

# Explorer et revenir pour un robot sous marin avec un échosondeur pour unique capteur extéroceptif

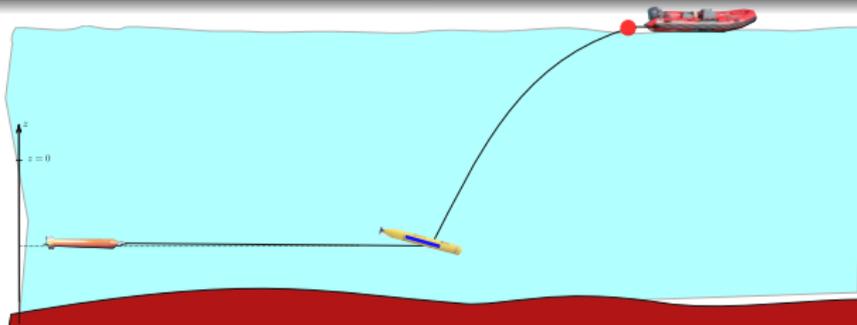
L. Jaulin

MOQESM 2018, Brest, SeaTechWeek  
8-9-10 octobre 2018



# Context







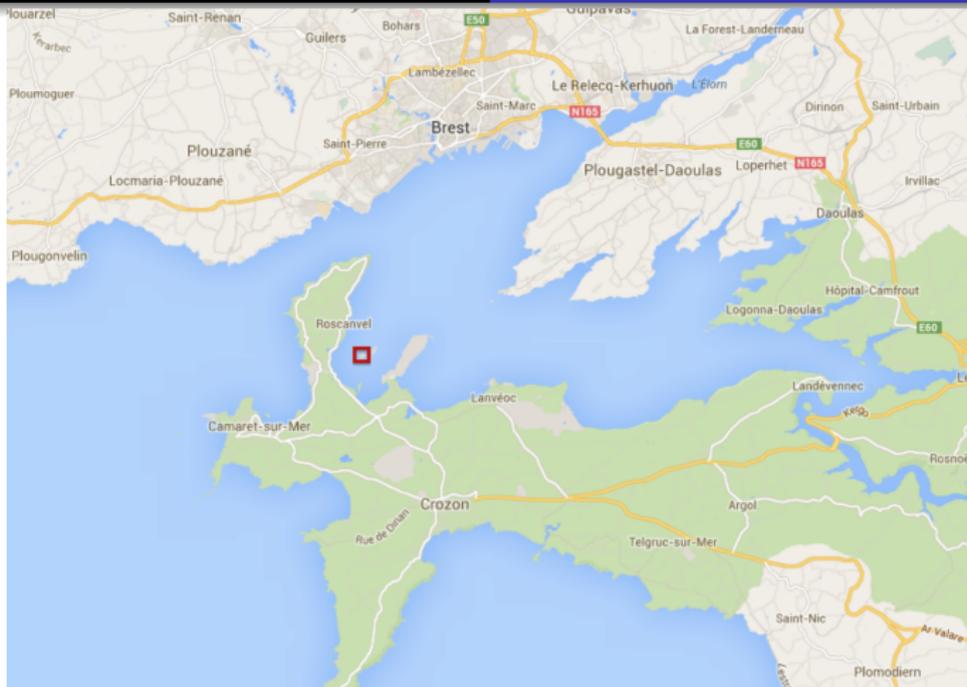
Tests du 7 juillet

[youtu.be/cxVs1fDdm1s](https://youtu.be/cxVs1fDdm1s)

