UNMANNED AERIAL VEHICLE FUTURE DEVELOPMENT TRENDS

Gabriel RĂDUCANU, Ionică CÎRCIU

Henri Coandă Air Force Academy of Brasov, Romania, (gabiraducanu@yahoo.ca, circiuionica@yahoo.co.uk)

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Abstract: *Unmanned aerial vehicles can be equated with multisystem entities that require transdisciplinary knowledge, concepts and technologies (for example: aerodynamics, electronics, informatics, materials) that train a range of resources across the entire technology chain (design, manufacturing, testing, operation). The use of a UAV in a hostile environment leads to a considerable reduction in the risk of human losses and allows the use of smart weapons outside the range of forces and means of the opponent.*

The article wants a descriptive presentation of UAV missions and future development trends in this area.

Keywords: *UAV, sensors, hybrid systems, UAV missions.*

Acronyms and symbols

IFR	Instrumental Flight Rules	IMINT	IMagery INTelligence
DDD	Dirty, Dull & Dangerous	EO-IR	Electroptic-infrared
SAR	Synthetic Aperture Radar	TESAR	Tactical Endurance Synthetic Aperture Radar
SMA	Shape Memory Alloy	UGV	Unmanned Ground Vehicles
USV	Unmanned Surface Vehicles	VTOL	Vertical Takeoff and Landing

1. INTRODUCTION

The use of unmanned aerial vehicles in modern airspace generates new challenges with leverage over aircraft operation and airspace management supported by legislation that needs to be adapted to new realities. Lack of coherence in addressing new concepts of aeronautical management (airport, logistics) may give rise to security implications sometimes with notable consequences.

It is important to highlight both the technological maturity of unmanned aerial vehicles and their concepts of operation and maintenance, both of which have implications for human resources using such technical systems. Unmanned aerial vehicles can be equated with multisystem entities that require transdisciplinary knowledge, concepts and technologies (example: aerodynamics, electronics, informatics, materials) that train a range of resources across the entire technology chain (design, manufacturing, testing, operation). Failure to know or knowledge of unmanned airplanes in terms of their mode of operation and requirements, limits and performances [1, 2, and 3] may have negative implications for airspace security.

1.1. Advantages and disadvantages of uav's

After analyzes, according to [1, 3] we can summarize a number of advantages and disadvantages regarding the use of unmanned aircraft. The advantages of UAV are mainly transposed into operational aspects (operation, maintenance), the most significant being: ease of launching and recovering, requiring no pretentious ground infrastructure, heavy overloads; has IFR flight capabilities from the outset, increased autonomy through lower fuel consumption, can carry out a wide range of dangerous DDD (Dirty & Dangerous) missions; reducing pilot training versus flight time eliminating the risk of losing lives.

Technological and manufacturing advantages are: the dimensions can be considerably reduced for the same range of missions; a greater payload on average of almost 25% compared to a conventional airplane (reduction of the mass resulting from the removal of the cabin, the catapult, the life-maintenance facilities, the equipment and the dashboard); considerably lower manufacturing costs.

Disadvantages: Field of view of the ground operator is limited which can lead to high collision risk (for vectors without sense and avoid); is prone to loss of radio link that often has destructive effects; the operator's delay caused by the radio wave gap; the need for broadband for data transfer; increased risk of jamming; the automatic pilot cannot act properly in the event of limit situations; lower loads for cargo transportation; dependence on unfavorable weather factors; lack of refueling capacity in the air.

1.2. Mission of uav

According to the specialist references [3, 4, 5], the current UAVs can carry out a wide range of missions such as: identification, attack, radio transmission and communication, observation, surveillance; air support of military actions; evaluation of the effects of the actions or blows; acquisition and laser targeting. The use of a UAV in a hostile environment leads to a considerable reduction in the risk of human losses and allows the use of smart weapons outside the range of forces and means of the opponent.

Engagement in direct air support missions can be extended to what USAF specialists call a closed loop precision procedure that includes surveillance, target acquisition, attack, impact assessment, and cycle resumption, if necessary, all in one very short time.

The images transmitted from the UAV are, as a rule, almost real time, and the results are communicated over encrypted data transmission channels. For the efficiency of the activity, the distribution of the images is made in real time both to the ground control station and to the command structure that requested it, the images being processed both during and after the mission [6].

