Leuven Station
422
422

Station Antwerp-Central

Ottignies
11:51
L
991
Namur Station

Station Brussels-South

WEZEMAAL
Station Wezemaal

Bruges Station

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Smartest TrainBrain 2019 ‘The Limpio’

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Michael Purser

Challenge

- Difficulties:
  - Cleaning → complex
  - Obstacles
  - Different awnings, heights, …

Foto luifel obstakels

- Requirements:
  - ‘Good enough’ cleaning in 1 pass
  - Easy to use - ‘plug-and-play’
  - Easy to move or change awning
  - Safe (overhead cables, power cuts, ...)
  - Robust to uncertainties

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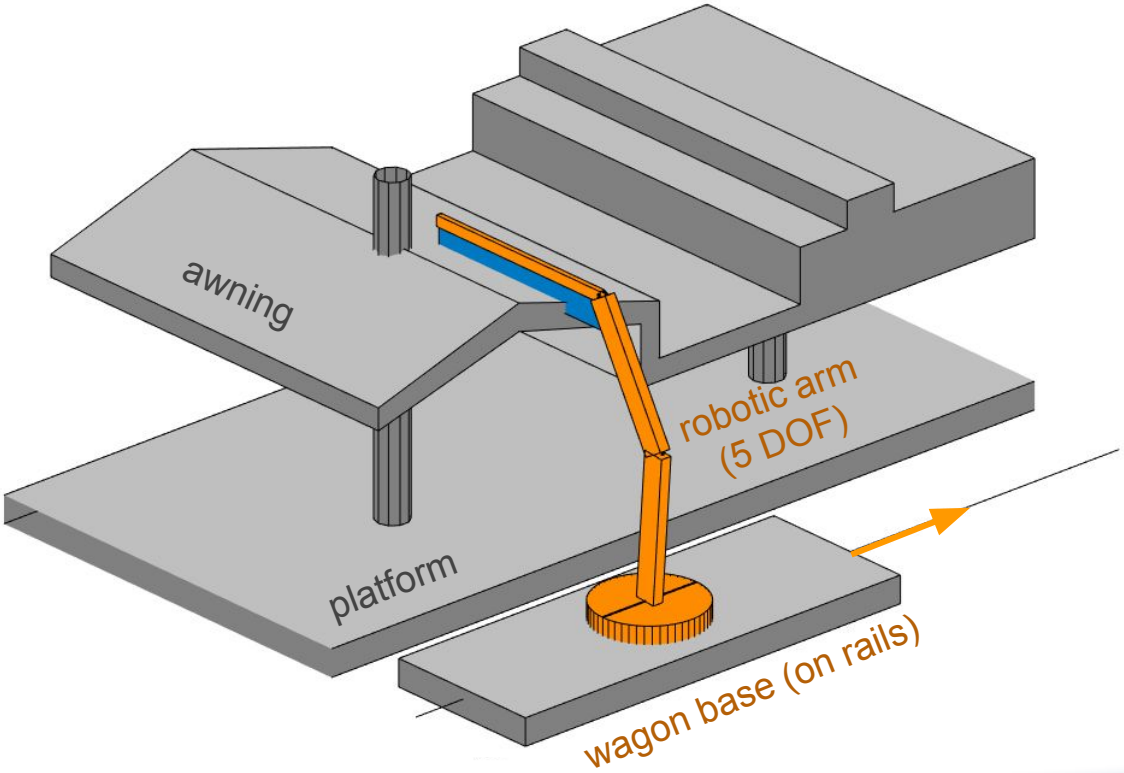
The Limpio