# Follow an isobath

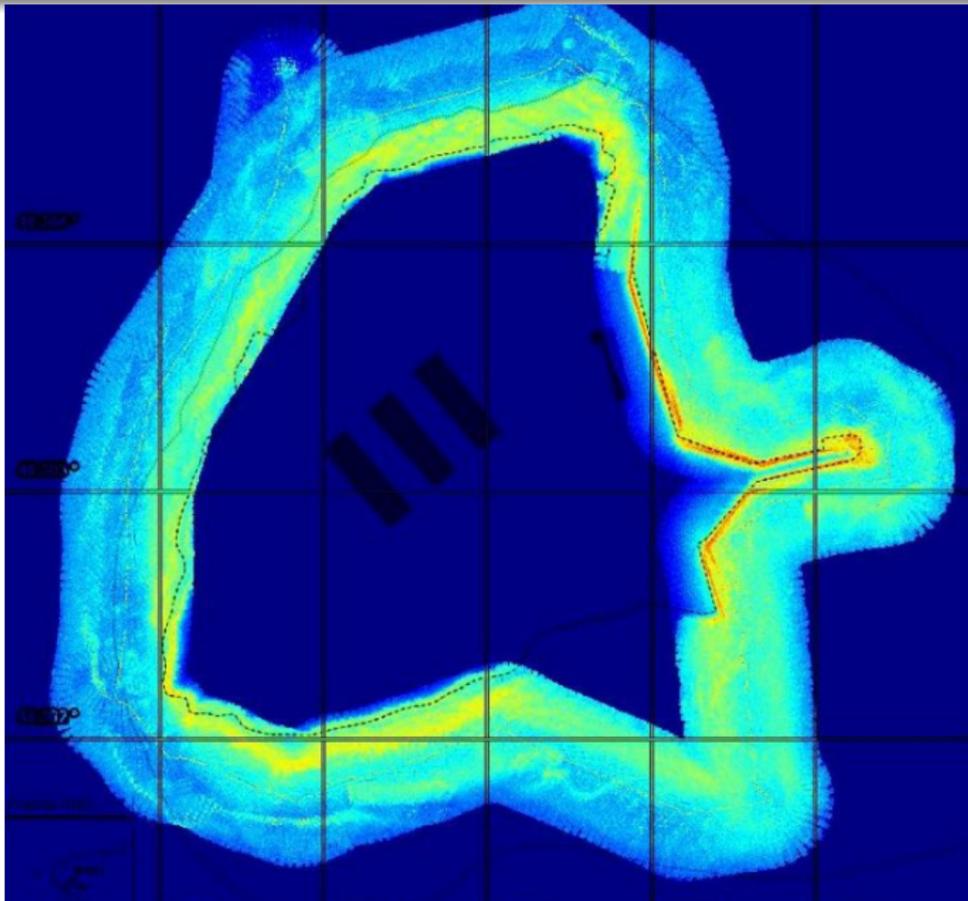
# Ile des morts experiment

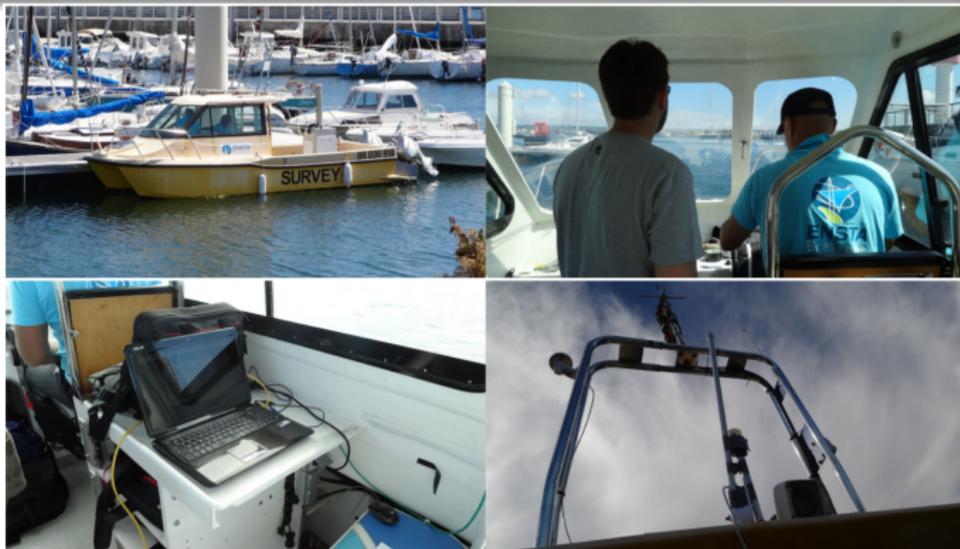
Context  
Follow an isobath  
Controller