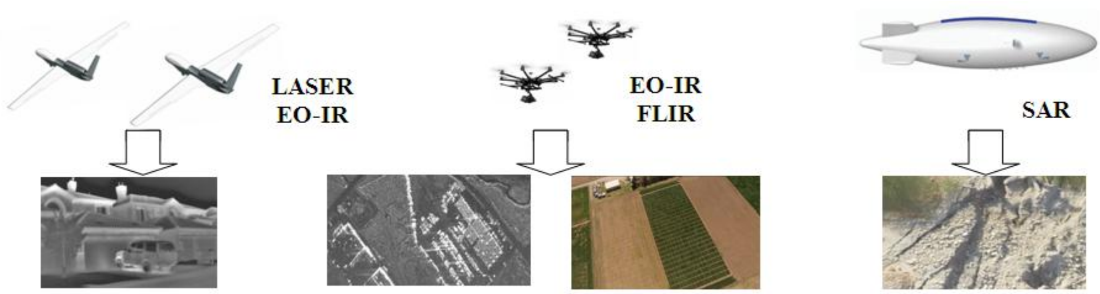


FIG. 1 Sensor data fusion UAV

The availability of a UAV is determined by the usefulness and quality of the payload, with most existing vehicles being represented by different types of sensors and concepts of use (data fusion, TESAR system), see Fig. 1 [8].

The transported sensors differ in type and performance according to the role of the UAV and mission requirements. To eliminate the influence of platform motion on UAV images, sensors can be fitted with a gyroscopic stabilization system. The significant increase in the computing power of the onboard computers, coupled with the reduction in size, weight and power requirements of sensors and their control systems, also leads to a continued increase in UAV usage. All useful IMIT (Imagery INTELLIGENCE) fieldwork tasks are characterized by the sensitivity they have in the construction and ultimately expressed through image quality, more precisely by resolution, [4].

2. FUTURE DEVELOPMENT TRENDS

Innovative concepts, methods, technologies and materials will have a major impact in the field of UAVs used in military operations and in civilian missions, which are based on advances in information technology, nanotechnology and miniaturization. The adoption of innovative aerodynamic concepts is an important research direction for the optimization of unpolluted systems both in terms of flight autonomy and range of action and versatility of the system (example: VTOL concept), see Fig. 2.


a

b

Fig. 2 VTOL concept, a. Tempest DL (VTOL), b. VBAT martin UAV, [17, 18]

Increased data processing power provides the ability to process in-vehicle sensor information in real-time and the ability to perform complex autonomous operations.

Most of the bandwidth is used to send raw data to the ground station for processing, so this leads to a decrease in the mass, the aural load, and implicitly the cost of manufacturing, maintenance and operation.

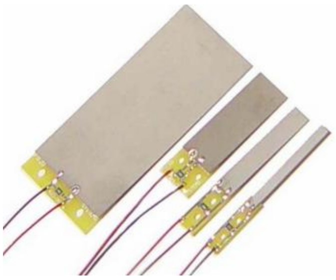
Miniaturization reduces costs, increases reliability, and increases the functionality and capability of UAVs. The inclusion of micro-electro-mechanical systems and other technologies (nanotechnology, morphing, intelligent materials) for sensors and data acquisition systems allows the miniaturization of complex systems and platforms see Fig. 3.

a


b

FIG. 3 Miniaturized systems, a. WASP microUAV, b. Black Widdow miroUAV, [9]

The use of ***intelligent materials*** in the realization of UAVs has direct influences on concepts of design, manufacturing, maintenance and operation. From this category we can mention: piezoelectric and ferroelectric materials, electro-structural materials, magneto-strictive materials, shape memory alloys (SMA), optical fibers, see Fig. 4.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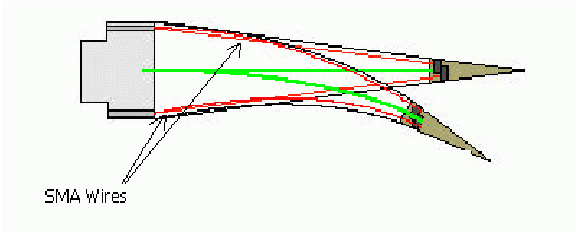

b

FIG. 4 Smart materials, a. piezoelectric sensors, b. memory shape alloys (SMA), [10]

The use of the ***morphing concept*** has led to a renewed interest in making substantial changes to the UAV shape and geometry, to the controlled change of the wing surface and curvature of its profile. Rapid and controlled modeling of the aperture and wing geometry can also be used to actively control some undesirable phenomena such as airplane detachments at low attack angles, or the occurrence of wing-induced aero-elastic loads, see Figure 5. Changing the shape and profile of a wing for different types of mission has been the subject of extensive studies reported in the literature [11, 12, 13, 14].

