UNEXMIN

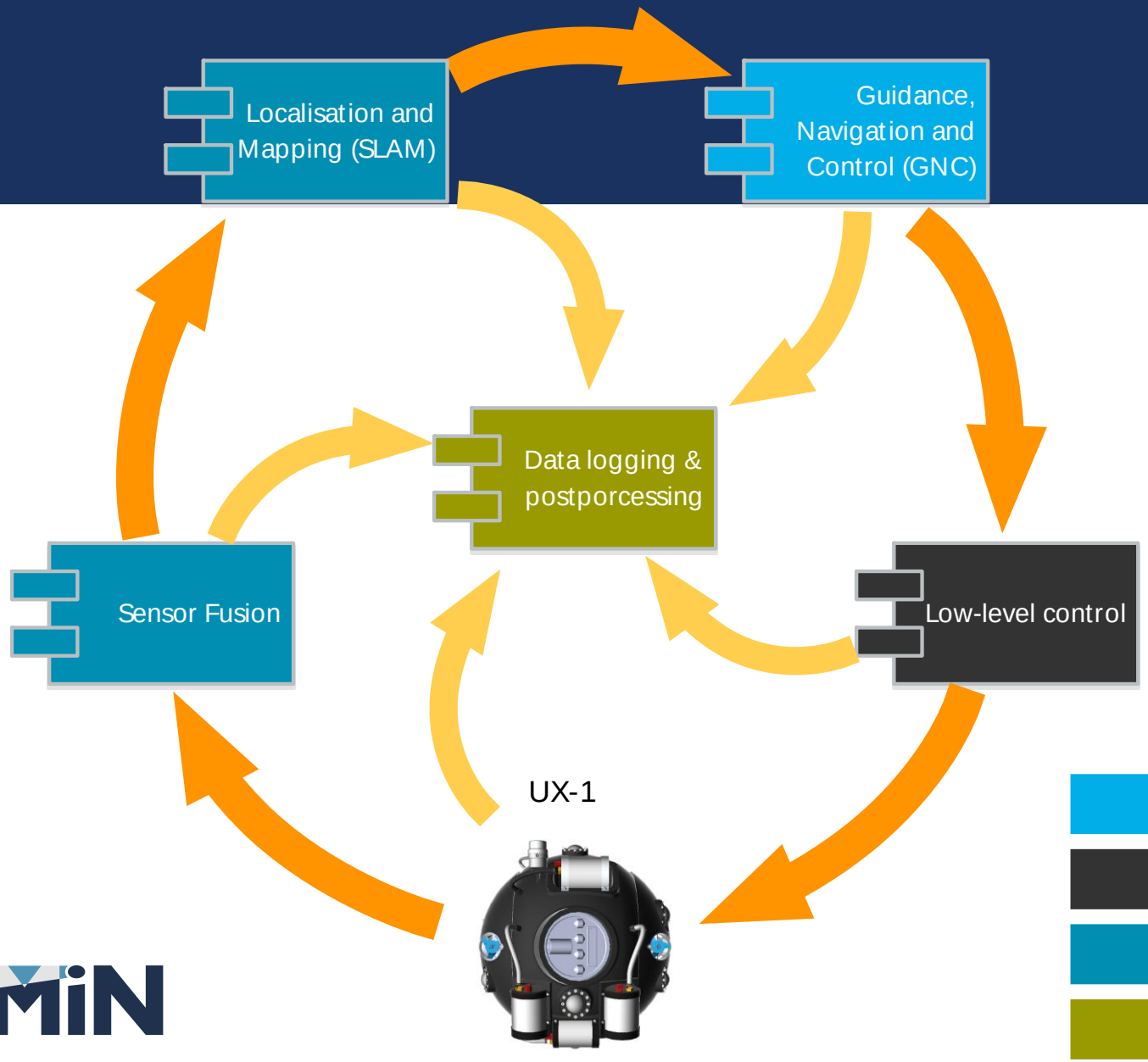
AN AUTONOMOUS UNDERWATER EXPLORER FOR FLOODED MINES

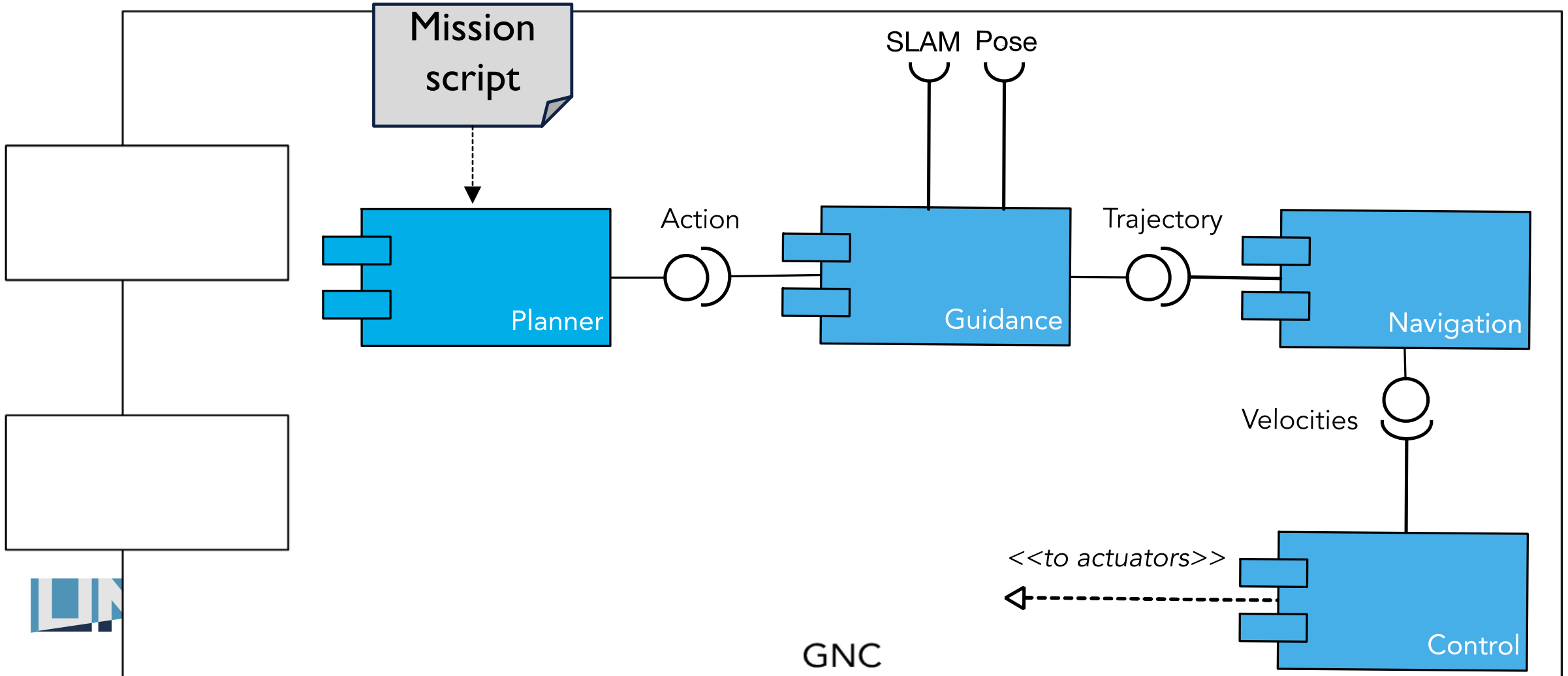
UX-1 CONTROL, GUIDANCE AND AUTONOMY

NEMO 33, UNEXMIN FINAL CONFERENCE

26TH SEPTEMBER 2019

This project has received funding from the European Union's Horizon 2020research and innovation programme under grant agreement No 690008.

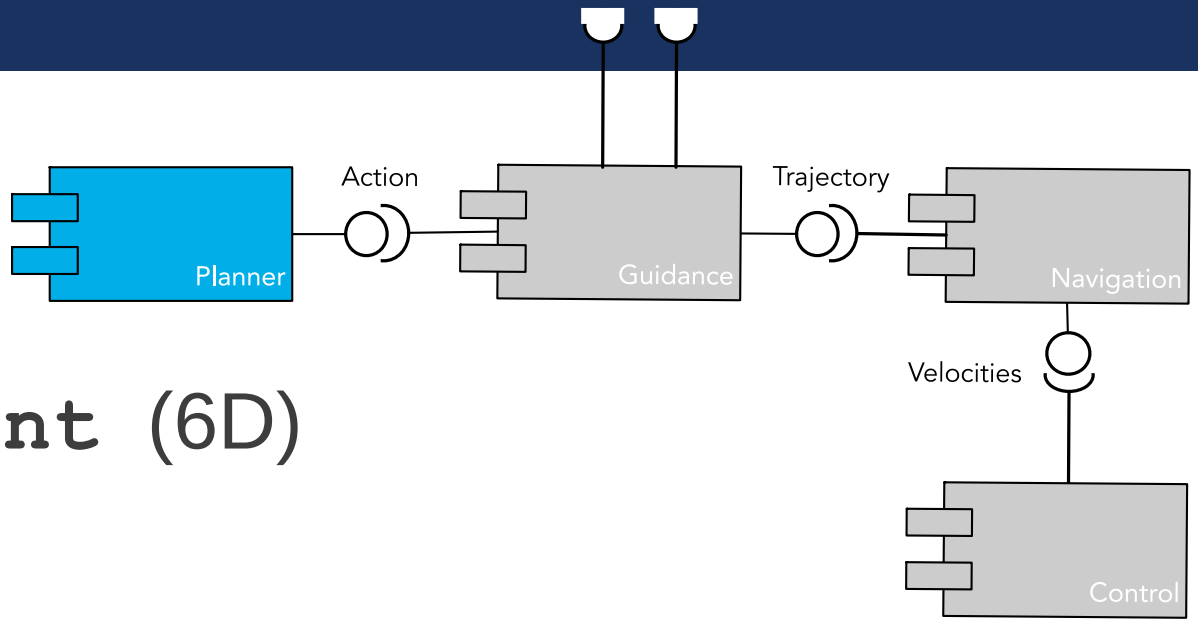

Localisation and Mapping (SLAM)
Guidance, Navigation and Control (GNC)
Data logging & postporcessing
Sensor Fusion
Low-level control
UX-1


Mission script
SLAM
Pose
Action
Trajectory
Planner
Guidance
Navigation
Velocities
<<to actuators>>
Control
GNC

MISSION SCRIPT: ACTIONS

Navigation actions

- Unknown map → **`explore`**
- Know map → **`go to point`** (6D)



Payload actions

- **`Take simple`**
- **`Turn on`**…

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MISSION SCRIPT: XML

```
<mission description="Waypoint navigation">

