

La Robotique Mobile

À la recherche de garanties...

Générer un mouvement

- Appliquer une force



Appliquer une force

- Par la réaction du milieu



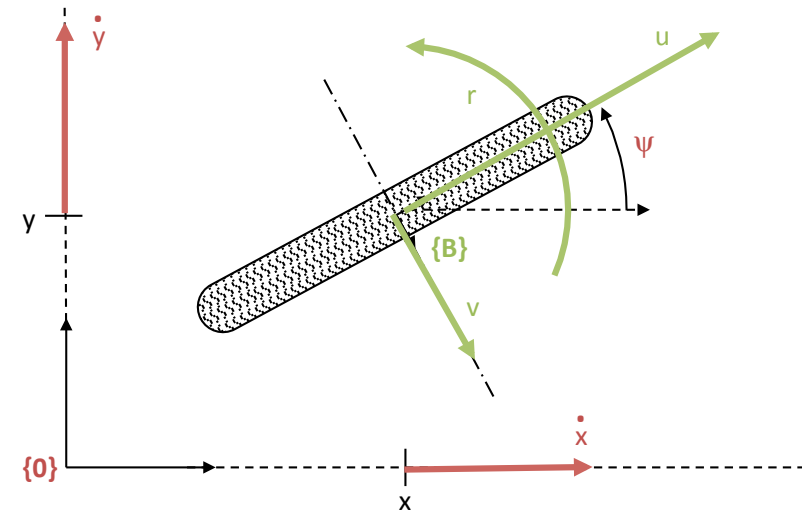
La réaction du milieu

- Contrainte cinématique / dynamique



Contrainte cinématique

- La non-holonomie



$$\begin{cases} \dot{x} = u \cdot \cos \psi - v \cdot \sin \psi \\ \dot{y} = u \cdot \sin \psi + v \cdot \cos \psi \end{cases}$$

Contrainte de non-glissement : $\dot{x} \cdot \cos \psi - \dot{y} \cdot \sin \psi = 0$

$$\begin{cases} \dot{x} = u \cdot \cos \psi \\ \dot{y} = u \cdot \sin \psi \end{cases}$$

La non-holonomie

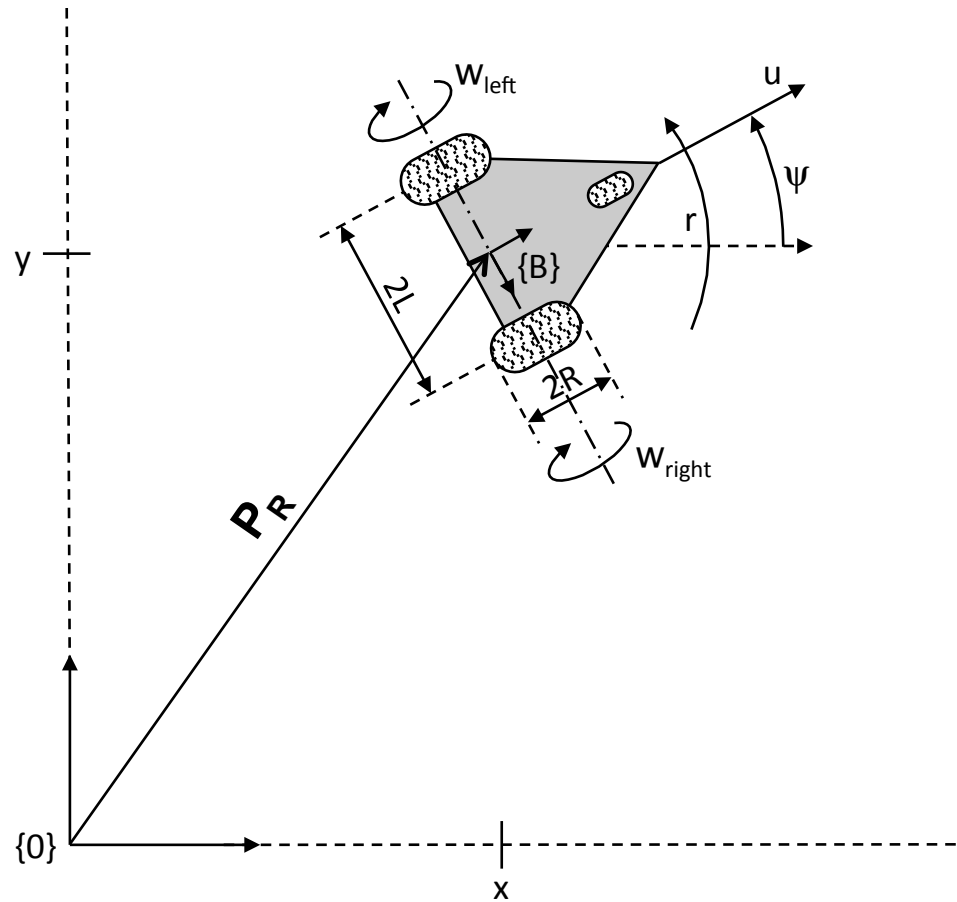
- Conséquences



$$\begin{cases} \dot{x} = u \cdot \cos \psi \\ \dot{y} = u \cdot \sin \psi \\ \dot{\psi} = r \end{cases}$$

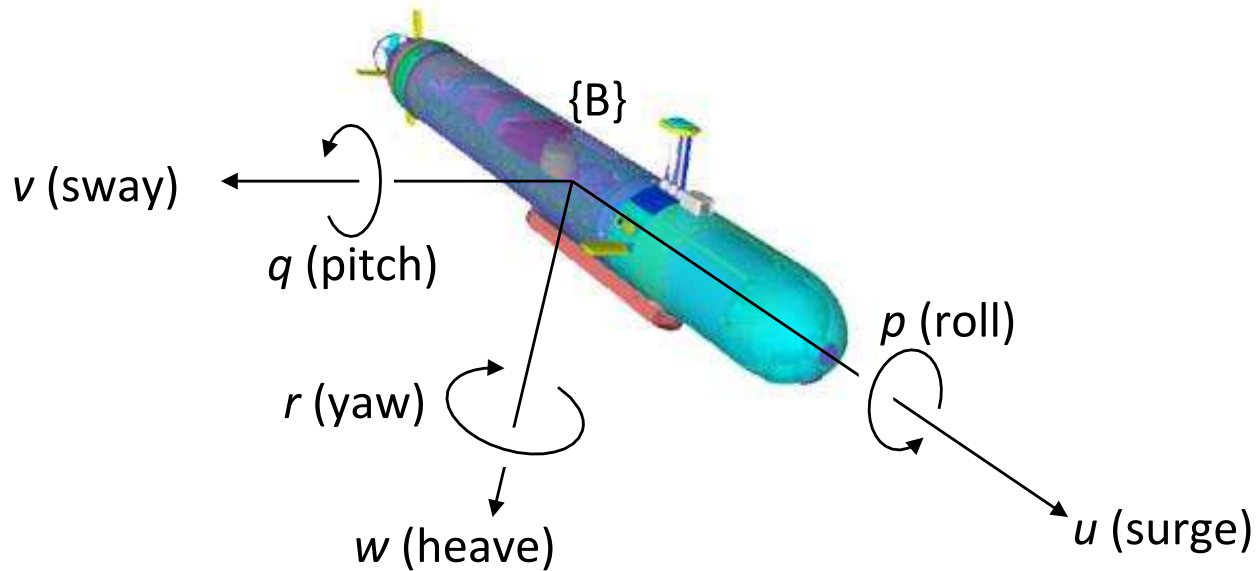
- Linéarisation impossible
 - Perte de la géométrie du problème
 - Linéarisé non-contrôlable
- Stabilisation
 - Une petite erreur engendre une grande manœuvre (non-uniformité de la convergence)
 - *There is no continuous control law which makes the origin asymptotically stable [R.W. Brockett, 1983].*

L'Unicycle



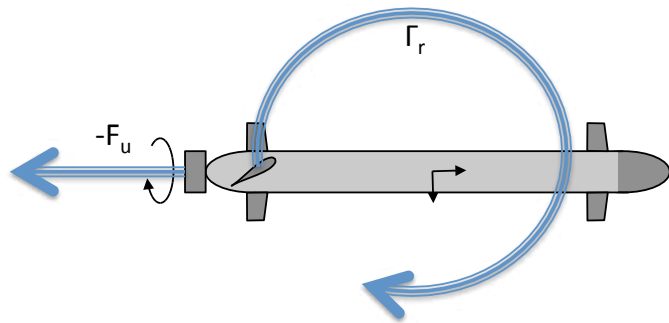
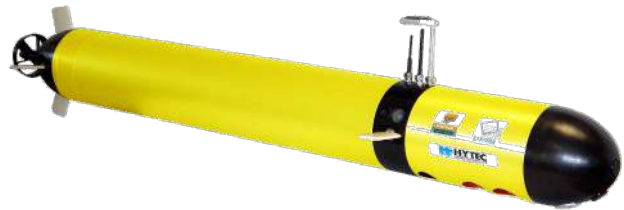
Contraintes dynamiques

- Propriétés de l'étage d'actionnement
 - Sous/Iso/Sur-actionnement
 - Capacité d'avoir une action selon les DDL du système.

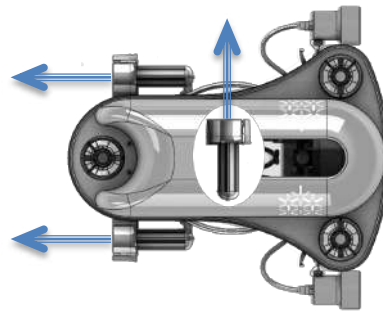


Contraintes dynamiques

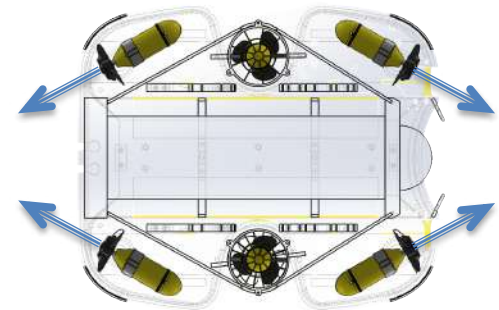
- Propriétés de l'étage d'actionnement
 - Sous/Iso/Sur-actionnement
 - Capacité d'avoir une action selon les DDL du système.



Sous-actionné



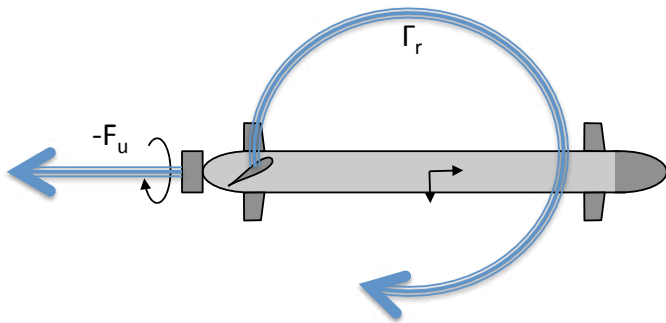
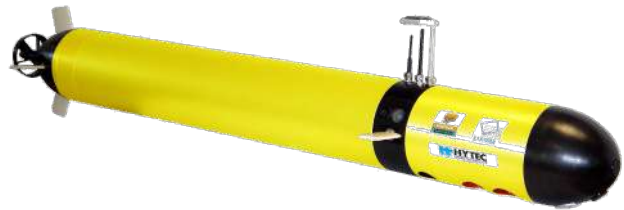
Iso-actionné



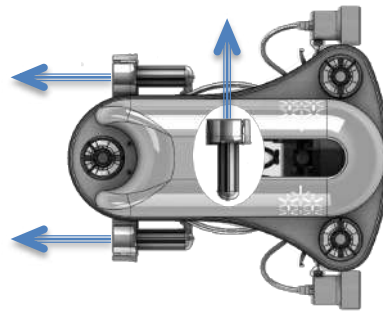
Sur-actionné

Contraintes dynamiques

- Propriétés de l'étage d'actionnement
 - Sous/Iso/Sur-actionnement
 - Capacité d'avoir une action selon les DDL du système.



