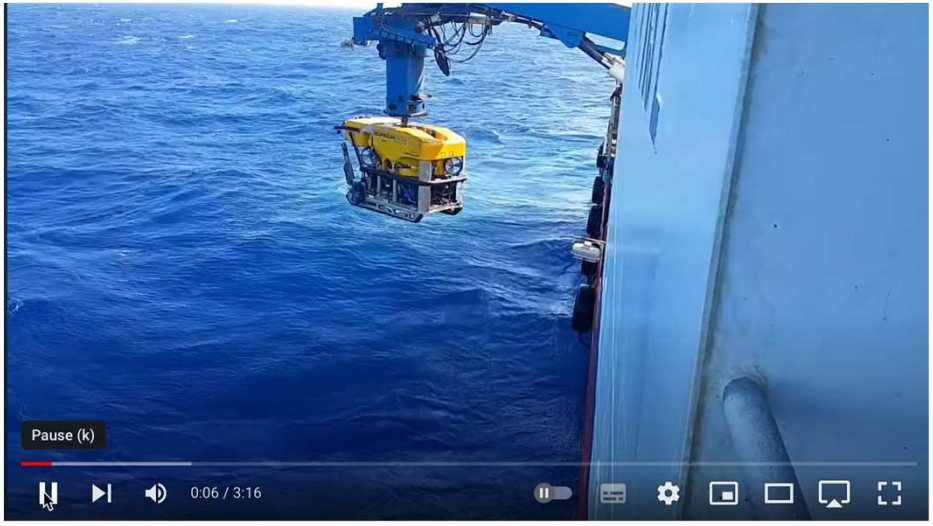
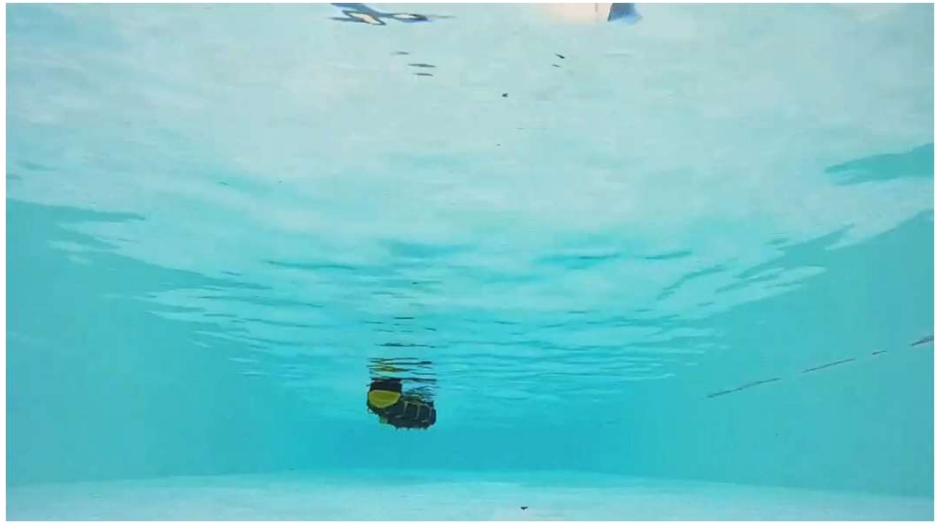
1. Anatomy

Marine Robotic Locomotion

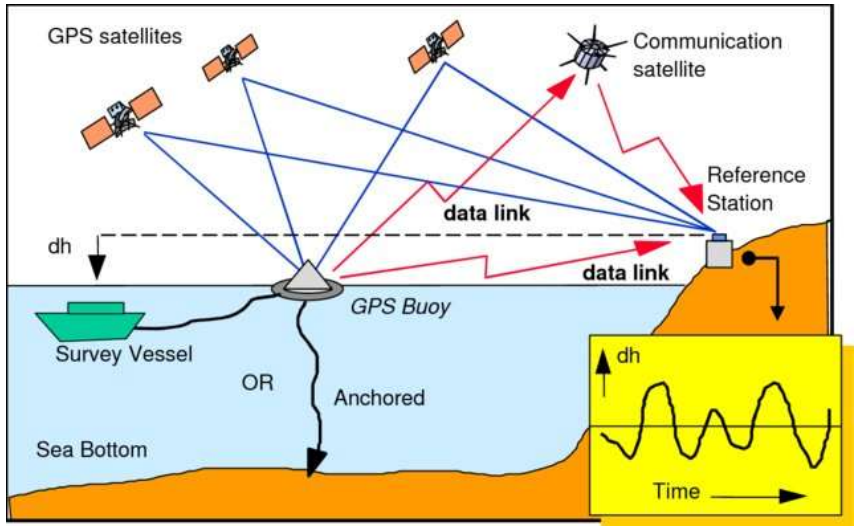


Marine Robotic Locomotion



Sensors

- GPS, just at surface

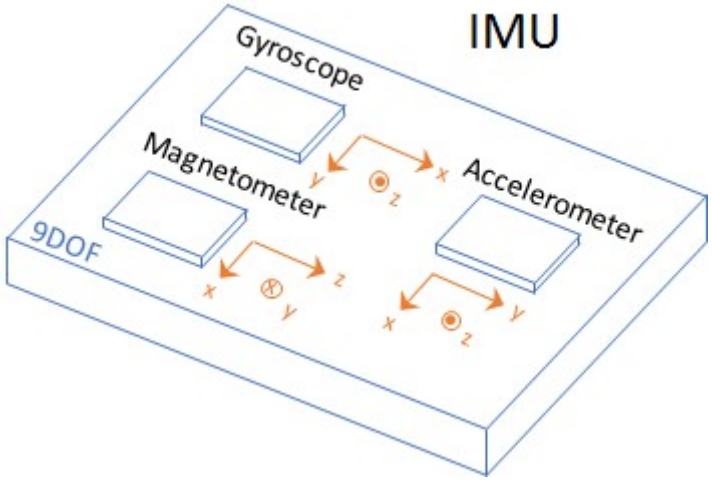


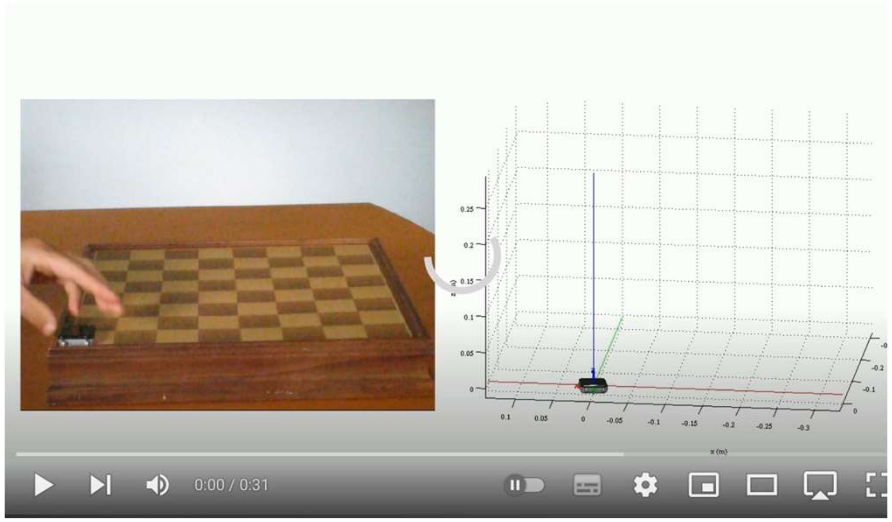
Georeferenced position
Yaw estimation
Trajectory estimation
Velocity estimation

Abidin, H. Z. (1999, March). Monitoring Sea Level Using GPS. In *Proceeding International Seminar on Application of Seawatch Indonesia Information System for Indonesian Marine Resources Development* (pp. 10-11).

Sensors

- Inertial Measurement Unit (IMU)



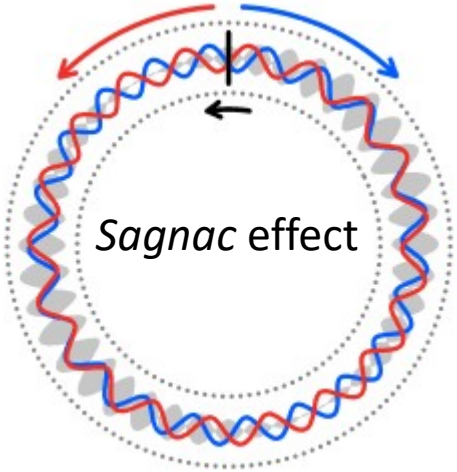


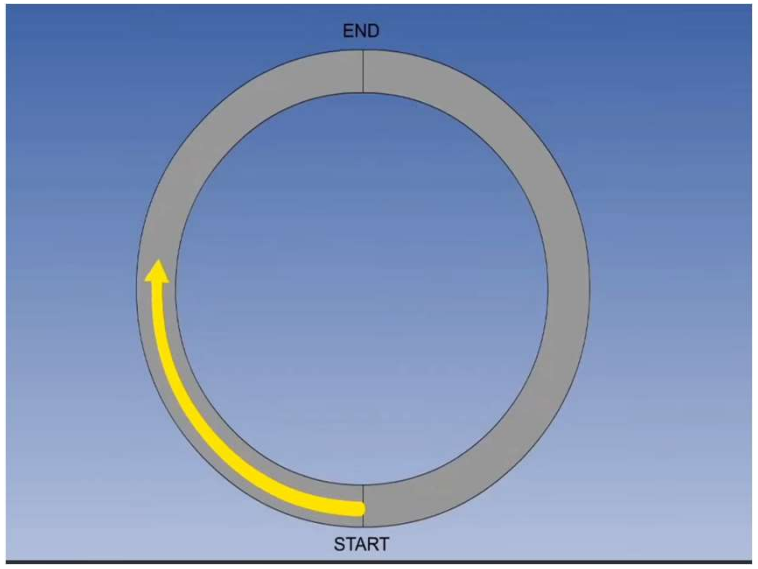
~~Trajectory estimation~~ (drift)

3D orientation estimation

Sensors

- Inertial Navigation System (INS)