        <task description="Go to point A">
                <point>
                        <x>Ax</x>
                        <y>By</y>
                        <z>Cz</z>
                </point>
        </task>

        <task description="Turn on MSU">
                <wait>x_secs</wait>
        </task>

        <task description="Go to point B">
                <point>
                        <x>Bx</x>
                        <y>By</y>
                        <z>Bz</z>
                </point>
                <wait>x_secs</wait>
        </task>
```

```
<event_handling>
        <event name="Low battery">
                <task description="ABORT_MISSION"/>
        </event>

        <event name="Emergency">
                <task description="ABORT_MISSION"/>
        </event>
</event_handling>
```

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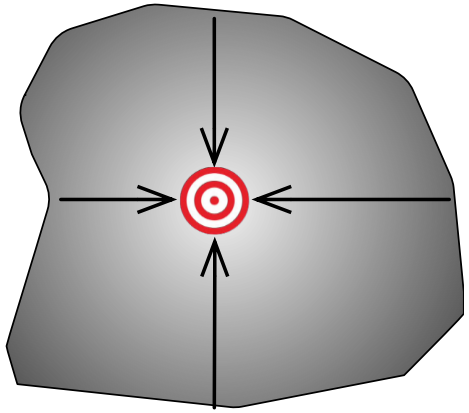
MISSION SCRIPT: ACTIONS