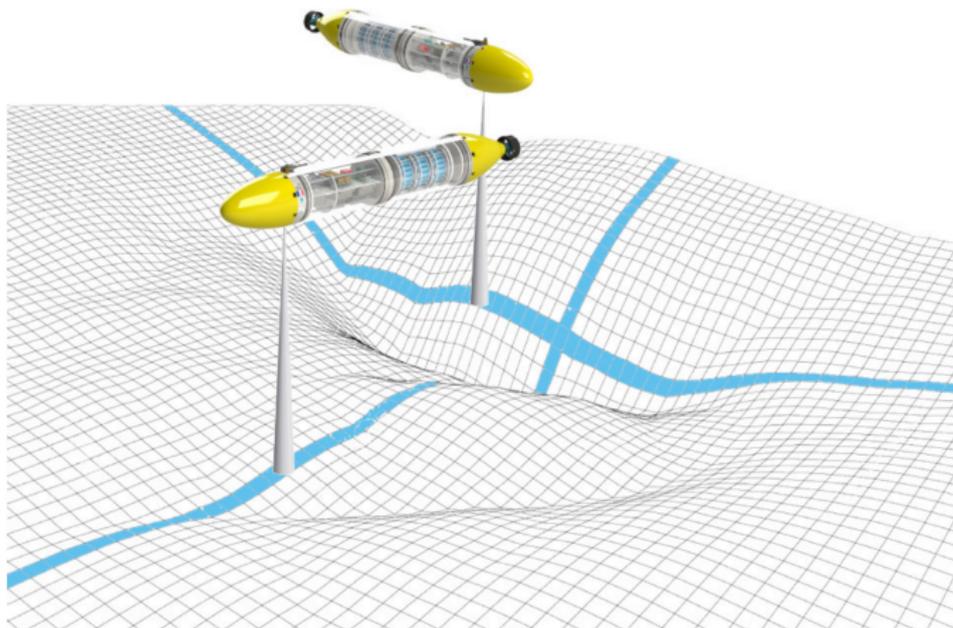
24 juillet 2013



**Objective:** Follow an isobath with an altimeter, a barometer and a low cost gyroscope.

## Exploration

- SLAM paradigm
- Bridge-river paradigm



[3]

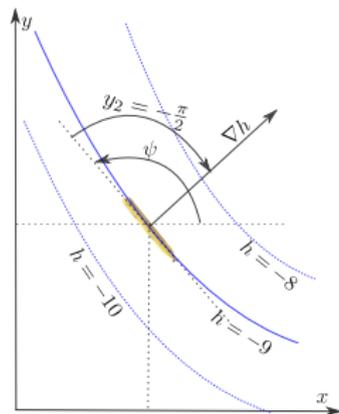
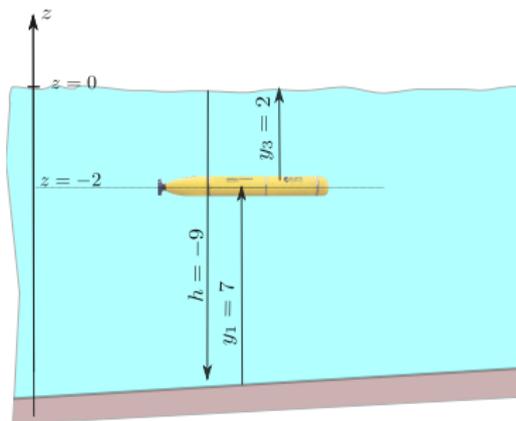
# Controller

