# MULTI AERIAL SYSTEM STABILIZED IN ALTITUDE FOR INFORMATION MANAGEMENT

**Vasile PRISACARIU*, Ionică CÎRCIU **, Cătălin CIOACĂ**,**
**Mircea BOŞCOIANU**, Andrei LUCHIAN *****

*"Transilvania" University, Brasov, **"Henri Coanda" Air Force Academy, Brasov, Romania
*** "Politehnica" University of Bucharest, Romania

***Abstract*** *: Multi agent Aerial system for information management, acronym MASIM aims acquisition of spatial information in areas of interest, refining and managing the data obtained using* ***a*** *multi agent miniaturized platform, coordinated by a mobile off-road earth station.*

***Key words****: MASIM, radio altimeter, saturation.*

## 1. INTRODUCTION

Multi agent systems are a complex area because it consists of several functional levels: lower level (with data collection based sensors, data fusion - combining data to reduce uncertainty, data for assessing the situation and threats); middle level (with agents who decide how to act effectively, to create a coordinated response); higher level (strategic planning that includes objectives and priorities to achieve response to several beneficiary structures).

MASIM is a decentralized architecture, which offers the advantage of robustness, scalability and versatility, built on a multidisciplinary approach:

- filtering and data fusion methods for estimating the relevant state variables (position of victims and rescue vehicles);
- decision-making and machine learning methods for determining the responses (when and where are the targeted intervention and evacuation vehicles);
- multi-agent systems, game theory and management mechanisms for modeling interactions between collective actors behavior;
- studies of various system architectures and topologies to exchange information (centralized, hierarchical or decentralized).

Mobile command center and network monitoring overflight is currently equipped with a solution for piloting the UAV equipment based on open-source architecture with web-based graphical targeting using manual choice points maps (like Google Earth).

The solution can run on mobile devices tablet / notebook to ensure mobility. This solution will be integrated in the database automatically and will transfer based scripts with optimal solution proposed in this project in order to simplify the UAV operator duty for manually entering overflight plan, eliminating any errors or increasing cost and saving time. (fig.1)

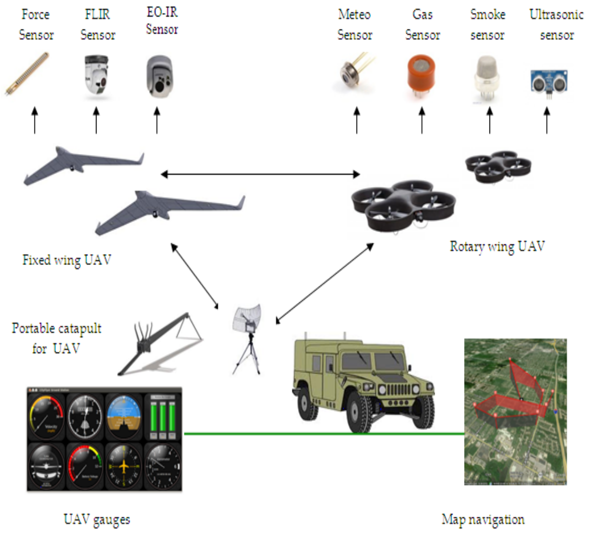

Fig.1 MASIM Concept

The portability level of the application implies the possibility of running an operating system dedicated to mobile devices with Java support (tablets or laptops).

Secondary features regarding the application are: configure various operational managers or users, configuring automatic data transmission format TXT / XML, archiving or restoring the database. The proposed solution for the MASIM system aims to implement fuzzy probabilistic algorithms to optimize an surveying area and network equipment necessary for UAV overflight in actions after a certain predetermined purpose and specific surface under certain conditions.[1,2,3]

Thus, once introduced into the application, specific patrol conditions - as input, for example, in the case of missing persons searches: size and shape of the surface; - Altitude overflight (depending on sensor performances optimal for this task); and pre-configured quality parameters that can be equipped with UAV sensors equipment (distance from that track, if they can detect day from night, etc.), the application will automatically run optimization algorithms, proposing one or many overflight solutions - as output data, depending on the purpose established: Radio altimeter provides accurate measurement of heights between 0–10000 m, flight range and corrective issue signals to the autopilot.