Navigation

- Unknown map → **`explore`**

- Generate a waypoint 0,5 m ahead, centered, then **`go to point`**



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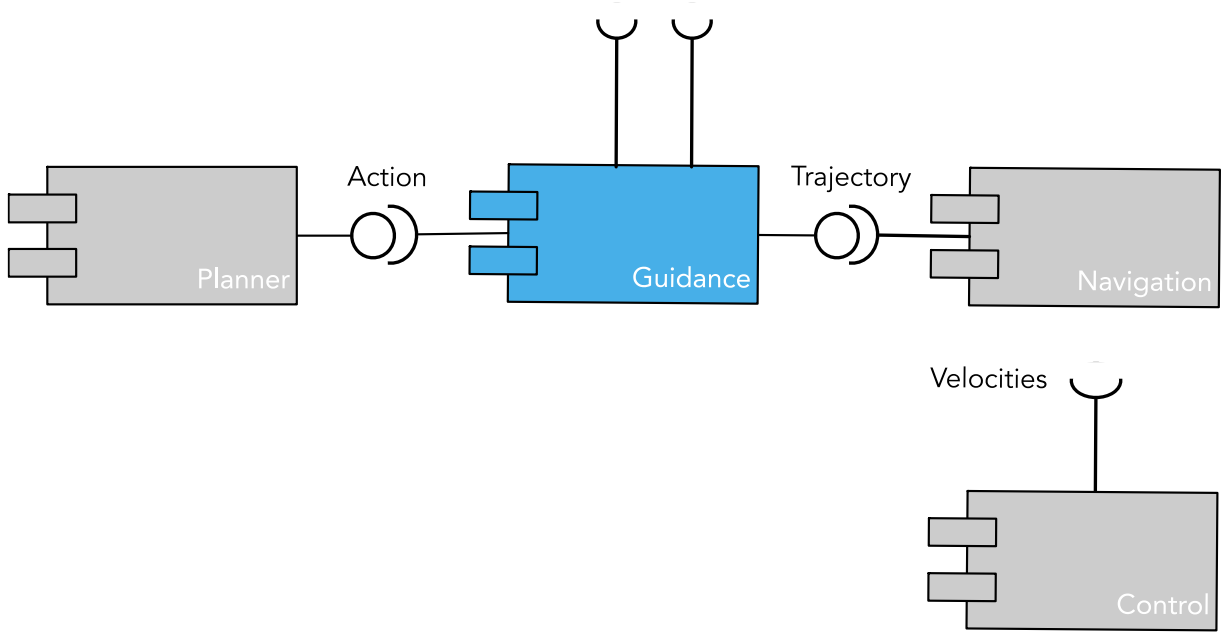
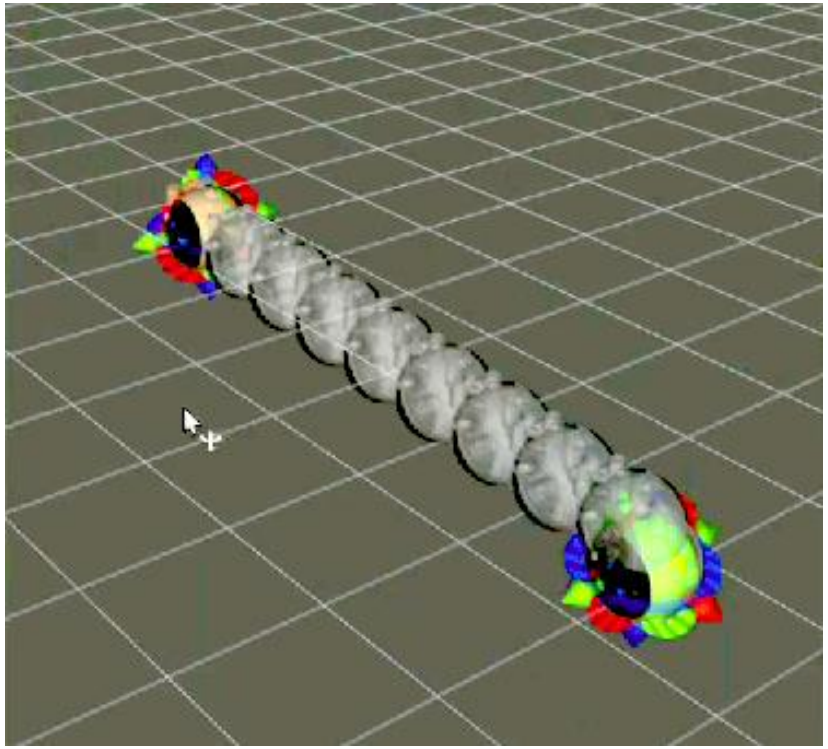
GUIDANCE