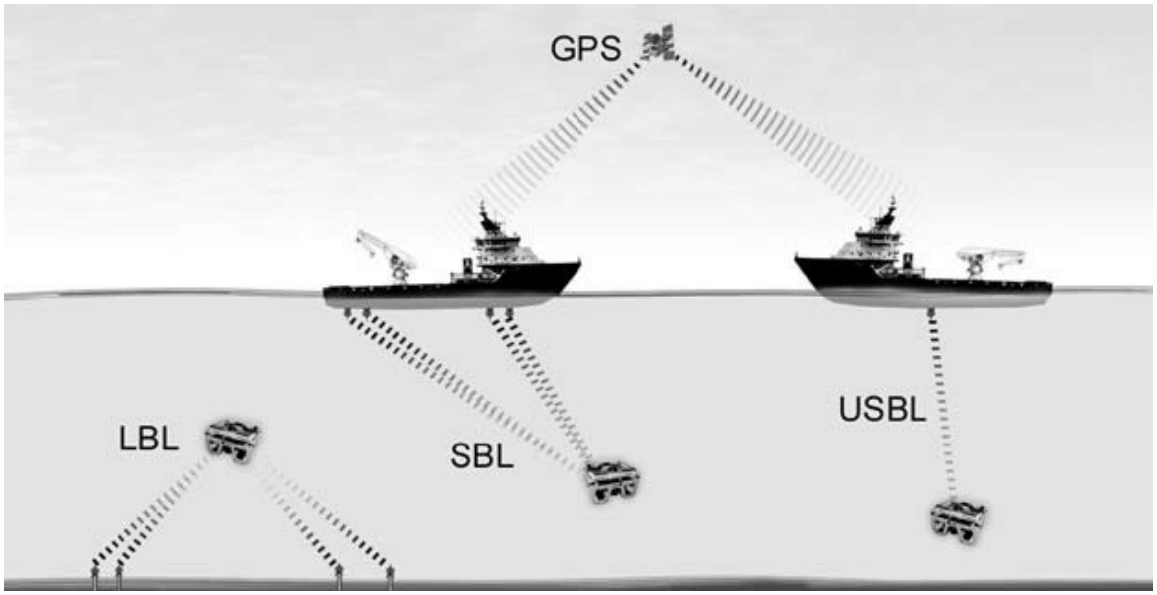


Trajectory estimation

3D orientation estimation

Sensors

- Ultra Short Base Line (USBL) Local position

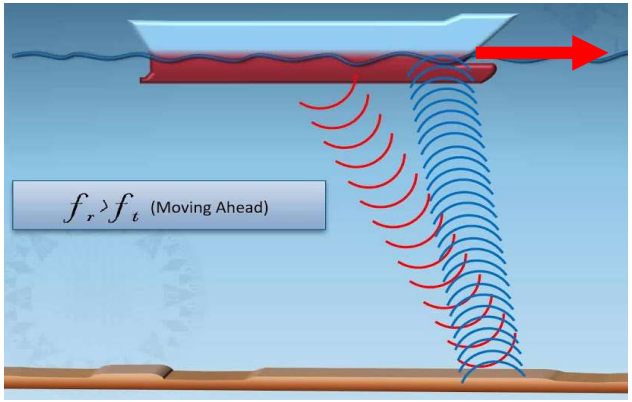


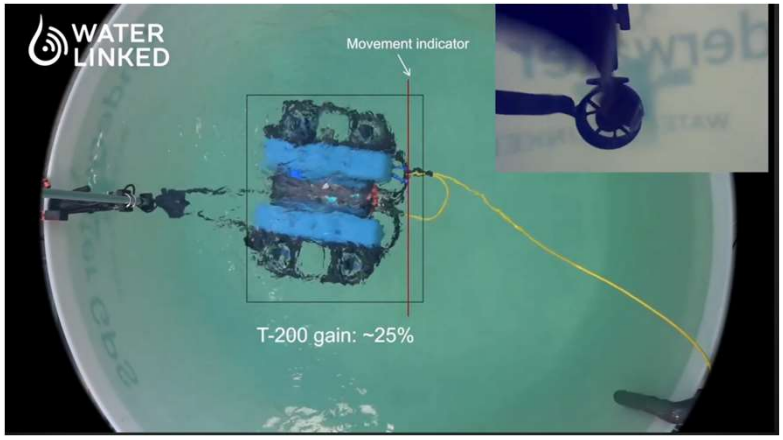
Local position

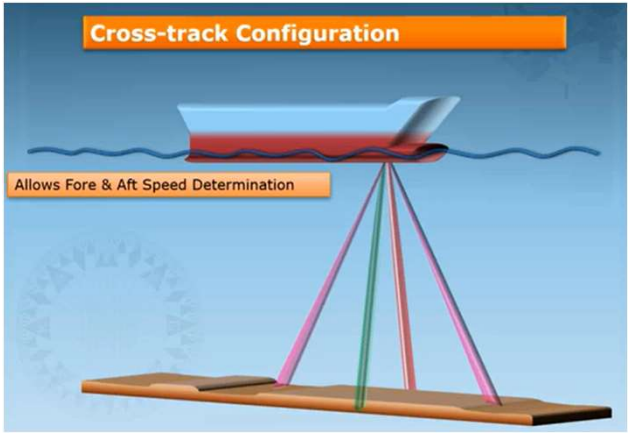
Georefenced position

Sensors

- DVL : Doppler Velocity Log



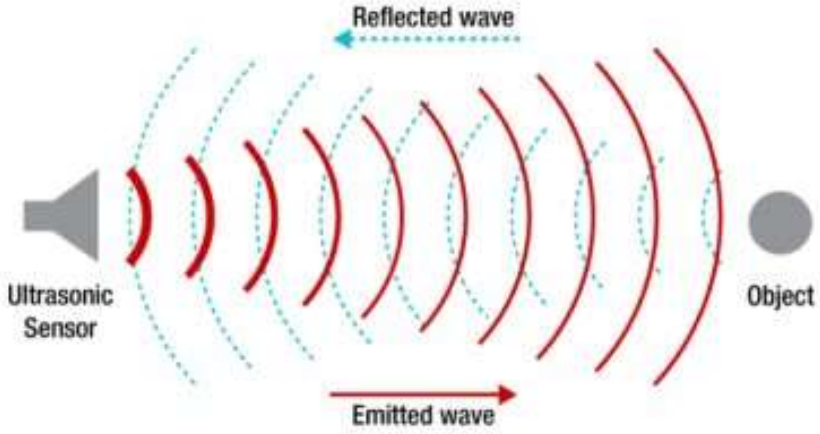




Velocity estimation

Sensors

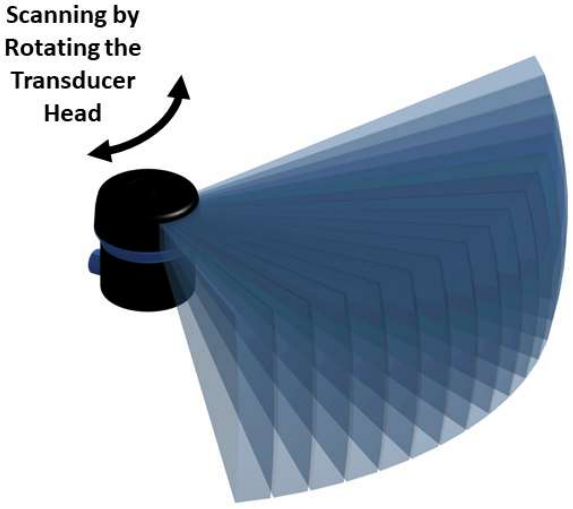
- Acoustic Pinger

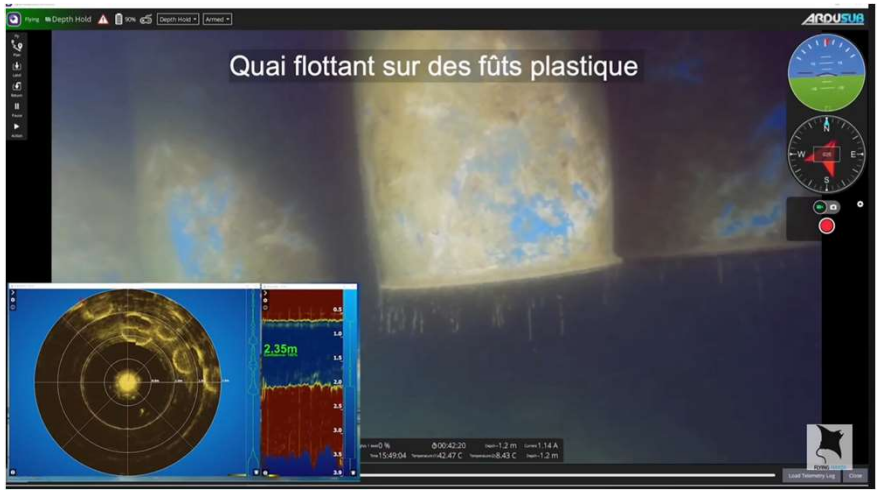


Distance to object estimation

Sensors

- Profiling sonar (mechanical pencil beam sonar)



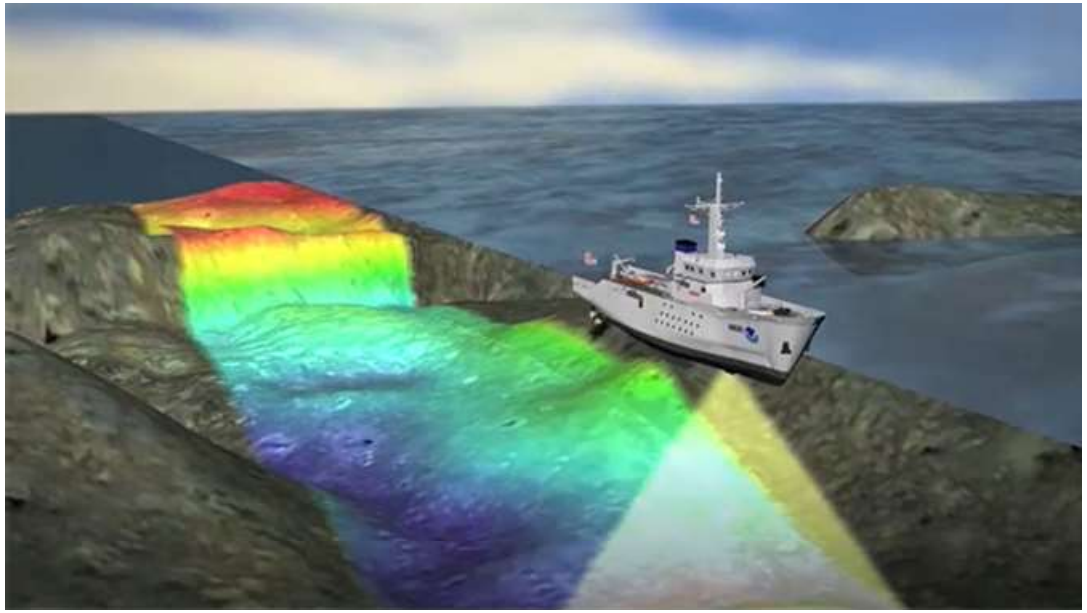


360° polar signature of the surrounding environment

Slow (0,16 Hz)

Sensors

- Multi-beam sonar (Electronial pencil beam sonar)

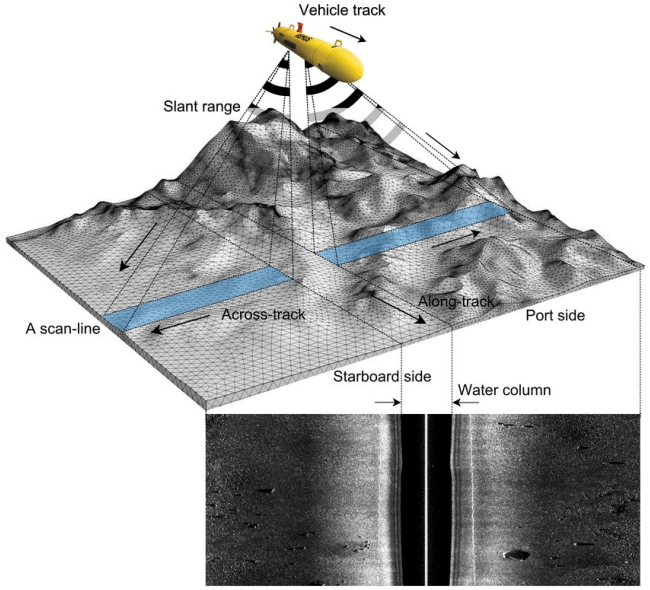


Partial polar signature of the surrounding environment

Fast (10 Hz)

Sensors

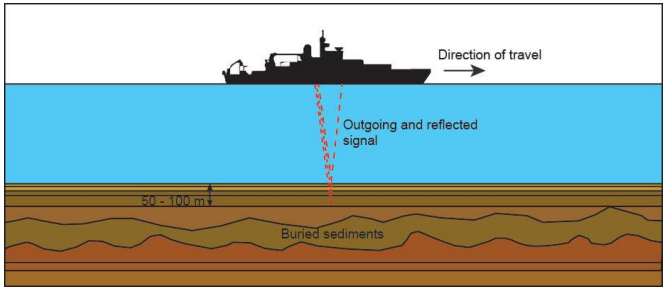
- Side Scan Sonar (SSS)

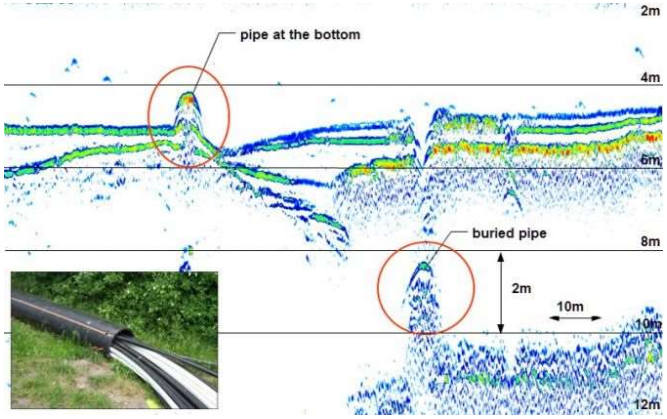


Seabed Mapping

Sensors

- Sub-Bottom Profling (SBP)

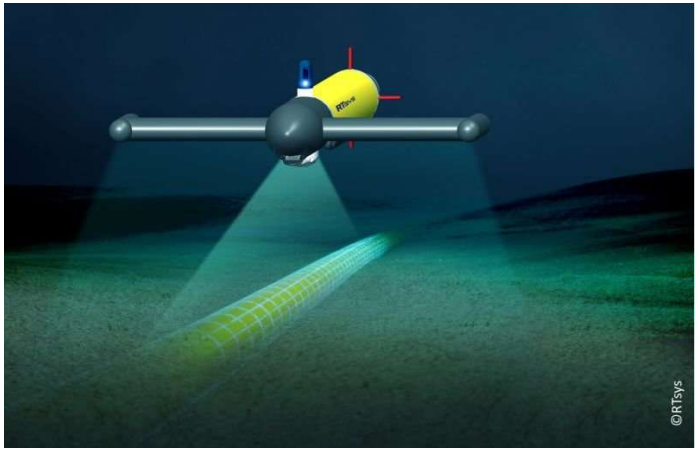


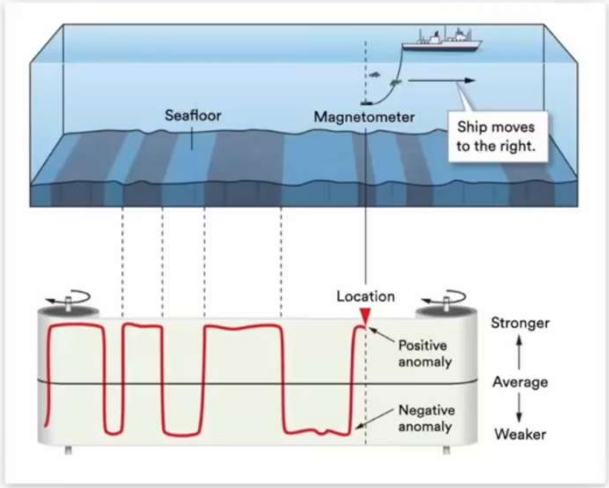


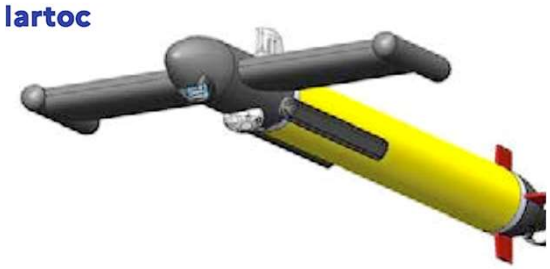
Sediment and seabed composition

Sensors

- Magnetic sensors







Magnetic mapping of the seabed

Sensors

- GPS, just at surface
- IMU, INS
- Camera(s)
- Magnetic Sensors
- USBL
- Doppler/Mechanical Velocity Log
- Acoustic pinger
- Multi-beam Sonar (mechanical / electronical)
- Sub-bottom profiling