Sous-actionné

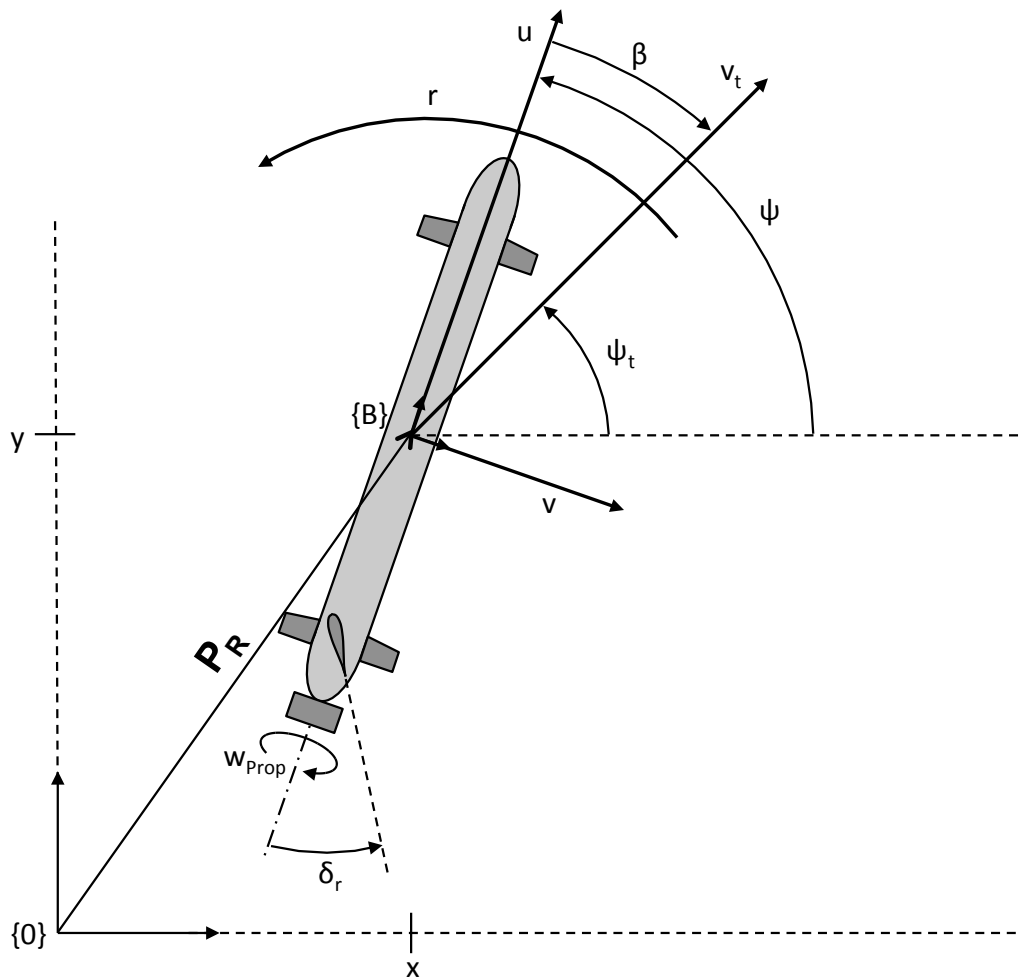


Iso-actionné



Sur-actionné

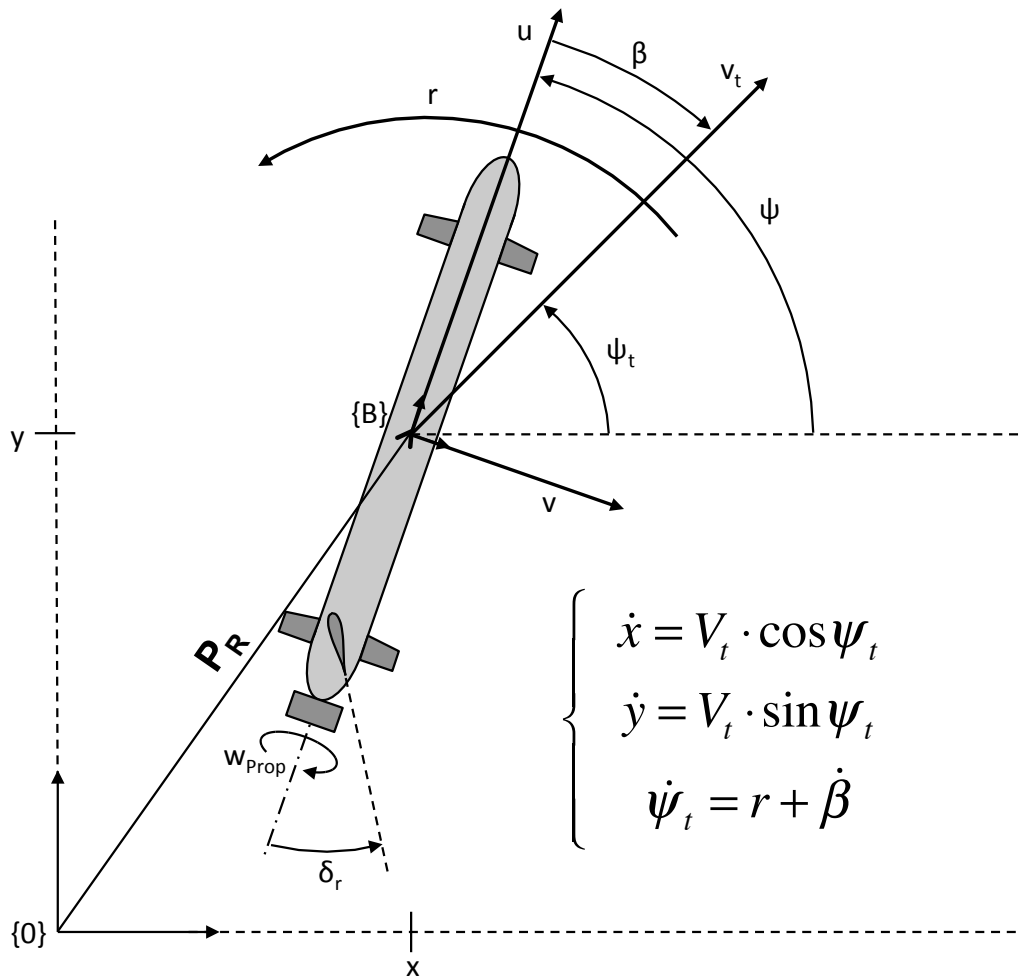
L'AUV



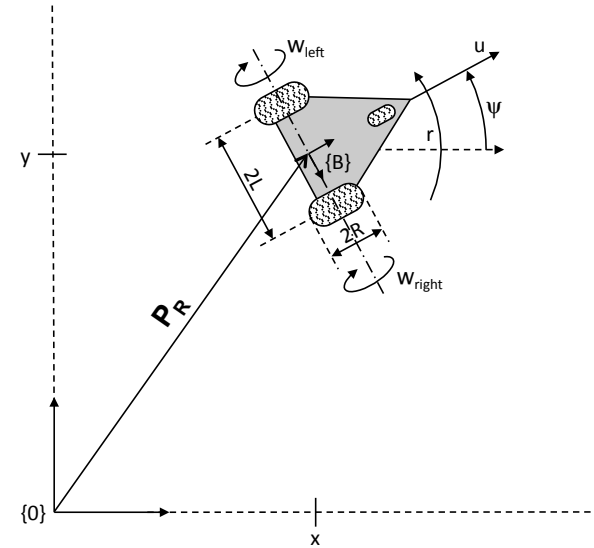
$$\begin{cases} \dot{x} = u \cdot \cos \psi - v \cdot \sin \psi \\ \dot{y} = u \cdot \sin \psi + v \cdot \cos \psi \\ \dot{\psi} = r \end{cases}$$

$$\begin{cases} \dot{x} = V_t \cdot \cos \psi_t \\ \dot{y} = V_t \cdot \sin \psi_t \\ \dot{\psi}_t = r + \dot{\beta} \end{cases}$$

L'AUV

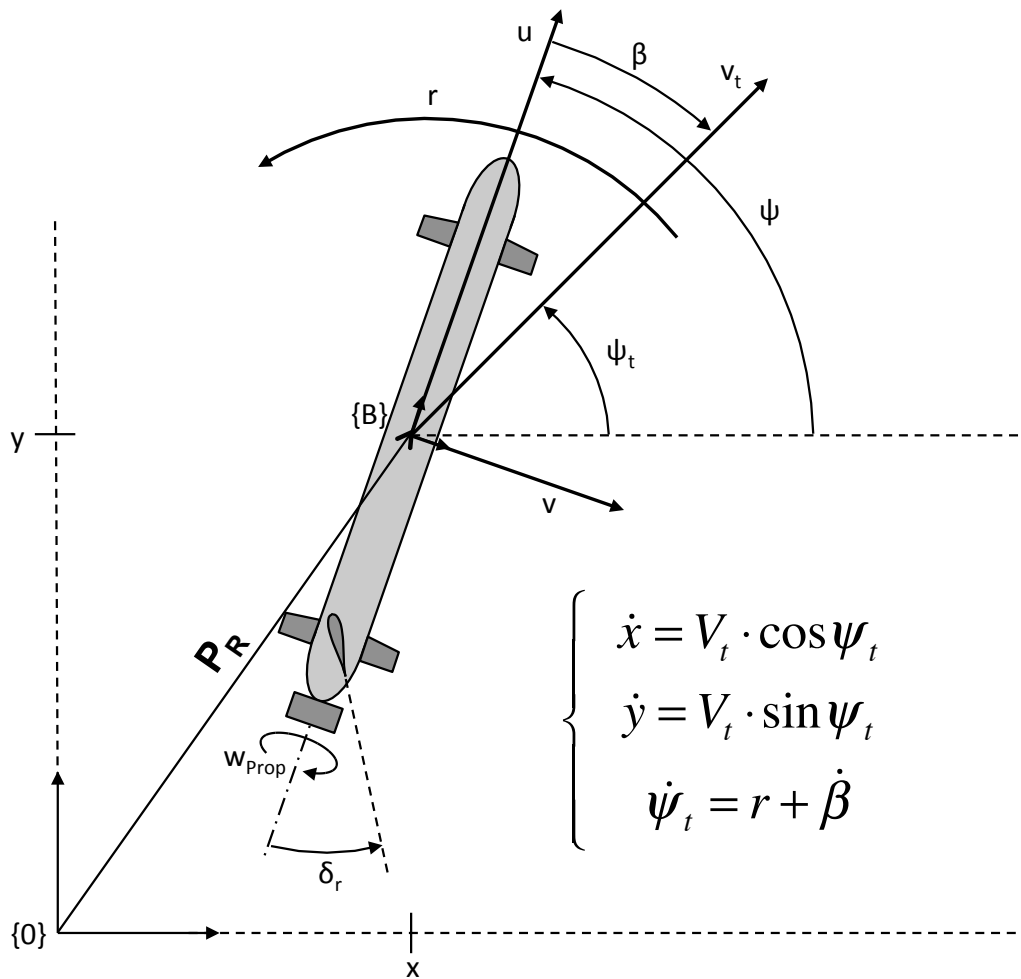


$$\beta = \arctan \frac{v}{u}$$



$$\left\{ \begin{array}{l} \dot{x} = u \cdot \cos \psi \\ \dot{y} = u \cdot \sin \psi \\ \dot{\psi} = r \end{array} \right.$$