## 2. THE OPERATING PRINCIPLE OF THE RADIO ALTIMETER WITH FREQUENCY MODULATION

Passive radio altimeter works on the principle of determining the distance or altitude, based on the propagation of radio waves in a straight line at a constant speed and especially their ground reflection (fig ...) radio altimeter transmitter (EM) which generates radio waves which are radiated through the emission antenna towards the ground.

Electromagnetic wave reflected from the ground, is captured by the antenna AR and applied to receiver Rec.

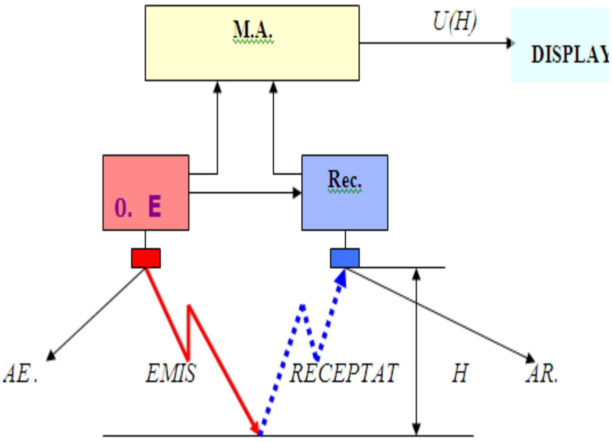

Fig. 2 Simplified block diagram of the radio altimeter MF

Altitude measurer generates voltage U(H) proportional to the time required for the electromagnetic wave to travel the distance H between the transmitting antenna and ground and ground to the receiving antenna, delay $t_h$ =2H/c as a signal from the reception moment compared to the emission moment. On the other hand, delay $\tau$=2H/c. Given the significance of sizes according to Figure 3.2., we can write:

$F_b=(2\Delta f/T_m)\times(H/c)$ (2.4)

$H=(F_{b\times}T\ c\ /2\Delta f)=F_b\times T\times c/2\Delta f$

$H=(c/2)\times(T_m/\Delta f)\times f_b$

$c/2 = ct.$ (1)

where: $T_m=ct.;\ \Delta f=ct.;\ H=KF_b$

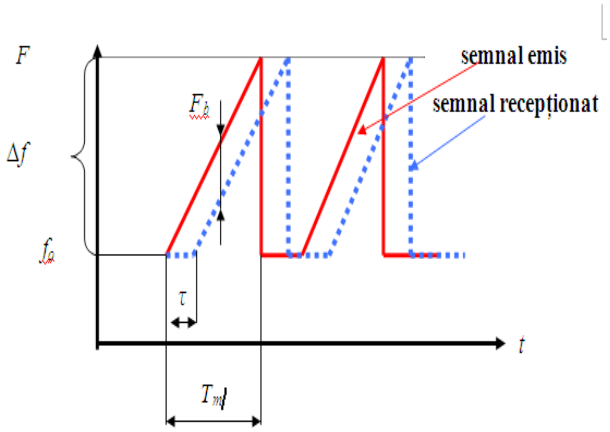

Fig. 3 Diagram regarding the operating principle of radio altimeter with frequency modulation

Frequency variation is kept fixed as Fb automatically maintained constant, resulting that Tm is proportional to the height H, the measurement period Tm is achieved by performing a conversion period - tension. Longitudinal control aims pitch angle, speed and altitude. This is achieved through three direct loops and two indirect.

Direct control loops depth, gauge and engine speed and indirect loops give direct orders.

Direct loops are the depth control, depending on the speed of rotation around the lateral axis ($V_y$); control the depth depending on the pitch angle; speed control ($n$) depending on the speed of flight.

Indirect loops: the depth control with altitude; depending on the depth control airspeed deduction [2,3,4].

## 3. THE CONTROL OF THE RADIO ALTIMETER

Item 1 is the UAV,control grouping is made by ψ, $\overset{\circ}{\psi}$ and command grouping by $\delta$. Item 3 makes corrections some passive or active, and N is the static characteristic of the actuator. The achieved structure is considered the control of three state variables involving features and superior dynamic performance.[5,6]