- **Modular**
- **Flexible**
- **State-of-the-art**



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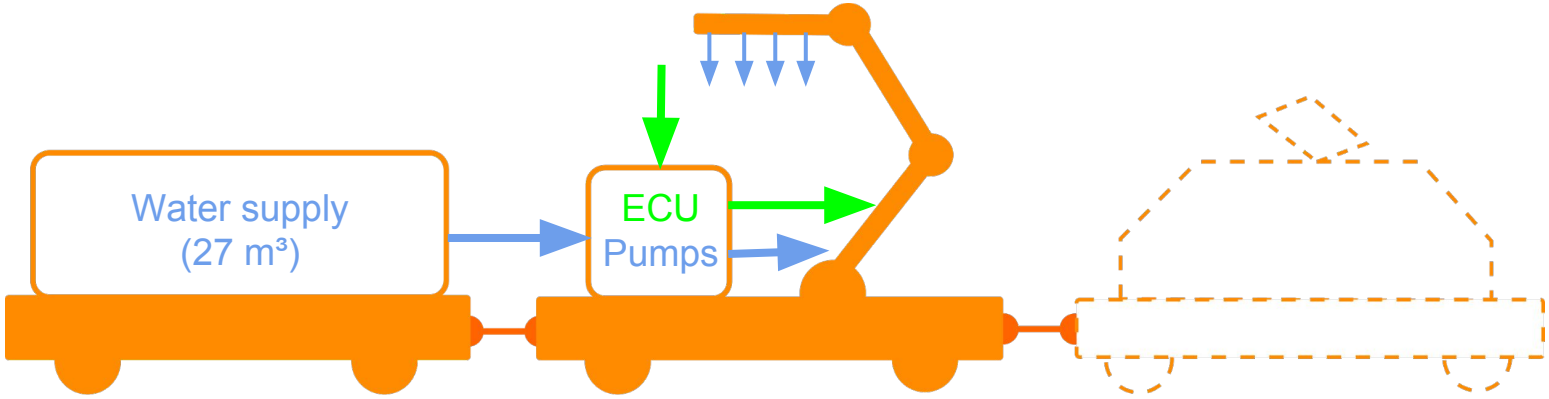
Concept - overview



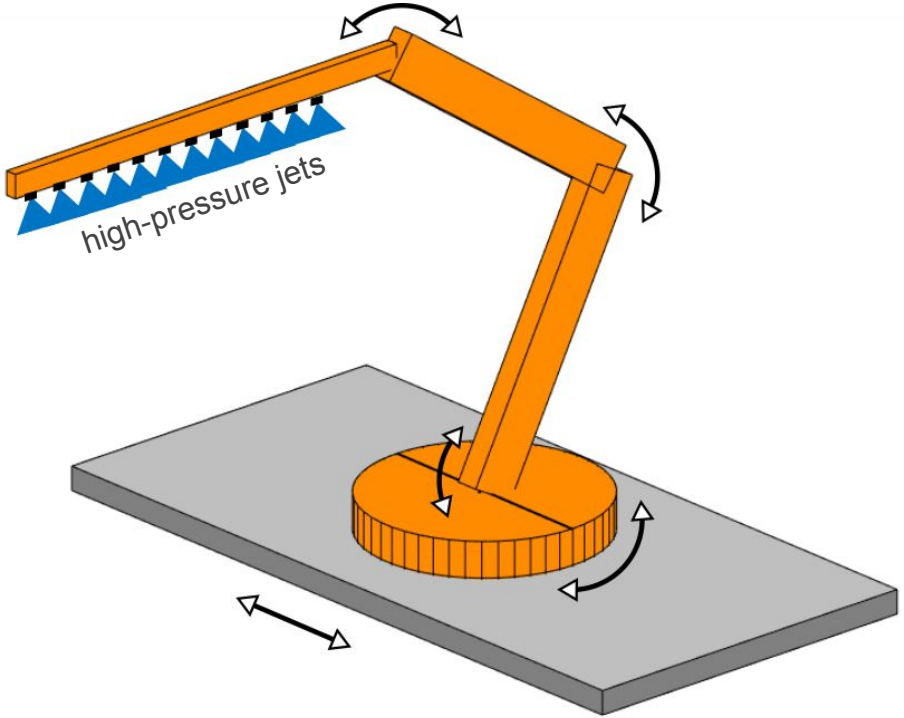
Tank wagon

Limpio - arm, pumps, electronics, ...

