INFORMATION MANAGEMENT IN UAS MULTIAGENT

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Summary: *Robotic aerial systems have seen a significant development in recent years, both due to technological development and the various missions that can be accomplished by the onboard equipment, leading to innovative approaches in inter and transdisciplinary fields due to technological and information management challenges, starting with concepts, materials, technologies, programming and ending with the educational and human resources area.*

The article wishes to present the UAS multi-agent systems from the perspective of information exploitation and sharing.

Keywords: *UAV / UAS, multiagent system, ad-hoc network, flying wing, multicopter*

Acronyms and symbols

UAV/UAS	Unmanned aerial vehicles/system	ISR	Intelligence, surveillance, reconnaissance
MAS	Multiagent system	WLAN	Wireless Local Area Network
NLS	Neutrosophic Logic System	GCS	Ground control station
MMAS	Max-Min Ant System	CACM	Clever Ant Colony Metaphor
EO-IR	Electro optic - infrared	WI-FI	wireless local area networking
STEM	Science, Technology, Engineering, Mathematics		
TCP-IP	Transmission Control Protocol - Internet Protocol		

1. INTRODUCTION

Robotic aerial systems have seen a significant development in recent years, both due to technological development and the various missions that can be accomplished by the onboard equipment, leading to innovative approaches in inter and transdisciplinary fields due to technological and information management challenges, starting with concepts, materials, technologies, programming and ending with the educational and human resources area. (STEM concept), [21, 23].

Specialized literature reveals a series of multiagent UAS in complex architectures that can carry out elaborate tasks and missions, sensor node networks on different locations [1, 2, 3, 19].

2. MULTIAGENT SYSTEM PROPOSAL

2.1. Information processing

The multiagent system consists of the following subsystems: the aerial system (both fixed and winged air vectors in modular design with flexible equipment, mission-adaptable), portable control station (portable platform, equipped with capabilities of command, control and maintenance), communications system, air-handling control platform and intelligent information management, see Figure 1, [3].

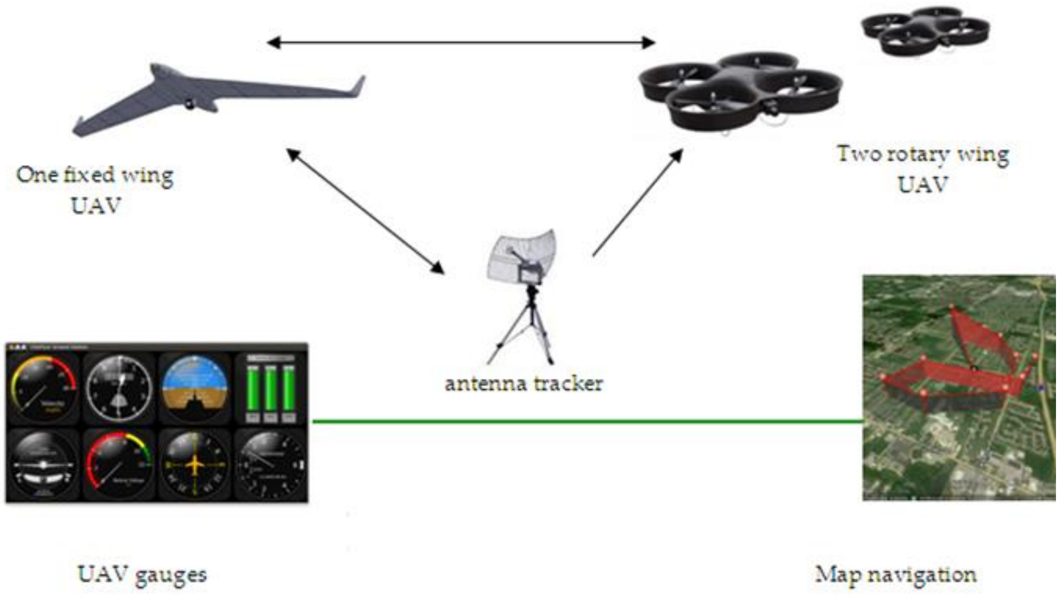

FIG.1. MASIM multiagent aerial system, [3]

2.2. Exploiting information

Unmanned aerial systems respond to any type of applications and missions carried out by classical aircraft and even an extension to the dangerous mission area, low life cycle costs, outstanding efficacy increasingly causing aerospace builders to turn to this type of research.

The ISR concept (*intelligence* – processed information, *surveillance* – information refinement through persistent observations and continuous collection, and *reconnaissance* - short-term coverage of a specific objective located in areas of interest) refers to the timely obtaining of accurate and relevant information at the same time as continuous and synchronized mission planning. ISR is based on the active use of wide-area sensors, information processing, exploitation and dissemination systems, providing full and effective decision support. ISR achieves a unique synergy that is based on the collection, provision, analysis of persistent and concentrated coverage, providing the ingredient for effective decisions in both urban and extra urban areas [5, 6].

