Considerations Regarding Detection and Combat Systems for UAV's

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Abstract
The use of UAV's in modern airspace means to required new concepts because of the non-compliance in the aeronautical domain, such as anti-drone system. Anti-drone combat systems are assigned to detect, identify, neutralize or destroy miniaturized air mainframe systems (UAVs), when the UAV violates areas or executes hostile action. These systems combine the active detection capability with passive detection systems. Thus, UAVs neutralization is achieved by radio methods or actual destruction. The articles aim is to make an introduction to the anti-drone systems and propose innovative technical solutions.

Keywords
UAV, sensors, anti-drone, target

Symbols and acronyms

DIY	-Do It Yourself	ISM	- Industrial, Scientific, Medical
RSSI	- Received Signal Strength Indicator	UCAV	- Unmanned Combat Aerial Vehicle
FMCW	- Frequency Modulated Continuous Wave	ISTAR	-Information, Surveillance, Target acquisition, and Reconnaissance
SIGINT	- Signal Intelligence	IR	- Infrared

1. Background about UAV's

UAV technology is mature and proven its versatility exponentially both in military and civilian use. There are reports and studies that provide information and different approaches about the field from simple low cost systems to air vectors used in combat missions (UCAV), covering international zone [1, 3, 4, 8...10] and the national zone [2, 4].

Miniaturization of electronic sensors (accelerometer, barometer, magnetometer, and gyroscope) and the emergence of development boards and actuators allowed industrial-scale production for miniaturized air robot systems, Figure 1.

accelerometer, magnetometer, gyroscope | video sensor | servo-mechanism | actuator

Fig. 1. Sensors and actuators [5]

Unmanned aerial vectors (UAV) are technical systems that can be purchased at affordable prices even by civilian users who can work or not with the specific conditions imposed by national and international regulations. The use of UAV's in modern airspace means to impose new concepts because of the non-compliance in the aeronautical domain, such as anti-drone system.

2. Considerations Regarding Detection and Combat Systems for Anti-Drones

The mission for anti-drone combat systems is to detect, identify, neutralize or destroy miniaturized air mainframe systems (UAVs), when the UAV violates areas or executes hostile action. These systems combine the active detection capability with passive detection systems.

Both specialized studies [20…22] as well as information producers [11, 12, 14, 17…19, 23] reveals a constant concern regarding the design, manufacture and operationalization for anti-drone systems. In what follows, are presented theoretical guidelines on the detection step and nondestructive counter-chase target, type UAV with rotary-wing (multi-copters).

2.1. Detection and target tracking

Detection and target tracking can be achieved with active sensors (radar) or by passive sensors (infrared monitoring system for audio), and with the data collected from the detection sensors, the azimuth of the target, distance and height can be identified.

Currently UAV structures, dimensions and low altitudes evolution, create detection problems using classical radar. In these circumstances arose specialized detection systems for UAVs, for example the system developed by *Blighter Surveillance System* using radar detection and having the capability to discover targets up to 10 km and follow up with passive video and thermal systems [11, 14], Figure 2 and Table 1.

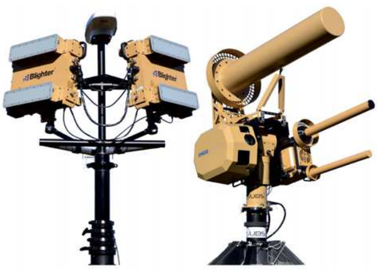


Fig. 2. Blighter Surveillance System Anti-drone System [11, 14]

Table 1. Tactical and technical characteristics [11]

Detection range	10 km	Minimal target size	0.01 m^2
Power output	4 W	Azimuth coverage	180°
Elevation adjustment	-40° ÷ 30°	Radar type	FMCW

Identification involves establishing membership for targets, if not hostile or by using a system code response radio or visual identification code (codes of lights).

Audio detection systems continuously scan the space in which they are installed and continually compare it with audio data library. Propellers rotations generate a unique frequency that can be identified at a considerable distance. Once the source is identified, we can specify which type of drone it is "custom or DIY drones "or we can identify precisely from the existing commercial systems. Figure 3 show audio detection systems by Drone-Shield [12].

Omnidirectional microphone Long-range microphone

Fig. 3. Audio detection systems by Drone-Shield [12]

Radio detection systems are designed to detect drones based on radio signals emission. Now all commercial drones frequently use "ISM Band" (Industrial, Scientific, Medical Band) approved for use in the different geographical areas, national [13] and international [15]. Issues that are addressed in the detection of radio drones are: radio signal modulation, coding protocol information, signal strength, RSSI, Figure 4.