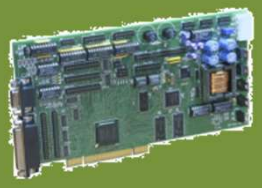
Robot components are:

Sensors,





Computer(s),



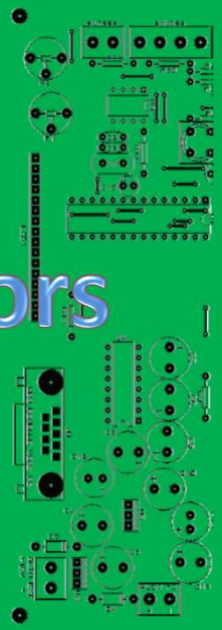
Actuators,



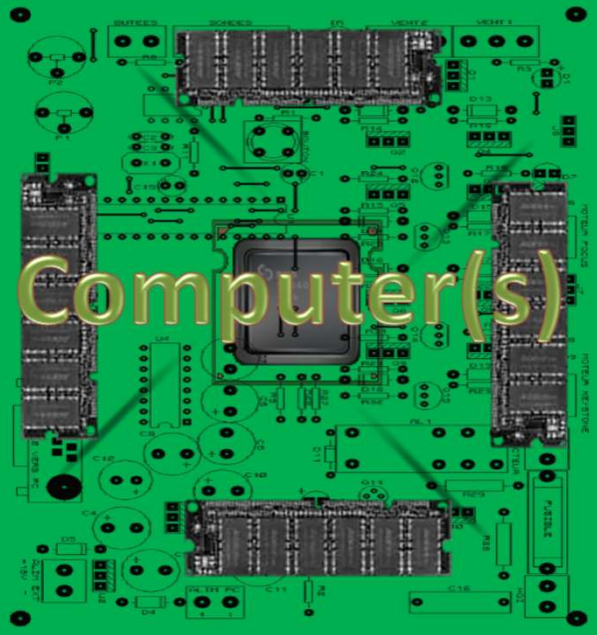

Environment.

Electronics

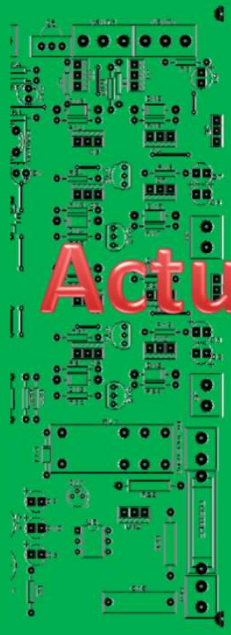
Embedded System



Sensors



Computer(s)