The main missions specific to aerial platforms networks are: support in fire fighting, search-rescue, crash situations in crowded locations. The current state of the distributed vector-based control concept of air vector-type agents shows that a multi-agent system (MAS) is based on a concurrent, asynchronous, stochastic, and distributed computerized system architecture. These features of a multi-agent system provide the functions of a dynamic system with discrete events, which can be studied with analytical methodologies, especially with Petri networks [7, 8].

The main function of multi-agent control systems is the use of the concept of "agent coordination" to implement the "distributed control" concept. The ad-hoc network allows any two nodes to communicate, either directly or through an arbitrary number of other nodes acting as relays. The network protocol is an implementation of the dynamic ad-hoc network routing protocol. A monitoring architecture has been incorporated for detailed performance monitoring.

In order to establish a robust networking framework for aerial platforms, it is necessary to consider: the establishment of the architecture (the number and types of platforms according to with the mission); mission planning (feasibility, optimal trajectories); information exchange between component platforms; data merger to increase bandwidth efficiency; optimization of sensor arrangement; avoiding collisions and obstacles (sense and avoid), [9, 10, 11, 12].

The difficulty of reconfiguring such a hierarchical control system can be solved with the Multi-Agent System with reconfiguration potential. The use of a single central controller for a group of platforms is complicated by the increase in the number of agents because the central controller has to be informed of all the knowledge and intentions of the agents.

The proposed IT solution aims at implementing neutrosonic algorithms to optimize an overflow area and a network of UAVs required in overflight action, after a predetermined purpose and under specific surface conditions.

Pre-configuring the sensor quality parameters with which UAVs can be equipped (the distance from which they can detect, whether they can detect day and night, etc.), the application will automatically run the optimization algorithms, proposing one or more overflight solutions as output data, according to the purpose set:

- generating the number of optimal UAVs to be used (with the appropriate sensors);
- the flight path for each UAV (trajectory/waypoint) equipment, e.g. increasing the likelihood of finding the missing person in the shortest possible time. The flight path consists of sets of GPS coordinates that will be automatically transmitted by the piloting console application. The resulting flight path will have to meet the following essential conditions: the overflight area to be fully covered; covered areas may overlap or not; there is no collision risk; the cost of flying is optimal as time and energy consumption.

The Mobile Surveillance and Command Center is currently equipped with a UAV pilot solution based on an open-source web-based graphical targeting architecture using manual mapping (Google Earth). The solution can run on mobile devices such as tablets/notebooks to ensure mobility. This solution will be integrated at the database level through automated script-based transfer with the optimization solution proposed in this project to simplify the UAV operator's task of manually entering the overflight plan, eliminating any errors, and offering advantages regarding costs and time.

2.3. The IT application

The IT application will be developed in web technology under a Windows-based HTML5 /Javascript platform that involves the exclusive existence of a browser (IE, Chrome or Firefox) and a minimum resolution of 1024x & 68 with a local, internal database that can keep track of route paths or a possible history of changes. The application will be able to run a set of reports on covered areas, time necessary for overflight, estimated energy consumption, etc.

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

The secondary functionalities of the application are: configuring various administrative or operational users, configuring automatic data transmission in TXT/XML format, archiving or restoring the database.

In the UAV system architecture, each node (multicopter, wing, GCS) will be equipped with wireless TCP / IP networking devices (WLANs) generally associated with communications in the IEEE 802.11 standard as follows, See figure 2:

A. GCS 1: WI-FI modem and access point
B. GCS 2: WI-FI Modem
C. Multicopter 1: WI-FI modem and access point
D. Multicopter 2: WI-FI modem and access point
E. Flying wing: WI-FI modem.

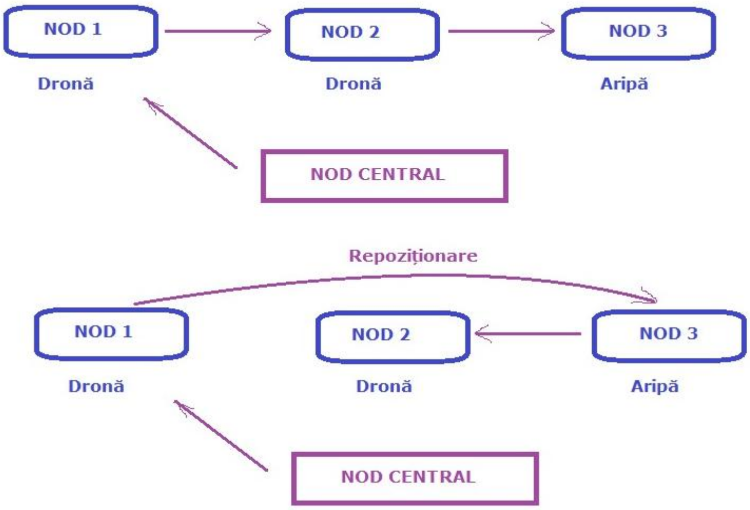

FIG.2 MASIM system architecture

3. AERIAL VECTORS

The master air vector is chosen in the fixed flying wing configuration (see figure 3), a configuration that was analyzed by numerical simulations and experimental tests in the subsonic sphere at INCAS Bucharest, the results being disseminated in a series of scientific references [13, 14, 17, 18].

