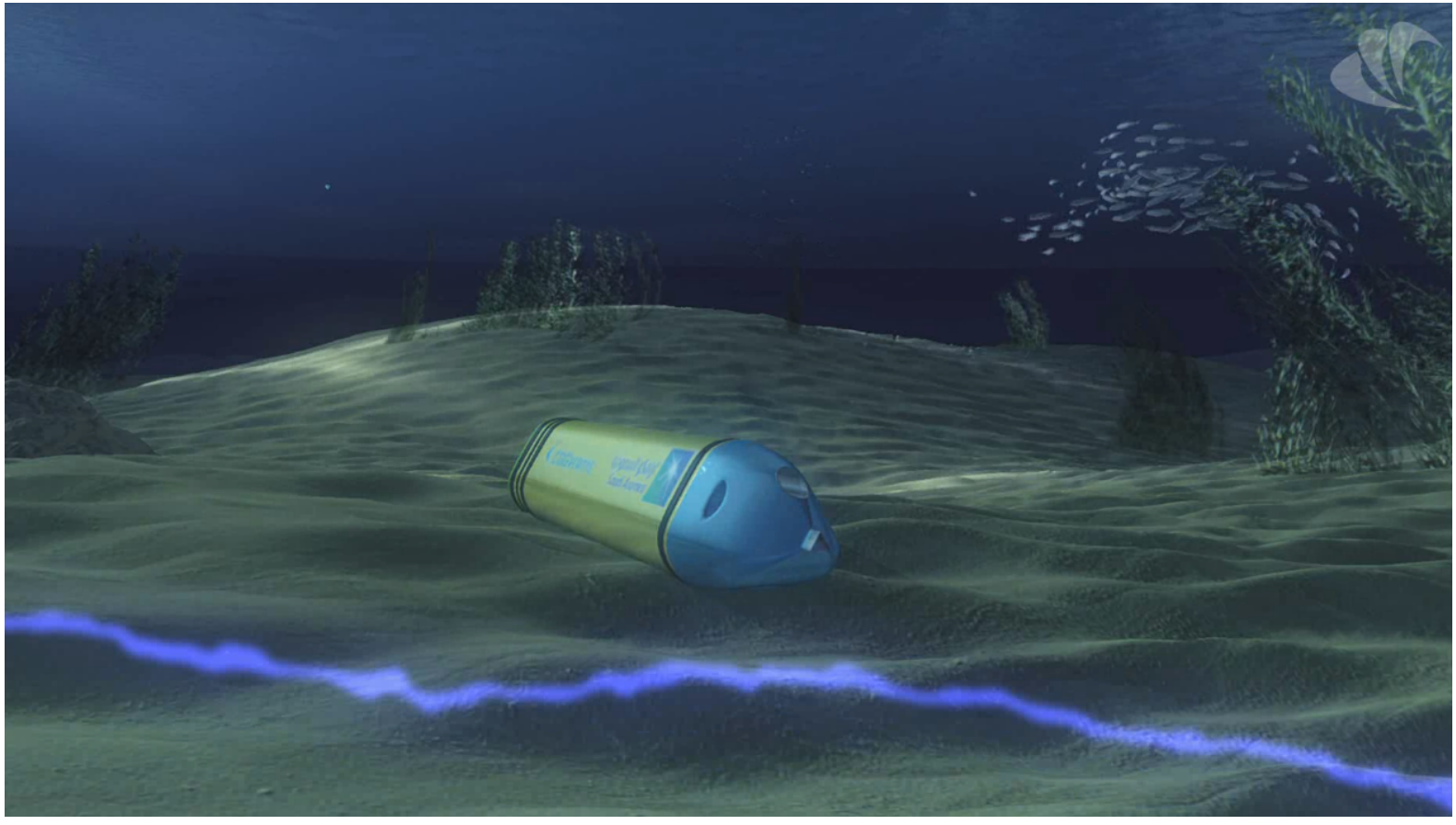
Muling

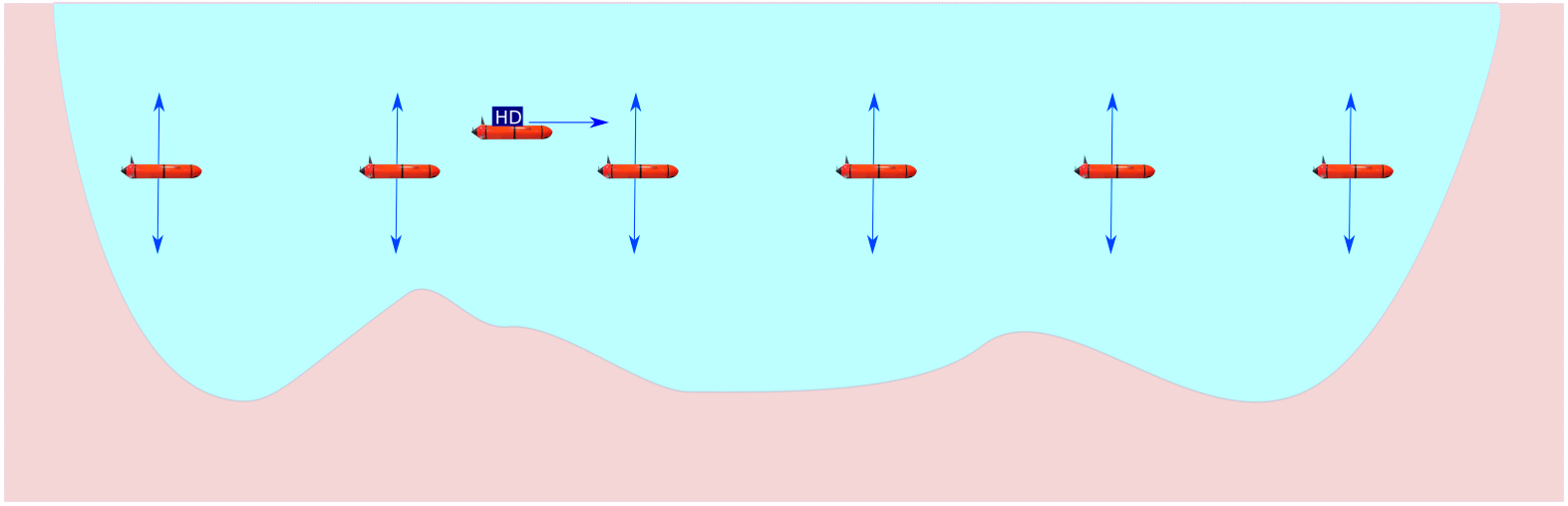
Architecture robotique
https://www.ensta-bretagne.fr/jaulin/archirob.html
Sept 2021- Feb 2022



Youtube

1. Post riders

https://www.frwiki.org/wiki/Relais_de_poste
https://en.wikipedia.org/wiki/Post_riders
https://en.wikipedia.org/wiki/Optical_telegraph


HD

Thermoelectric generator

Between 300m deep to 1000m, the temperature varies of about 20 degrees.
https://en.wikipedia.org/wiki/Thermocline

A thermocouple is an electrical device consisting of two dissimilar conductors.
It produces voltage which depends of ΔT due to the Seebeck effect.
A thermoelectric generator converts heat flux directly into electrical energy using the Seebeck effect.

Stirling motor

The produced energy is

$$\begin{aligned} Q &= PV\frac{\Delta T}{T}\cdot \ln\left(\frac{V_{max}}{V_{min}}\right) \\ &\simeq 10\cdot 10^5 * 10^{-3}\frac{10}{300}\cdot ln(10) \\ &= 20W \end{aligned}$$