L'AUV



$$\begin{cases} \dot{x} = V_t \cdot \cos \psi_t \\ \dot{y} = V_t \cdot \sin \psi_t \\ \dot{\psi}_t = r + \dot{\beta} \end{cases}$$

$$\beta = \arctan \frac{v}{u}$$

$$\begin{cases} F_u = m_u \cdot \dot{u} + d_u \cdot u \cdot |u| \\ 0 = m_v \cdot \dot{v} + m_{ur} \cdot u \cdot r + d_v \cdot v \cdot |v| \\ \Gamma_r = m_r \cdot \dot{r} + d_r \cdot r \cdot |r| \end{cases}$$

$$\dot{\psi}_t = r \cdot \left(1 - \frac{m_{ur}}{m_v} \cdot \cos^2 \beta \right) + f(u, v)$$

$$\frac{m_{ur}}{m_v} < 1$$

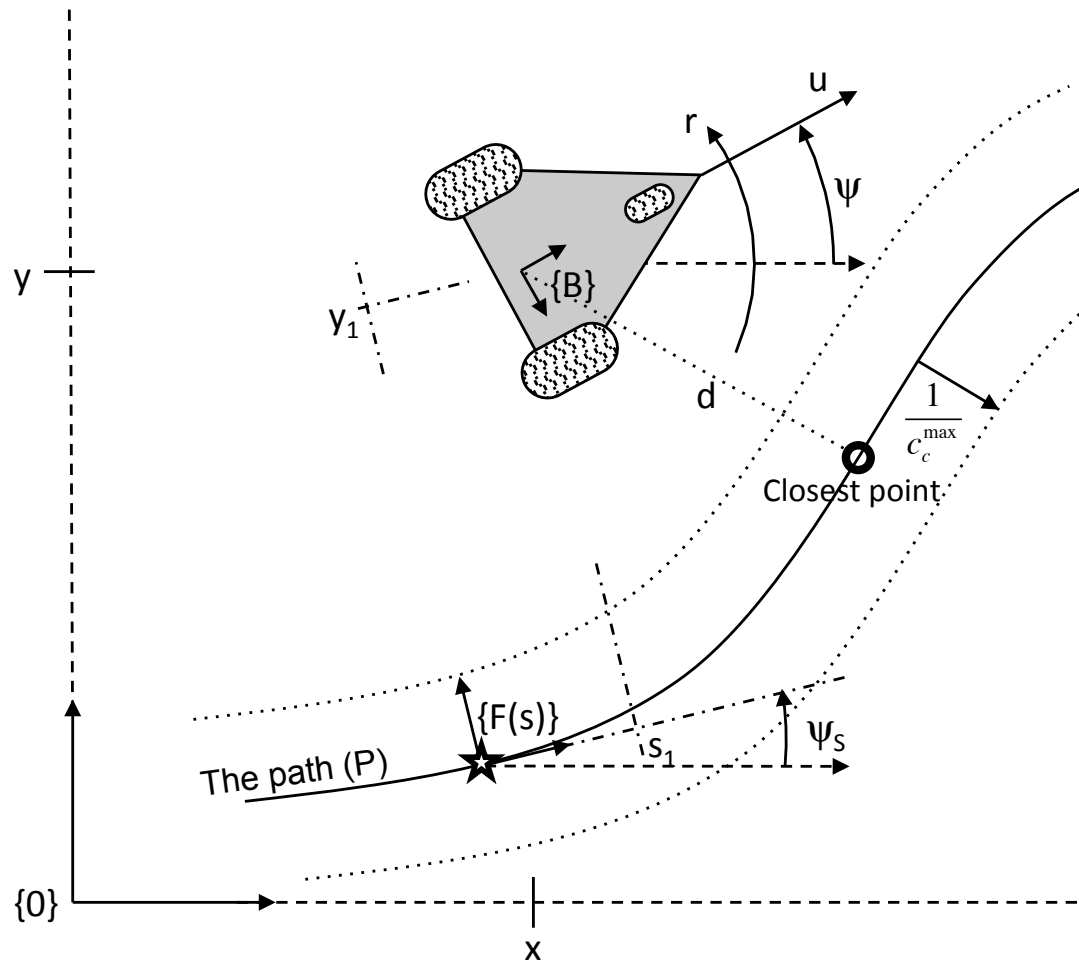
Le suivi de chemin

- Retirer la référence temporelle de la trajectoire
 - Formulat° autonome, respect saturation actionneurs

Path following (3D)	Trajectory tracking (3D + time)
<ul style="list-style-type: none">• <i>Reference path is given using a time-free parameterization</i>• <i>Independently controlled forward velocity</i>• <i>'Smooth' convergence to the path</i>	<ul style="list-style-type: none">• <i>Time-space reference trajectory</i>• <i>The vehicle may turn back in its attempt to be at a desired reference point at a prescribed time</i>• <i>Danger of stalling</i>
<p>The diagram shows a solid black line labeled 'Path' and a dashed line labeled 'Possible Vehicle Trajectory' that curves towards the path. A yellow car icon is shown below the path, with a line labeled 'error' connecting it to a point on the path.</p>	<p>The diagram shows a solid black line labeled 'Path' and a dashed line labeled 'Possible Vehicle Trajectory' that curves away from the path. A yellow car icon is shown below the path, with a line labeled 'error' connecting it to a point on the path.</p>

Le suivi de chemin

- Le principe de la cible virtuelle



La stratégie d'approche

$$\delta = -\text{sign}(u) \cdot \arctan(k_\delta \cdot y_1)$$

La fonction d'erreur

$$V = \frac{1}{2} \cdot (\theta - \delta)^2 + \frac{1}{2} \cdot (s_1^2 + y_1^2) > 0$$

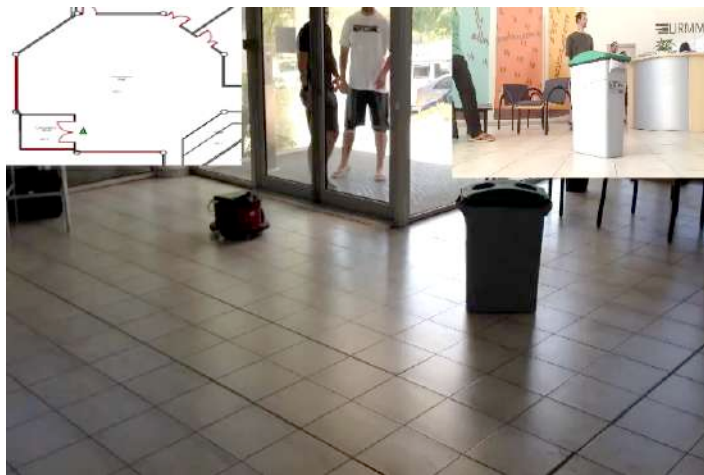
$(\theta = \psi_s - \psi)$

La loi de commande

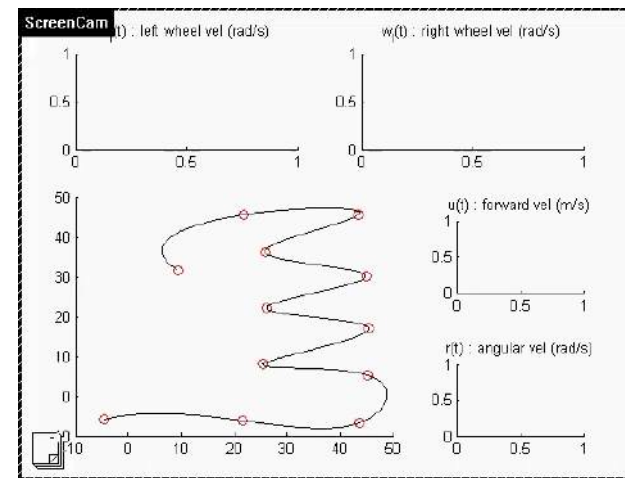
$$\begin{cases} u = u_d \\ r = \dot{\delta} - k_2 \cdot (\theta - \delta) + c_c \cdot \dot{s} \\ \dot{s} = u \cdot \cos \theta + k_1 \cdot s_1 \end{cases}$$

$$\left. \begin{array}{l} \lim_{x \rightarrow \infty} V(x) = \infty \\ \dot{V} < 0, \forall x \neq 0 \\ \ddot{V} \text{ bornée} \end{array} \right\} \text{Convergence GUAC}$$

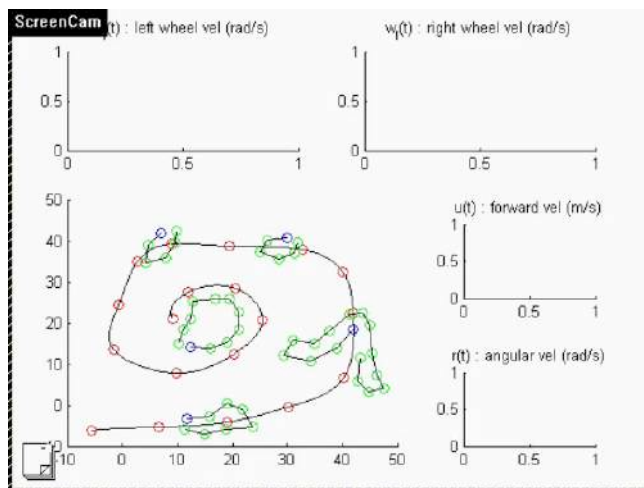
Extensions (Unicycles)



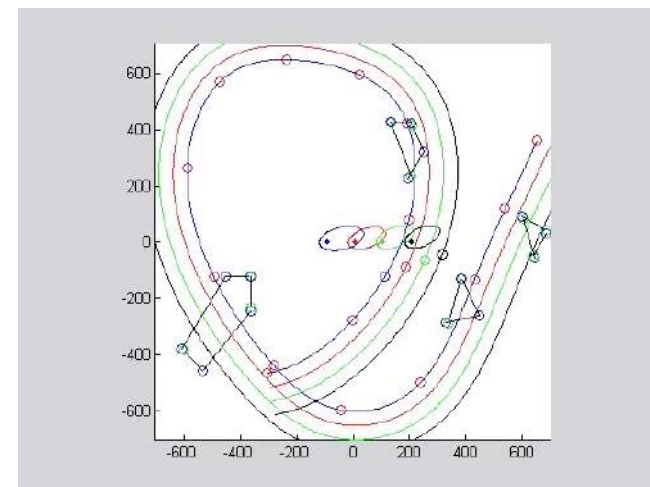
Suivi de chemin (OA)



