“Marine Autonomous Observing Systems: Scientific Requirements and Technological Opportunities” Workshop

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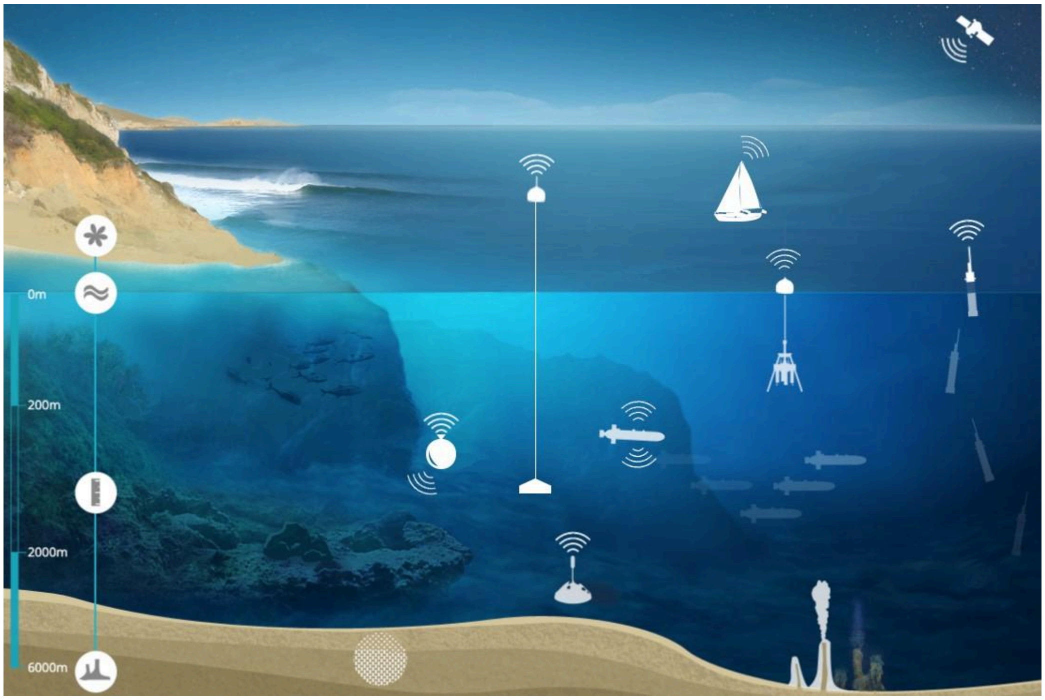
White Paper

“Stratégie décisionnelle et fiabilité mono et multi-engins, intelligence artificielle”



Guidelines:

- **Coordinators:** Claire Dune, Jan Opderbecke
  Please send email to coordinators to notify your interest for this section
- **Objective:** report on SMA2M "table ronde" and highlight technological opportunities and prospects.
- **Length (soft limit)**: 4 to 6 pages per subsection (e.g. "Energy and reliability", ...) figures included
- **Structure**: each subsection (e.g. "Energy and reliability", ...) should adopt the following structure:
  - Background / introduction
  - Item 1 (e.g. "Fixed-point observatories"):
    - Background
    - Description of relevant opportunities with expected outcomes
  - Item 2…
- **Highlighting opportunities:** opportunities should be highlighted with **bold, red fonts**
- **Table:** fill the sheet entitled "technological opportunities" in the following spreadsheet:
  - https://docs.google.com/spreadsheets/d/1aIDtzbTsZqSEzydYGZsivjrf-04ci0UOyyGddkv6e_M/edit?usp=sharing
  - The data will be used to assemble a visual synthesis of these sections
- **References:** provide pointers/links toward relevant papers, projects, efforts.
- **Keywords:** each subsection should have a list of keywords related to either autonomous platforms relevant features, characteristics.

discussion / general comments:

(please identify yourself)

1.1. Decision-making strategy and single and multi-engine reliability, artificial intelligence

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1.1.1 Introduction

The deployment of autonomous systems raises many issues that have been avoided by wired systems until now: energy autonomy, communication, localization, and decision making. In this section we focus on the last aspect, which is the decision-making autonomy of measurement systems.

Autonomous systems will make it possible to carry new payloads, to operate longer, deeper missions, with greater data density and ever more precise resolutions. When we imagine the autonomous measurement systems of the future, we imagine systems that are easier to use, deployed independently of their home ship, and even delegate some of the work of scientists to them. What if the system could select measurements, pre-process the data, label them, and analyse?

But as a scientist, are we ready to give decision power to a robot? How can we transfer the knowledge and analytical skills of a scientist to a robot? How much intelligence must be onboard to ensure that an autonomous system meets a scientific need?