FIG. 5 The concept of morphing, [15]

Use of ***UAV-UAV, UAV-UGV, UAV-USV hybrid*** air systems to increase the range and total operating time (operating in different environments).

UGVs are somewhat deficient in completing a more complex mission because the field of vision obtained by both on-board cameras and sensors is limited to 2D. A UGV can carry additional loads and sensors beyond the weight and power limits of an unmanned air vehicle and can easily carry out missions of longer duration. A possible solution could be to adopt a UAV that would overhang the ground vertically to the UGV, so the visual range would increase considerably. To minimize the intervention of operators, the autonomous capabilities of the platforms involved will be improved. The UAV-UGV hybrid system is used in surveillance missions, cooperative mapping and mine detection and disposal [16], see Fig. 6.

FIG. 6 Unlisted hybrid systems (UGV-UAV), [16]

Implementing artificial intelligence

Current research efforts aim to operate UAVs under full ownership as a function of mission pre-programming. Increasing the autonomy of an unmanned aerial vehicle requires the implementation of a program complex in the UAV's onboard computer before the mission. A completely autonomous system is the system capable of operating in the environment, without any form of external control, for long periods of time. By autonomy is meant the use of artificial intelligence, reaction in the shortest possible time and accumulated experience, in order to overcome an unplanned situation by the airborne individual.

The study of artificial intelligence has experienced an explosive development, in a manner similar to that of UAS development. For the development of artificial intelligence, two approaches were considered. One is a bottom-up approach that attempts to develop some neural networks similar to those necessary for the functioning of a human brain. Another approach, which comes in contradictory terms and is known as top-down, involves the use of high-speed algorithms to simulate the performance of a human brain.

Li-Ion/Li-Po intelligent battery

Most air vehicles are propelled by electric motors, so most times that the battery is the component with the largest weight of the platform. To limit this inconvenience, but also to improve the performance of a UAV, to increase the range of action and flight autonomy, a battery concept based on lithium-ion (Li-Ion) has been developed. These batteries have a relatively high density of energy compared to other types of batteries. This energy density is due to the fact that lithium is the most electropositive (standard electrode potential = -3.04 V) but also the lightest metal (equivalent mass = 6.94 g/mole). Li-Ion batteries have a low discharge rate, a wide range of operating temperatures, and a long-life cycle. The advantages offered by this type of batteries mainly used by UAVs are: high energy density; low maintenance costs; low self-discharge properties; the flexible battery housing allows a design freedom in terms of profile thickness; their operation over a thousand load cycles. A disadvantage of these batteries is *the short-circuit* and overload vulnerability, see Fig.7.

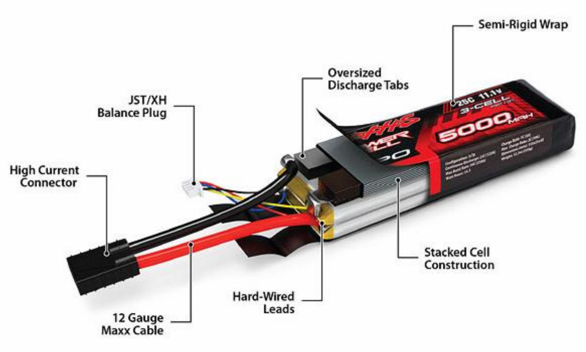

FIG. 7 LiPo batteries

Use of multispectral / hyperspectral sensors

For the development of unmanned airborne vector ISR / ISTAR capabilities, specialists' concerns have focused on the use of sensors used to acquire data constituting both the actual mission and the acquisition of data necessary for navigation and trajectory control. An important category of sensors is those used to acquire image data (hyperspectral), used to enhance the optoelectronic image for providing stereoscopic and spatial data.

The raw data provided by the multispectral sensors are refined with specialized software tools that process pre-calibrated databases and provide optic finite information including radiometric, spectral, textural and contextual data [19, 20].

3. CONCLUSIONS

Modern warfare requirements are more and more varied and complex, and the UAVs have taken over for the most part, with a great success rate and operating expenses considerably lower. In the context of the current armed conflict requirements, more and more UAV missions are being given. This type of mission requires the design of the new aerial vectors, considering the reduced size with a high maneuverability, smallest radar and noise footprint, and last but not least with a good transport capacity. The simultaneous fulfillment of these conditions greatly increases air superiority in combat.

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