ParCS-S2
Park Cleaning Swarm Supervision System
Position Paper

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***Abstract*—The research presented in this paper is a collaborative project that is jointly developed by the Mugen Company[1] and the MUSE (Mobility, Ubiquity, Security) research group at LaBRI[2]. Its goal is to combine a Multi-Unmanned Systems (UMS) mission designed, validated and developed at LaBRI, with monitoring and supervision tools developed at Mugen.**

I. Introduction

The LaBRI[3] (Laboratoire Bordelais de Recherche en Informatique) is a French public computer science research center which is part of the University of Bordeaux[4]. It gathers more than 300 researchers and engineers who work on many different domains including distributed and mobile networks. The MUSe research group specializes in this last topic and more precisely focuses on autonomous and communicating swarms of Unmanned Systems (UMS).

The Mugen Company is a french start-up which develops software solutions that make it possible to get information from (and to control) the payload of a drone from mobile platforms.

Both LaBRI and Mugen are members of the AETOS[5] cluster which supports the development of the RPAS (Remotely Piloted Aircraft Systems) domain (industry and research) in Région Aquitaine.

This work is partly funded by the *Direction Générale de l'Armement* and the *Région Aquitaine*.

[1] http://www.mugen-sas.com/
[2] http://muse.labri.fr/
[3] http://www.labri.fr/
[4] http://www.u-bordeaux.fr/
[5] http://www.aetos-aquitaine.fr/

This position paper presents a collaboration that has been setup between these two actors in order to combine a Multi-Unmanned Systems mission designed, validated and developed by the MUSe group, with monitoring and supervision tools developed by the Mugen company.

The rest of this paper is organized as follows. Section II introduces the concept of swarm of Unnamed Systems; section III presents the contribution of the MUSe research group; section IV presents the contribution of the Mugen company; section IV describes the global collaboration.

II. Swarms of UMS

A Unmanned System [1] (UMS) is a mobile entity which has a certain level of autonomy in terms of decision and action. Since a few years, many applications involving UAVs (Unmanned Aircraft Systems) have been developed both in the military context and the civilian world. Some of these applications could be improved by using several UAVs at the same time in order to offer additional features and to perform the mission faster with better energy consumption. For instance, monitoring forest fires, searching and rescuing victims after an avalanche, overseeing industrial areas could be made more efficient by using several UAVs; such swarm based approaches already exist [2] [3] [4].

A swarm of UAVs can be implemented in three ways which are illustrated in Figure 1. The *manual* implementation consists simply in using as many human operators as the number of UAVs that compose the swarm. Even though this kind of implementation is theoretically the easiest to setup, it is totally unrealistic and makes it almost impossible to perform any collaborative mission. The second possibility of implementation is the *centralized* approach. We can notice that this technique is the one that is used in the examples referred to above. This implementation consists in managing the flight and the collaboration process of all the UAVs involved in the swarm from a single control station. Even though this technique is strongly efficient (i.e. the collaboration process is computed and managed by a single unit), it is the less resilient since a problem in the unique control station leads to a global failure of the system. This is the reason why we claim that the *distributed* implementation should be preferred. It consists in making each UAV of the swarm completely autonomous. Indeed, UAVs take their own decisions and make all the calculations on board independently of the other UAVs of the swarm. They share their own information with the other UAVs (broadcast based communication) in order to collaborate to achieve a global mission.

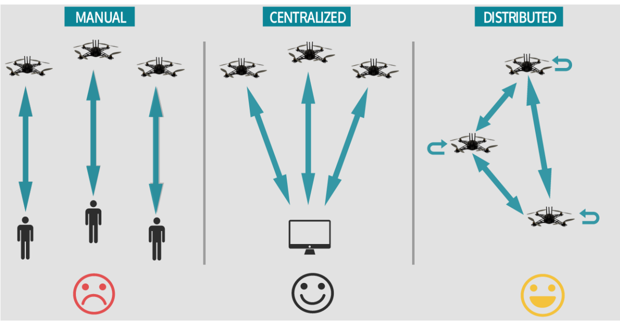

Figure 1. Different swarms implementation strategies.

A quick comparison of these implementations is presented in Figure 2. It can be noticed that the distributed implementation is the best in terms of autonomy, collaboration and resilience.

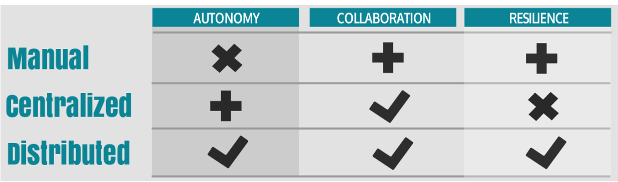

Figure 2. Comparison of the swarm implementation strategies.