How to guarantee that we do not miss information or focus on irrelevant salliancy?
Finally, how to guarantee the reliability of these systems? First, the reliability of the system itself: the more autonomous a system is, the more complex it is and the more difficult it is to guarantee its integrity. And secondly, the reliability of the measurements they acquire and their interpretation?

This round table was divided into four parts: the first will focus on autonomous data acquisition. Then we will ask ourselves what the embedded intelligence should be and what is hidden behind these terms. The more the systems are autonomous, the more complex they are and the more difficult it becomes to interoperate and to make their behavior reliable. We will see that methods exist however and finally, we will see how scientists will be able to define their missions in the future and transfer a part of their knowledge to the systems

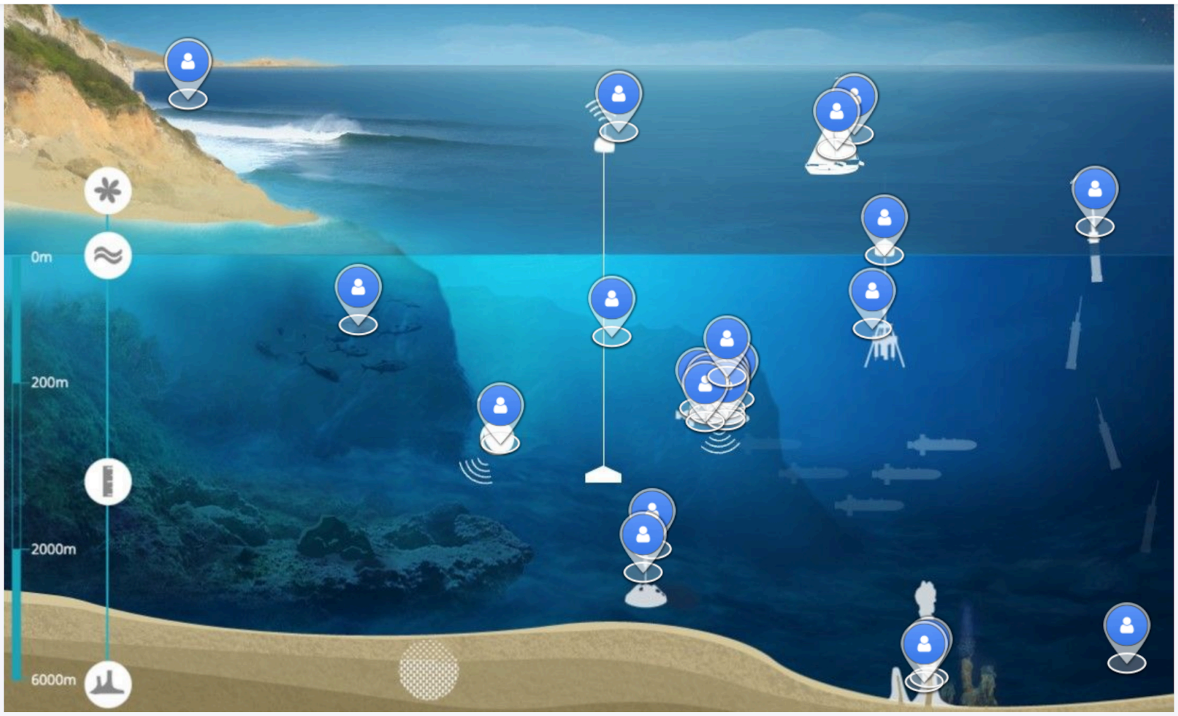

Figure 1. 50 persons assisted at the round table. When they were asked to localise themselves on this activity map, this is where they stood.

1.1.2 Autonomous measurement acquisition strategy

First, we have to define what “properly observing a phenomena” means.

Three strategies can be designed
1. Following a predefined path : this is typically what is done so far with AUVs
    a. predefined transect
    b. assumption on the terrain
    c. constant depth / altitude
2. Online adaptation of the path according to perceived data
    a. Suivi de la frontière d’une zone physique
    b. Suivi d’une espèce en déplacement
    c. Suivi de gradients physique
3. Adaptatif sampling

Three robot functionalities needs to be developed :
1. Mapping phenomena
2. Sampling area selection
3. Planning data acquisition

This demands a *constant* and *close* dialogue with experts.

1.1.3 Embedded intelligence

There are several levels of decision making :

1. decision making for the conservation of the robot itself and its reliability,
2. decision making for the realization of the mission,
3. decision making on the acquisition and processing of the data.

The two first ones are often forgotten (see Fig.2) yet essential.

There are two ways of dealing with artificial intelligence, or decision making

1. Model driven : the phenomena description can be explicit by mathematical formulas and parameters that can be used to determine robot action. This is machine learning.
2. Data driven : the phenomena is not modeled but rich data sets are available and describe it. This is what we call deep learning.