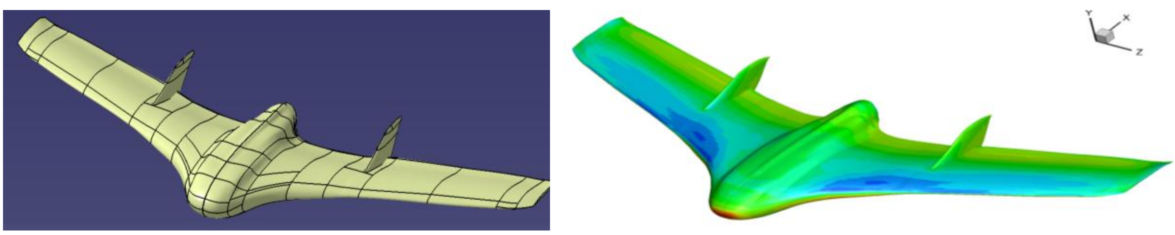

FIG.2 MASIM flying wing, [13]

The multicopters complete the aerial vector network by performing missions defined and selected by the high-speed vector (flying wing), data acquisition (EO-IR or biometric data) missions on delimited areas, see Figure 3.

a b

FIG.2 MASIM Multicopter, (a. multicopter, b. precision agriculture map)

4. CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

The main future research directions include: identifying innovative technologies for tactical and operational decision support based on mobile sensor networks; developing strategies to increase the performance of air platforms (fixed wing and rotating wing) while miniaturizing them; designing special algorithms for miniaturized aerial platform missions; developing coordination strategies for the control of miniaturized aerial platforms (using a single autopilot for the formation head); developing "sense and avoid" strategies to avoid fixed or mobile obstacles.

With regard to the patenting of some of the innovative solutions within the project, the following are being taken into account: the solutions to increase the performances and capabilities of flying wing and rotary wing aerial platforms by modularity and the introduction of the morphing adaptability concept [15]; innovative mission planning algorithms under conditions of resource and airspace management restrictions based on the use of neutroscopic logic and NLS or social network analysis methods including CACM and MMAS solutions, 20, 24]; filtering and control algorithms that are specific to the models resulted for representation of the network of aerial platforms with sampled information; software implementation solutions for data control and distributed filtering algorithms.

STEM approaches [21], the UAV limits [22] and the experimental methods of assessing UAV performance [25] determine a conceptual propagation in the adjacent and interaction domains of robotic technical systems with the human resource that makes and uses this type of aerial vectors.

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REFERENCES

[1] Maza, I., Kondak, K., Bernard, M. et al., *Multi-UAV Cooperation and Control for Load Transportation and Deployment*, J Intell Robot Syst (2010) 57: 417. , doi:10.1007/s10846-009-9352-8;

[2] Ding, Xu Chu, Amir R. Rahmani, and Magnus Egerstedt. *"Multi-UAV convoy protection: An optimal approach to path planning and coordination"*, IEEE Transactions on Robotics 26.2 (2010): 256-268;

[3] Prisacariu V., Cîrciu I., Cioacă C., Boşcoianu M., Luchian A., *Multi aerial system stabilized in altitude for information management*, REVIEW OF THE AIR FORCE ACADEMY, 3(27)/2014, Braşov, Romania, ISSN 1842-9238; e-ISSN 2069-4733, p 89-94;

[4] Barnhart R.K., Hottman S.B., Marshall D.M., Shappee E., *Introduction to unmanned aircraft systems*, CRC Press, 2012, ISBN 978-1-4398-3520-3, 215p;

[5] Butler, Jeffrey T., *UAVs and ISR sensor technology*. No. AU/ACSC/033/2001-04. AIR COMMAND AND STAFF COLL MAXWELL AFB AL, 2001;

[6] Eggers, J. W., and Mark H. Draper. *"Multi-UAV control for tactical reconnaissance and close air support missions: operator perspectives and design challenges."* Proc. NATO RTO Human Factors and Medicine Symp. HFM-135. NATO TRO, Neuilly-sur-Siene, CEDEX, Biarritz, France. 2006;