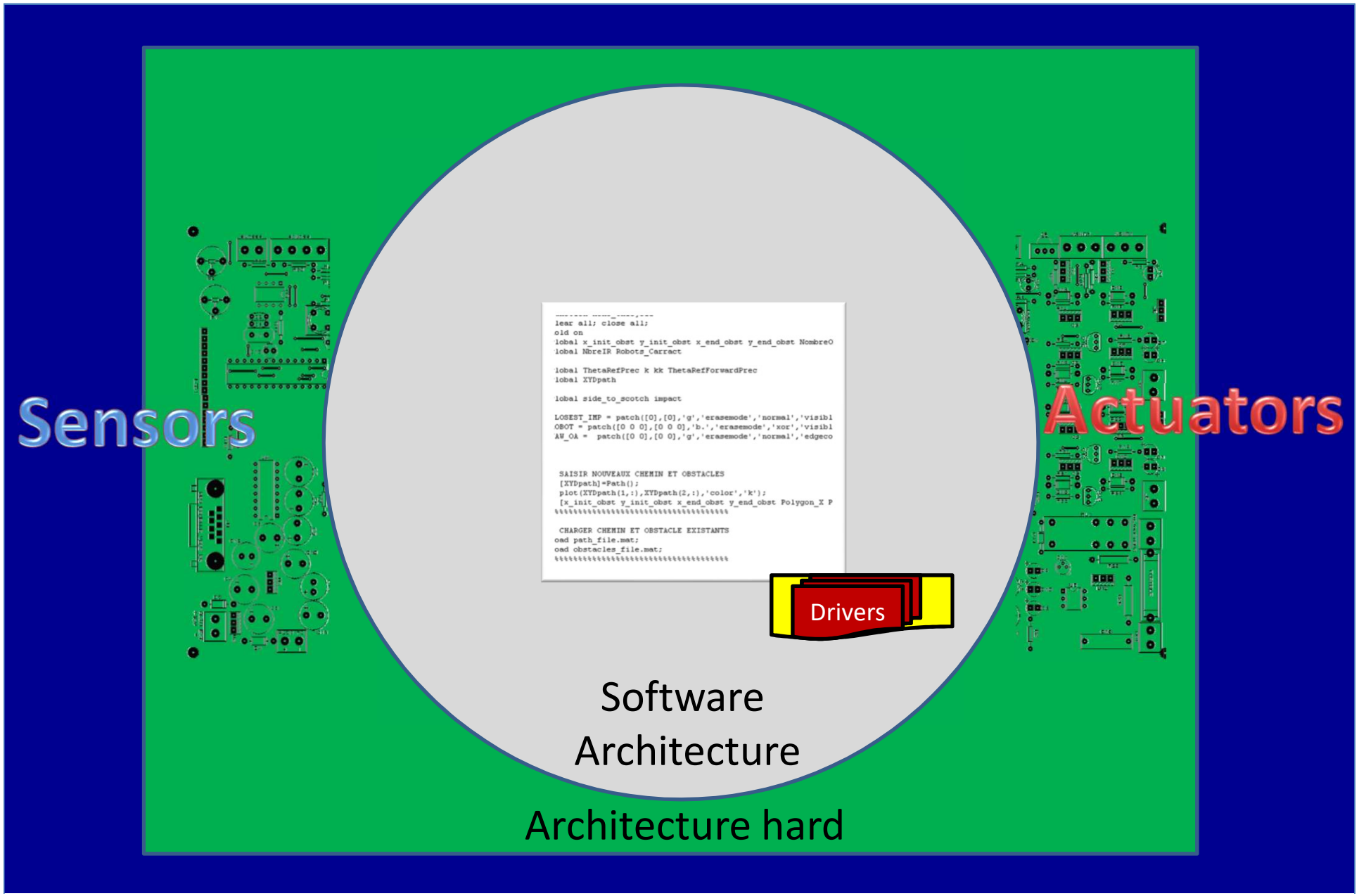


Actuators

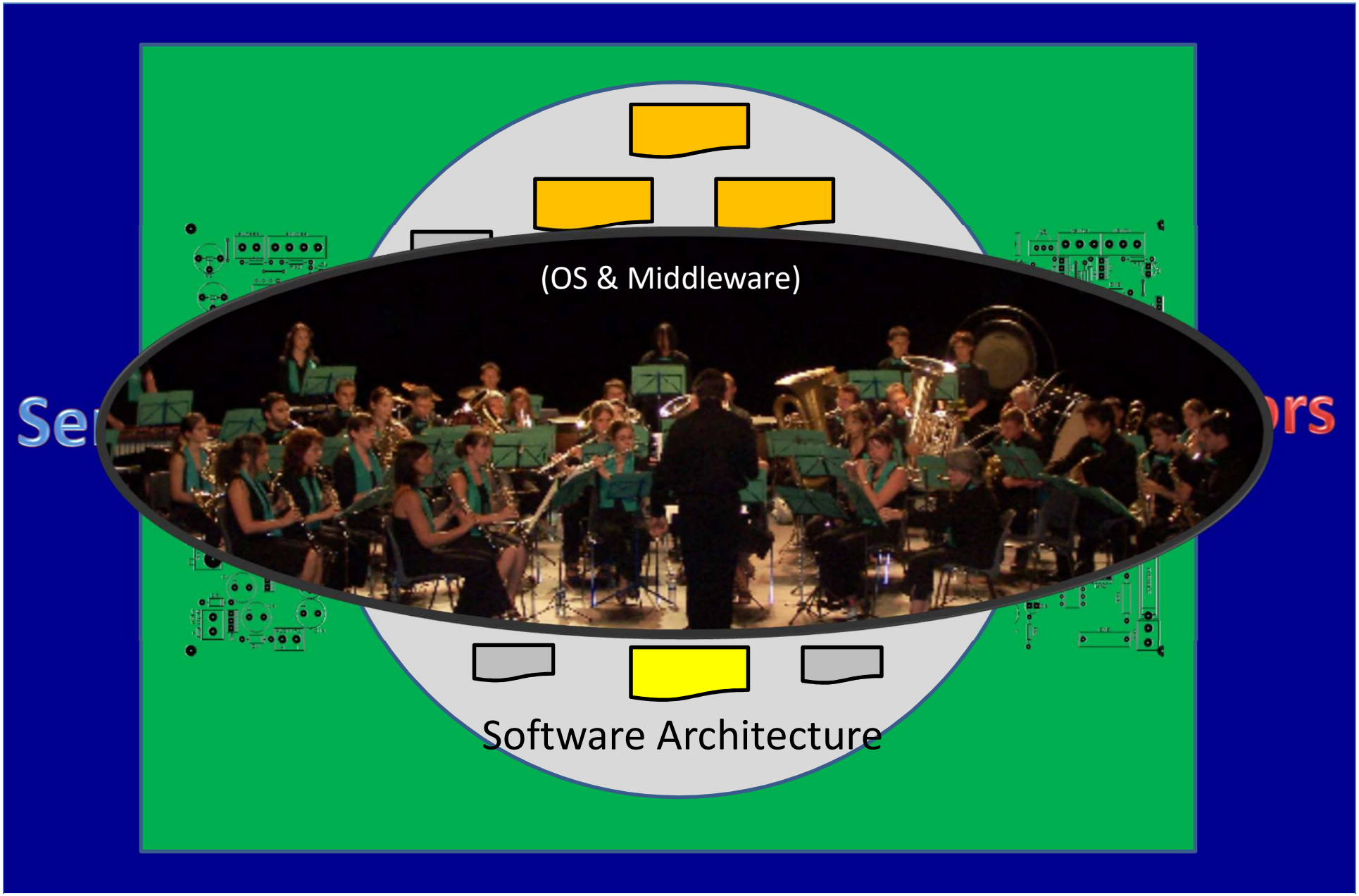
Hardware Architecture

Environment

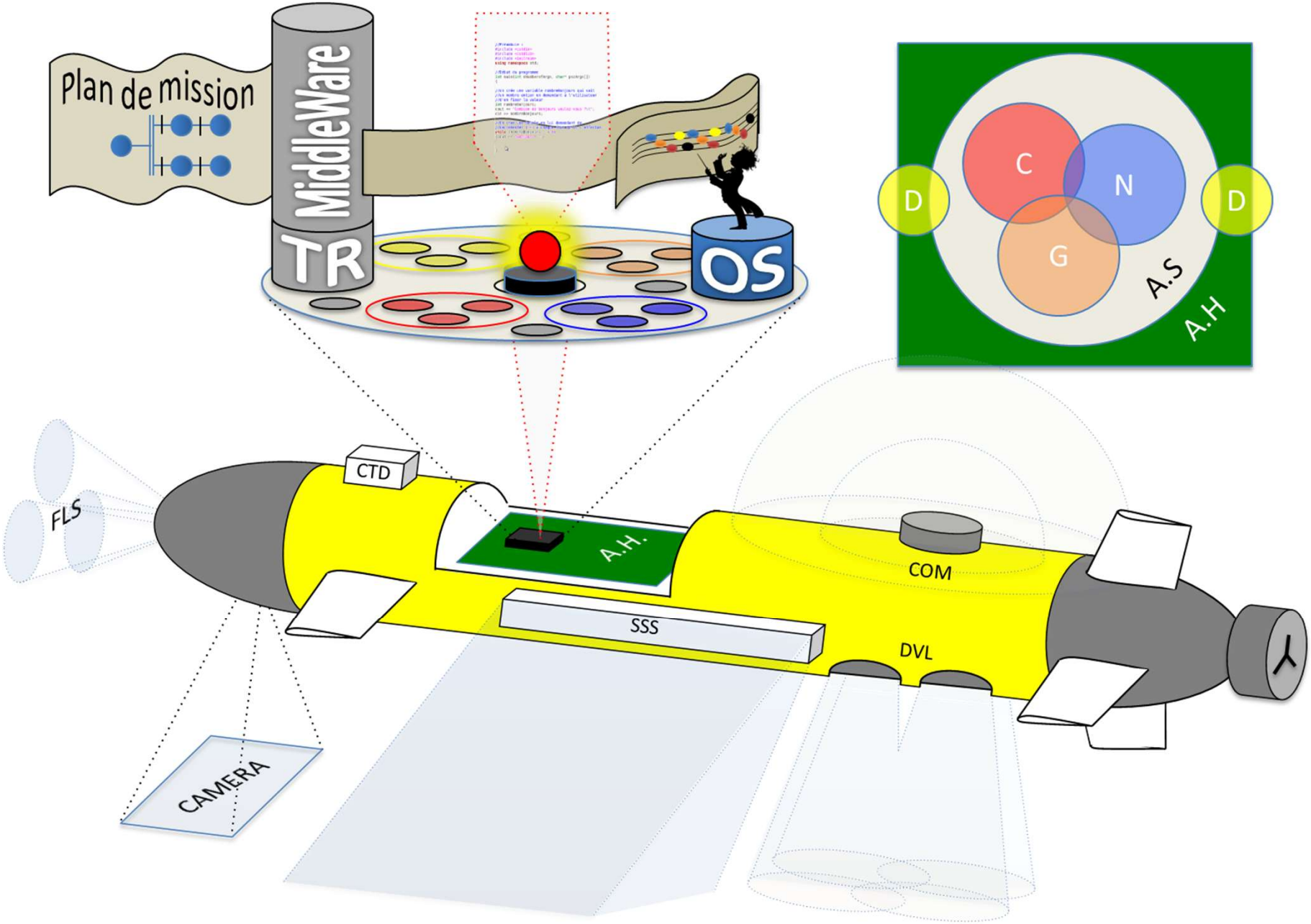
Software Architecture

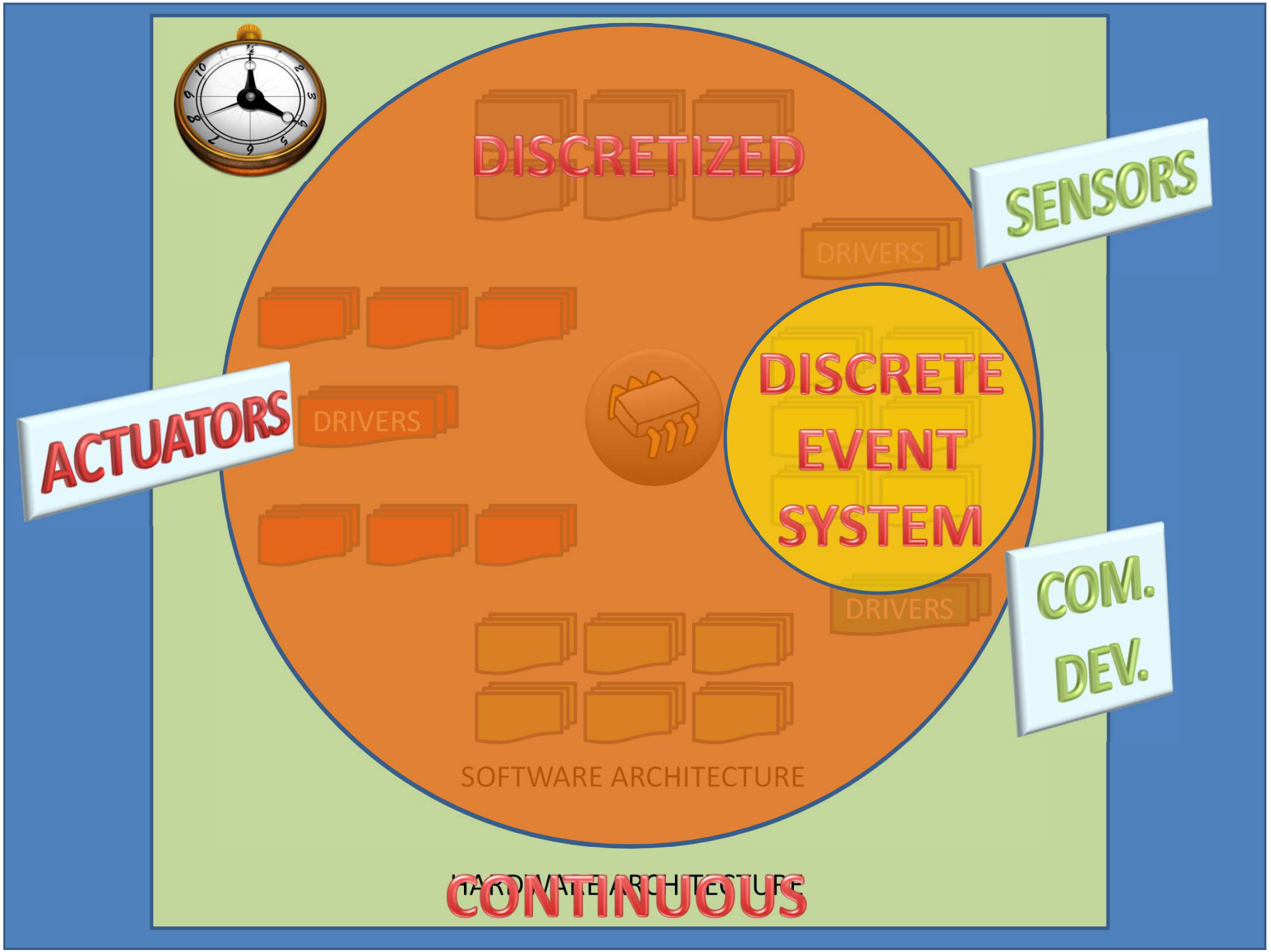


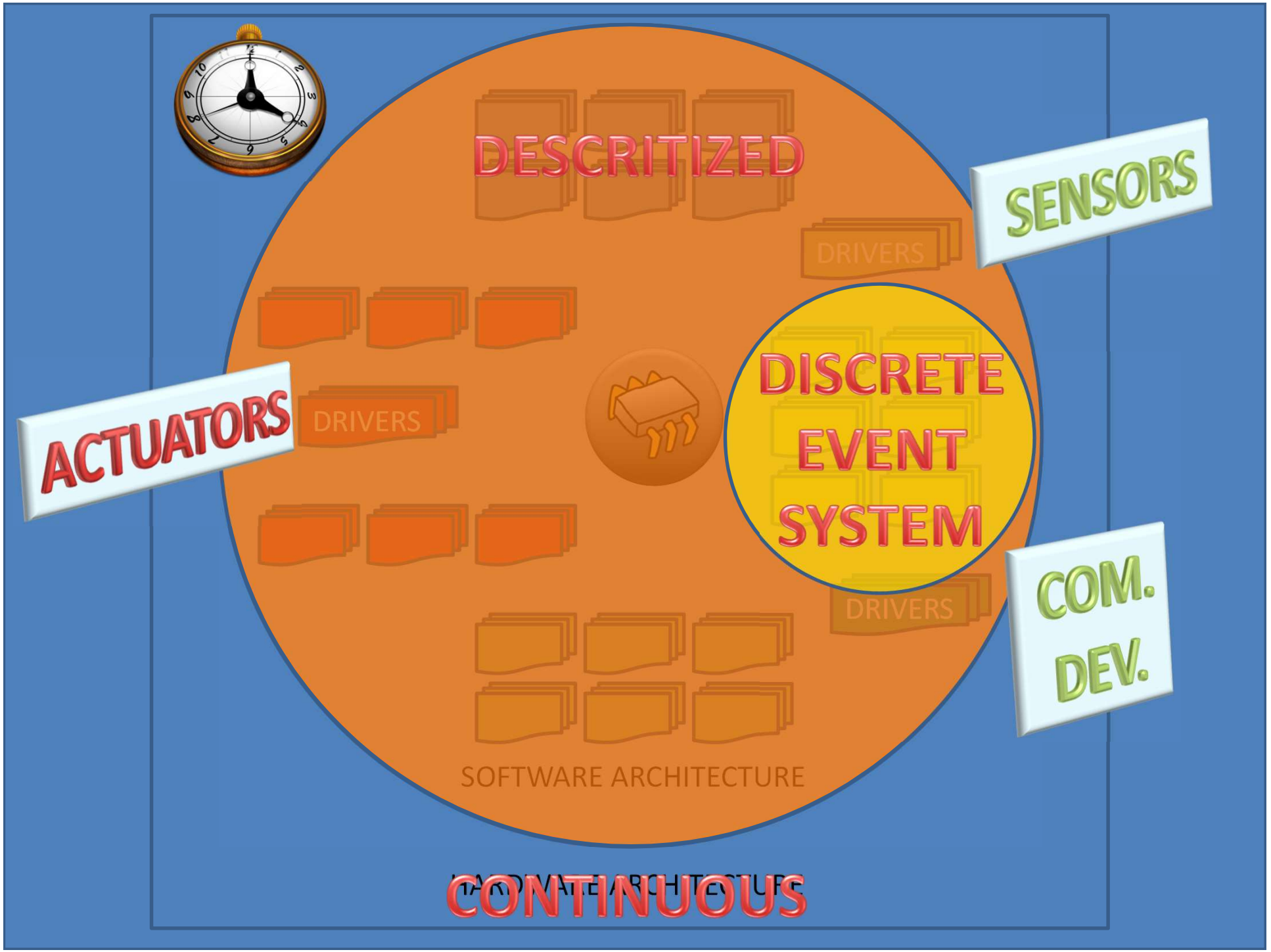
Software Architecture

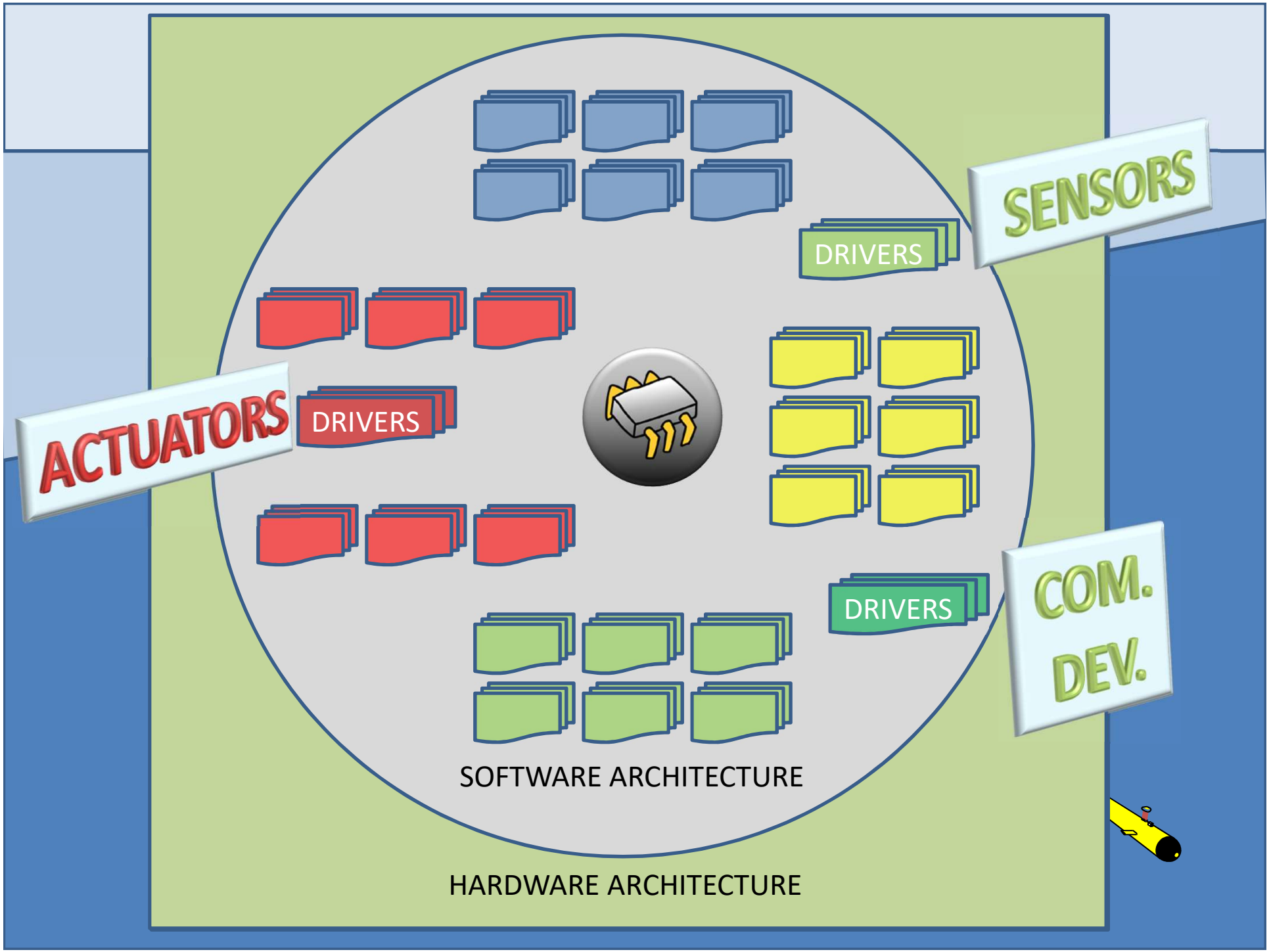


Software Architecture

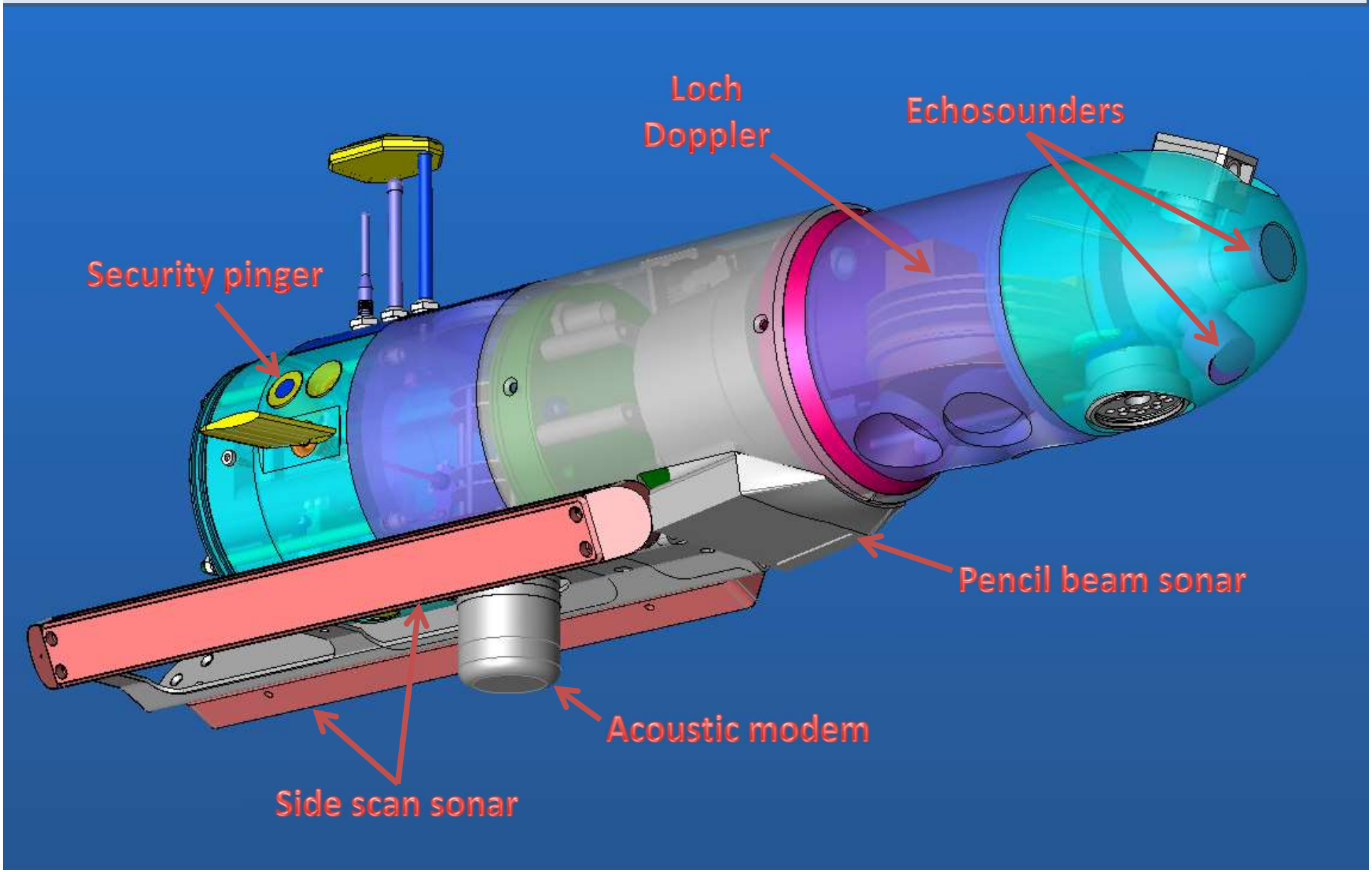



DISCRETIZED
SENSORS
DRIVERS
DISCRETE EVENT SYSTEM
ACTUATORS
DRIVERS
COM. DEV.
DRIVERS
SOFTWARE ARCHITECTURE
CONTINUOUS

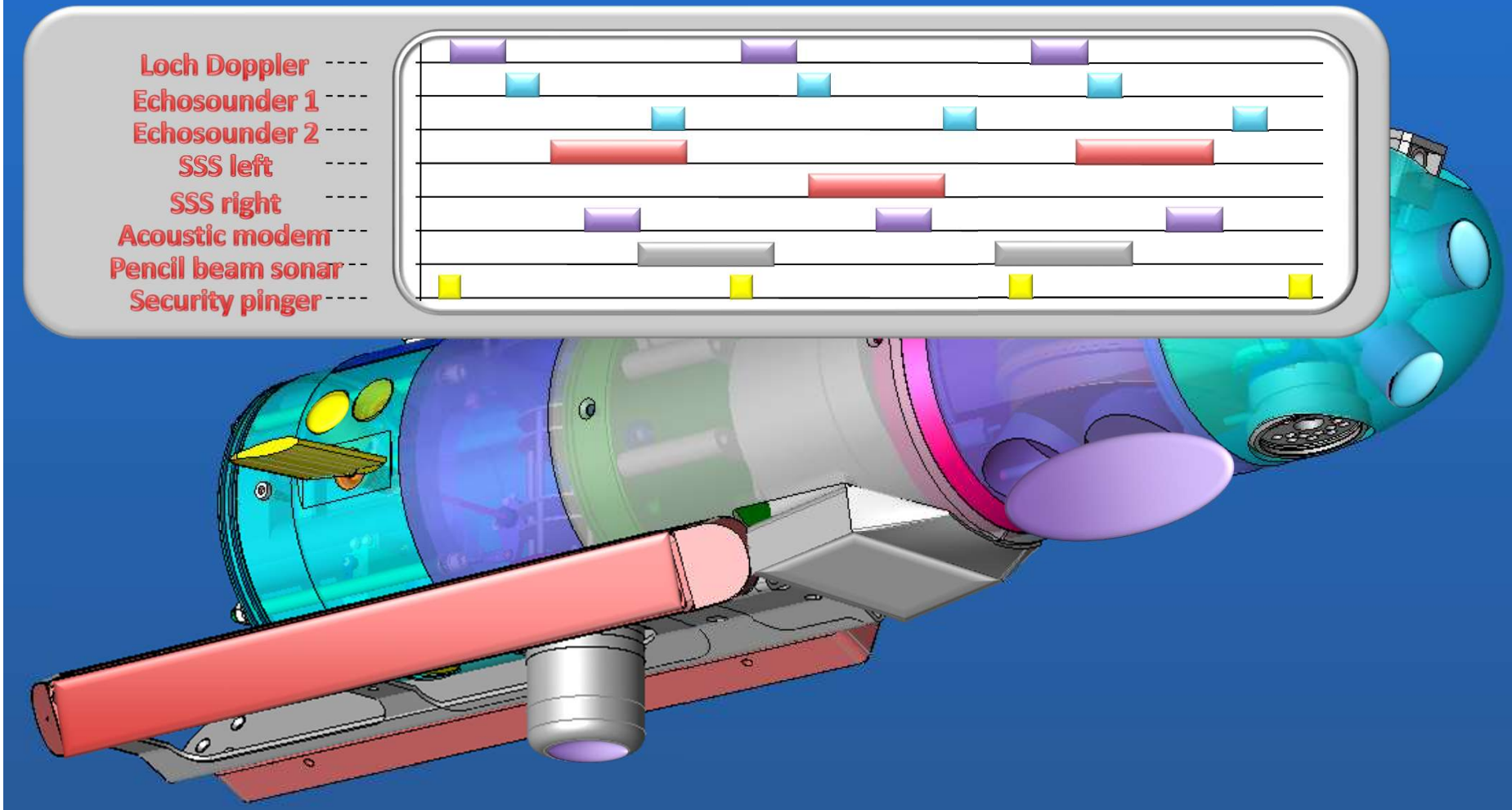

DESCRITIZED
SENSORS
DRIVERS
ACTUATORS
DRIVERS
DISCRETE
EVENT
SYSTEM
DRIVERS
COM.
DEV.
SOFTWARE ARCHITECTURE
CONTINUOUS


SENSORS