Generate a **trajectory** of intermediate waypoints with 0,5 m spacing

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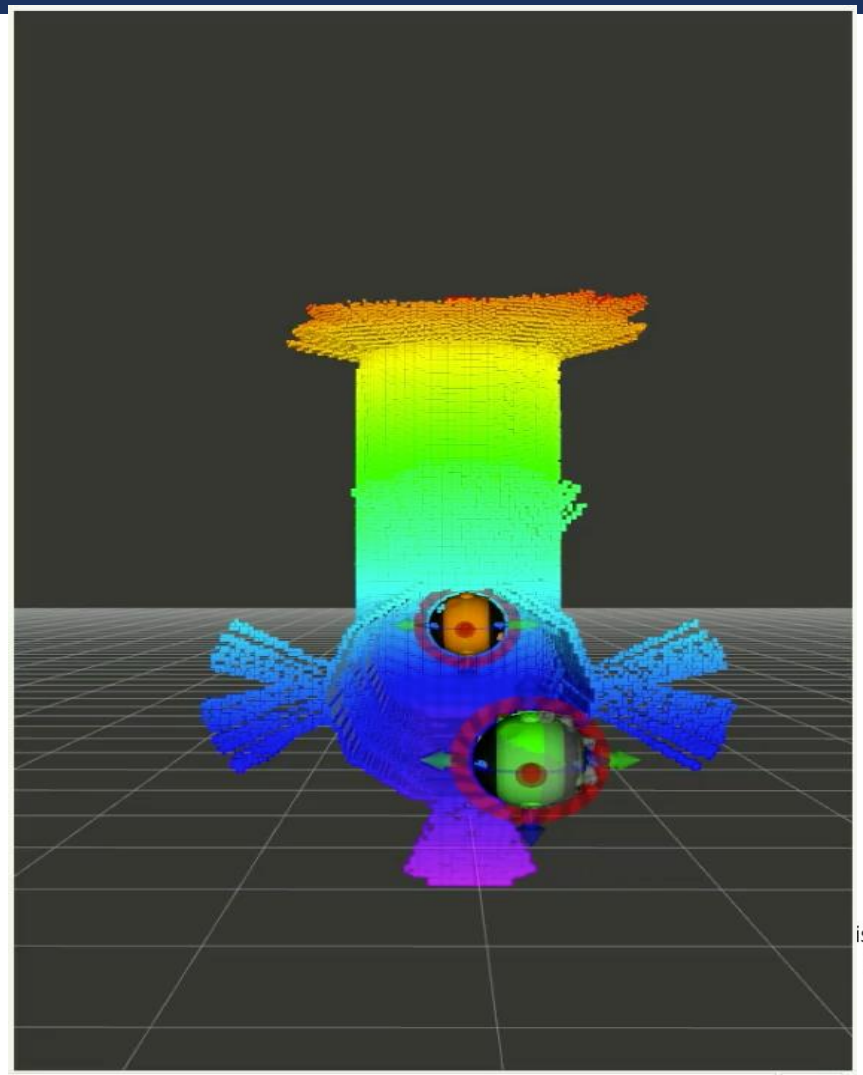
GUIDANCE



Simulations

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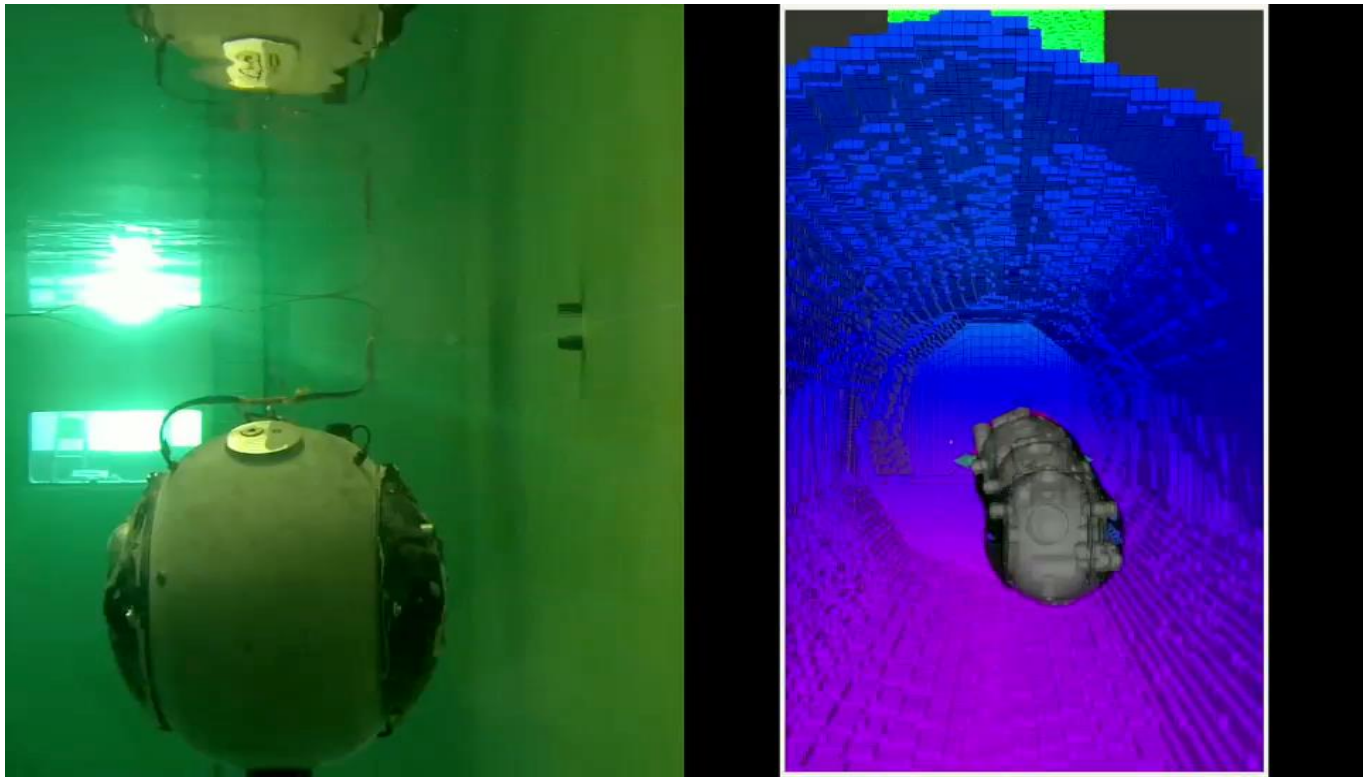
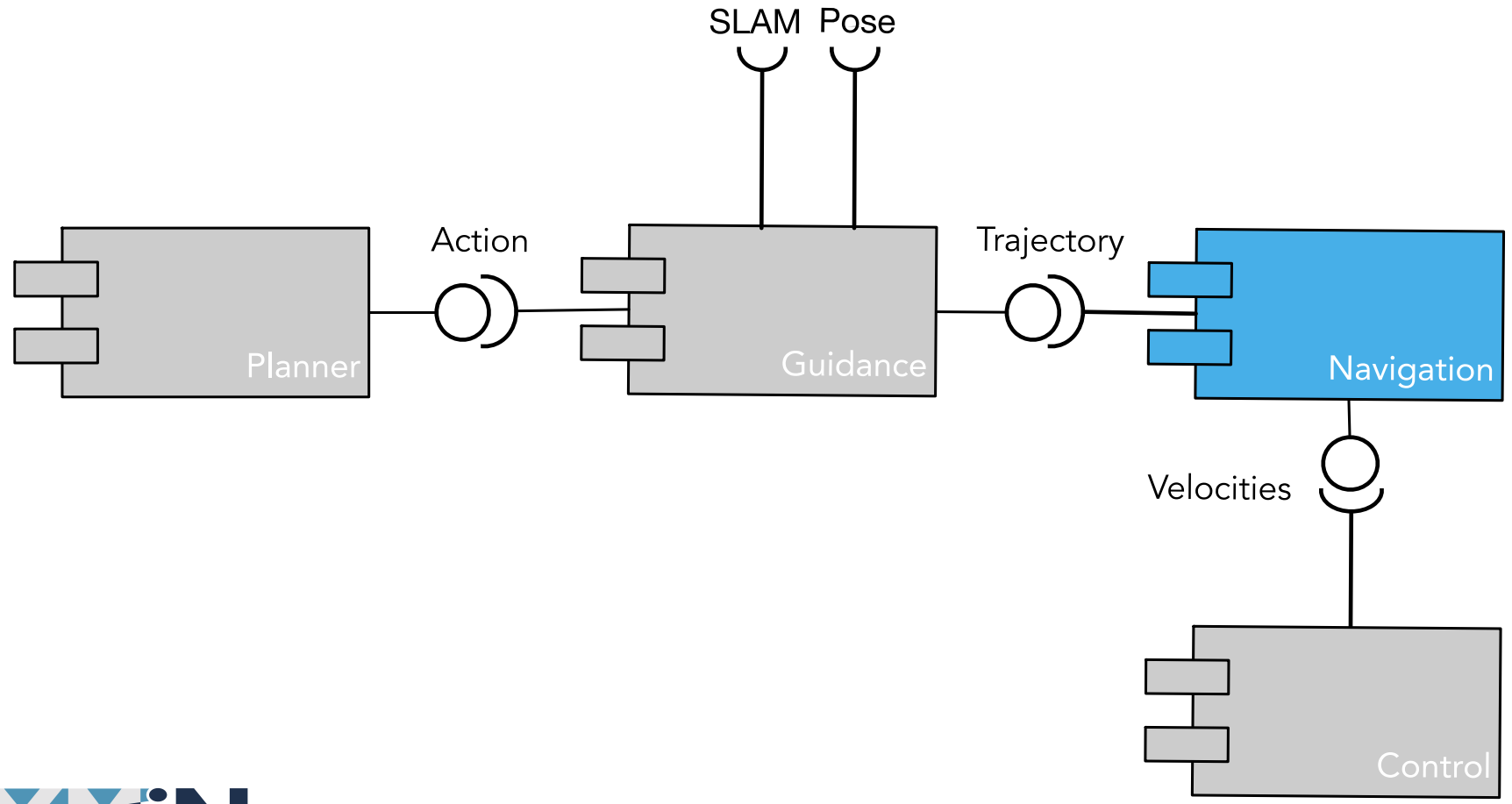
GUIDANCE