Limitation des actionneurs

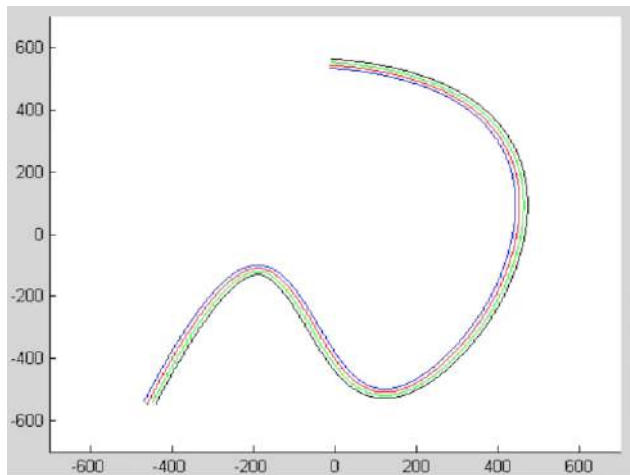


Evitement d'obstacle réactif

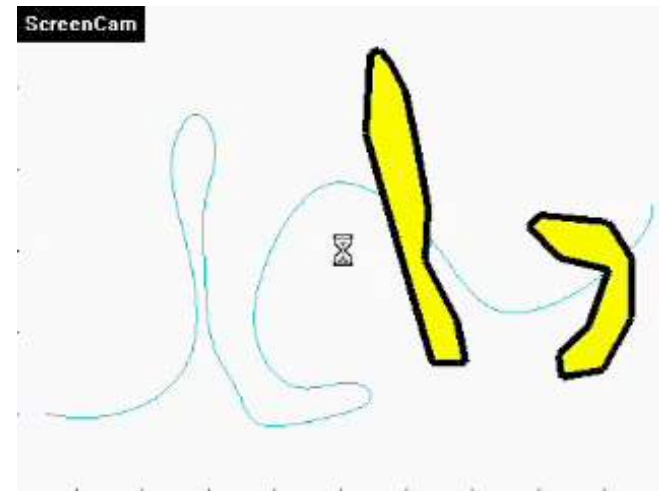


Généralisation à la flottille

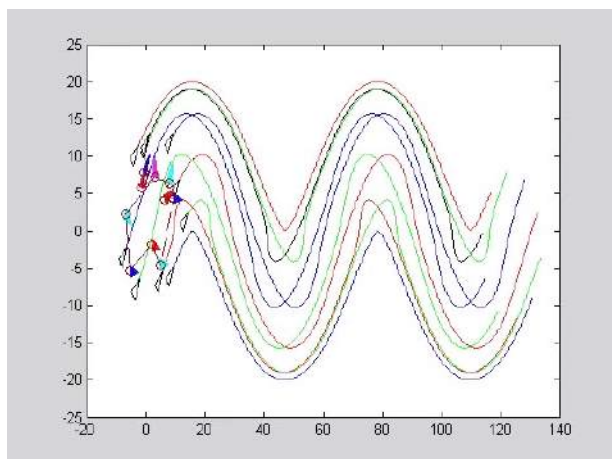
Extensions (Unicycles)



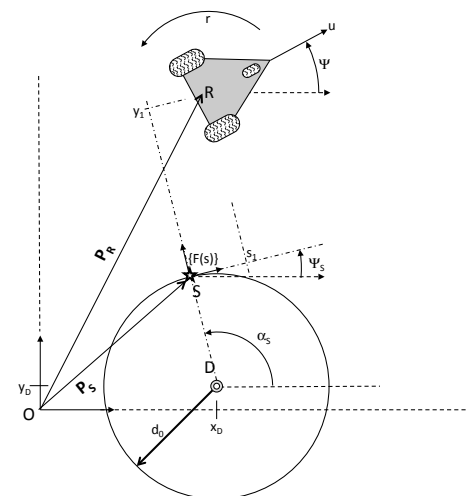
Flottille (*Collision Avoidance*)



Flottille (tenue du niveau de la com)



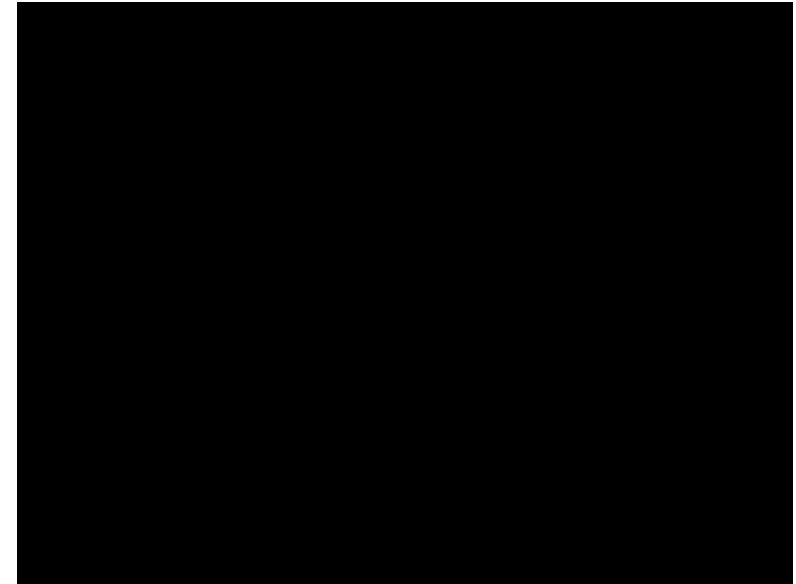
Flottille (tenue de formation)



$$\begin{cases} k_2 = \frac{2}{\pi} \cdot r^{\max} \\ k_\delta = \frac{\sqrt{3}}{2} \cdot \frac{r^{\max}}{u} \end{cases}$$

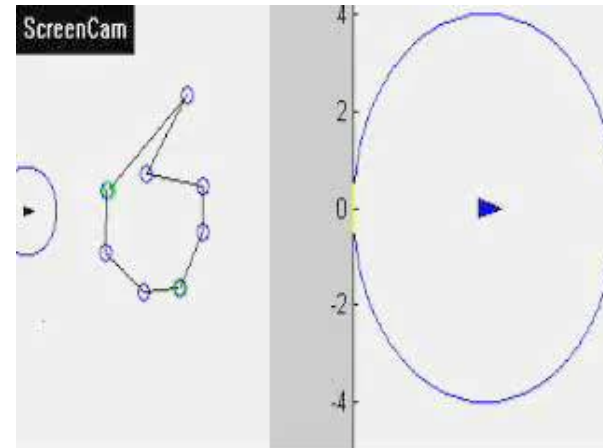
Retour sur la stabilisation

Extensions (AUV)



