Journal scientific and applied research, vol. 14, 2018
Association Scientific and Applied Research
International Journal

Original Contribution ISSN 1314-6289

STUDY OF UNMANNED AIR VEHICLES UNDER EXTERNAL IMPACT

P.Getsov*,**,D.Jordanov**, WangBo*

*NINGBO UNIVERSITY OF TECHNOLOGY-CHINA;
**SPACE RESEARCH AND TECHNOLOGY INSTITUTE –BAS, BULGARIA

E-mail: bo305@hotmail.com, director@space.bas.bg , djordanov@space.bas.bg

ABSTRACT: *By modeling a unmanned air vehicles, the possibilities for impact on the operation of the autopilot for the purpose of terminating the flight and destroying the aircraft were examined.*
KEYWORDS: *UAV,CONTROL SYSTEM, SAFETY,AUTOPILOT*

Past years between the wars in former Yugoslavia and Syria have shown a growing role for unmanned aircraft. The real idea of their capabilities is now being formed and different ideas are attempted to counteract terrorist operations with them. All modern UAVs are managed by an autopilot that can get the task from a pre-modeled flight mode. If constructed with an onboard computer, they are capable of operating autonomous flights outside of the direct visibility zone between the operator and theUAV. So they are independent of the radiolink, the signal from which it can fall from natural failures of technique. The control point is used only to bring the airplane to the starting point for autonomous flight and for trajectory adjustments. Mass UAVs, however, have no onboard computer and their value is low. Exactly such devices most often carry an explosive and are equipped with contact explosive devices. They rialise damage after being destroyed around the objects for which they are designed and targeted (airports, warehouses, etc.). They are managed by radiolink from a ground or airborne control point. The apparatus is equipped with a reception system for the signals from this point. This fact shows that each UAV(including onboard computer) capable of receiving signals and reacting to them as a command or field-correction command can be the object of systems that will upset the current management processes and bring it in a trajectory to the ground before it reaches its target objects. This can be used by the Radioelectronic Combat Systems (RED).

In order to be able to divert UAVs detectedьь in the surveillance zone, it is necessary to interfere with the control via autopilot signals that change the flight path.This idea can be set as a way to block autopilot (AP) work. The proposed development has been tested by modeling some variants that are provoked by the modeling and investigation of various failures of autopilot:

The models are in GOST 20058-80 for a hypothetical unmanned airplane with a mass of 50kg and are basically of the model developed in [1]. Inputs simulating the performance of Radioelectronic Combat Systems (RED) are used to match pulse generators developed in Simulink. Flight is a spatial maneuver at a height of 10m to 500m and a speed of 100km/h. The modeling data required were calculated according to the methodology of [3].

Autopilot control laws in the model UAVs are as follows:

Ailerons: $\delta_e = K_e^{\gamma}(\gamma - \gamma_{set}) + K_{1e}\int(\gamma - \gamma_{set})dt + K_e^{\omega_x}\omega_x$

$$\gamma_{set} = K_e^{\psi}(\psi - \psi_{programme}) + \gamma_{programme} + \gamma_{set\,from\,pilot} - K_Z(Z - Z_{programme})$$

$$\gamma_{set\,from\,pilot} = K_{pilot}(\gamma - \gamma_{programmeof\,pilot})\frac{K}{Tp+1}$$

Where: δ_e - variation of ailerons; γ - bank of angle; ψ - yaw (course) of angle; Z-side variation; K-transmission coefficients; ω_x-rolling speed;

Elevator: $\delta_h = K_h^{\vartheta}(\vartheta - \vartheta_{set}) + K_h^{\omega_z}\omega_z + K_h^H(H - H_{set})$

