

## Chapter 15

# A Centralized Autonomous System of Cooperation for UAVs– Monitoring and USVs– Cleaning

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### ABSTRACT

*This article proposes an approach which deals with the problem of monitoring ocean pollution and cleaning dirty zones using autonomous unmanned vehicles. The authors present a cooperative agent-based planning approach for heterogeneous unmanned vehicles with different roles. Unmanned aerial vehicles (UAVs) monitor multiple ocean regions and unmanned surface vehicles (USVs) tackle the cleaning of dirty zones. Due to the rapid deployment of these unmanned vehicles, and the increase of ocean pollution, it is convenient to use a fleet of unmanned vehicles. Thus, most of the existing studies deal with the monitoring of different zones, the detection of the polluted zones and then the cleaning of the zones. In order to optimize this process, the authors' solution aims to use one UAV and one USV to reduce the pollution level of the ocean zones while taking into account the problem of fault tolerance related to these vehicles.*

## 1. INTRODUCTION

Water is the fundamental element in all socio-economic processes. The water quality, due to the illegal oil rejection, has become a major issue for public authorities, national and international instance and organizations. For example, IFREMER (Institut Français de Recherche pour l'Exploitation de la Mer) figured out more than 50 million tons of waste between 0 and 250m deep in the Bay of Biscay, 15000 tons of plastic bags which circulate between two waters and 50,000 tons of these bags rest at the bottom of the gulf (Ifremer, 2006).

At the same time, manufacturers in many sectors face a challenge between producing better and reducing the pollution. These sectors produce very diverse effluents which require at each time new investigations and the development of specific treatment processes. Therefore, this has stimulated and encouraged the improvement of existing de-pollution techniques and the development of new processes, satisfying and conforming with the increasingly restrictive international standards in such environments. For that purpose, there was a growing interest on several sectors to use unmanned vehicles at first in the military domain and later in civilian domains (Cox, Nagy, Skoog, Somers & Warner, 2004). With the increase in the number of these vehicles at lower cost, several applications have emerged such as the help to weather forecasts, evaluation of natural disasters such as the floods, the monitoring of industrial and maritime regions and the cleaning of the oceanic regions where soil and water pollution is dispersed.

Region monitoring is an important task for collecting information and physically detecting the phenomena. Generally, the task of surveillance handles the problem of image processing and updating for a given region (Jakob, Semsch, Pavlicek, & Pechoucek, 2010). The task of cleaning of a zone represents a very big interest because of its significant not only environmental or economic, but also social impact. An effective ocean region monitoring is a precious action to detect the dirty zones. To cope with this situation, a big mobilization of human, material, energy or even software resources is necessary (Jakob et al., 2010). However, the posed challenge by the monitoring and cleaning problem is the reduction of the required time to monitor a region and analyze it to detect dirty zones by an autonomous unmanned aerial vehicle (UAV). Then make decisions to launch autonomous unmanned surface vehicle (USV) to clean these disasters by considering the reduced energy of each vehicle in order to reduce the execution time of the mission. Due to the decisional autonomy and the low cost of unmanned vehicles, they became a candidate solution in the deployment of such field: monitoring and cleaning dirty zones.

The cooperation of Unmanned Aerial Vehicle (UAV) and Unmanned Surface Vehicle (USV) attracts more and more researches, essentially for the complementary skills provided by each type of vehicle (e.g. payload, computing power, motion speeds, local vision, etc.). Thus, the deployment of UAV and USV in a cooperative way allows a wide range of applications.

In this regard, in order to improve the efficiency of these applications, some researchers have integrated a centralized decision. This decision includes a real or artificial agent that automatically plans or organizes unmanned vehicle activities, monitors the performance of their objectives, and monitors the state of the systems.

The main objective of this work is to propose a cooperative approach based on UAV and USV to carry out in a coordinated way a set of dedicated tasks: monitoring, detection and cleaning of dirty zones in an ocean zone.

In this paper, we propose a centralized architecture for UAVs and USVs. This paper focus on monitoring unknown ocean regions, detecting dirty zones and cleaning these zones using USVs. The geo-referenced images of the UAV are collected using the sensors that will be used in this work to create

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