AUV Risk Management in Coastal Water surveys

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Abstract -

The Unidad de Tecnología Marina (UTM) is a technical unit of the Spanish Research Council (CSIC) that provides technical support to the Spanish research vessel fleet. The Unit acquired two small Autonomous Underwater Vehicle (AUV) in October 2010 as test platforms for coastal research. The main objective during this time has been to build confidence among the scientific community on these platforms and to explore protocols for its use as a scientific tool on coastal and inner waters.

These scenarios are quite dangerous for the vehicles and a risk management policy is advisable for such type of operations. In this paper we will present three cases where we use the protocol that UTM is developing to minimize the risks on such operations.

Keywords

AUV, marine research, coastal oceanography, risk management

INTRODUCTION

The Unidad de Tecnología Marina (UTM), a division of the Spanish Research Council (CSIC) is the main marine technologic service provider to the Spanish marine research community. It manages different sea-going facilities, as well as the Spanish Antarctic Base and has been operating two small Autonomous Underwater Vehicles (AUVs) on coastal waters since late 2010 with the final goal of adding these platforms to the support service offered to the Spanish marine research community.

These AUVs were acquired as testing devices for R+D and instrument platforms for marine research in littoral and shallow waters. Part of the initial operations policy was to try to minimize risks during training initial operations as part of a confidence build-up period. Broad directives were issued as well as a general insurance policy.

During these past two years some of the procedures have been optimized and we outline below the current risk mitigation policy using three different scenarios where we have been working.

OPERATIONAL RISKS ON COASTAL WATER OPERATIONS.

AUV's started during mid 60's decade as experimental vehicles within the military sphere but during the 90's, the economic situation allowed industrial partners (offshore) users to slowly get the technology at work, which with the latest technical advances and miniaturization led to an increased, yet slow, use by the scientific community.

Manley [1] suggest that operational risks associated with to AUV operations could be one of the reasons of the slow grow of operation in the commercial and scientific business areas.

Traditionally it has been considered that the most critical phases of any AUV operation are launching and recovering. This is true for deep ocean AUV's which are operated from relatively big ships in are fairly "quiet" environment.

Coastal AUV operations on the contrary used to be carried from either shore or small boats, in shallow, waters, near the shore, with a high probability to find uncharted obstacles or surface traffic of various intensity.

Several approaches have been made to try to quantify the ongoing risks on AUV operations on different scenarios, taking advantage of the extensive field experience on this particular issue of other autonomous platform operators, as the military AUV / UAV operations. Different scenarios have been studied [2] and coastal surveys have been recognized as one of the most challenging setups, being the survival probability between 0.97 and 0.99 for mission ranges below 30 km for this particular case.

Coastal water surveys are one of the most demanding scenarios for AUV [3], where the potential risks are numerous and might include man-made structures, environmental hazards and risks derived from human activity. Also the relative frequency of occurrence of such episodes is quite high and they can be present at the same time.

With the purpose to achieve a high survival probability, a risk mitigation strategy is necessary.

PRACTICAL CASES

In order to illustrate how we manage this issue we will show three different cases that we have been working (fig 1):

Port Forum (Barcelona):

This area is used for sensors and vehicle testing as it is only 40 minutes away from our base laboratory. It is located 2 n.m. north of Barcelona Port, this area is

Fig 1.- Locations areas studies. Left, Sada Bay with mussels rafts. Top, Barcelona Port. Bottom, Soller Port

outside the commercial ship lines but has two nearby marinas with moderate to high motor boat activity, especially in summer time.

This area is shallow (20 – 50 m) and has two sewage pipes (one inactive) that can be used to target location tests. It also has many beaches where the vehicle can be diverted in case of emergency.

The main hazards in this area are (in order of importance):

- Motor board traffic (mainly during summer).
- Artisanal fishing (early hours of the day).
- Besos river discharge (episodic).

In this case, the specific mitigation measures adopted where the following:

- Always deploy the vehicle in areas where no fishing activity is visible or after the fisherman had gone to port (usually before mid-morning).
- Plan the recovery and the GPS check points outside the usual paths of circulation (approaches to the marinas, leisure boat corridor, etc.).
- In summer try to recover the vehicle before midday when the wind gets stronger and the sailing activity increases.

Port Soller (Mallorca):

This natural harbour is located in the Tramontana Mountains (Mallorca). This is a very touristic place along the year, but especially during the summer season. The study area has two sections. On one hand, the military harbour output and the entrance of the recreational boats (max. depth 15 m). On the other hand, the second section is situated close to a cliff, in a deeper area.

In this case, the objectives of this mission were to check the entrance of seabed with a side scan sonar and to film the seagrass areas.

The principal risks in this area are (in order of importance):

- Motor board traffic and anchored boats.
- Natural risk (shallow depth, proximity to the cliff).

After a brief GPS calibration it is decided to station the Rigid Inflate Boat (RIB) at one tip of the bay (using a GPS check point) to avoid collisions when the vehicle surfaced. There is no risk of collision when the mission was underway as it ran deeper than the allowed draft of the ships entering the harbour.

Sada (La Coruña):

The study area is located on a small bay on the Rías Altas. One of the most important economic resources of this area is the mussel culture. Environmental studies of these sites is essential to determine the conditions for optimal growing rates and they also could help to predict toxic algae blooms that could lead to farm and economical closure[4].