Hardware-in-the-loop tests

NAVIGATION


SLAM
Pose
Action
Trajectory
Planner
Guidance
Navigation
Velocities
Control

CONTROL

$$\boldsymbol{\eta} = \begin{bmatrix} \boldsymbol{P}^n_{b/n} \\ \boldsymbol{\Theta}_{nb} \end{bmatrix} = [x, y, z, \phi, \theta, \psi]^\top \quad (1)$$

$$\boldsymbol{J}_\Theta(\boldsymbol{\eta}) = \begin{bmatrix} \boldsymbol{R}^n_b(\boldsymbol{\Theta}_{nb}) & \mathbf{0}_{3\times3} \\ \mathbf{0}_{3\times3} & \boldsymbol{T}_\Theta(\boldsymbol{\Theta}_{nb}) \end{bmatrix} \quad (2)$$

$$\boldsymbol{\nu} = \begin{bmatrix} \boldsymbol{v}^b_{b/n} \\ \boldsymbol{\omega}^b_{b/n} \end{bmatrix} \quad (3)$$

$$\boldsymbol{\tau} = \begin{bmatrix} \boldsymbol{f}^b \\ \boldsymbol{\tau}^b \end{bmatrix} \quad (4)$$

Complex math inside

$$\dot{\boldsymbol{\eta}} = \boldsymbol{J}_\Theta(\boldsymbol{\eta})\boldsymbol{\nu} \quad (5)$$

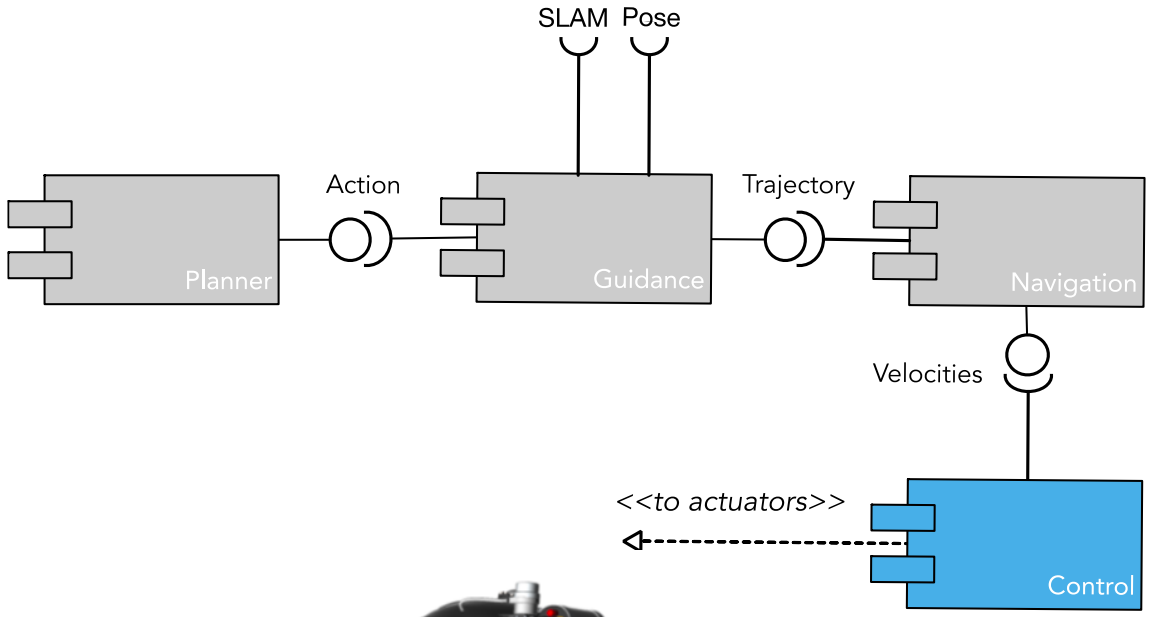
$$\boldsymbol{M}\dot{\boldsymbol{\nu}} + \boldsymbol{C}(\boldsymbol{\nu})\boldsymbol{\nu} + \boldsymbol{D}(\boldsymbol{\nu})\boldsymbol{\nu} + \mathrm{g}(\boldsymbol{\eta}) = \boldsymbol{B}\boldsymbol{\tau} \quad (6)$$