Figure 2. What new scientific application comes to mind when you think of embedded intelligence? (19 participants)

1.1.4 Reliability and robustness of autonomous measurement systems

There are well-established formalisms and development methodologies for the reliability and safety of airplanes, trains, ... the robotic systems we are talking about embody a much more complex set of software functions, for which such formalisms and methodologies remain largely undefined.

1. Guarantee Calculus : check if the robot completes the exploration of the environment, although the navigation and the sensor have uncertainty
    a. Interval analysis
    b. Constraints programming
2. System Reliability : check if the system is safe
    a. Unpredictable event handling

b. Detect failure

Figure 4. What is the most important functionality of an autonomous system to you? (40 participants)

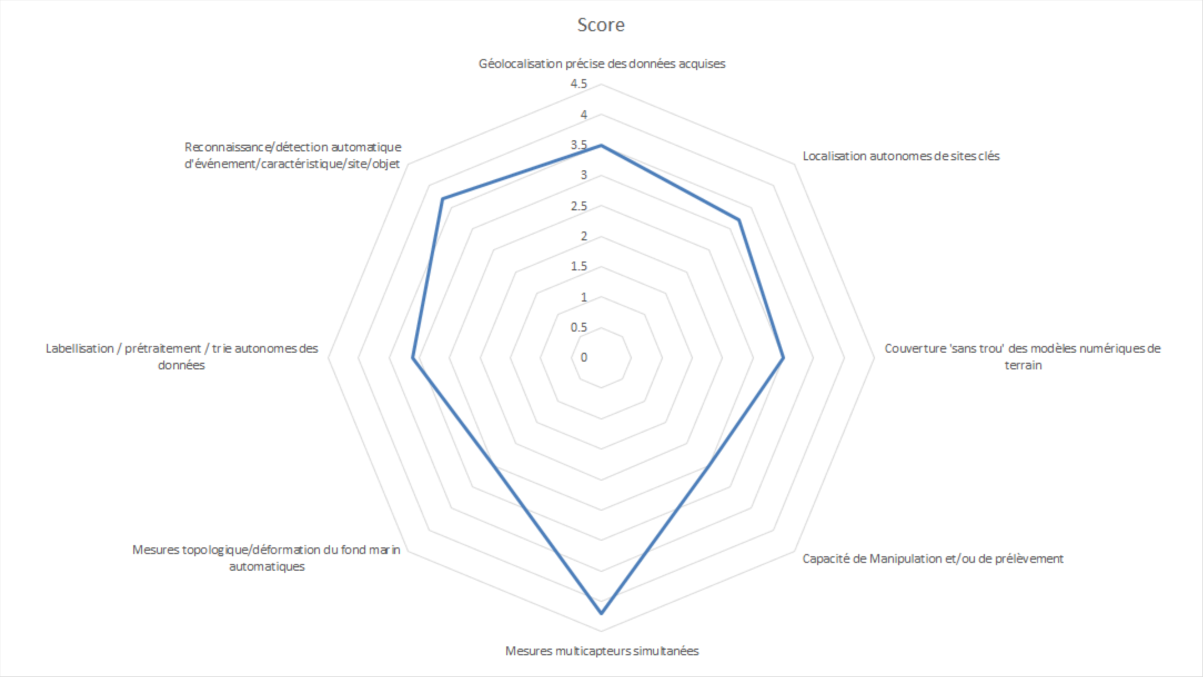

Figure 5. How important are these features to you? (19 participants)

1.1.5 Evolution of mission protocols with autonomous vehicles

Main issues

- Balance/compromise between strictly defined and adaptive behaviors
- Guarantee interpretability of the execution
- Expressing operational and operator constraints

- Integrate scientific processing methods, protocols and algorithms

Conclusion

1 Limites actuelles

- Evitement automatique de danger (USV)
- Résolution spatiale
- Utilisation drones/AUV en zone côtière : cohabitation avec autres usages
- Cadre juridique : drones/AUV peuvent ils être utilisés de façon autonome dans ZEE française?
- difficulté d'implémentation

2 Opportunités

- ♥1 Cartographie des habitats
- ♥1 cartographie variabilité océanique petite échelle
- Surveillance habitats halieutiques essentiels (frayères, nourrisseries)
- Orienter échantillonnage/mesure

3 Nouvelles fonctionalités

- ♥2 Surveillance d'écosystèmes
- ♥1 Mise au point sur un organisme avec une caméra/appareil photo
- Charge utile acoustique halieutique large bande
- mesure et validation simultanée de cette mesure
- détection d'événement

4 Risque

- résultat incertain
- Passer à côté d'un événement d'interêt
- Automatiser les déplacements d'un crawler qui est sous environnement Windows?

References

[Gu17] Guiochet, J., Machin, M. and Waeselynck, H. Safety-critical advanced robots: A survey. In Robotics and Autonomous Systems, vol. 94, pp. 43-52, august 2017. Elsevier.