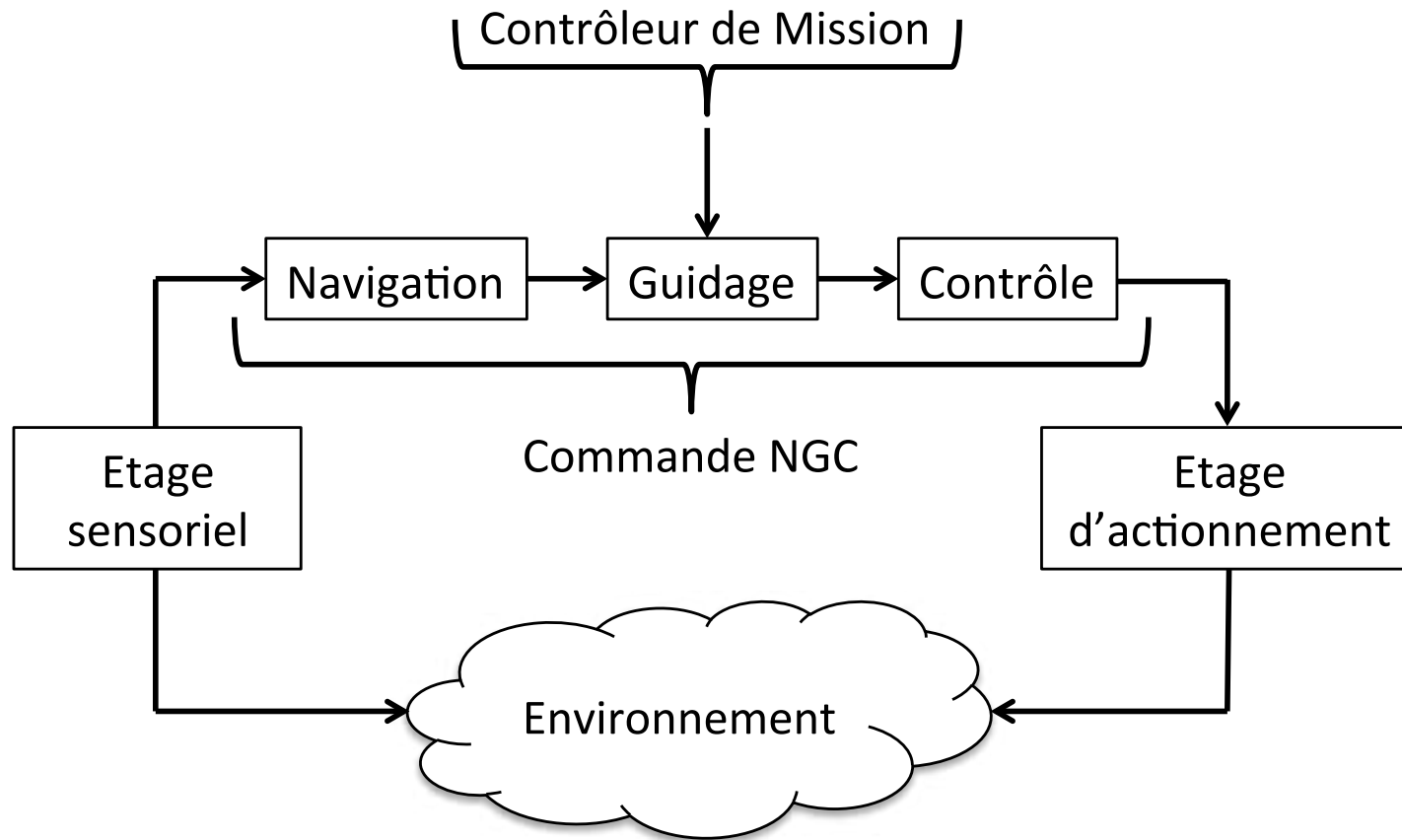
Lyapunov
Backstepping
Contrôle commuté

Dynamique et Robustesse

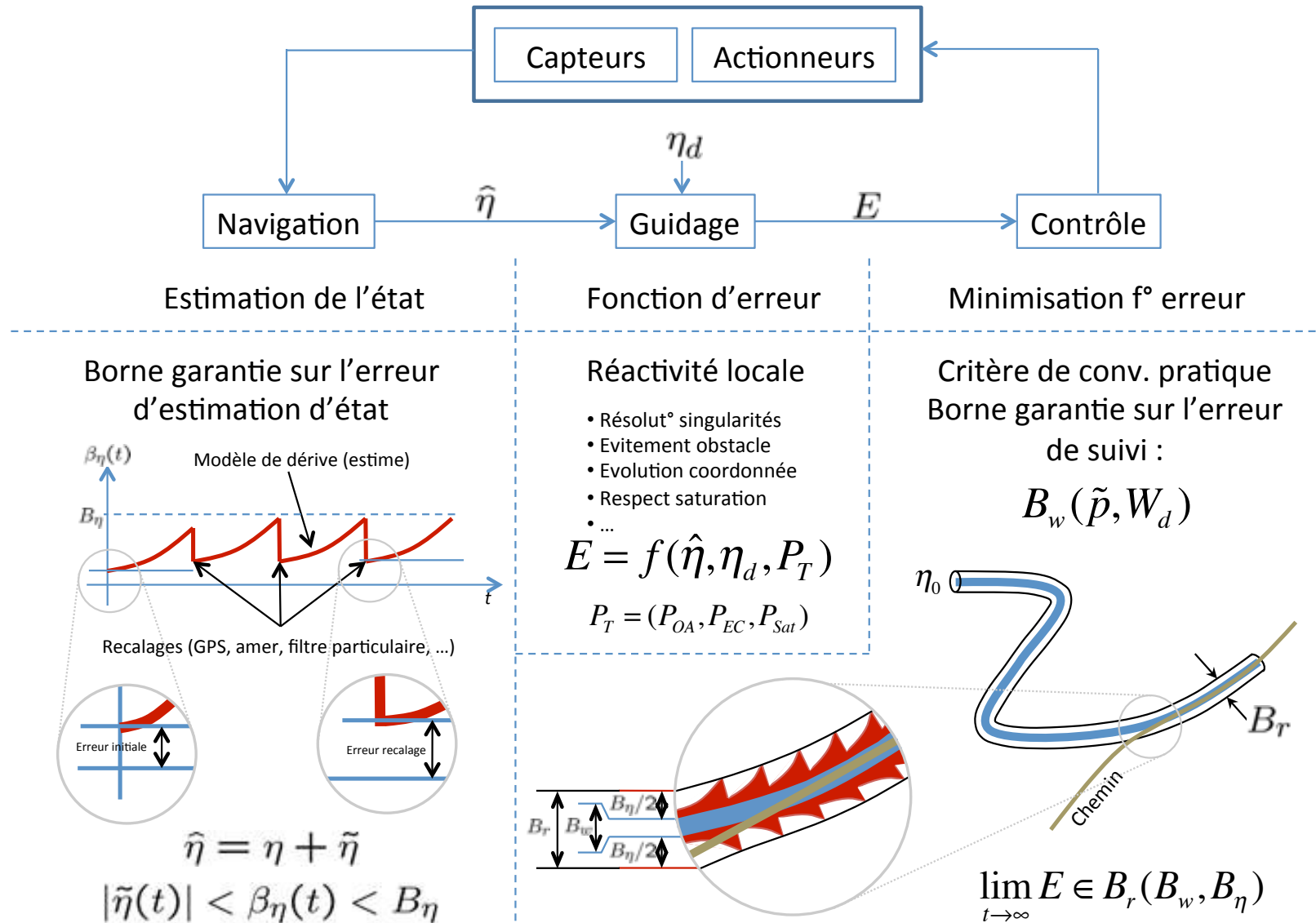


Suivi de mur

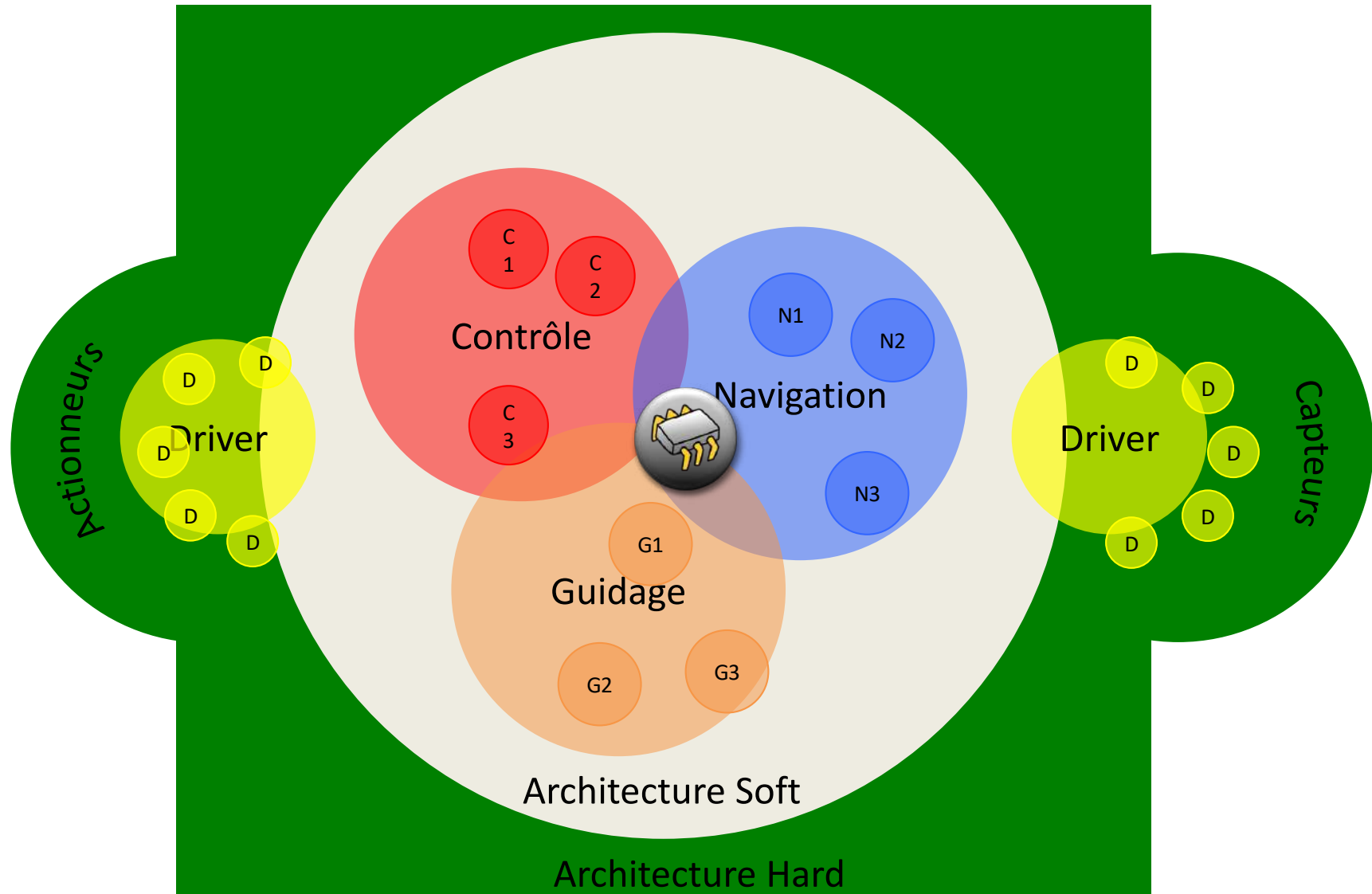
La commande NGC



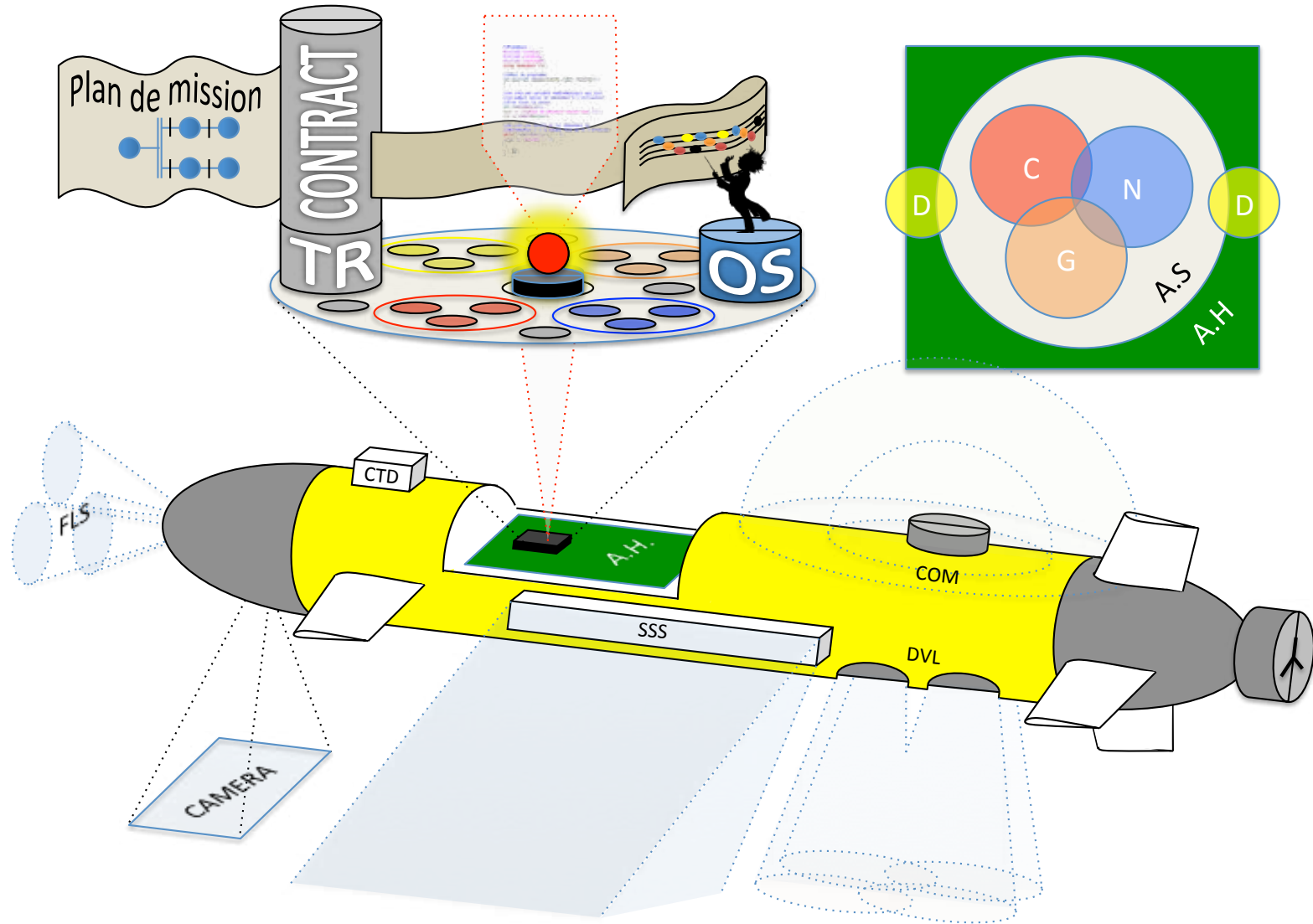
La commande NGC (garanties)