DRIVERS
ACTUATORS
DRIVERS
DRIVERS
COM.
DEV.
SOFTWARE ARCHITECTURE
HARDWARE ARCHITECTURE

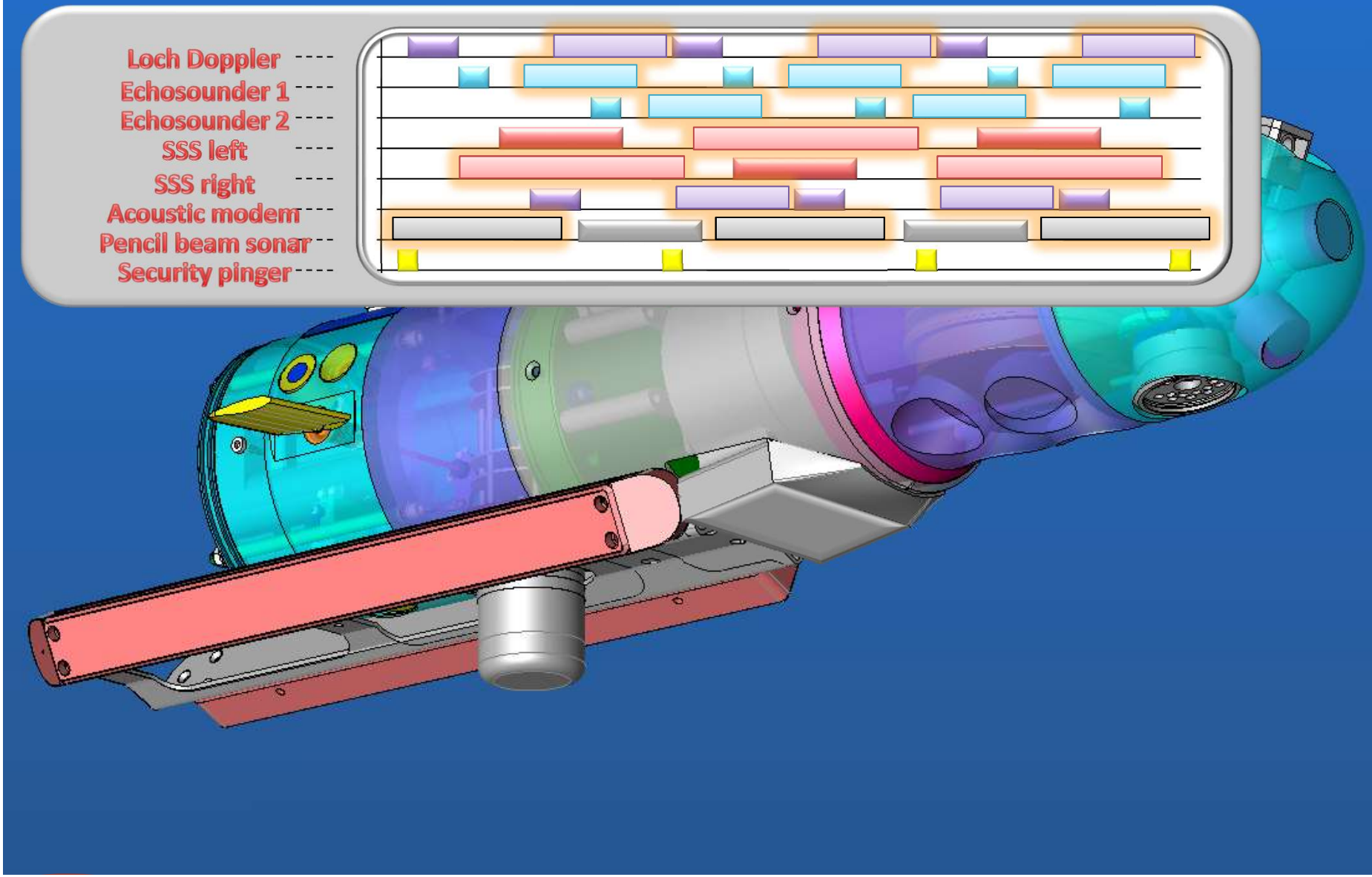
ACOUSTIC SENSORS



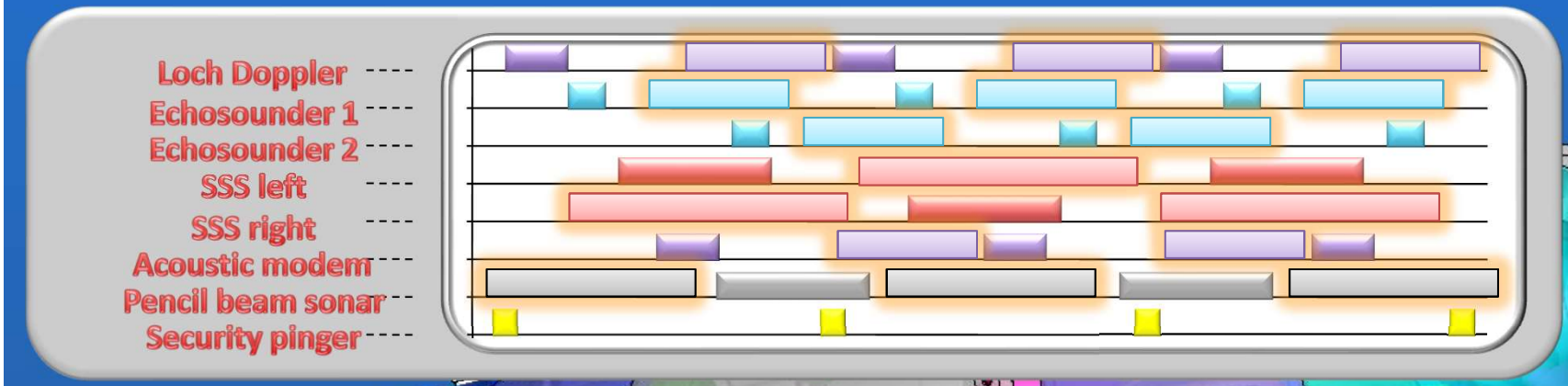
ACOUSTIC SENSORS

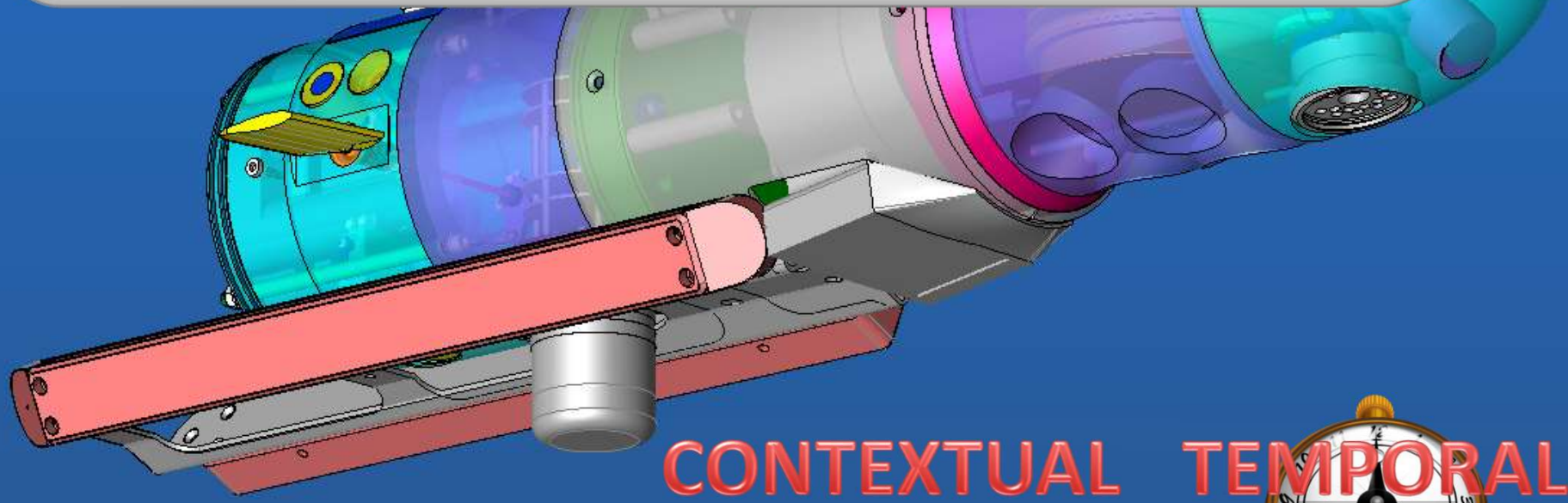


ACOUSTIC SENSORS



ACOUSTIC SENSORS





CONTEXTUAL EMISSION ?

TEMPORAL DRIFT

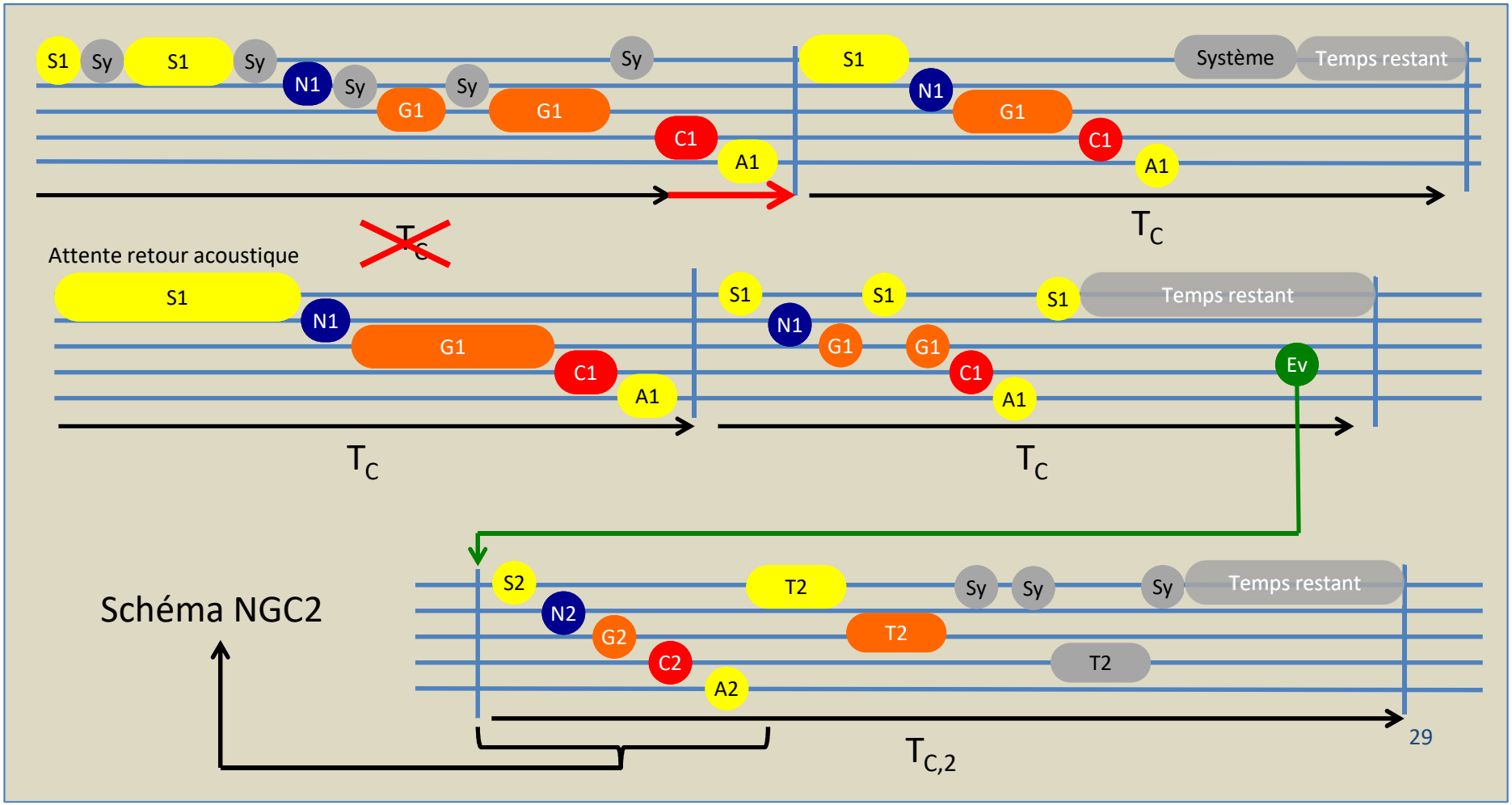
INTERFERING ACOUSTIC SENSORS

Pert. ⇒ ⇑	SBES 12	SBES 210	MBES 12	MBES 24	MBES 100	SBP 3.5	ADCP 38	ADCP 150	Roxann 38	Pinger 12	USBL 16	TT 8-16	USBL 24
SBES 12			💣	⚡	-	-	💣	-	💣	?	💣	💣	⚡
SBES 210	-		-	-	-	-	-	⚡	-	-	-	-	-
MBES 12	🚢	-			-	-	💣	-	💣	🚢	💣	🚢	⚡
MBES 24	-	-			⚡	-	⚡	-	⚡	-	⚡	-	💣
MBES 100	-	🚢	-	-		-	-	⚡	-	-	-	-	-
SBP 3.5	⚡	-	⚡	-	-		-	-	-	⚡	⚡	⚡	-