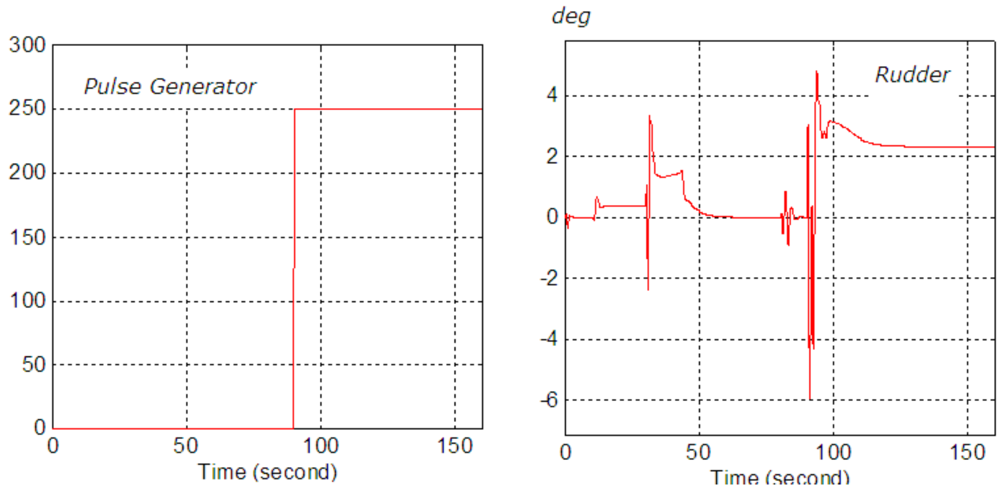
Where:

δ_h -variation of elevator; ϑ -pitch; ω_Z-pitching speed; H-height of flight.

The rudder direction only works with an angular rate of risk signal and is essentially a damping machine for the course variations.

The modeling shows that, in a horizontal flight, the sudden disruption of the control signal from the AP to the UAV rudder is not effective enough and leads to a slow downgrading along the sloping trajectory as the steering gear is in the neutral position.

In the case of a strong single signal from the AP, resulting from the external single cuts affecting the Radioelectronic Combat Systems (RED (Fig.1a), there is a sharp deviation of the steering gear (Fig. 1b,2) and there is a rotation around the three axes, with predominantly rotation around the longitudinal axis. Total movement is characterized by a rapid decrease of the height, and in the course of the movement the angle of attack exceeds the critical (25degrees) (fig.3). The overload is about 5g, which can cause damage to the hypothetical apparatus in the air. The aircraft rapidly reaches the ground at a pitch angle of -50 degres and breaks at a vertical velocity of about 5m/s, rapidly on a steep spiral trajectory. The variation of elevator is significant, which takes the plane to the critical angles of attack and heavy overloads. The ailerons, in the event of interference, strive to bring the plane to a large angle of inclination. This happens quickly and after 10 seconds the ailerons occupy a neutral position (Fig. 2). The autopilot has perceived the interference as a set slope of over 25degrees. Since the interference is constant, the steering gear movements do not change after 100 seconds. Movement between the 90th and 100th seconds can be seen as a transient process after a constant disturbance. The plane is spinning in a steep spiral. The aircraft goes into supercritical angles of attack and overloads overtaking operational, and for some planes and destroying.



a) b)

Fig.1. Signal from the pulse generator and variation of the rudder under the influence of the developed angular rate of risk fluctuations at the fall of an UAV.