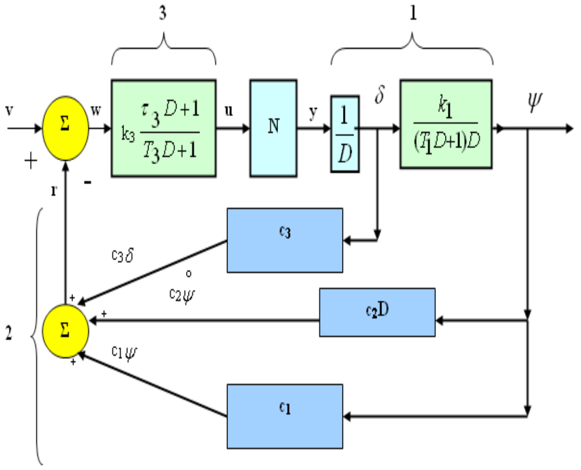

Fig.4 Command and control structures

In this architecture we have minimal state vector[6]:

$$x_1 \cong r = c_1\psi + c_2\psi + c_3\psi$$

$$x_2 = \overset{\circ}{x}_1 - c_2c_3T_1y \qquad (2)$$

$$x_3 = \overset{\circ}{x}_2 + T_1r-(k_1c_2+c_1c_3)y$$

We have the following operators:

$$H_1(D) = \frac{k_1}{(T_1-1)D^2}, \qquad (3)$$

$$H_2(D) = c_1 + \left(c_2 + \frac{c_3}{k_1}\right)D + \frac{c_3T_1}{k_1}D^2, \qquad (4)$$

$$H_2(D) = k_3\frac{\tau_3 D}{T_3D+1}, \ \tau_3 \neq T_3. \qquad (5)$$

State equations of the system

$$\overset{\circ}{x} = \mathbf{M}x + \mathbf{N}y + \mathbf{P}p + \mathbf{F}v,\ y = g(u) \qquad (6)$$

$$u = \mathbf{N}^T x + \mathbf{F}y + \mathbf{L}^T p$$

which performs control after 3 state variables elements:

$$\mathbf{M} = \begin{bmatrix} -\frac{1}{T_1} & k_2 & 0 & 0 \\ 0 & 0 & \frac{1}{T_2} & 0 \\ 0 & 0 & 0 & 0 \\ -\frac{k_3\tau_3}{T_3^2}(k_3-1) & 0 & 0 & \frac{-1}{T_3} \end{bmatrix}, \qquad (7)$$

$$\mathbf{N} = \begin{bmatrix} c_3 \\ \frac{k_1c_2}{T_1} \\ \frac{c_1k_1}{T_1} \\ 0 \end{bmatrix}, \qquad (8)$$

$$\mathbf{P} = \begin{bmatrix} -\frac{k_3\tau_3}{T_3} \\ 0 \\ 1 \\ 0 \end{bmatrix}, \qquad (9)$$

$$\mathbf{F} = \begin{bmatrix} 0 \\ 1 \\ 0 \\ \dfrac{k_3\tau_3}{T_3} \end{bmatrix}, \quad L = \frac{k_3\tau_3}{T_3}, \qquad (10)$$

For linear systems, parallel-opposed correction by connections $c_2$ and $c_3$ of member 2 is similar to a serial correction of member 3 and has the following form :

$$H_{3e} = k_{3e}\frac{b_2D^2 + b_1D + b_0}{a_2D^2 + a_1D + a_0} \qquad (11)$$

If nonlinearity N is replaced with a beam with uniform slope memory, equivalent operator $H_{3e}(D)$ has the following expression[6]:

$$H_{3e}(D) = \frac{(T_1D+1)D}{T_1D^2 + (1+c_3T_1)D + k_1c_2} \qquad (12)$$

## 4.THE CONTROL AND THE REACTIONS TO MAINTAIN A STABLE CONSTANT ALTITUDE

Control system which adjusts the altitude for UAV created in SIMULINK and commanded from MATLAB. In Figure 5 we are introducing the controls and command model performed in MATLAB Simulink 2010.[5]

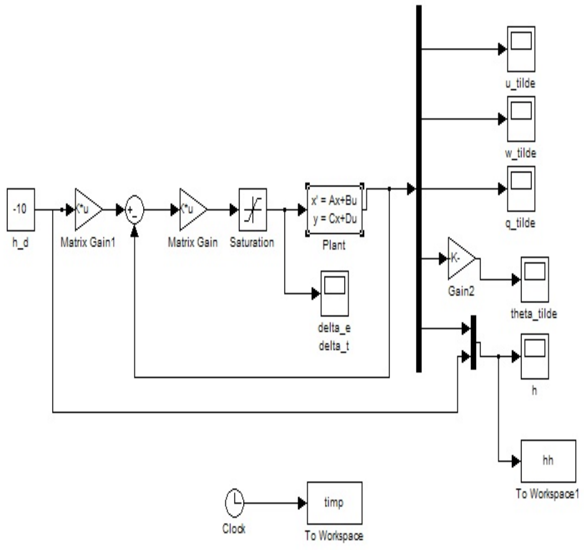

Fig. 5 Simulink model

We will study the reaction time to stabilize the radio altimeter command line on a 20-second interval.

