



ABCDE



Scientific Report

First name / Family name

Eduard Santamaria

Nationality

Spanish

Name of the *Host Organisation*

Fraunhofer IOSB

First Name / family name
of the *Scientific Coordinator*

Igor Tchouchenkov

Period of the fellowship

01/06/2012 to 31/05/2013



I – SCIENTIFIC ACTIVITY DURING THE FELLOWSHIP

The general topic of my work during the fellowship has been the utilization of multiple heterogeneous unmanned vehicles for rapid aerial mapping. This work has been carried out in the context of the SENEKA project, which aims at providing first responders and rescue teams with sensors and robot based tools to gather valuable data for decision making in a short time after a natural disaster or a big incident occurs. An important asset brought to the SENEKA project by Fraunhofer IOSB is the AMFIS system, a generic ground control station able to control multiple sensors and vehicles.

The focus of my research has been the development of path planning methods for miniature unmanned aerial vehicles to gather imagery and generate a high resolution up-to-date picture of a given area. Since the algorithms resulting from my research work needed to be integrated into AMFIS, its architecture and capabilities, especially those aspects related to mission planning, were studied.

The main problems addressed during the fellowship period have been (1) the partitioning of an area of interest so that each vehicle can be allocated a part according to its capabilities, and (2) the generation of flight paths that completely cover the area. Pictures taken along these paths will be stitched together to obtain a complete view of the area.

These are some general requirements of the developed methods:

- Computation should be fast. Finding an optimal solution to the partitioning and path generation problem could be very time consuming and, therefore, not suitable for emergency situations.
- The generated path should be efficient. While we do not aim at obtaining an optimal solution, the resulting flight paths should have a reduced length and number of turns.
- Coverage should be complete, i.e., all parts of the area of interest should be photographed.
- Areas with concave shapes and with no-fly zones inside should be supported.
- Vehicles with different ranges and sensor size/resolution should be supported.

The AMFIS system already implemented an initial algorithm for solving the partitioning problem, however it didn't provide support for vehicles with different sensor footprints and range. Taking advantage of the existing code, the algorithm has been extended in order to be able to deal with these new requirements.

For the path planning method, it was decided that a new solution able to cope with non-convex areas and areas with holes should be developed. Therefore, after researching the state of the art, a new algorithm for fast generation of efficient complete coverage paths has been designed and implemented. The resulting algorithms have been integrated into the AMFIS system and the obtained results published in the conference papers listed in section II.

Additionally, the fellowship period also has given me the opportunity to improve my project management skills through the supervision of a team of students working on the integration of ROS based robots into AMFIS. Such integration will enable the utilization



of ROS based robots for the acquisition of aerial images.

During the fellowship I had the opportunity to participate in several meetings related to the SENEKA project which involved researchers from different Fraunhofer institutes. I also regularly attended the weekly meetings of the AMFIS team, and a number of meetings of the Interoperability and Assistance Systems department, where the activities of the different research groups were coordinated.

II – PUBLICATION(S) DURING THE FELLOWSHIP

[1] Santamaria, E., Segor, F., Tchouchenkov, I., Schönbein, R. (2013) Path Planning for Rapid Aerial Mapping with Unmanned Aircraft Systems, Proceedings of the Eighth International Conference on Systems, Seville, Spain. [Best paper award]

[2] Santamaria, E., Segor, F., Tchouchenkov, I. (2013) Rapid Aerial Mapping with Multiple Heterogeneous Unmanned Vehicles, Proceedings of the 10th International Conference on Information Systems for Crisis Response and Management, Baden-Baden, Germany.

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

Conferences/workshops with presentation:

- ICONS 2013 - Eighth International Conference on Systems. January 27 - February 1. Seville, Spain.
- ISCRAM 2013 - The 10th International Conference on Information Systems for Crisis Response and Management. 12-15 May. Baden-Baden, Germany.

Attended Seminars:

- ABCDE Seminar, 24-26 October 2012, Toulouse, France.

Other:

- “Flight & Mission Management for UAS”. Presentation given at IAS department of Fraunhofer IOSB, Karlsruhe, Germany – 31/07/2012
- “ICONS Panel: New Tendencies in User-Centric System”. Panelist. Seville, Spain – 29/01/2012
- “AMFIS: Monitoring with mobile and stationary networked sensors”. Presentation given at the LSTS laboratory of the Faculdade de Engenharia da Universidade do Porto, Portugal – 30/04/2013



IV – RESEARCH EXCHANGE PROGRAMME (REP)

1st REP visit: AIT (Austrian Institute of Technology), November 26 – 30, 2012, Wien, Austria

During this visit I met scientists from the New Sensor Technologies business unit, the Safe and Autonomous business unit and the Information Management business unit. I presented my work with the AMFIS team and learned about the activities carried out at the different business units. Their work on sensor technologies, image processing and crisis management is very relevant in relation with the development of unmanned vehicle systems and their applications.

2on REP visit: Faculdade de Engenharia da Universidade do Porto (FEUP), April 29 – May 3, 2013, Portugal

During this visit I was hosted by the scientists from FEUP's Laboratório de Sistemas e Tecnologia Subaquática. They presented their unmanned aerial and underwater vehicles to me and gave me the opportunity to try their ground control station software. In a presentation to the research group I described the systems available at Fraunhofer IOSB and my work. The realization of the complementary nature of our efforts led us to develop an initial road map for collaboration between the two institutions.