ADCP 38	-	⚡	-	⚡	⚡	-		⚡	💣	-	-	-	⚡
ADCP 150	-	⚡	-	-	⚡	-	-		-	-	-	-	-
Roxann 38	-	-	-	⚡	⚡	-	💣	⚡		-	-	-	⚡
Pinger 12	?	-	-	-	-	-	-	-	-		💣	💣	⚡
USBL 16	🚢	-	⚡	⚡	-	-	⚡	-	⚡	🚢		🚢	⚡
TT 8-16	🚢	-	🚢	🚢	-	-	🚢	-	🚢	🚢	🚢		🚢
USBL 24	-	-	-	💣	⚡	-	⚡	-	⚡	-	⚡	🚢	

Source : P. Arzeliers (Ifremer)

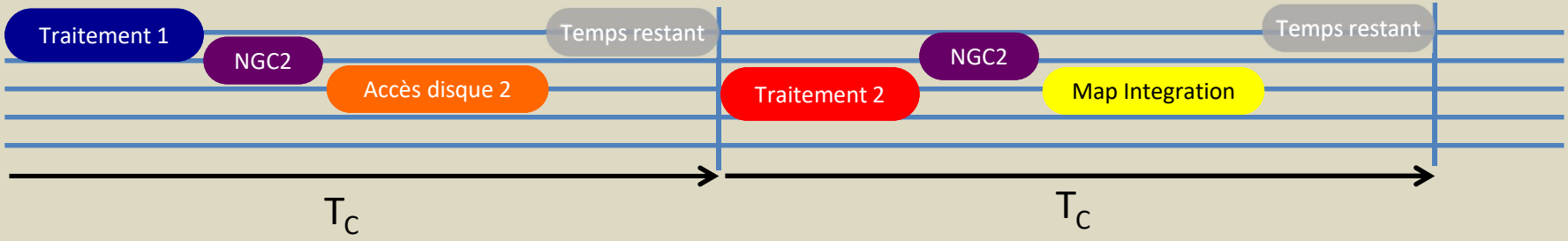
Software Architecture

- The Execution Partition

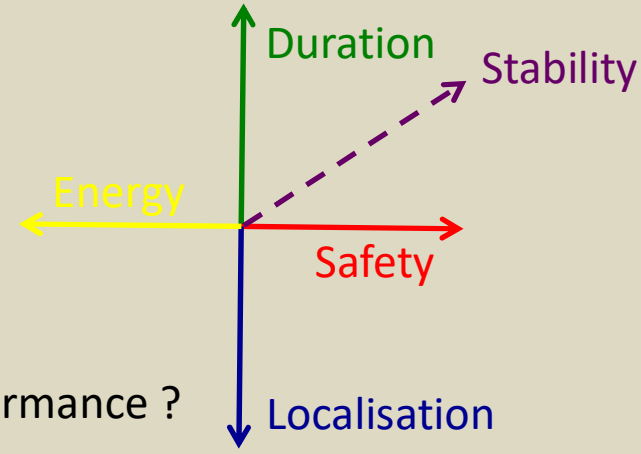


Software Architecture

- The Execution Partition



- Dealing with different Temporalities
  - Continuous / Discrete
  - Periodical and multi-rate
  - Event driven

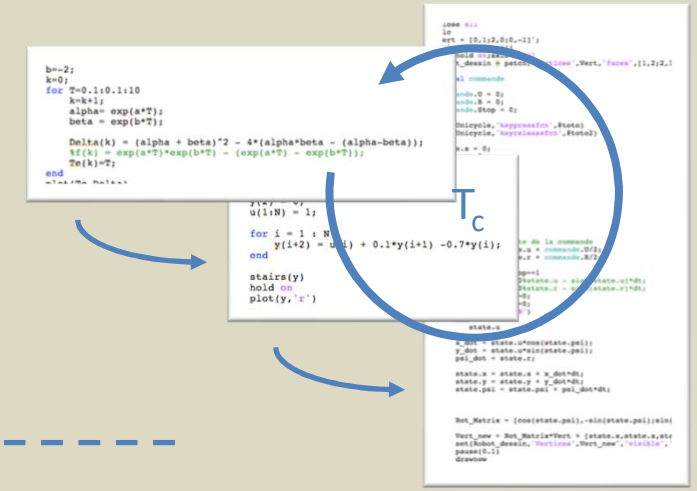


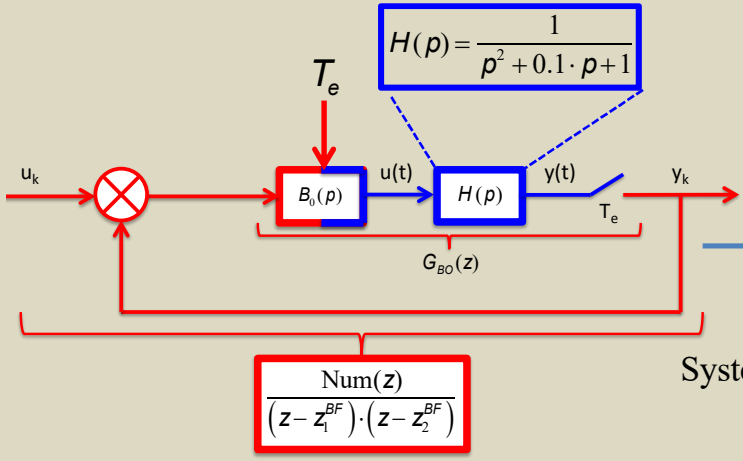
Are we able to guarrantee performance ?