External locomotive (optional)

How does The Limpio clean?

- 12 high-pressure waterjets
- 300 bars
- 7200 L/h → 720 m²/h
- 73.5 kW
- 27.000 L tank wagon



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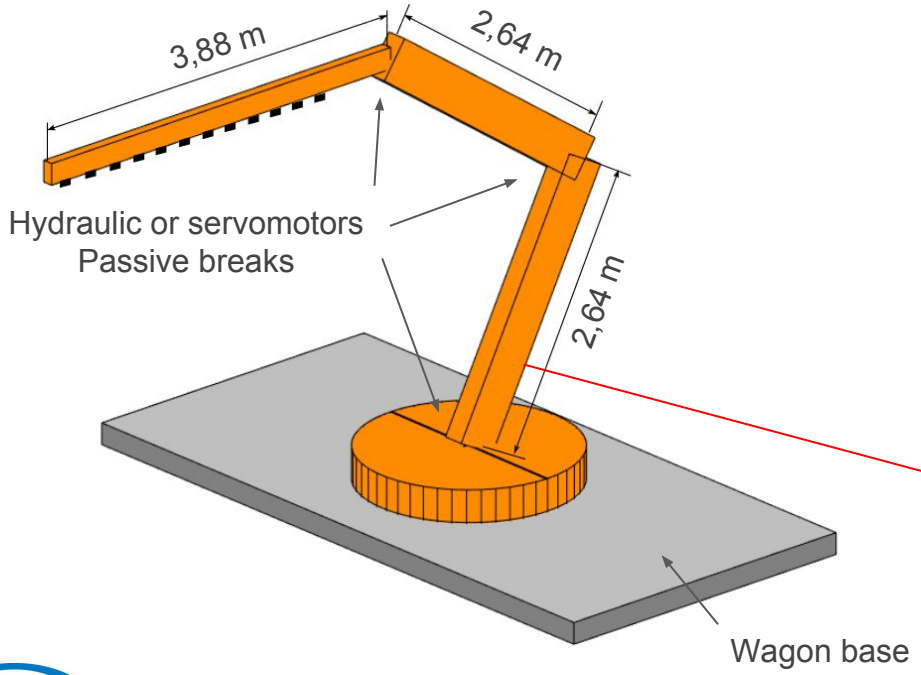
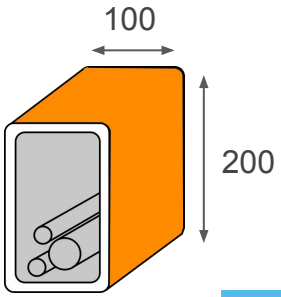
Mechanical design



- Don’t hit overhead cables!!
- Clean widest platform in Leuven Station (C)
- Cleaning clearance: 50 cm



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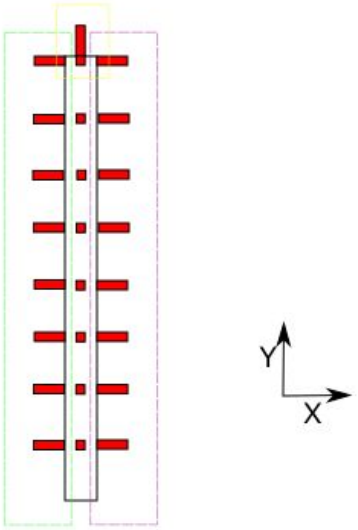
Control

- 40 laser sensors
- Encoders in the joints
- Finite State Machine (FSM)
- Inverse kinematics