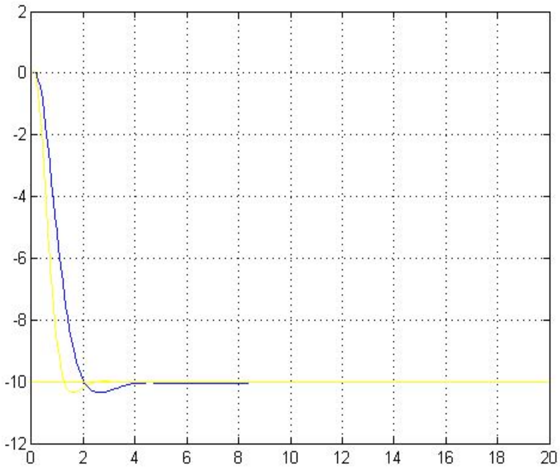

Fig.6 Saturation for a altitude of 100 meters

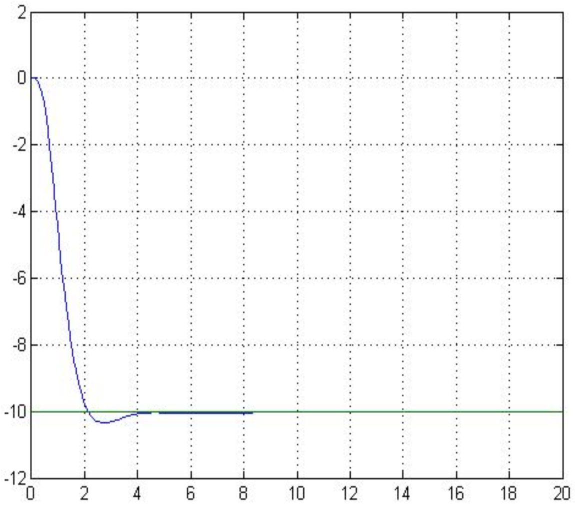

Fig.7 Saturation for a altitude of 1000 meters

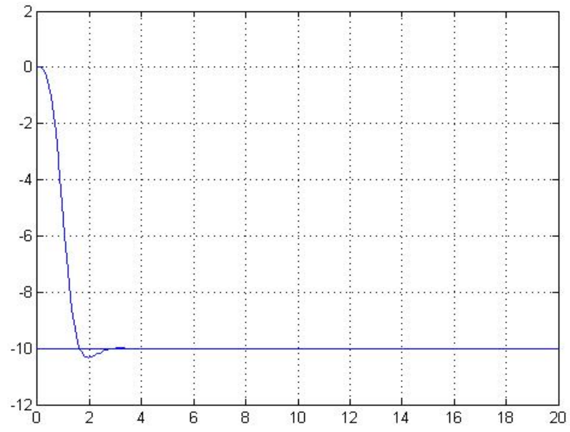

Fig.8 Saturation for a altitude of 10000 meters

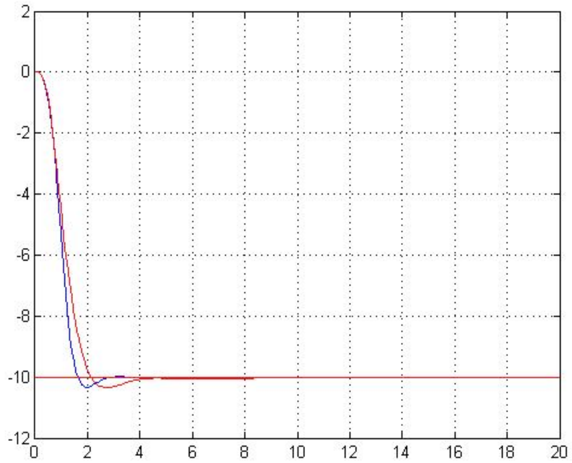

Fig.9 Constant negative saturation for a altitude of 100 meters

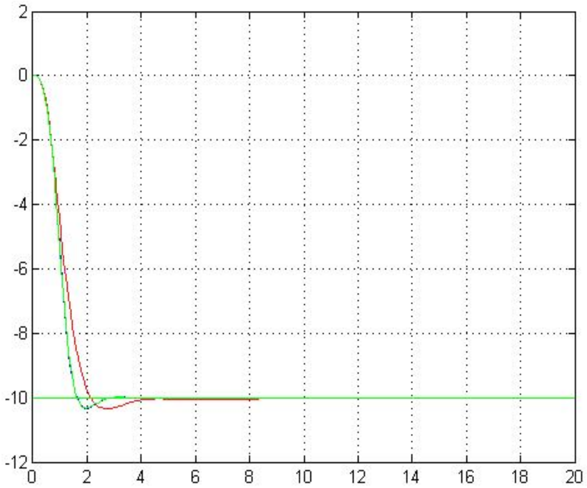

Fig.10 Constant negative saturation for a altitude of 1000 meters

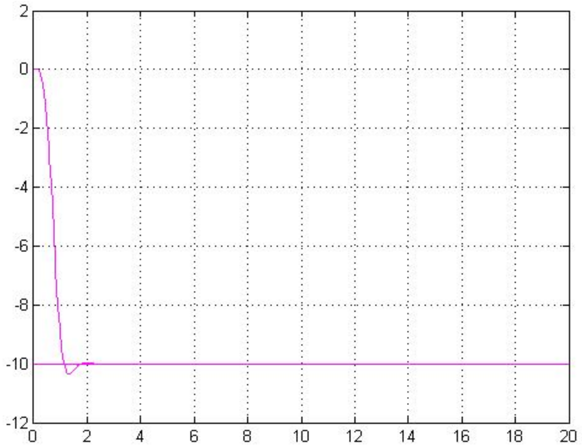

Fig.11 Constant negative saturation for a altitude of 10000 meters

We see on OX reaction time, which is set up to limit of 20 seconds and on OY axis command line it should be constant. As you can see this becomes constant after 4 seconds. Saturation values during the control limits the time until it becomes a constant (the courts). Increasing saturation limits, especially the negative ones (errors), the command line acts in a period of 2 seconds at 10,000 feet.

In the first chart we set an altitude of 100 meters, 2nd chart have an altitude of 1000 and the 3rd chart have an altitude of 10000 feet. The negative saturation was modified.

Starting at the chart 4 we kept the negative saturation values and increased the value of positive saturation at these altitudes: 100, 1000 and 10,000 meters ( fig. 6,7,8,9,10,11).

## CONCLUSIONS

Maintaining constant altitude flight is an important parameter for MASIM concept, this can be realized through radio electronic means.