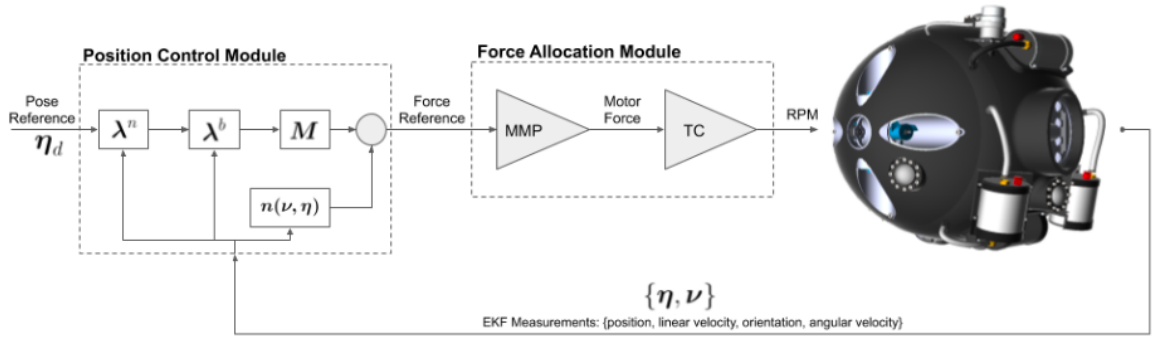
with:

$$\boldsymbol{M} = \boldsymbol{M}_{RB} + \boldsymbol{M}_A, \quad \boldsymbol{M} = \boldsymbol{M}^\top > 0 \quad (7)$$

$$\boldsymbol{C}(\boldsymbol{\nu}) = \boldsymbol{C}_{RB}(\boldsymbol{\nu}) + \boldsymbol{C}_A(\boldsymbol{\nu}) \quad (8)$$

$$\boldsymbol{D}(\boldsymbol{\nu}) = \boldsymbol{D} + \boldsymbol{D}_n(\boldsymbol{\nu}) \quad (9)$$





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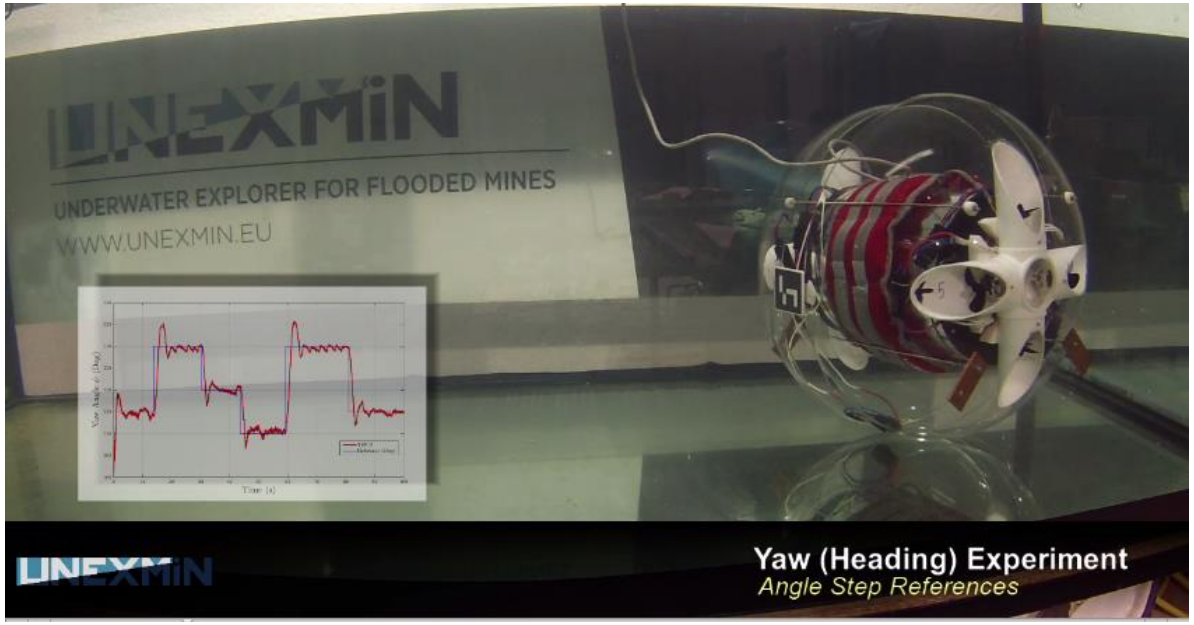
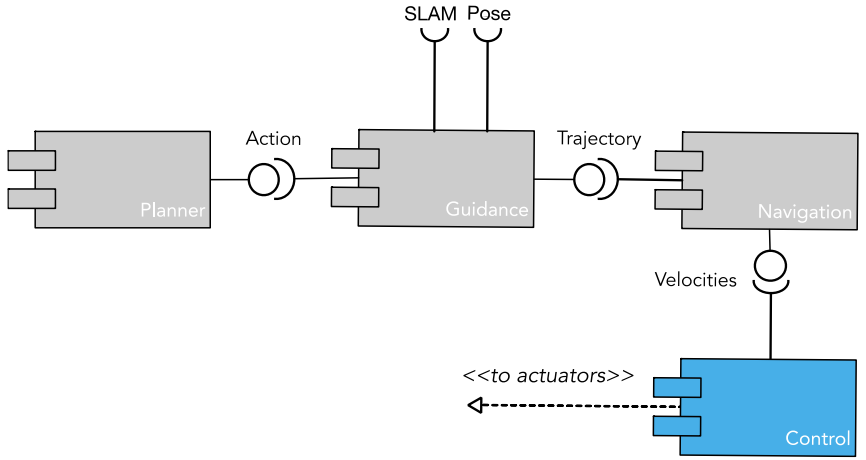
CONTROL