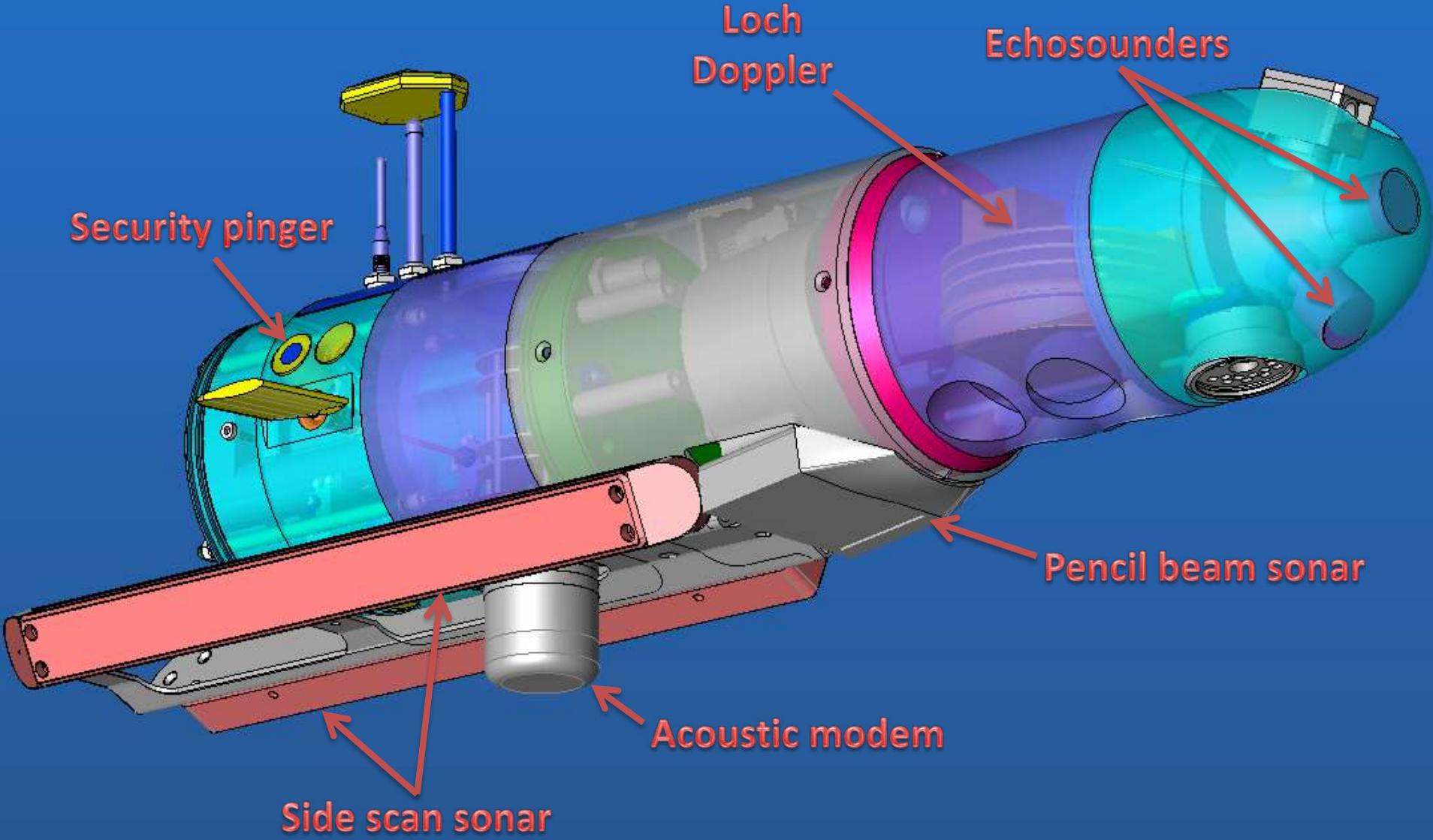
Implémentation



Implémentation

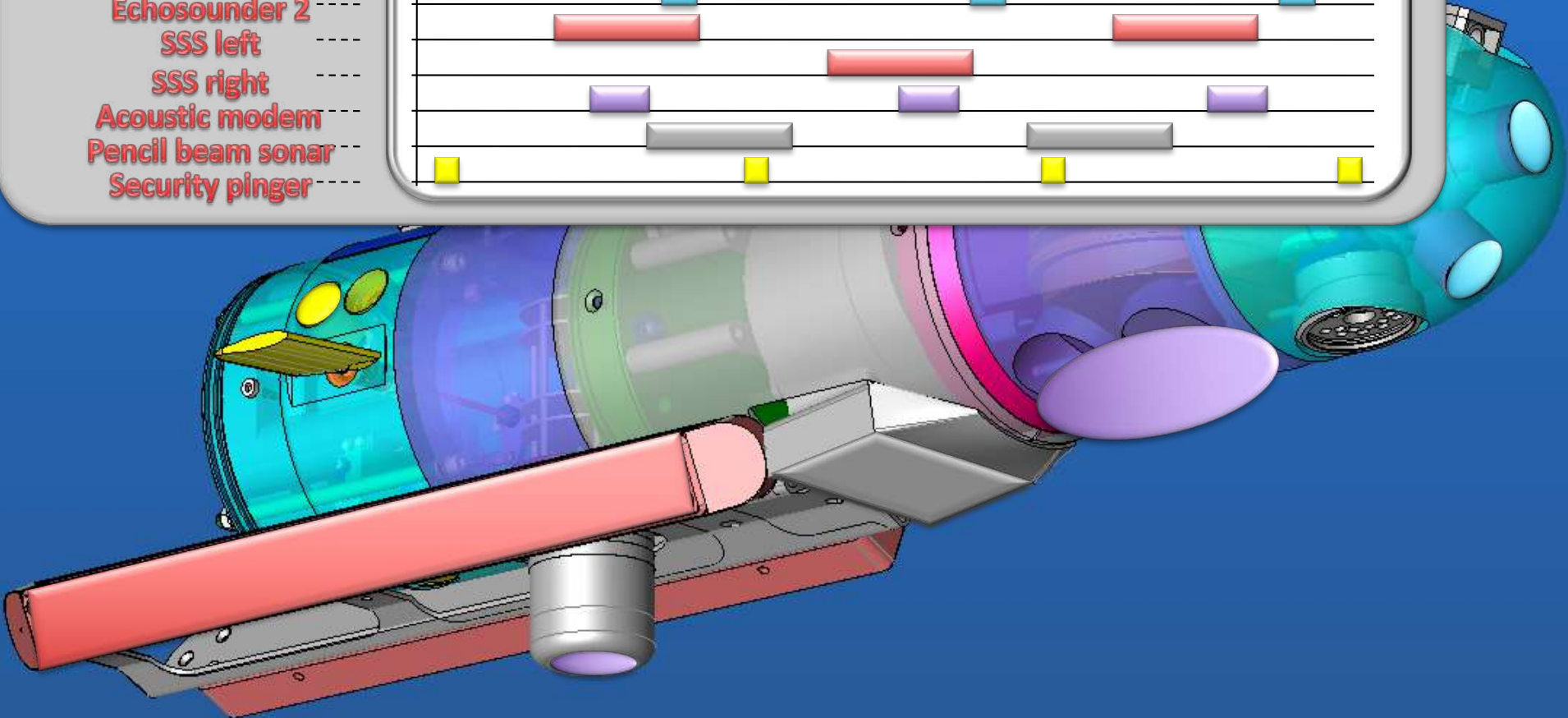
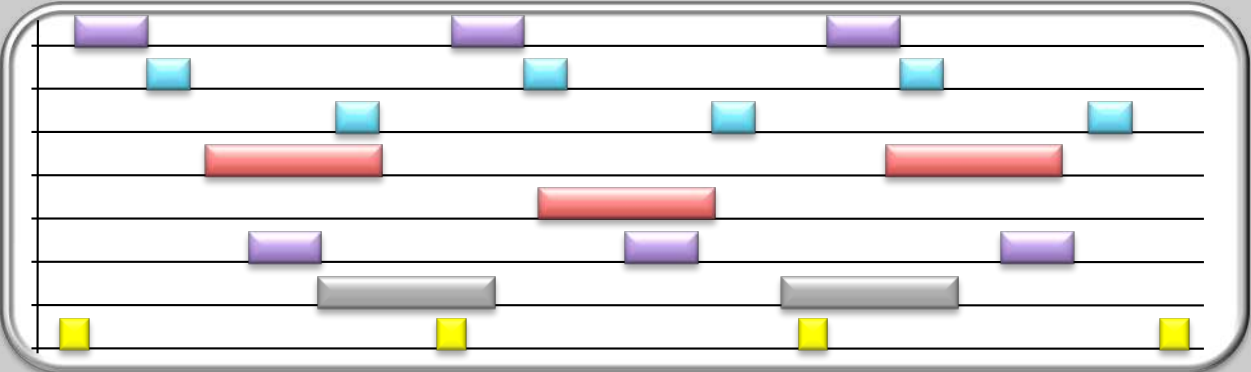


ACOUSTIC SENSORS



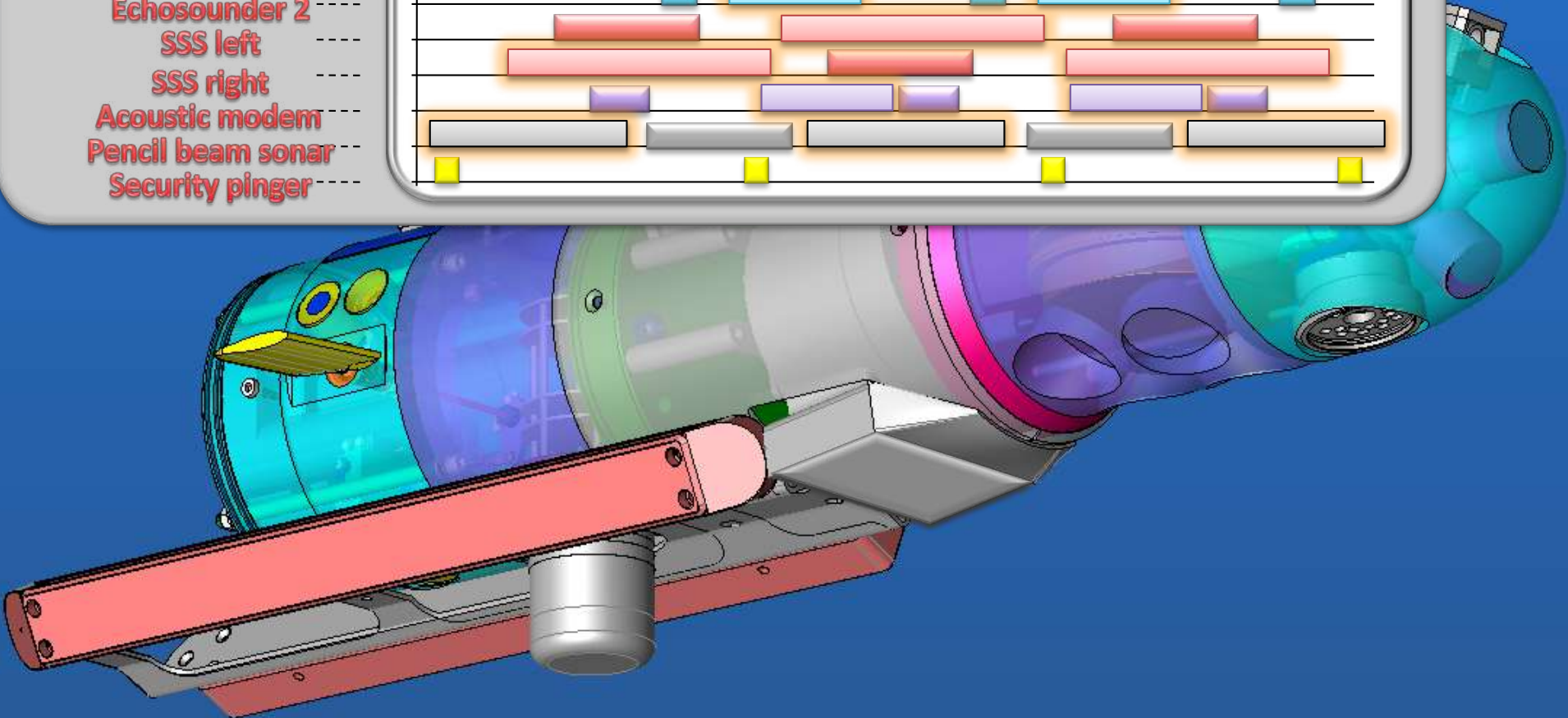
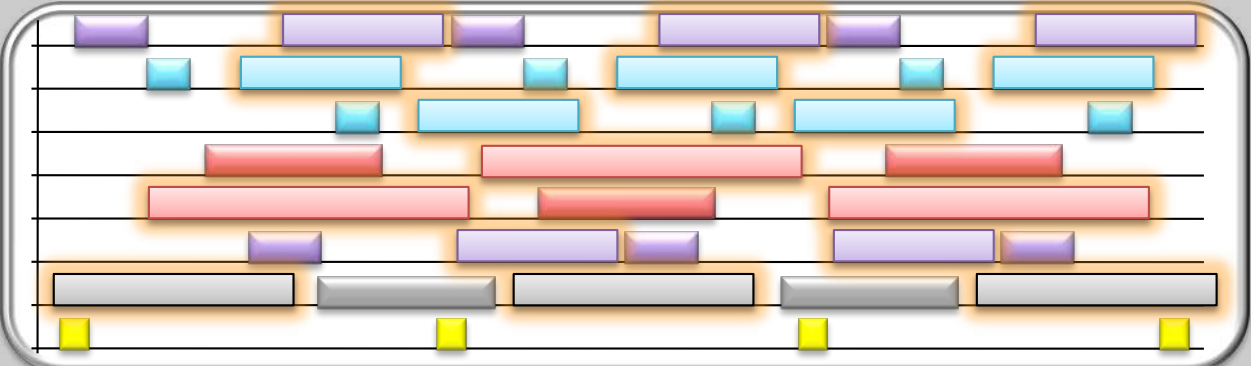
ACOUSTIC SENSORS