Maintaining constant altitude require adjustments on the longitudinal flight: pitch angle and speed.

Positive saturation is 10 times smaller than the negative one, control error is small due to the fact that increased error space left for calculations will help correct the difference.

## ACKNOWLEDGMENT

The National Authority for Scientific Research, Romania supported this work – CNCS-UEFISCDI: PN-II-PT-PCCA-2013-4

"Multi Agent Aerial System with Mobile Ground Control Station for Information Management".

## BIBLIOGRAPHY

1. UAS Yearbook, *Unmanned aircraft systems – The Global Perspective 2011/2012*, Blyenburg & Co, june 2011, Paris, ISSN 1967-1709, 216 p., www.uvs-info.com

2. Beguin B., Breitsamter C., Adams N, *Aerodynamic investigation of a morphing membrane wing*, AIAA Journal, vol.50, no.11, nov. 2012, p2588-2599.

3. Barbarino S., Bilgen O., Ajaj R.M., Friswell M.I., Inman D. J., *A review morphing aircraft*, Journal of intelligent material system and structures, vol 22, 2011, p823-877.

4. Melin T., Isikveren A. T., Friswell M.I., *Cost appreciation of morphing uav projects at a conceptual design stage*, 2008, p 6., http://michael.friswell.com/PDF_Files/C239.pdf, consultat 07.12.2012

*5. Simulink basics tutorial*, 26 p. http://faculty.uml.edu/pavitabile/22.457/UMICH_Simulink_Tutorial.pdf

6. Prisacariu V., Cîrciu I. *The analysis of the flying wing in morphing concept,* INCAS BULLETIN, Volume 5, Issue 2/ 2013.