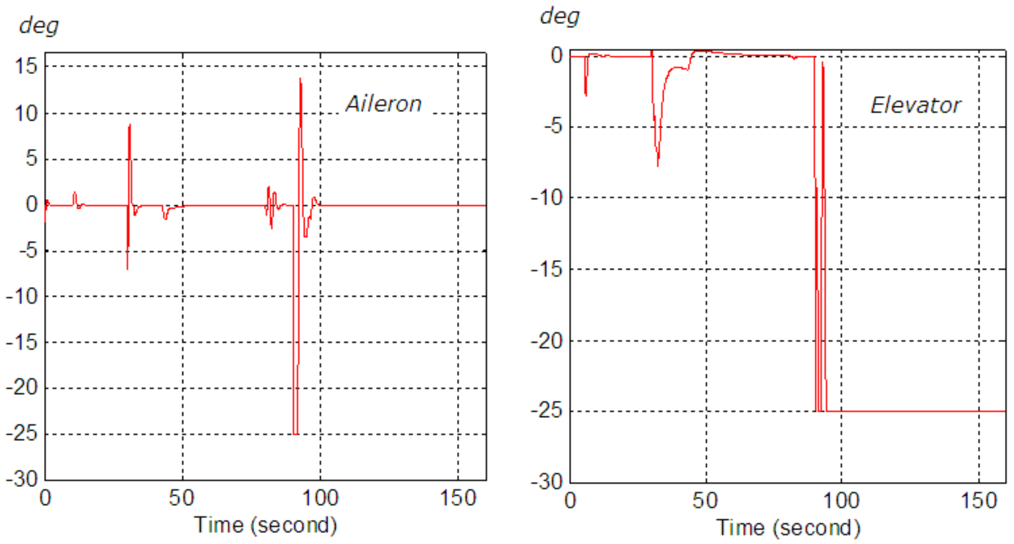


Fig.2. Variations of the ailerons and the elevator of the steering gear under the influence of the programmed autopilot mode and the overturned pulse generator disturbance.

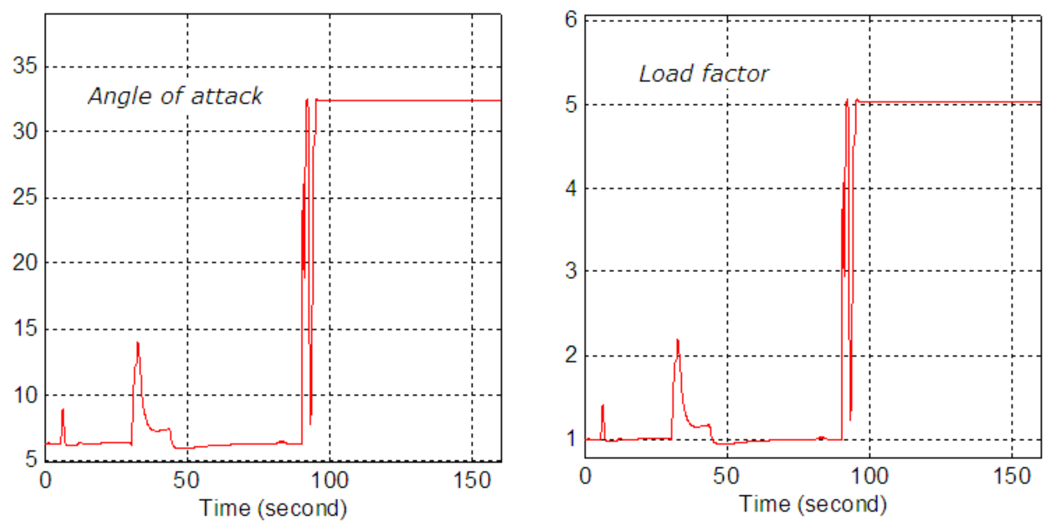
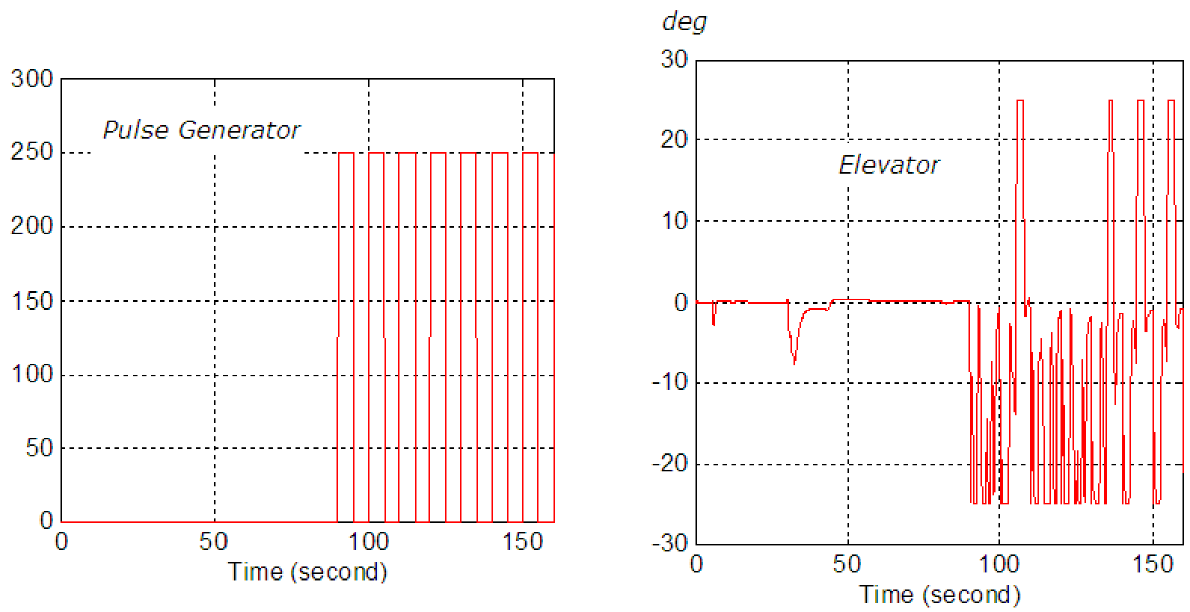