- Loch Doppler
- Echosounder 1
- Echosounder 2
- SSS left
- SSS right
- Acoustic modem
- Pencil beam sonar
- Security pinger



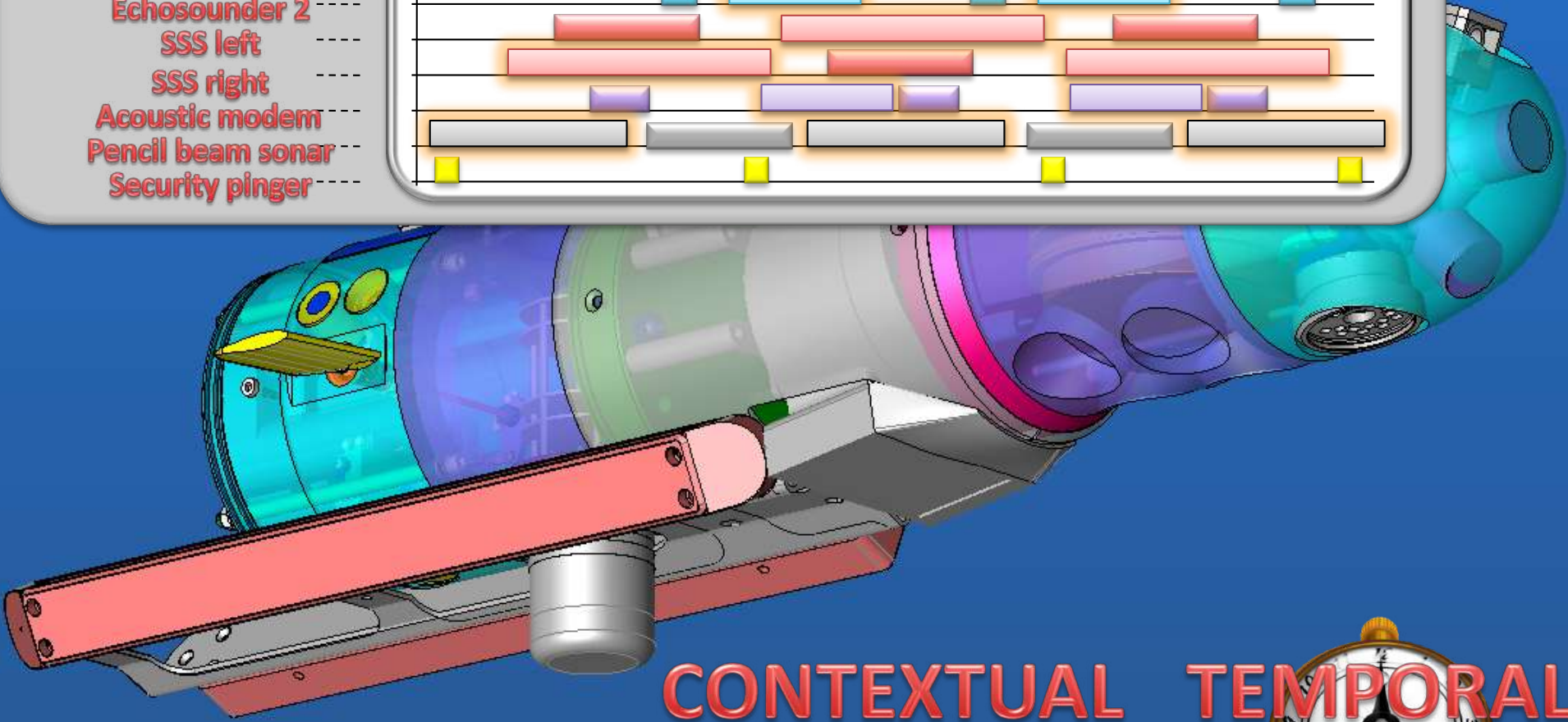
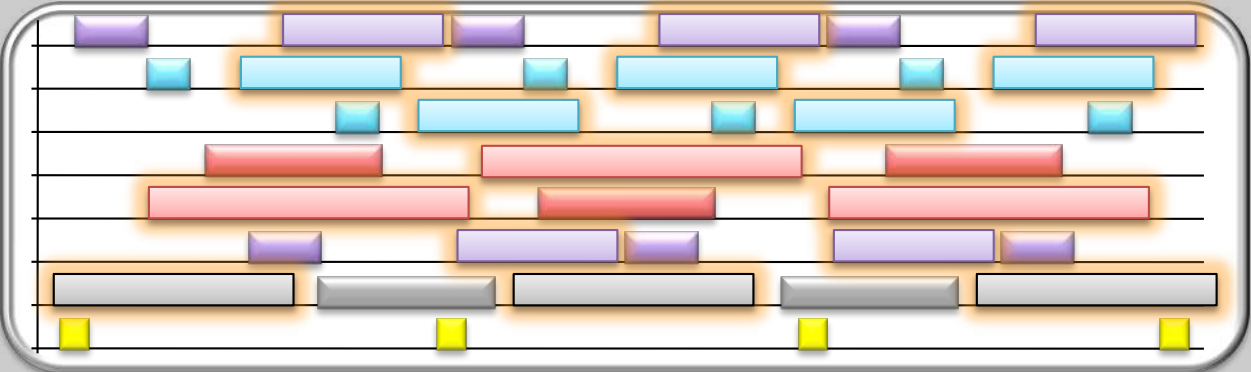
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ACOUSTIC SENSORS