Consider an underwater robot:

$$\begin{cases} \dot{x} &= \cos \psi \\ \dot{y} &= \sin \psi \\ \dot{z} &= u_1 \\ \dot{\psi} &= u_2 \end{cases}$$

The observation function is

$$\begin{cases} y_1 &= z - h(x, y) \\ y_2 &= \text{angle}(\nabla h(x, y)) - \psi \\ y_3 &= -z \end{cases}$$

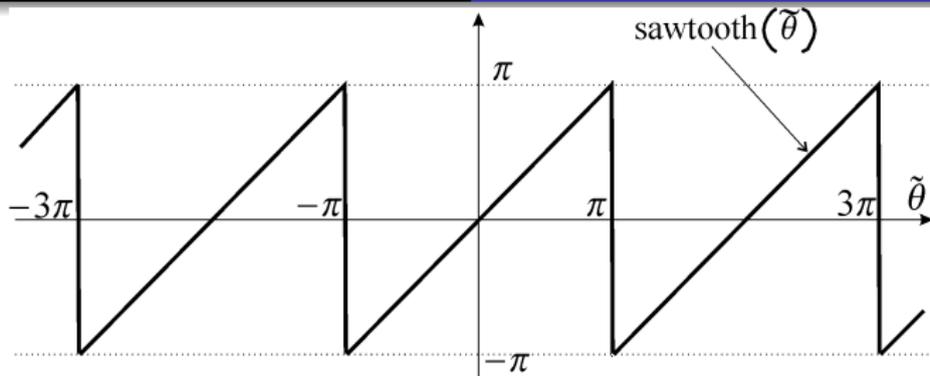


For the control of the depth:

$$u_1 = y_3 - \bar{y}_3$$

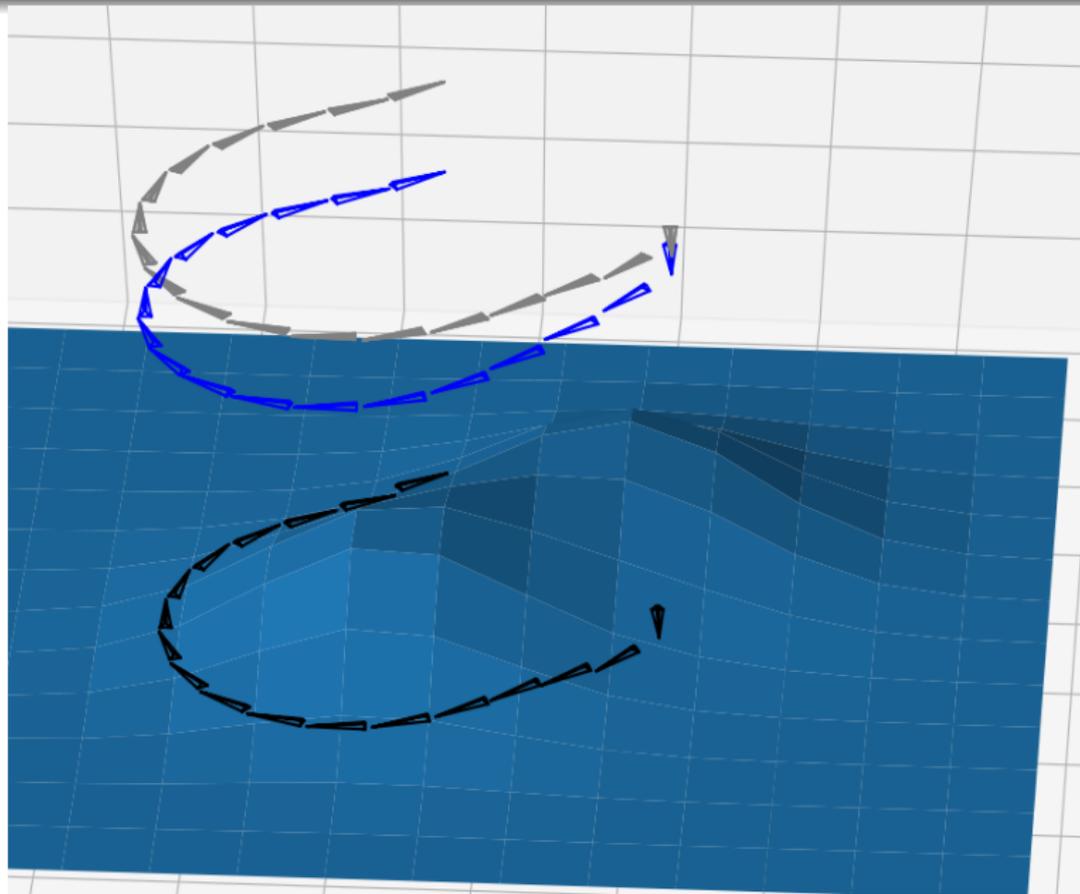
For the heading, we take [1]:

$$\begin{aligned} u_2 &= \tanh(e_2) + \text{sawtooth}(e_1) \\ &= -\tanh(h_0 + y_3 + y_1) + \text{sawtooth}(y_2 + \frac{\pi}{2}) \end{aligned}$$



The controller is

$$\mathbf{u} = \begin{pmatrix} y_3 - \bar{y}_3 \\ -\tanh(h_0 + y_3 + y_1) + \text{sawtooth}(y_2 + \frac{\pi}{2}) \end{pmatrix}$$



The output  $y_2 = \text{angle}(\nabla h(x, y)) - \psi$  should thus be estimated [2].  
In the robot frame the underneath plane satisfies

$$z_1 = p_1 x_1 + p_2 y_1 + p_3$$

**Prediction.** We assume the seafloor locally planar. Thus:

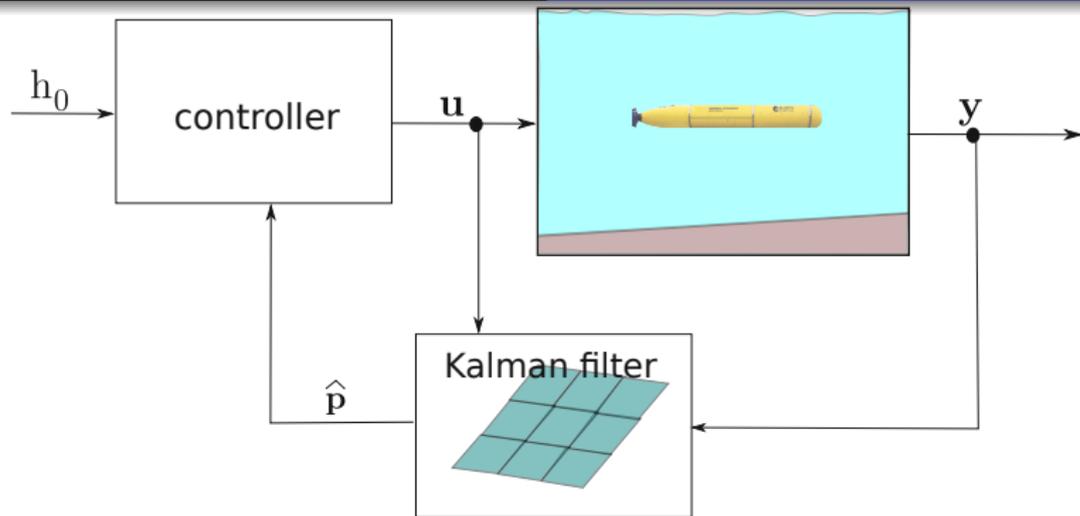
$$\dot{\mathbf{p}} = \begin{pmatrix} 0 & \dot{\psi} & 0 \\ -\dot{\psi} & 0 & 0 \\ 1 & 0 & 0 \end{pmatrix} \mathbf{p}.$$

