either remote or hostile.

D. CyberSecurity Measures

Classic intrusion detection methods may be helpless in case of unknown threats, the machine learning algorithms-just anomaly detection algorithms, to be more precise-play a vital role. These algorithms are normally trained on normal behavior patterns of the UAV network, its control systems, and streams of data. If there is suspicious activity-which could include suspect packets of communication or strange movements-this system sends an alert. K-NN, Random Forests, and Deep Learning Neural Networks are some of the techniques that have been used to find the presence of such complex attack vectors. Deep learning methods, for example, can analyze large-scale real-time data from UAV sensors and detect minute deviations that are usually missed by traditional algorithms.[11]

Profiling of Behaviour: Each behavioral aspect of the operation gets profiled for normal traffic, commands, and system operations for every UAV. Whenever a behaviour deviates, that would be the signal for further investigation or immediate action. In particular, this plays an important part when defending against insider threats or zero-day exploits, where normally traditional signature-based systems would fail.

Beyond mere detection, prevention mechanisms will actively drop or nullify the threats detected. The UAVs can automatically take actions on packet filtering, updates of access control lists, or session termination to eliminate malicious connections. Diverting the suspicious traffic to a sandbox environment, where it may be analyzed without harming the system, assures higher security without disrupting the mission.

VI. CONCLUSION

The fast pace of UAV technologies, most notably in the areas of HALE, MALE, and UCAV platforms, has further underlined the growing importance of UAVs in modern military operations. This has been facilitated by relentless strides in the sciences of materials, propulsion, and sensors incorporated into these drones, giving them capabilities for strategic surveillance missions, strike missions, and operations that are far-reaching. These drones are able to carry out their hostile environment missions effectively through characteristics like stealth, low energy consumption, and superior cybersecurity features, which most importantly ensure that superiority over the adversary defenses is maintained.

The paper will address the critical components of operational success with advanced stealth technologies integrated in radar minimization, use of composite materials for durability and efficiency, and multi-layered cybersecurity protocols that safeguard the platforms from emerging threats of GPS spoofing and data breaches.[10]

Advancements in sensor technology have been continuous. For instance, the inclusion of LiDAR, radar, and AI-driven decision support systems has generally improved the autonomy of the UAV, enabling it to perform its mission with better precision and effectiveness. The increased use of low-power-consumption solutions, such as the use of solar cells and bases related to the use of hybrid propulsion systems, undeniably indicates unending development efforts to further extend the operational endurance of such platforms in prospective and no less challenging future conditions.

With this technology having continued to mature, attention is now directed towards making enhancement of the existing systems deliver advanced performance. Research in the future should be done to concentrate and perfect advanced stealth characterization, the provision of advanced cybersecurity measures, and maximize energy efficiency. These advances will keep HALE, MALE, and UCAV UAVs absolutely dominant in present-day warfare, serving as indispensable elements for maintaining strategic dominance in an ever more complicated security environment at the global level.

VII. FUTURE SCOPE

The future of UAV technology, especially in HALE, MALE, and UCAV platforms, is bound to continue with significant developments impelled by the operational need to maintain air superiority in ever-contested environments.

The most promising avenues of future research are, for sure, the development and integration of plasma stealth technology in UAVs. It creates a plasma field around the aircraft that is capable of absorbing radar waves and considerably reducing the RCS. Still in the experimental phase, plasma stealth may finally make UAV stealth capabilities second to none, making them virtually invisible for radar detection systems. Future studies need to put a guarantee on solving the technical problems of plasma generation and control and also integrate this technology with existing material and design stealth.