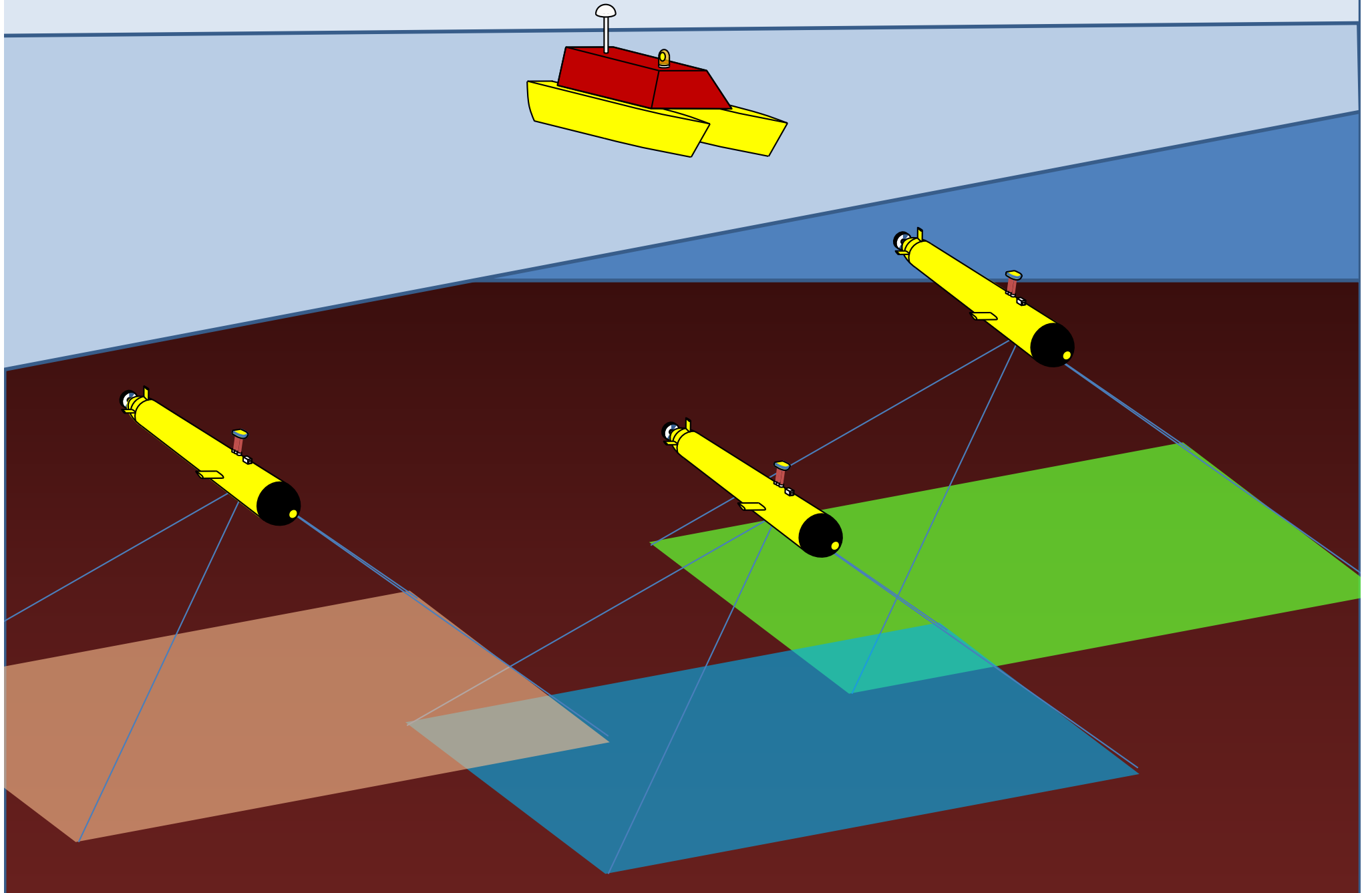
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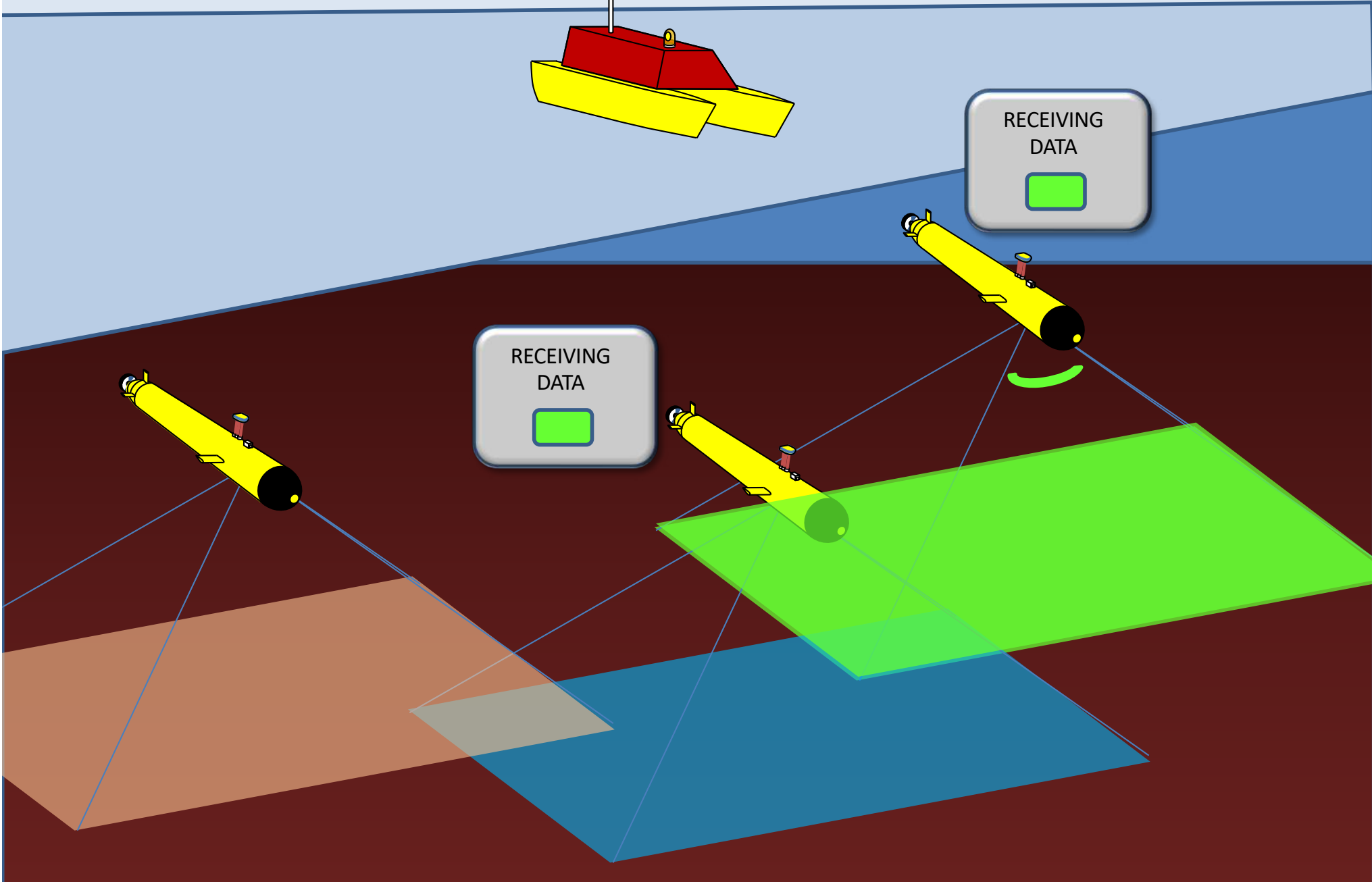
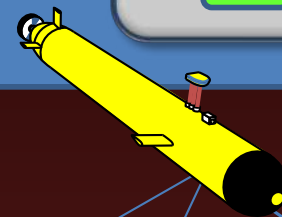
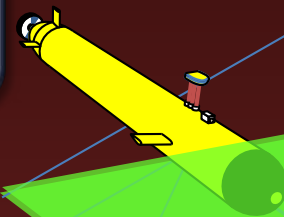
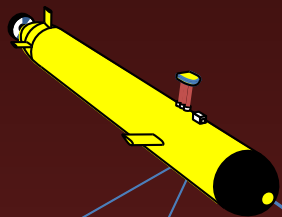
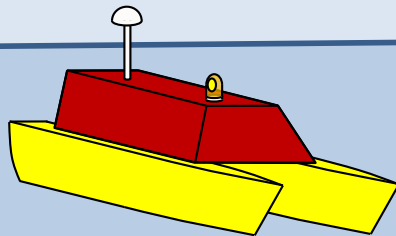
CONTEXTUAL
EMISSION ?



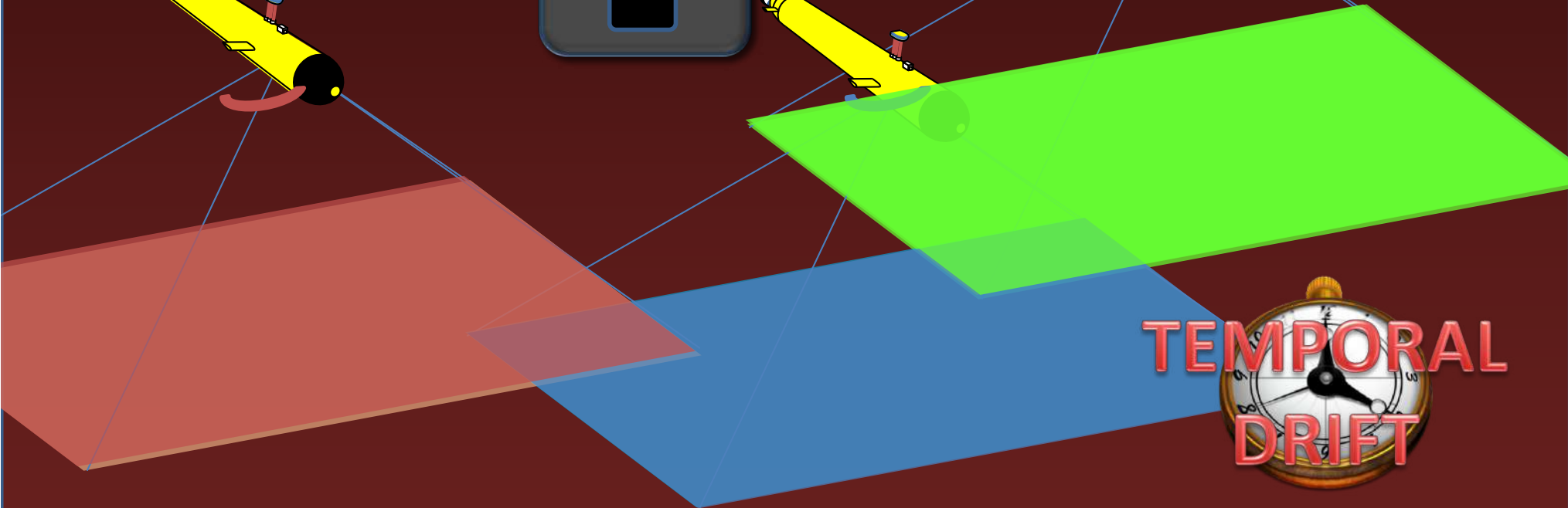
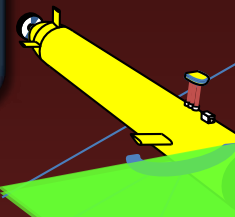
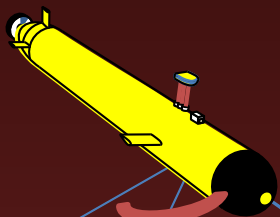
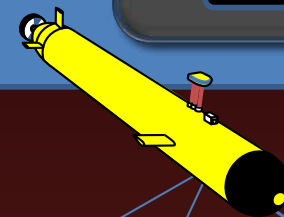
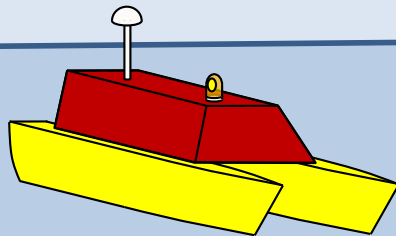
COLLABORATIVE SAMPLING



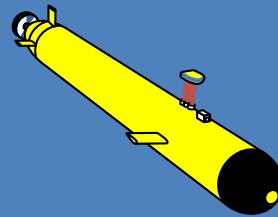
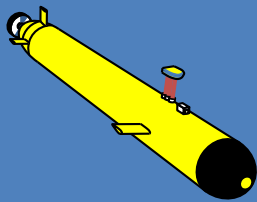
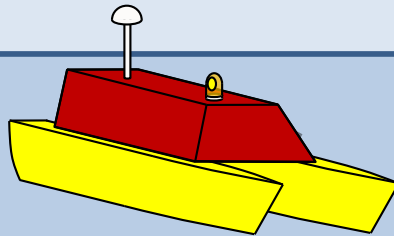
COLLABORATIVE SAMPLING



COLLABORATIVE SAMPLING



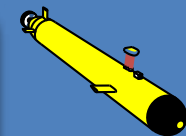
PERIODIC BROADCAST



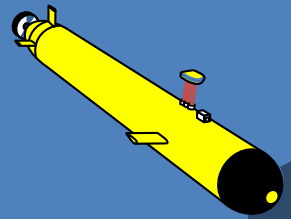
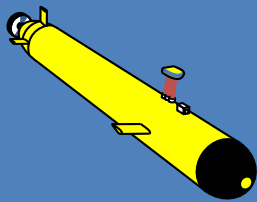
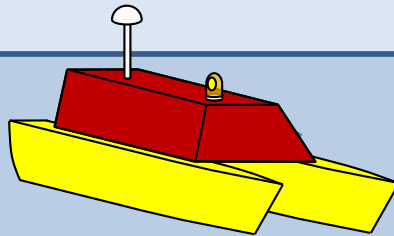
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RECEPTION		DELAY
<input checked="" type="radio"/>	<input type="radio"/>	28.5

RECEPTION		DELAY
<input type="radio"/>	<input checked="" type="radio"/>	∞



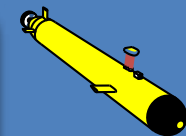
PERIODIC BROADCAST



RECEPTION	DELAY
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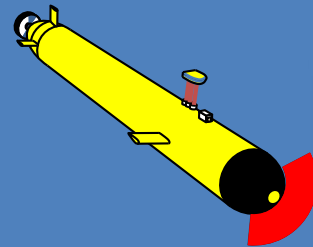
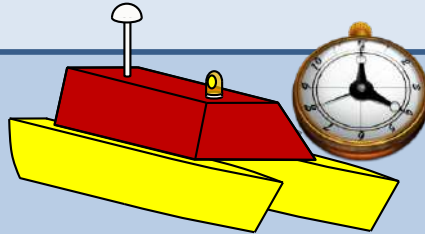
RECEPTION	DELAY
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RECEPTION	DELAY
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PERIODIC BROADCAST


TEMPORAL DRIFT



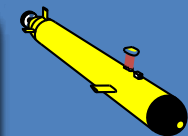
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RECEPTION	DELAY
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RECEPTION	DELAY
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A la recherche de garanties

- Propager les garanties à l'exécution.