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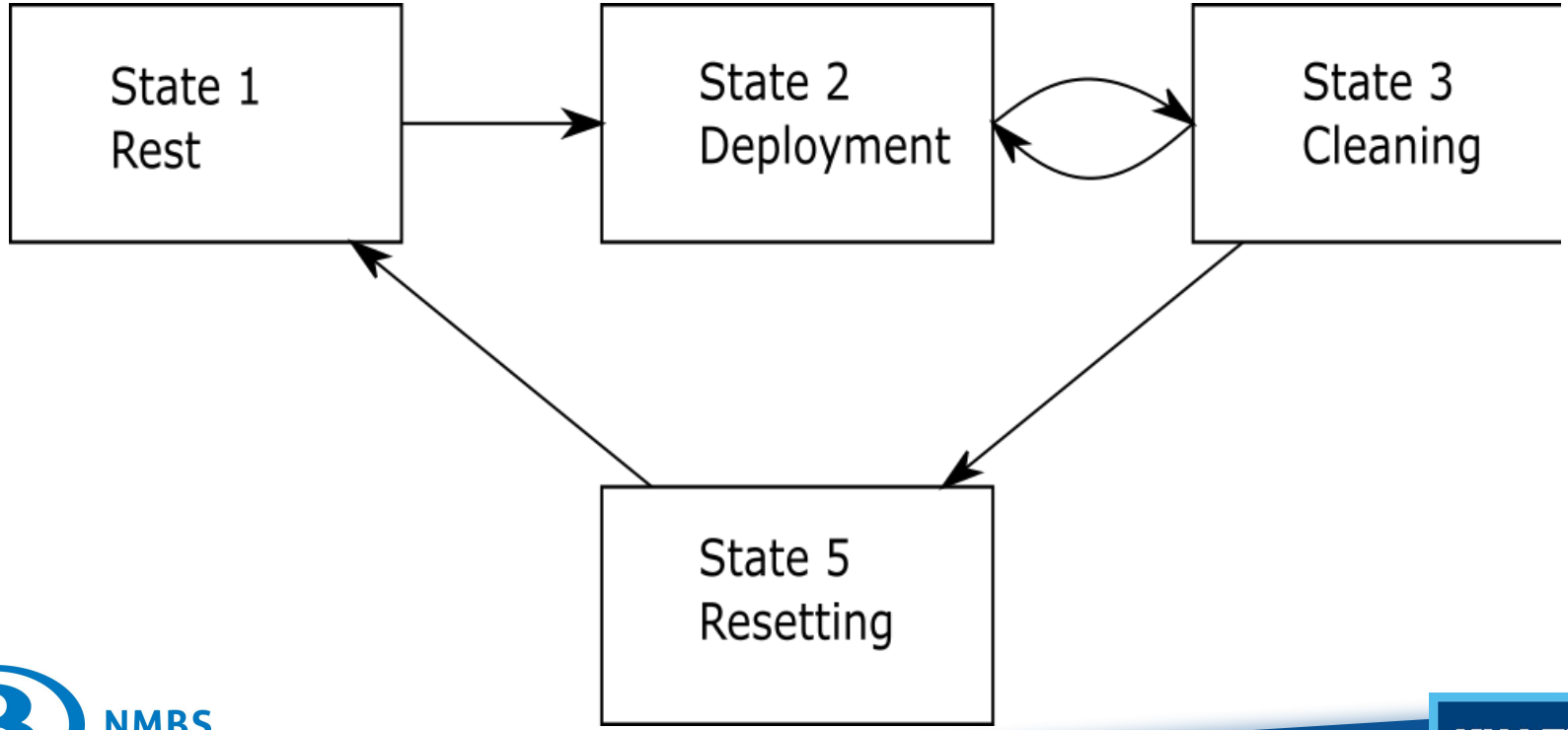
FSM - Overview