Dimensioning

We take the following coefficients

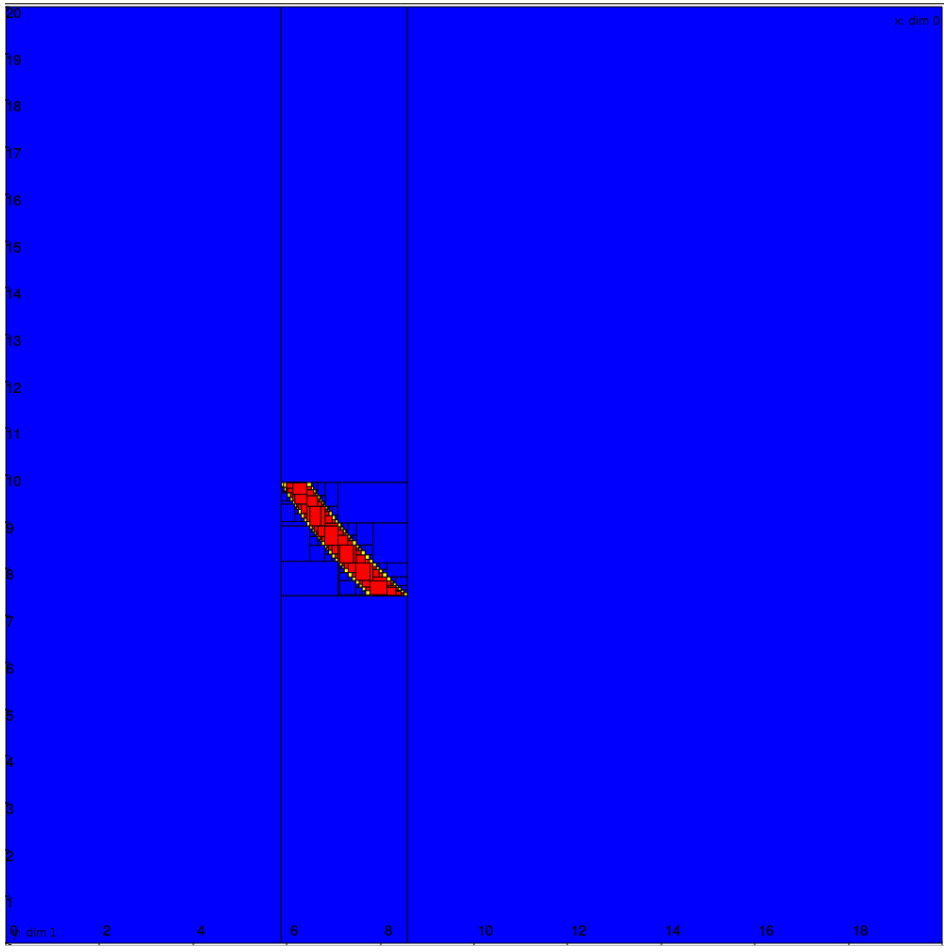
Drag	C_x	$[0.5, 0.6]$
Front surface	S_x	$[0.01, 0.011]\text{m}^2$
Water density	ρ_{water}	1000kg.m^{-3}
Energy of batteries	E_{bat}	$[10, 11]\text{MJ}$
Mule number	N	$[100, 110]$
Distance	D	$5000000 \cdot [1, 1.1]$

P	Power for propulsion
v	Work speed
d	Work distance for one mule
T	Total time

If we are interested by the pair (v, T_{day}), where $T_{day} = \frac{T}{86400}$, we have

$$\begin{aligned} v^2 &= \frac{E_{bat} N}{\frac{1}{2} C_x S_x \rho_{water} D} \\ T_{day} \quad v &= \frac{D}{86400} \end{aligned}$$

We get the following feasible set for (T_{day}, v). We estimate the travel time of about 6 days for a speed of the hard disk of about $10 m \cdot s^{-1}$.



The program is available at: https://replit.com/@aulin/mulingdim

Transmission rate

Assume that each mule can carry $M = 20\text{Tbyte}$. What is the transmission rate ?

Using a thermoelectric generator, each mule can recharge its own battery at $p = 10W$.
The time to get the batteries fully charged is

$$\delta = \frac{E}{p} = \frac{10^7 J}{10W} = 10^6 sec = 11 days.$$

A new hard-disk can be send every 11days. The rate is thus

$$\tau = \frac{M}{\delta} = \frac{20 \cdot 10^{12}}{10^6} = 2 \cdot 10^7 bytes/sec$$