Key variables in this study are the physic-chemical parameters and the amount of food, which is estimated from the fluorescence of the water column.

The study was conducted under a worst-case scenario setup. The highest exposures in this place are (in order of importance, Figure 2):

- Mussel farms are a highly dynamic environment. Rafts are anchored at one point but they move with the wind and tidal currents.
- A mussel farm can be very active area with several 30-ton service boats operating continuously and simultaneously.
- This zone is located on a small bay, surrounded by rocky cliffs and only has a narrow beach with many surface obstacle for the emergency route.
- The seafloor below the mussel farm is full of debris, including anchors, ropes and mussel lines.
- This region suffers adverse weather during autumn and winter seasons.

This case was complicated and many additional measures were adopted:

- A complete GPS survey was done prior to the deployment in order to geolocate precisely all the mussel rafts to plan the safest route for the vehicle. In scenarios with fixed structures this info would be ideally inserted on a GIS for future reference.
- We had full collaboration of the main producer at the mussel farm. A deployment plan was envisaged in order to coordinate as much as possible the path of the AUV with the movement of the support barges, either in time or space.

- We planned full scale deployments to be done outside the normal schedule for the farm (early morning, late afternoon, and weekends), partial lines and test were more compatible with the daily farm activity.
- Weather was bad and unstable. A tight monitoring of the weather forecast was set to abort the missions if necessary.

RISK MITIGATION PROTOCOL

In order to reduce the risk of loss during our AUV operations we have developed a small protocol which is divided in three phases. The basic outline is as follows.

1. Information phase.

The objective of this phase is to gather the maximum Information about potential hazards in the study area. A small form has been produced to ask the scientist / users about their knowledge of the area, including:

- Recreational activities (divers, motorboats, etc.).
- Fisheries / industrial activities.
- Local authorities contacts (Police, Coast Guard, Port Authority, etc.) in case some of the AUV activities could be in their area of influence/ surveillance.

If necessary, further information is collected directly from the local authorities or doing a personal research.

With this information the most probable hazards are identified and the specific mitigation measures are studied if needed.

2. Execution phase.

These mitigation measures are going to be implemented during the execution of the survey; there are general measures (to be applied in all the scenarios) and specific measures that are adapted to each deployment from the information collected during Information phase.

General precautions include:

- GPS calibration and obstacle georeferencing.
- Tests dives (compass calibration, GPS check, trimming tests, etc.).
- Surface runs at the area to validate path and check for submarine obstacles.
- Regular GPS tracking of the vehicles when surfacing and while are submerged (to check that no emergency mission has been triggered).
- Acoustic location when possible.
- Safety boat (launch & recovery, safety at surfacing points, seaweed checking, etc.).
- Weather monitoring.
- Specific precautions may include:
- Pre-survey meetings with local authorities or people likely to work in the area (fishermen, marinas, etc.).
- Try to establish a boat traffic schedule (fishermen, regular leisure boats, etc.).
- Gathering of information regarding scuba activity in the area.
- Planning recon missions to get information of the local bathymetry, currents, seafloor composition, etc.

3. Analysis phase.

During the survey, an incident log should be maintained. Post cruise analysis of the results of the risk mitigation protocol shall help to enhance the security of the future surveys in the area.

This is the less developed aspect of our protocol as we have few data to do a quantitative analysis and the systematization of the data gathered has to be developed yet.

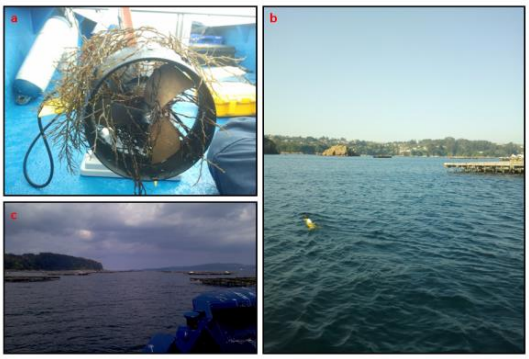

Fig 2.- Operational risks. Top left (a) Seaweed obstructing the propeller. Bottom left (c), Mussel farmt. Right (b), AUV close to a mussel raft. (Sea Technology, August 2012.)

Most of our current missions until now have been short ranged (less than 2-3 hours) or tests, and a tight monitoring have been provided for the longer lines. The protocol has been quite successful so far, although the operations have not been excluded of some “close calls”, mostly due to surface traffic activity and technical problems.

Unfortunately both vehicles have been most of the last year at the factory, addressing technical issues and we do not have enough data to make a consistent tracking of the result of this policy, to make corrective actions.

To address this problem a new reporting protocol is being implemented to fill the data gaps and establish a data base which can help to improve our operations in the near future.

CONCLUSIONS.

Despite the actual low rate of use, a consistent risk mitigation policy has been established for our AUVs. The protocol is divided in three phases where basic information is gathered prior to the survey execution

and surveys results are evaluated to identify potential risks for future operations.

Risk mitigation protocols can be embarrassing and may seem to be against some of the theoretical advantages of the AUVs and a waste of time. However, it is a strong confidence builder and it could be a big advantage when the vehicle is working on repetitive surveys on relative small areas, increasing the security and productivity of such surveys.

The increased use of the vehicles will allow us to build a suitable dataset to help on the decision making process

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