III. Contribution of the LaBRI

The MUSe research group at LaBRI works on swarms of mobile and communicating autonomous systems. One of the most important results of the group in this field is the CARUS project[6] [5]. The objective of this project was to keep under surveillance a given set of points of interest where incidents (such as starting forest fires) can arise. Each individual UAV operates in an autonomous manner and the decisions are taken by each aircraft in the air rather than on the ground, based on information built from asynchronous communication between vessels.

More recently, MUSe began focusing on heterogeneous swarms. It is for instance possible to create a swarm composed of UAVs and UGVs (Unmanned Ground Vehicles) [6]. Heterogeneity is not only at the level of the Unmanned Systems: several UAVs can embed different payloads that make them different from the others. The MUSe group is thus working on distributed collaboration mechanisms that take into account the specificity of each entity in the swarm [7].

In this context, the MUSe group has developed the ParCS (Park Cleaning Swarm) scenario which offers a solution to achieve selective collection of garbage in a park by using an autonomous swarm composed of UGVs and UAVs. The UGVs are informed by the UAVs of wastes to collect. The latter have a global aerial view of the park that can be disseminated among the UAVs and the UGVs based on the opportunistic communications they can have with the other members of the swarm (either on the ground, in the air or from the air to the ground). All of them autonomously self-organize (on ground and in the air) so as to manage the collection of wastes and to clean the park. This scenario and its validation is part of a thesis funded by the French Army and Région Aquitaine.

Among the main goals that are part of the work described above are (we list here only the goals that are relevant to the Mugen/LaBRI collaboration):

- design and validation of the required algorithm;
- implementation in JBotSim [8], a simulator that we use to observe the algorithmic behavior of the swarm;
- implementation on real vehicles.

IV. Contribution of Mugen

The Mugen Company develops software solutions that make it possible to get information from (and to control) the payload of a drone from mobile platforms (e.g. tablets, laptops or mobile phones). They can recover telemetry data captured by a UAV. These data are then distributed to the mobile devices (possibly several at the same time) through a server and presented by means of specialized interfaces

[6]In collaboration with DGA, Thales, GIS Albatros, Fly-n-Sense, Région Aquitaine and Bordeaux TechnoWest.

depending on the profile of the user. Each mobile device can then work with the others, exchanging information or transferring control to each other (depending on privileges - this will not be detailed here).

M2UV, the current main Mugen software solution is illustrated in Figure 3.

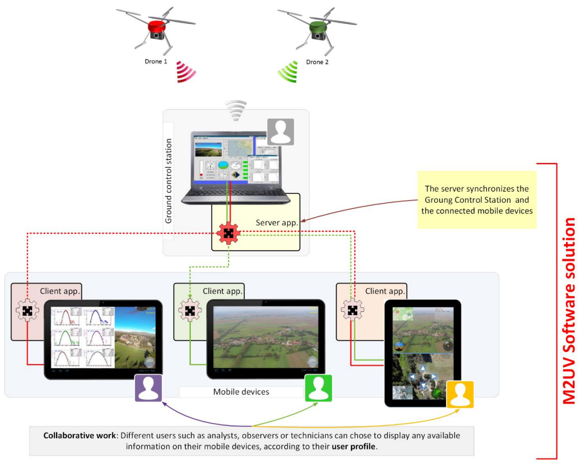

Figure 3. The M2UV software solution of Mugen.

The main features currently implemented in the Mugen supervision and control system that are relevant to the Mugen/LaBRI collaboration are:

- data collection from the health management system and from the payload;
- distribution of data between supervising mobile terminals;
- profile management.

Collaboration

Mugen and the LaBRI come together to collaborate on interfacing both ParCS demonstrators (simulation mode and real world deployment) developed at LaBRI with the mission supervision and monitoring system developed by Mugen. This innovative joint work focuses on supporting the multi-UMS missions concerns of LaBRI by using and extending the Mugen system initially designed for a single unmanned vehicle. This requires designing and implementing new software components dedicated to the supervision of multi-UMS systems (organized as an autonomous swarm) that collaborate to achieve a common global mission. These software components and a global demonstrator will be the output of the project. This project takes the name of Park Cleaning Swarm Supervision System, abbreviated as ParCS-S2.

An illustration of the project is given in Figure 4.

Figure 4. The user interface of the ParcCS-S2 project.

The integration is provided at two levels:

- At the simulator level. The ParCS project is initially run on a simulator (JBotSim) with which the supervision system developed by Mugen will be interfaced. This will produce ParCS-S2/simulation mode [9].
- At the level of an actual swarm of ground and aerial drones. Here the purpose of the ParCS project is to present a demonstrator with real functional drones. It will be interfaced with the supervision system of the Mugen Company which will produce ParCS-S2/real word.

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