https://vimeo.com/259423959



Control: Feedback Lin., PID

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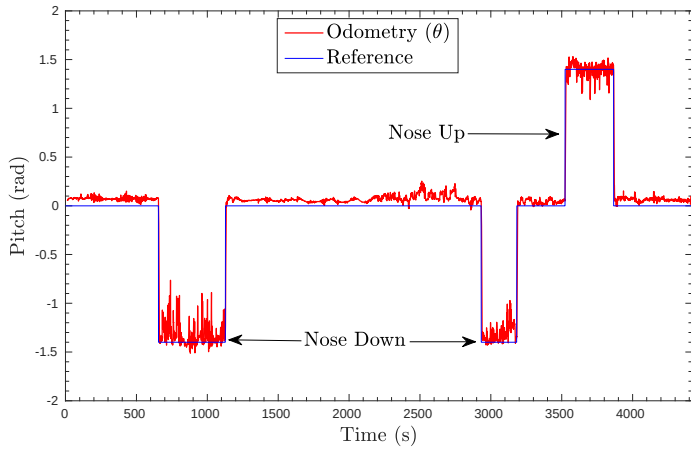
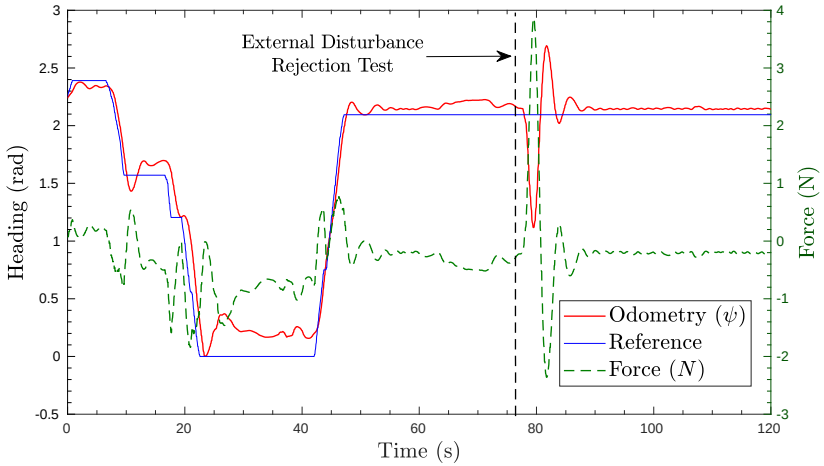
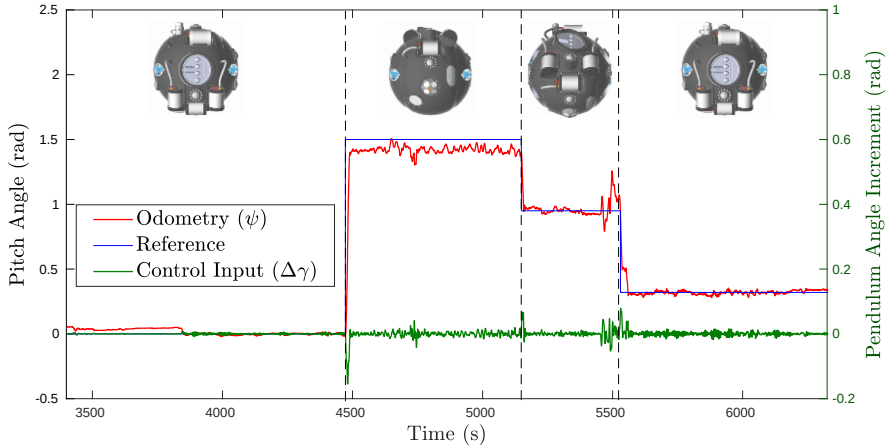
CONTROL







Control: LQR, Feedback Lin.