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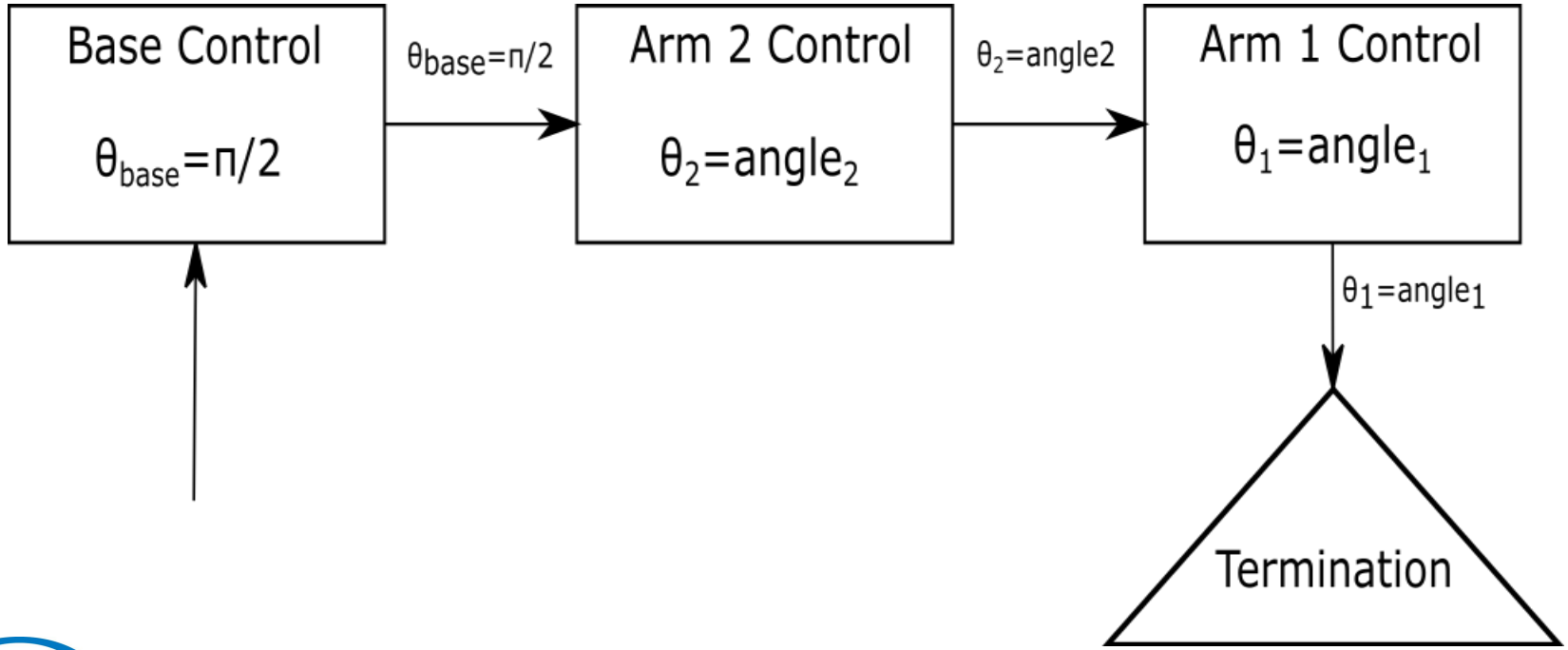