Fig.3.Angle of attack and normal overload during flight.

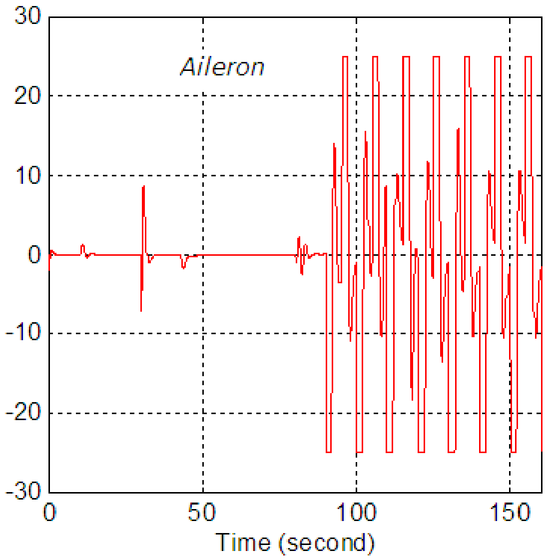
By 90 seconds, the aircraft operates on the programmed trajectory. The autopilot operation is then manipulated by the pulse generator. The aircraft goes into supercritical angles of attack and overloading over operating, and for some planes and the destructive

When generating the generator ("Pulse Generator" from "Simulink") for pulse operation, the signal radiating signals are also received by the AIRCRAFT-AUTOPILOT subsystem (Figure 4a). They arrive summed up with the autopilot to complete the flight plan (in this case, for a "round flight"). The helm and helmets begin to move continuously over a wide range (sometimes from end to end of constructive constraints) (Fig. 4b, 5).



a) **b**

Fig.4. Model signal from pulse generator setting for interference and elevator.



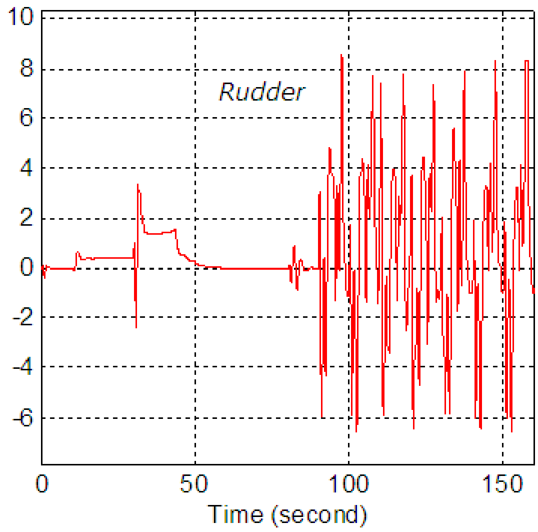


Fig. 5. Deviation of the ailerons and rudder with predominant interfering signal impact.