The prediction for the underneath plane is

$$\mathbf{p}(k+1) = \begin{pmatrix} 1 & dt \cdot u_2(k) & 0 \\ -dt \cdot u_2(k) & 1 & 0 \\ dt & 0 & 1 \end{pmatrix} \mathbf{p}(k) + \alpha(k).$$

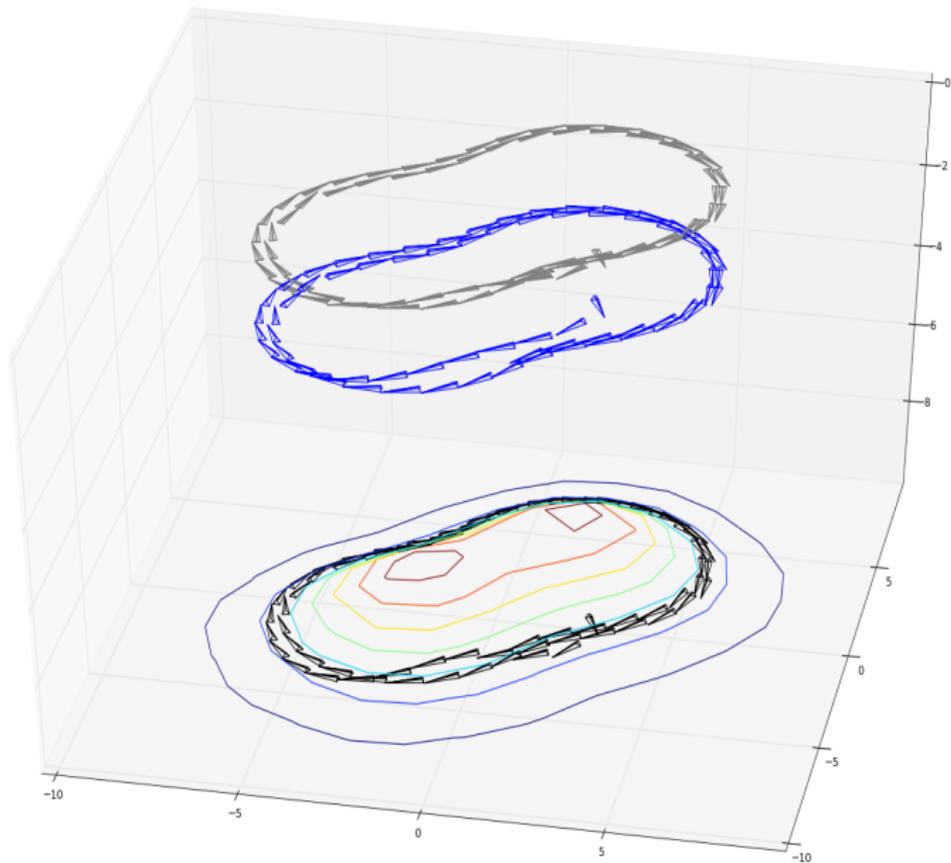
Correction.

$$-y_1 - y_3 = \begin{pmatrix} 0 & 0 & 1 \end{pmatrix} \mathbf{p}(k) + \beta(k).$$



The controller is thus

$$\mathbf{u} = \begin{pmatrix} y_3 - \bar{y}_3 \\ -\tanh(h_0 - \hat{p}_3) + \text{sawtooth}(\text{atan2}(\hat{p}_2, \hat{p}_1) + \frac{\pi}{2}) \end{pmatrix}.$$





L. Jaulin.

*Automation for Robotics.*

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L. Jaulin.

Isobath following using an altimeter as a unique exteroceptive sensor.

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S. Rohou.

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PhD dissertation, Université de Bretagne Occidentale, ENSTA-Bretagne, France, december 2017.