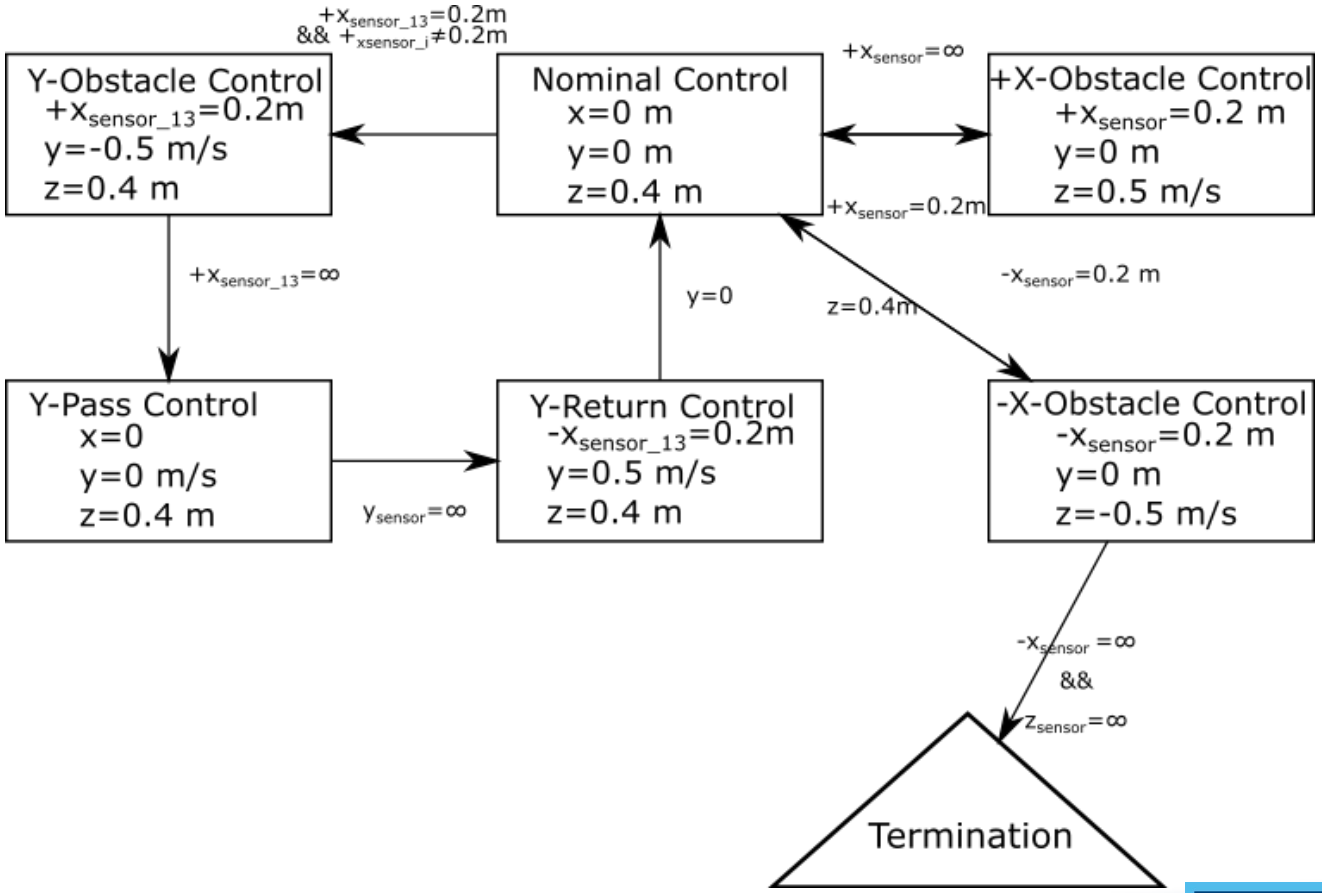
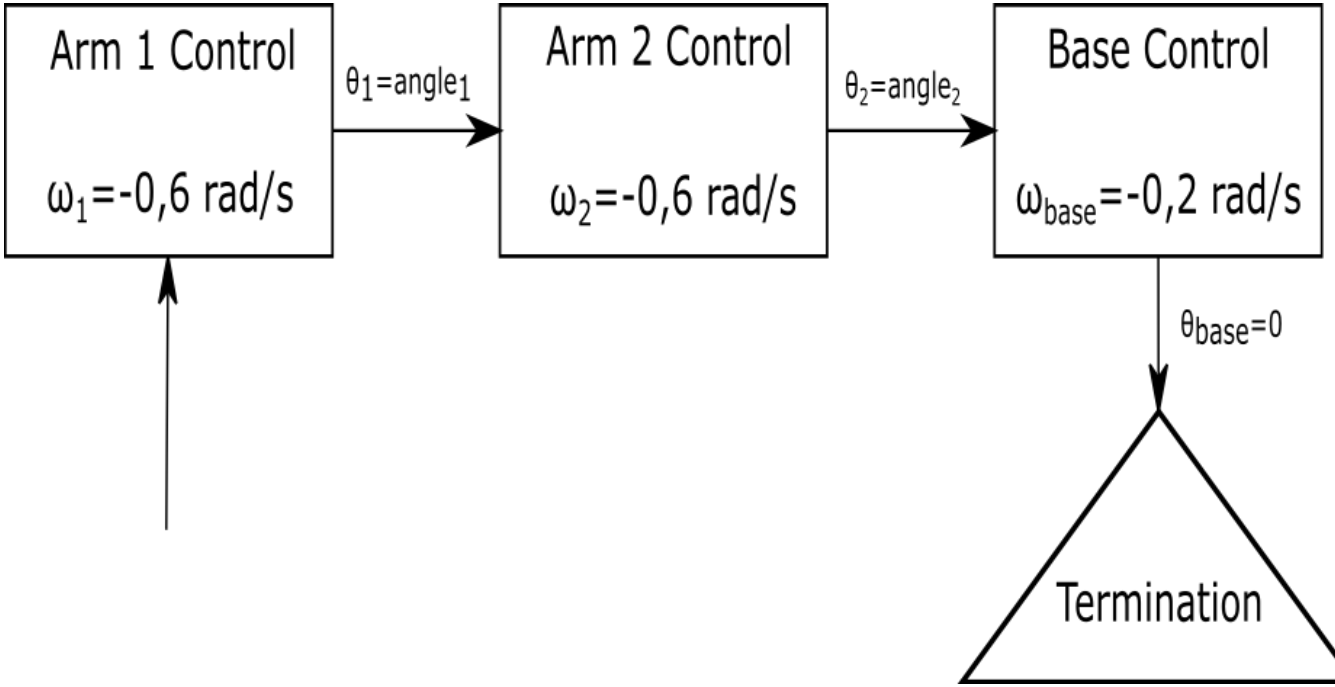
Deployment