The UAV trajectory, after the impact of the pulse generator, is a chaotic rotation around the three axes with a general, uneven downward tendency. The angle of attack in this short-circuited movement (of impulses) passes into and out of the critical area. The overloading also exceeds and plane will destroyed (for the particular apparatus is critical n = 4g).

Conclusions:

1. The results show an opportunity to counteract perceived UAVs by manipulating their management. The degree of efficiency depends on the setting of the interferometer, the autopilot laws and the dynamic properties of the airplane.
2. For a concrete airplane and autopilot, the setting of the constant loud interrupter is a more effective means of radio-electronic combat. With such a signal, the trajectory is steeper and the time to reach the land surface of 300m is about one minute. The impact on the ground has a vertical velocity of 5m/s. Destruction in the air is possible for airplanes with breakdown overloads of less than 5g, which is often considered as a normative design value for drones, because it guarantees a lighter structure.

Reference:

[1]. Jordanov D., Gecov P. *"Unmanned aircraft – modeling and control"*, Third Scientific Conference with International Participaton, „SPACE, ECOLOGY, NANOTECHNOLOGY, SAFETY", 27–29 June 2007, Varna, Bulgaria.

[2]. Jordanov D., Gecov P., "CONTROL THROUGH MODEL OF UNMANNED AIRCRAFT", XV International Conference on Transport, Construction, Road and Lifting Transport Equipment and Technologies, 18-20.09. 2008 Sozopol, http: /www.trans-MOTOAUTO.com

[3]. Jordanov D., S.Fotev *"Autopilot Failures During Operation of the Unmanned Complex"* International UNMANNED VEHICLES Workshop UVW 2010 10-12 June , Istanbul, Turkiye, www.hho.edu.tr/uvw2010.

[4]. Yordanov D. Design and Research of the "Unmanned Airplane" -Autopilot System by Computer Analogue "SPACE, ECOLOGY, SAFETY" 2 - 4 November 2016, Sofia, Bulgaria, http: /www.space.bas.bg

[5]. Yordanov D., Getsov S., "Investigation of the Role of the Flight Safety Management System" Twelfth Scientific Conference with International Participation "SPACE, ECOLOGY, SAFETY" 2 - 4 November 2016, Sofia, Bulgaria, http:/www.space.bas.bg

[6]. P. Getsov ,Wang Bo, D. Zafirov,G. Sotirov,St. Nachev,R. Yanev,P. Gramatikov ,V. Atanassov,H. Lukarski,S. Zabunov,AN UNMANNEDAERIAL SURVEILLANCE SYSTEM IN URBAN ENVIRONMENTS,Aerospace Research in Bulgaria, 2018, 29, http:/www.space.bas.bg

Acknowledgements

I. The study was performed with the use of the base:

1. Set up under the project BG161PO003-1.2.04-0053 "Information complex for aerospace environmental monitoring" (IKAMOS), financed by the operational program "Development of the competitiveness of the Bulgarian economy "2007-2013, co-financed by the European regional development fund and from the national budget of the Republic of Bulgaria.

2. Project "Strengthening and Expansion of the Aerospace Technology Transfer Office in the Field of Protection of Citizens' Health in Disasters" - BG161PO003-1.2.02 under the Operational Program "Development of the Competitiveness of the Bulgarian Economy" 2007-2013"

II. The authors gratefully acknowledge the support of K. C. Wong Education Foundation.