While most modern UAVs come fitted with advanced sensors and rudimentary autonomous functions, the next frontier is the creation of fully autonomous systems capable of making complex decisions in real time without human intervention. This includes refinement in AI-based navigation, target identification, and threat assessment to make the UAVs more effective in dynamic and unpredictable environments. Research should also probe into ethical and operational implications regarding autonomous UAVs and ensure that those systems are compliant with international norms and standards.[13]

The endurance and efficiency of UAVs are critical for extended missions. Future research needs to be done for developing the hybrid propulsion system further, including developing a more advanced solar cell and energy storage system. This lightweight, high-capacity battery constitutes a field of evolving research and development, as well as hydrogen fuel cells as an alternative energy source that can further extend the range of a mission by a UAV and the operational time. It is also recommended that studies be geared towards improving the energy scavenging technologies to fully utilize every available resource given throughout a flight.

Of the very exciting areas for future research, adaptive materials are those whose properties can change based on environmental response. Such material would grant the UAVs active shape, surface characteristics, and thermal signature changes for performance optimization and stealth. Materials that would shift their characteristics depending on the frequency of incoming radar signals-for example, radar frequency-absorbing-would greatly improve survivability in hostile environments.

REFERENCES

[1] Chamola, V., Kotesh, P., Agarwal, A., Naren, Gupta, N., & Guizani, M. (2021). A comprehensive review of unmanned aerial vehicles. An extensive survey of UAV-related threats and methods for their neutralization. Ad Hoc Networks, 111, 102324. https://doi.org/10.1016/j.adhoc.2020.102324.

[2] Coşar, M. (2022). A study on cyber vulnerabilities of UAVs and preventive cybersecurity measures. The

Eurasia Proceedings of Science, Technology, Engineering and Mathematics, 21, 258-265. https://doi.org/10.55549/epstem.1226251.

[3] Tsach, S., Yaniv, A., Avni, H., & Penn, D. (1996). The use of HALE UAVs in intelligence gathering missions. Israel Aircraft Industries Ltd., Ben-Gurion Airport, Israel. ICAS-96-4.2.1.

[4] Adamski, M. (2019). A performance review of UCAVs in contemporary military operations. Faculty of Aviation, Military University of Aviation, Dywizjonu 303 35, 08-521, Dęblin, Poland

[5] Carey, S. B. (2014). Enhancing UAV endurance and payload capabilities using thin-film solar cells (Master's thesis). Naval Postgraduate School, Monterey, California, USA. Retrieved from http://hdl.handle.net/10945/42594.

[6] Duriez, E., Guadaño Martín, V. M., & Morlier, J. (2022). Material selection and ecodesign optimization in HALE UAVs. ICA, Université de Toulouse, ISAE-SUPAERO, MINES ALBI, UPS, INSA, CNRS, Toulouse, France.

[7] Prisacariu, V. (2017). The development and evolution of UAV technology up to the 1970s. The History of UAVs, 8, 181-189.

[8] Metrick, A. (2017). The limitations of UAVs in contested operational environments. Defense360, December

[9] Bhatta, N., & Geetha Priya, M. (2017). Radar technology and its modern applications. Journal of Radar Systems, 10, 1-9

[10] Schwartz, C. E., Bryant, T. G., Cosgrove, J. H., Morse, G. B., & Noonan, J. K. (n.d.). Radar systems designed for UAVs.

[11] Rudys, S., Ragulis, P., Laučys, A., Bručas, D., Pomarnacki, R., & Plonis, D. (2022). Comparative study of UAV detection using solid-state marine radar systems. Electronics, 11(16), 2502. https://doi.org/10.3390/electronics11162502

[12] Weibel, R. E. (2005). Safety issues for operating various UAV classes within national airspace (Master's thesis). Dept. of Aeronautics and Astronautics, Massachusetts Institute of Technology, Cambridge, MA, USA.

[13] Khawaja, W., Semkin, V., Ratyal, N. I., Yaqoob, Q., Gul, J., & Guvenc, I. (2022). Threat analysis and counterstrategies for UAVs and underwater vehicles. Sensors, 22(10), 3896. https://doi.org/10.3390/s22103896

[14] Banga, N. (2017). Analysis of stealth aircraft technologies and their influence on radar systems in modern warfare. Journal of Advanced Defense Technology, 9(8), 55654-55658.