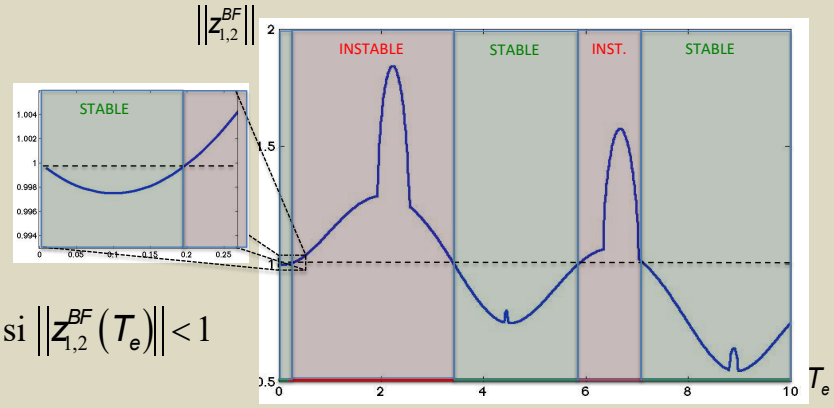
Software Architecture

- The choice of the control period

$$\begin{cases} \dot{s} = u \cdot \cos\theta + k_1 \cdot s_1 \\ r = \dot{\delta} - \gamma \cdot y_1 \cdot u \cdot \dfrac{\sin\theta - \sin\delta}{\theta - \delta} - k_2 \cdot (\theta - \delta) \\ u > 0 \end{cases}$$





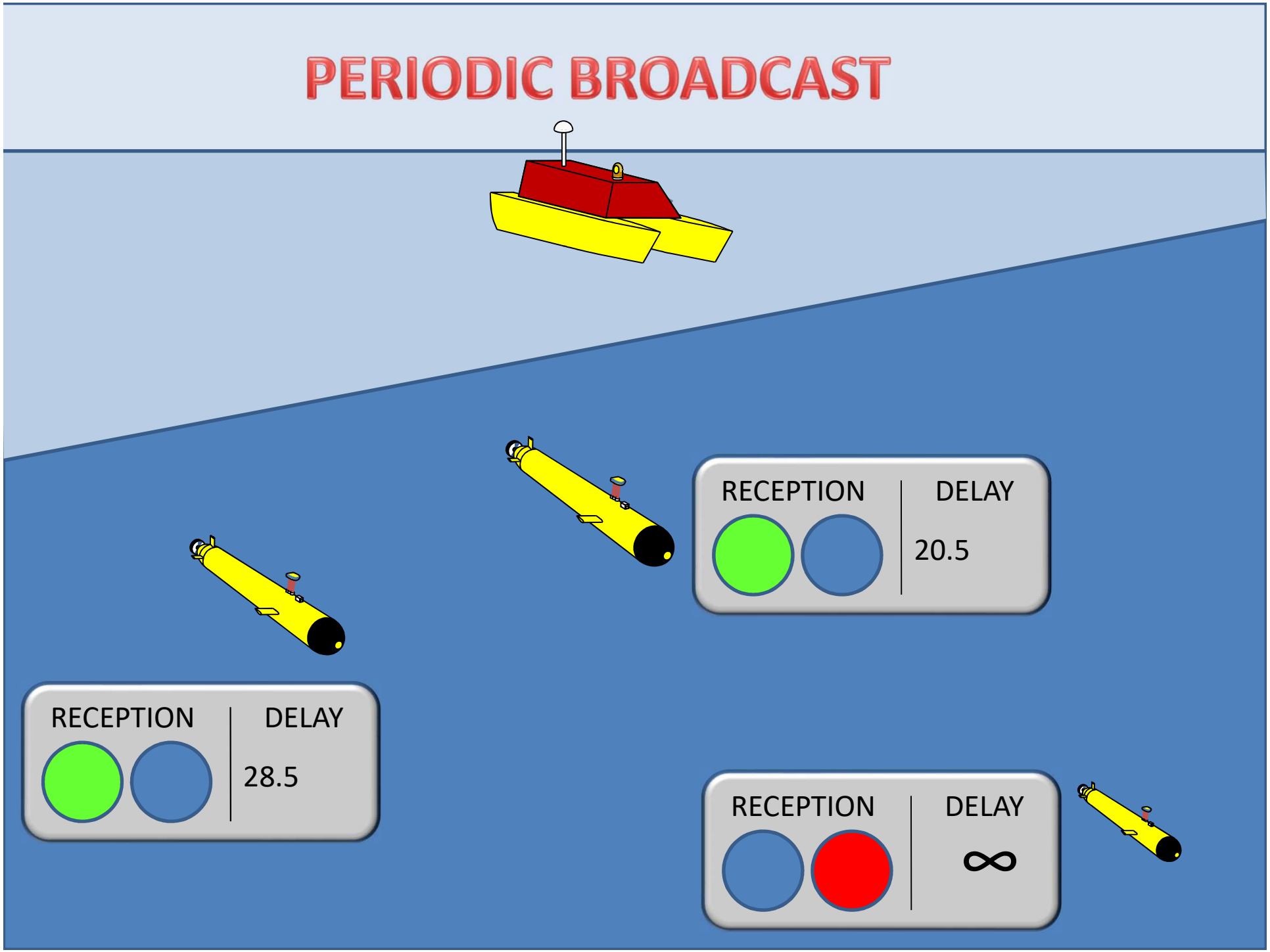


Système stable si $\left\| z_{1,2}^{BF}(T_e) \right\| < 1$

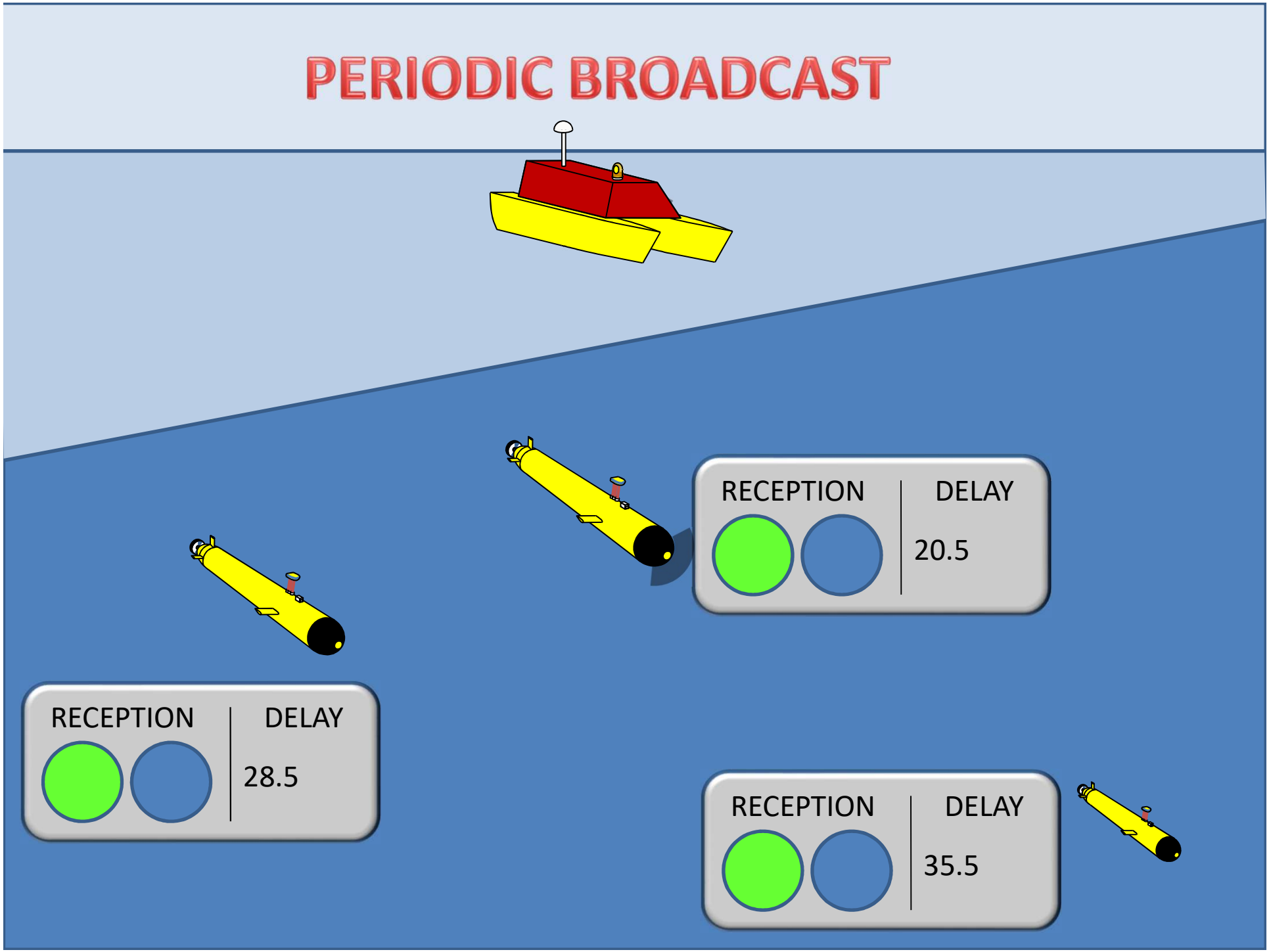
Robot Components

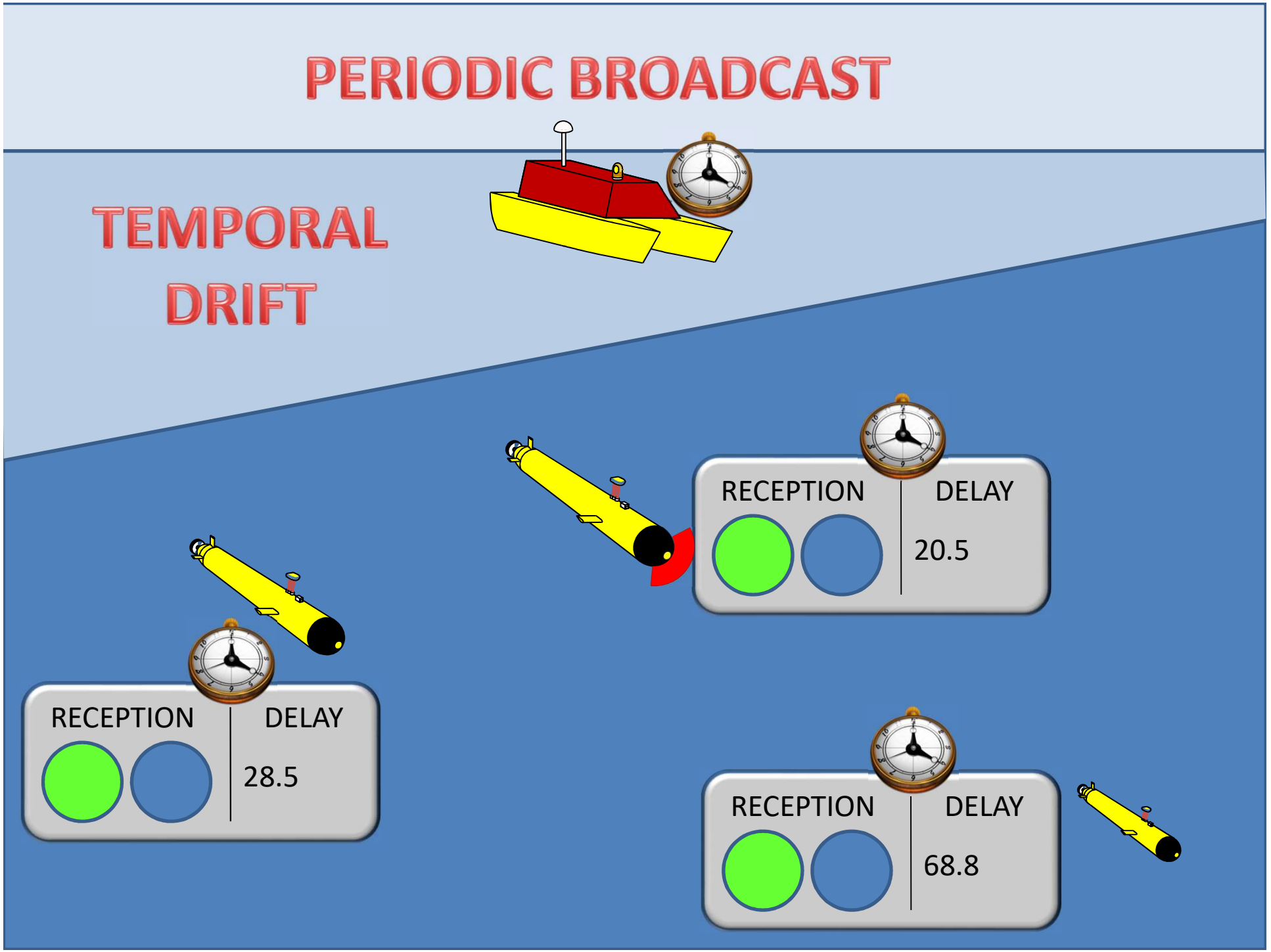
- Actuators
- Sensors
- Computers
  - OS and Middleware
    - Software Architecture
      - Implements algorithms : **robotics functionnalities**
        - » Navigation, Guidance, Control, mission control
        - » Sensors recruitment
        - » Actuators allocation
- -> which guarantees ?
        - » RT, bounded errors, convergence rate…