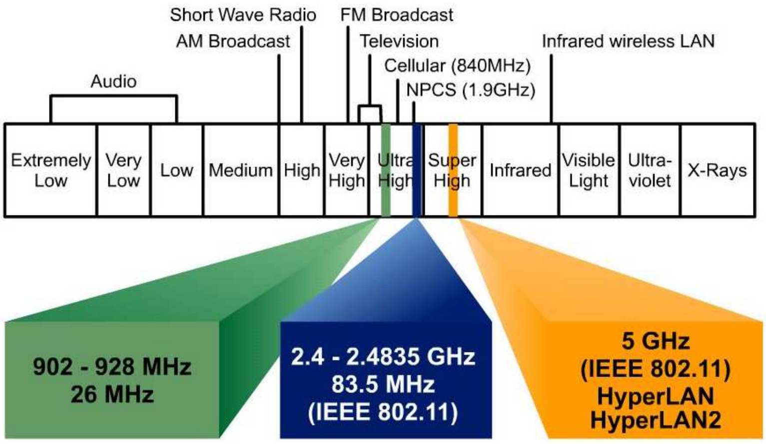


Fig. 4. ISM band [16]

Based on this information anti-drone systems that identify radio signal compare it with the existing databases which is loaded on the aircraft, Figure 5.


Fig. 5. Advanced Anti-Drone Protection and Neutralization System [17]

The ReDrone system (Figure 6) is designed to detect, identify, trace and neutralize different types of drones flying across a range of communication protocols, radio frequency that can operate with ISTAR SupervisIR systems (infra-red wide-area persistent system) allowing SIGINT operations capabilities and thermal image sensing for hostile drones.

Detection systems use visual recognition technology to form the image. These cameras can be used both in visible and infrared spectrum having the ability to recognize the aircraft by applying a mathematical algorithm on the captured image (Figures 6 and 7) [18, 19].

2.2. Non-destructive combat against drones

Non-destructive combat can be classified by different criteria, the most important being the jamming and purse.

Combat fighting systems with active jamming disrupts useful reception of electromagnetic signals caused by the overlap of signals across these parasitic issues with the same frequency and higher power. Once activated the jamming system, the UAV will enable (for those who have implemented this feature) fail safe function that will order an immediate landing of the aircraft in the area using data collected by the barometric sensor [23…27] as presented in Figures 8 and 9, and Table 2.

Fig. 6. Re-drone system [18]

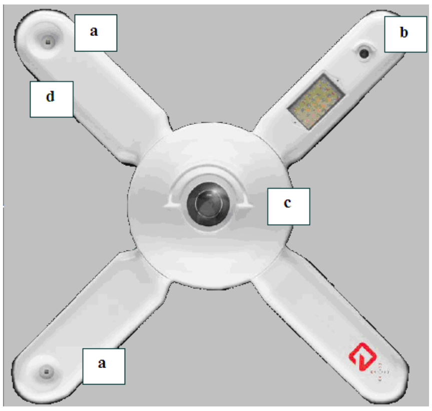


Fig. 7. Drone Tracker [18]
a - acoustical sensors; b - IR sensors; c - video sensors; d - Wi-Fi sensors

UAV Drone Jammer CPB-4030C [23]

Fig. 8. Anti-drone jamming systems

DroneGun Tactical Drone Jammer [25]

Drone jammer disruption [26]

Fig. 9. Drone jammer system gun

Table 2. Tactical and technical characteristics [23]

Power supply	220V	Jamming range	500 m
Power consumption	100/200W	Operation time	24 h and 7 days
Weight	42 kg	Jamming bands	4

Combat fighting systems with purse use a purse launched by a vector air (missile or drone) being a carrier in the vicinity of the target, Figures 10 and 11 [6, 28].

3. Proposal for a Combat Air Module against Drones

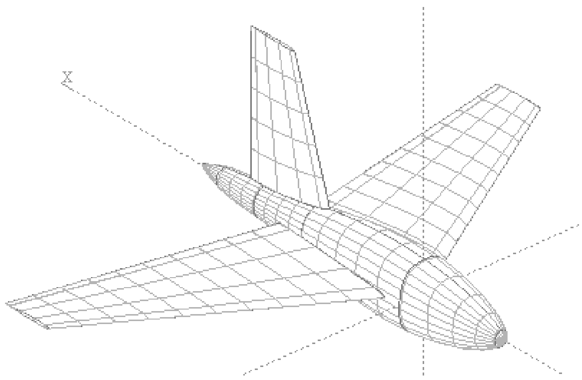
To achieve a functional model in terms of minimum and maximum speeds for an air vector we propose four different aerodynamic versions, presented in Figure 12, versions that can perform combat missions for stationary and quasi-stationary targets.