Base Control
$\theta_{base}=\pi/2$
$\theta_{base}=\pi/2$
Arm 2 Control
$\theta_2=angle_2$
$\theta_2=angle2$
Arm 1 Control
$\theta_1=angle_1$
$\theta_1=angle_1$
Termination

Cleaning


+x_sensor_13=0.2m
&& +xsensor_j≠0.2m
Y-Obstacle Control
+x_sensor_13=0.2m
y=-0.5 m/s
z=0.4 m
Nominal Control
x=0 m
y=0 m
z=0.4 m
+x_sensor=∞
+X-Obstacle Control
+x_sensor=0.2 m
y=0 m
z=0.5 m/s
+x_sensor=0.2m
+x_sensor_13=∞
y=0
z=0.4m
-x_sensor=0.2 m
Y-Pass Control
x=0
y=0 m/s
z=0.4 m
y_sensor=∞
Y-Return Control
-x_sensor_13=0.2m
y=0.5 m/s
z=0.4 m
-X-Obstacle Control
-x_sensor=0.2 m
y=0 m
z=-0.5 m/s
-x_sensor =∞
&&
z_sensor=∞
Termination

Reset


Arm 1 Control
ω_1=-0,6 rad/s
θ_1=angle$_1$
Arm 2 Control
ω_2=-0,6 rad/s
θ_2=angle$_2$
Base Control
ω_{base}=-0,2 rad/s
θ_{base}=0
Termination

The Limpio in action

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Safety aspects

- No operator needed (but possible)
- No loads on awnings
- Passive breaks against power cuts
- Coded to avoid overhead cables

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Cost estimation

Unit	Cost/unit (€)	Quantity
Hydraulic engine	800	5
Servomotor	400	3
Laser distance sensor	100	40
Controller	500	3
Tank wagon	1000	1
NMBS inhouse parts	?	?

Total parts cost (excluding in-house) : 11 700 €

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