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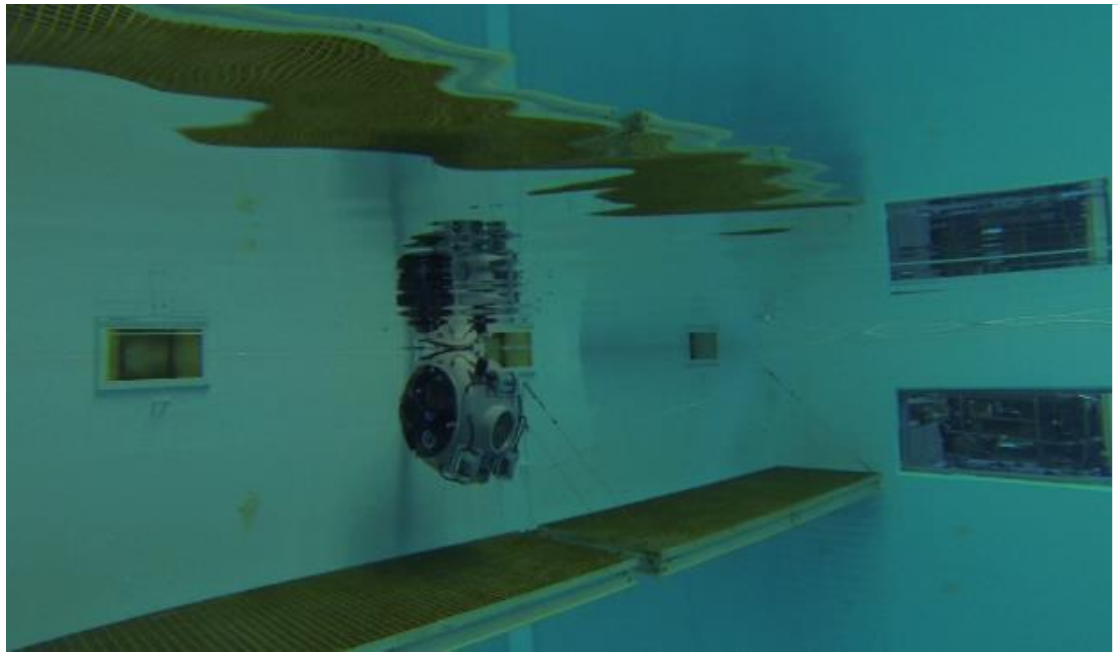
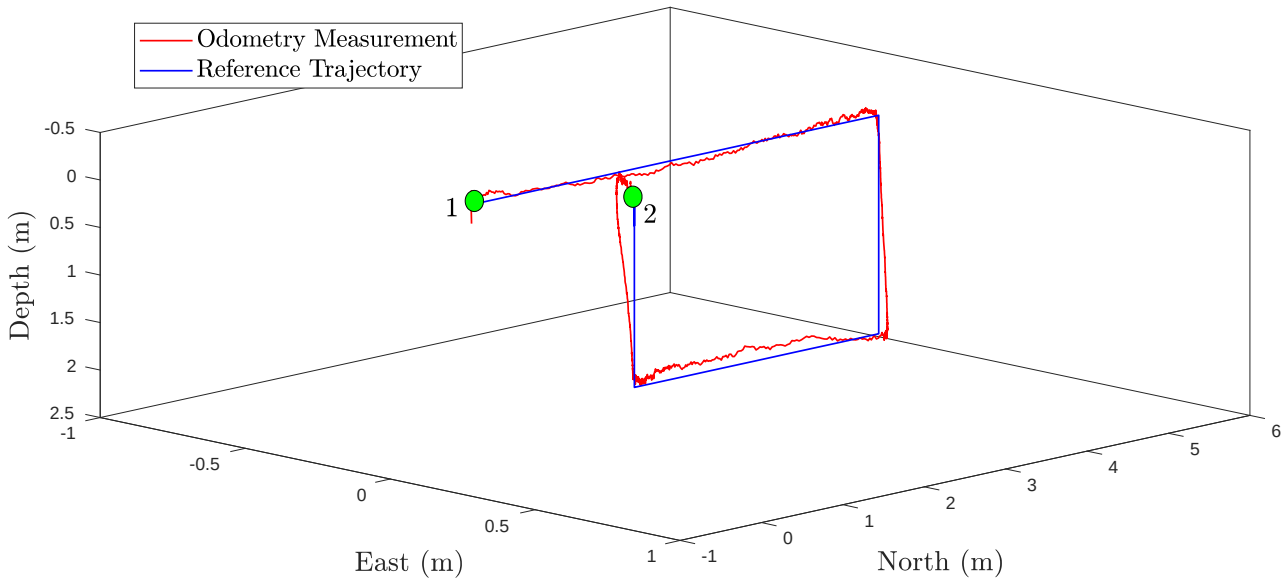
CONTROL





https://vimeo.com/321295926

Control Pool tests with Feedback Lin.

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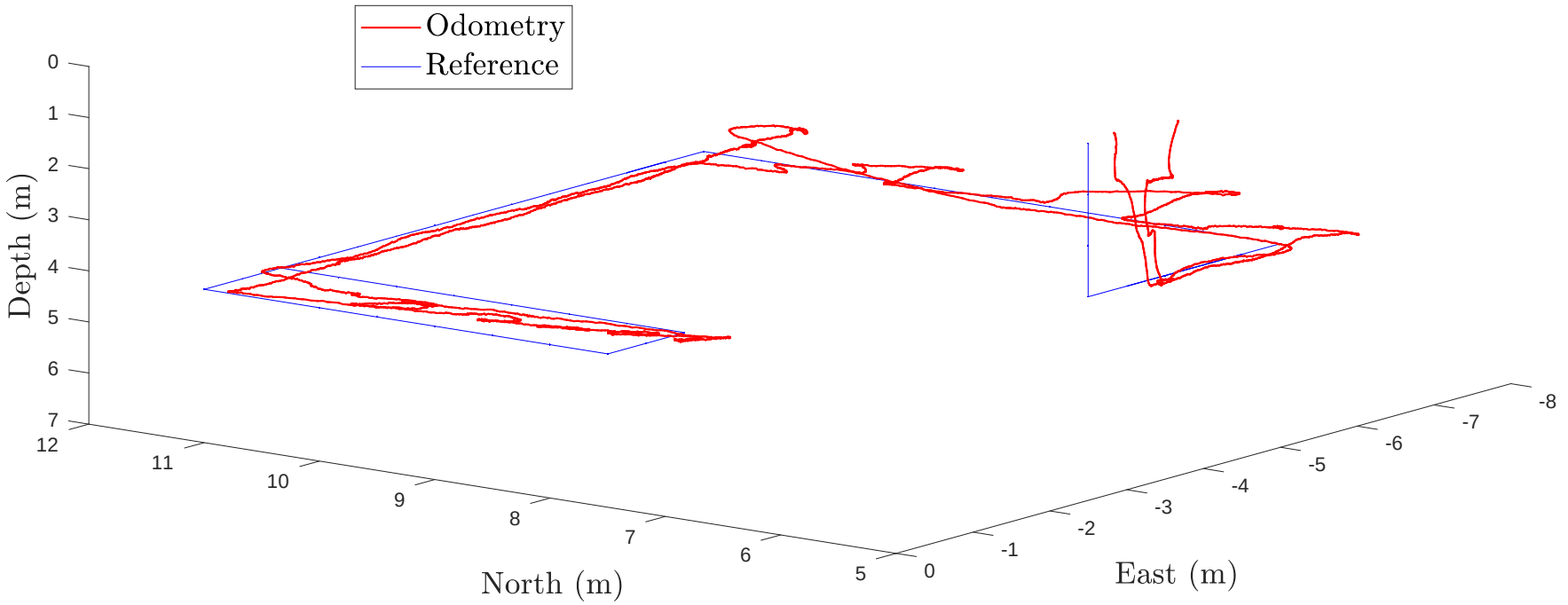
CONTROL



Janos Cave mission

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