a *b*

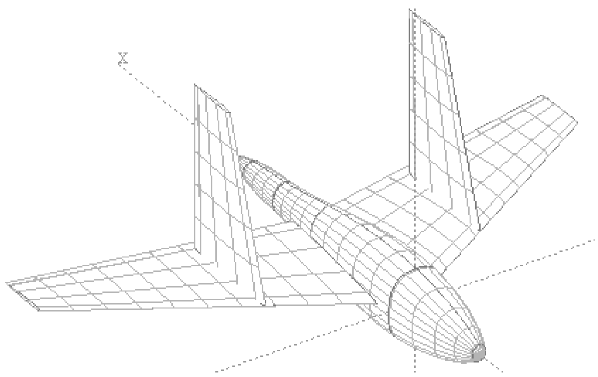
Fig. 10. Sky Wall systems [28]
a - Gun system; b - Projectile launch drone system

a *b*

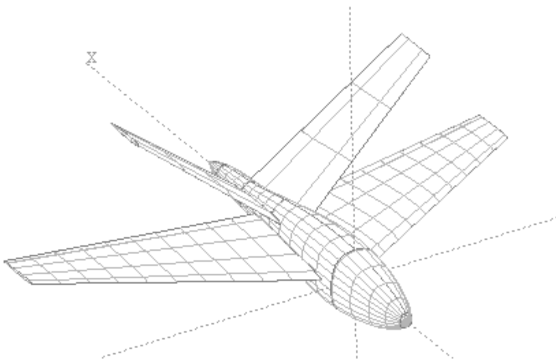
Fig. 11. M.A.L.O.U. Tech System [6]
a - in flight; b - in action



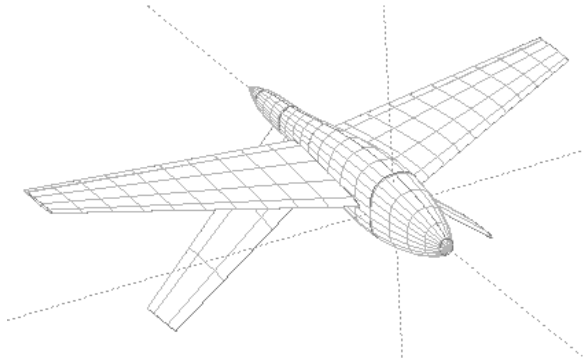
a. Classic version



b. A two-derived version



c. V-tail version



d. V-tail reversed version

Fig. 12. Constructive versions for anti-drone vector

The proposed aerodynamic versions are made with 3D instrument module XFLR 6.09 software; freeware tool analyzes which uses both 2D and 3D analysis and stability [29, 30, 31].

The proposed versions have the common characteristics in Table 3.

Table 3. The characteristics aerial vector

Wingspan / Length [m]	0.5	Maximum weight [kg]	0.5 ÷ 0.7
Lifting surface [m^2]	0.5	Range [m]	100
Elongation	5	Propulsion	Electric, propulsive propeller
Maximum speed [m/s]	20	Launch device	Portable device

The method to combat a target with such a vector is based on the use of nets launched to a target, and the recovery step is performed using a parachute, [7, 32] to prevent of the mechanical shocks that can affect radio-electronic equipment. Aerodynamic variants have an electric motor with pusher propeller and parachute recovery in the front of the fuselage, Figure 13.

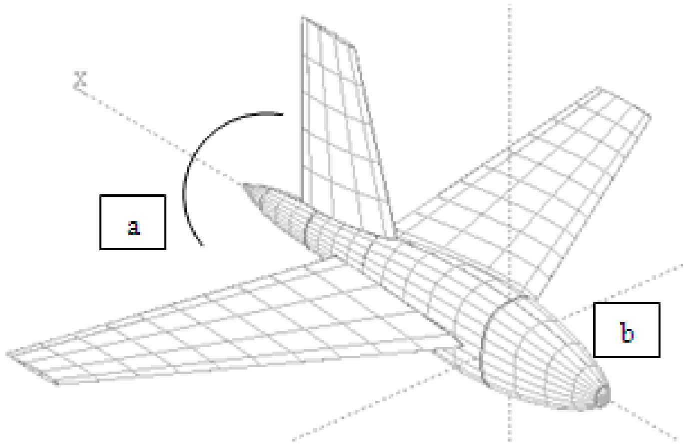


Fig. 13. Aerial vector
a - propulsion system; b - recovery module

4. Conclusion

Most unmanned aircraft from the mini and micro class use electric motors as propulsion system. Although they are less efficient than internal combustion engines, size and low noise makes them ideal for reconnaissance missions at low height. Anti-drone systems development is evolving normal, being used in modern airspace under low compliance conditions and military combat operations.

The future of UAV belongs to fully autonomous systems which uses for data acquisition and neutralization. The neutralization concept can be applied regardless of the anti-drone system.

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