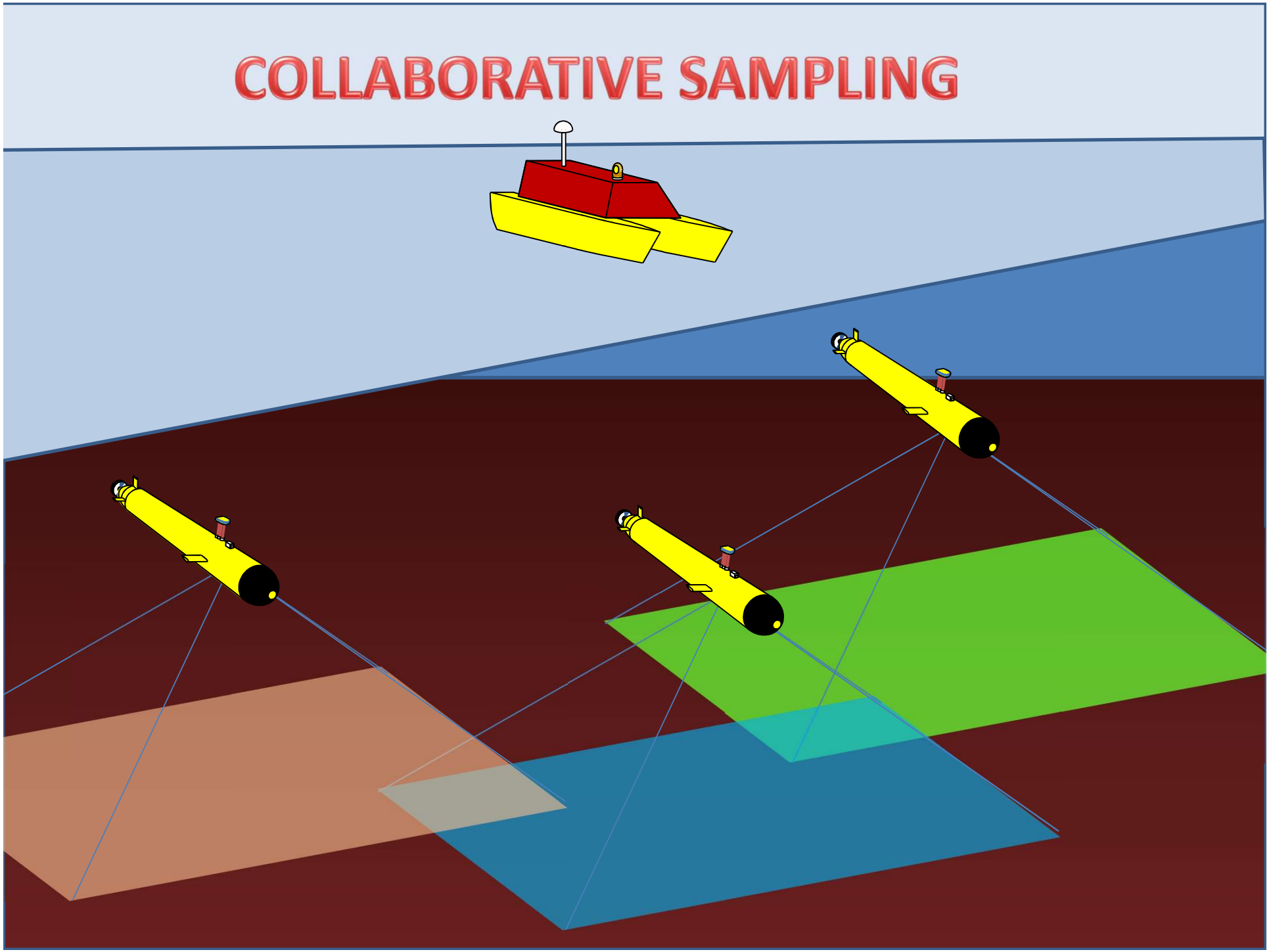
PERIODIC BROADCAST

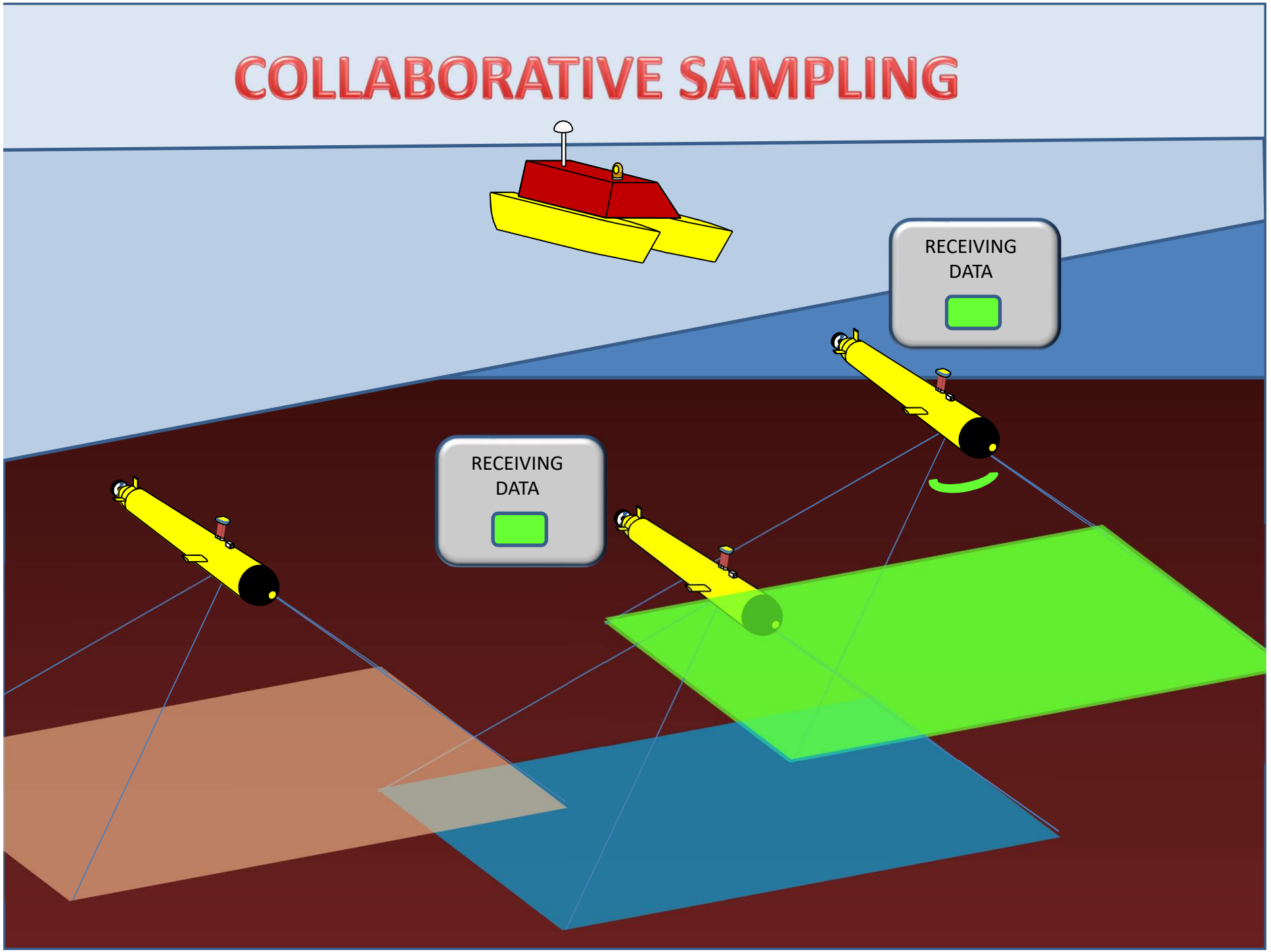


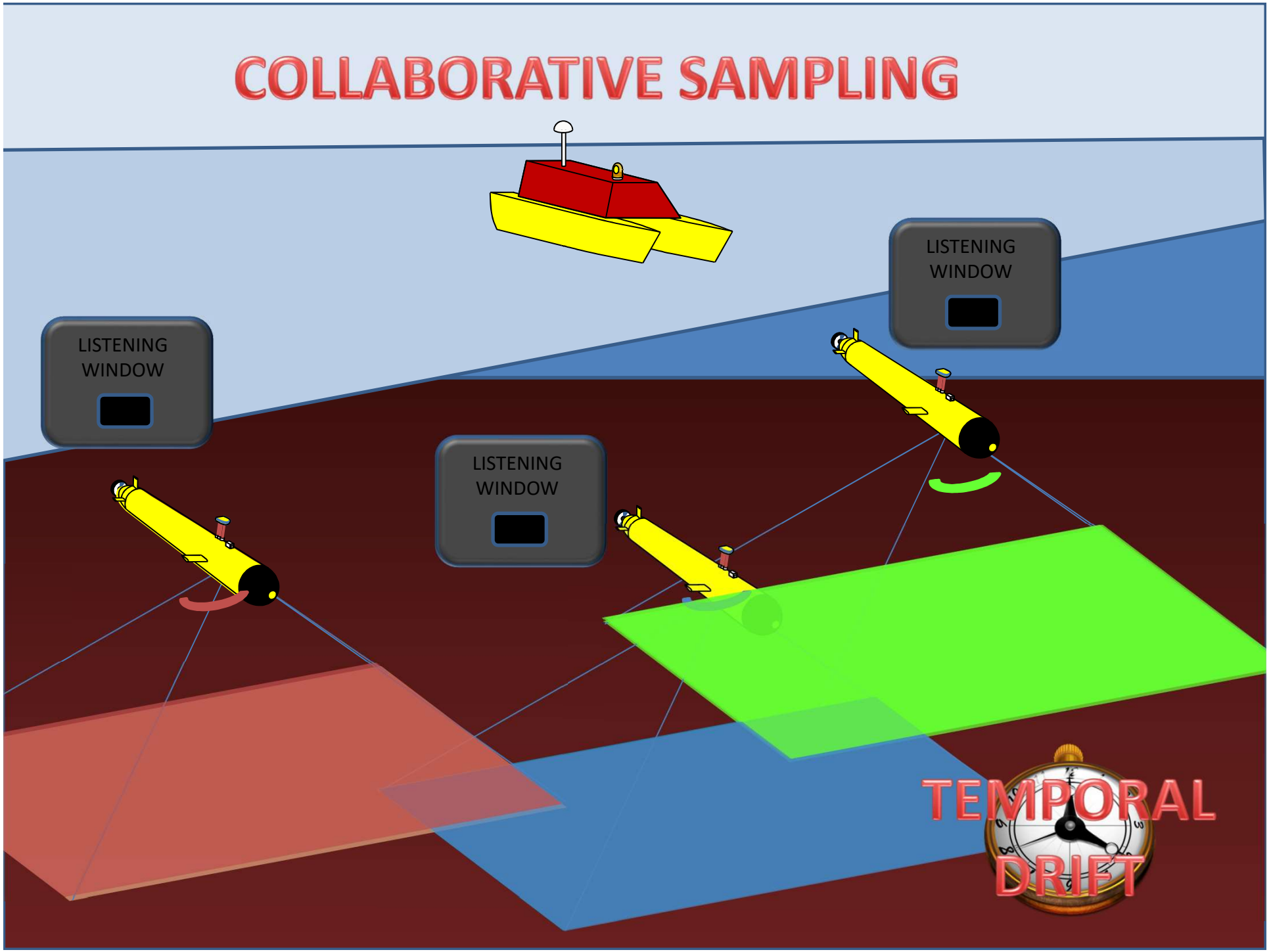
PERIODIC BROADCAST




PERIODIC BROADCAST
TEMPORAL DRIFT
RECEPTION
DELAY
20.5
RECEPTION
DELAY
28.5
RECEPTION
DELAY
68.8


COLLABORATIVE SAMPLING


COLLABORATIVE SAMPLING
RECEIVING DATA
RECEIVING DATA


COLLABORATIVE SAMPLING
LISTENING WINDOW
LISTENING WINDOW
LISTENING WINDOW
TEMPORAL DRIFT