[7] Love, Joshua Alan. *Network-Level Control of Collaborative UAVs*. Diss. University of California, Berkeley, 2011;

[8] Love, Joshua, et al. *"Csl: A language to specify and re-specify mobile sensor network behaviors."* Real-Time and Embedded Technology and Applications Symposium, 2009. RTAS 2009. 15th IEEE. IEEE, 2009;

[9] Muraru A., Cioaca C, Boscoianu M., *Modern Sense and Avoid Strategies for UAV*, la the 9th International Scientific Conference New Trends in Aviation Development, Technical University Kosice – Faculty of Aeronautics, Gerlachov-High Tatras, September 16-17, 2010, Slovak Republic, ISBN 978-80-553-0475-5;

[10] Hutchings, Tim, Susan Jeffryes, and S. J. Farmer. *"Architecting UAV sense & avoid systems."* Autonomous Systems, 2007 Institution of Engineering and Technology Conference on. IET, 2007;

[11] Prats, Xavier, et al. *"Requirements, issues, and challenges for sense and avoid in unmanned aircraft systems."* Journal of aircraft 49.3 (2012): 677-687;

[12] Billingsley, Thomas B., Mykel J. Kochenderfer, and James P. Chryssanthacopoulos. *"Collision avoidance for general aviation."* IEEE Aerospace and Electronic Systems Magazine 27.7 (2012): 4-12;

[13] Pepelea D. Cojocaru M.G., Toader A., Niculescu M.L., *CFD analysis for UAV of flying wing, SCIENTIFIC RESEARCH AND EDUCATION IN THE AIR FORCE-AFASES 2016*, DOI: 10.19062/2247-3173.2016.18.1.22, p.171-176;

[14] Prisacariu V., *CFD Analysis of UAV Flying Wing*, INCAS Bulletin, vol. 8, 3/2016, ISSN 2066 – 8201, DOI: 10.13111/2066-8201.2016.8.3.6, p 65-72;

[15] Valasek J., *Morphing aerospace vehicles and structures*, Wiley, ISBN 978-0-470-97286-1, 2012, p286;

[16] Fahlstrom P.G., Gleason T.J., *Introduction to UAV systems*, fourth edition, Aerospace Series, 2012 John Wiley & Sons Ltd., ISBN 978-1-119-97866-4, 280p;

[17] Prisacariu V., Boşcoianu M., Cîrciu I., Lile Ramona, *Aspects Regarding the Performances of Small Swept Flying Wings Mini UAV-s in Aggressive Maneuvers*, Applied Mechanics and Materials, vol. 811, p. 157-161, Trans Tech Publications, 10.4028/www.scientific.net /AMM.811.157, ISSN: 1662-7482;

[18] Prisacariu V., Boşcoianu Corina, Cîrciu I., Boşcoianu M,, *The Limits of Downsizing –a Critical Analysis of the Limits of the Agile Flying Wing MiniUAV*, APPLIED MECHANICS AND MATERIALS Vol. 772 (2015) pp 424-429, © (2015) Trans Tech Publications, Switzerland, doi:10.4028/www.scientific.net /AMM.772.424, p. 424-429;

[19] Ahmadzadeh, Ali, et al. *"Multi-UAV cooperative surveillance with spatio-temporal specifications."* Decision and Control, 2006 45th IEEE Conference on. IEEE, 2006;

[20] Vladareanu V., et al. "Development Of Intelligent Algorithms For Uav Planning And Control." *Scientific Research & Education in the Air Force-AFASES* 1 (2016), doi 10.19062/2247-3173.2016.18.1.29, p.221-226;

[21] A.M. Baldea, M. Garabet, V. Prisacariu, I. Neacsu, *Educational approaches of the Romanian MASIM research project*, ICERI 2016 Proceedings, ISBN: 978-84-617-5895-1, ISSN: 2340-1095, doi: 10.21125/iceri.2016.2257, p.5201-5211;

[22] Prisacariu V., Boşcoianu M., Luchian A., *Innovative solutions and UAS limits*, REVIEW OF THE AIR FORCE ACADEMY, 2(26)/2014, Braşov, Romania, ISSN 1842-9238; e-ISSN 2069-4733, p51-58;

[23] F. X. Bogner, S. Schmid, O. Dieser, *Pathway – Predarea Ştiinţelor prin investigaţie*, Ghid pentru profesori, Creative Commons Attribution - NonCommercial-ShareAlike 3.0 Unported License, 2013;

[24] Smarandache, Florentin. *Neutrosophic Theory and Its Applications, Vol. I: Collected Papers*. Infinite Study, 2014;

[25] Anton S., Parvu P. *"Experimental Methods for UAV Aerodynamic and Propulsion Performance Assessment."* INCAS Bulletin, ISSN 2066–8201,Volume 7, Issue 2/ 2015, pp. 19–33.