



# Smart Tooling Promo event II

## 27 september 2018

Autonomous solution for  
no-man entry tank cleaning

# Het doel van de ontwikkeling

Minder manuren in besloten ruimtes







<b>O2 Concentration</b> <b>21%</b> Symptoms Natural air 	<b>O2 Concentration</b> <b>18%</b> Symptoms Limit level for not causing serious health problems. Continuous ventilation is required 	<b>O2 Concentration</b> <b>16% - 12%</b> Symptoms Rapid breathing, Increase in pulse rate, Loss of concentration, Headache, Nausea, Ear ringing 
<b>O2 Concentration</b> <b>14% - 9%</b> Symptoms Stupor, Headache, Nausea, Cyanosis, Faintness on the entire body 	<b>O2 Concentration</b> <b>10% - 6%</b> Symptoms Comatose, Loss of consciousness, Muscle spasm on the entire body 	<b>O2 Concentration</b> <b>6% or less</b> Symptoms Unconsciousness, Comatose, Cessation of breathing, Cardiac arrest, Die in 6 minutes 



osha.gov/pls/imis/AccidentSearch.search?acc\_keyword="Tank%20Cleaning"&keyword\_list=on

UNITED STATES DEPARTMENT OF LABOR

Occupational Safety and Health Administration

ABOUT OSHA - WORKERS - EMPLOYERS - REGULATIONS - ENFORCEMENT - TOPICS - NEWS & PUBLICATIONS - DATA - TRAINING

### Accident Search Results

Description, Abstract, Keyword	SIC	NAICS	Date Range	Office	Insp Nr
Keyword: "Tank Cleaning"	All	All	All	All	All

Sort By: [Date](#) | [Office](#) [Return to Search](#)

By Date Results 1 - 20 of 105  
Result Page: [1](#) [2](#) [3](#) [4](#) [5](#) [6](#)

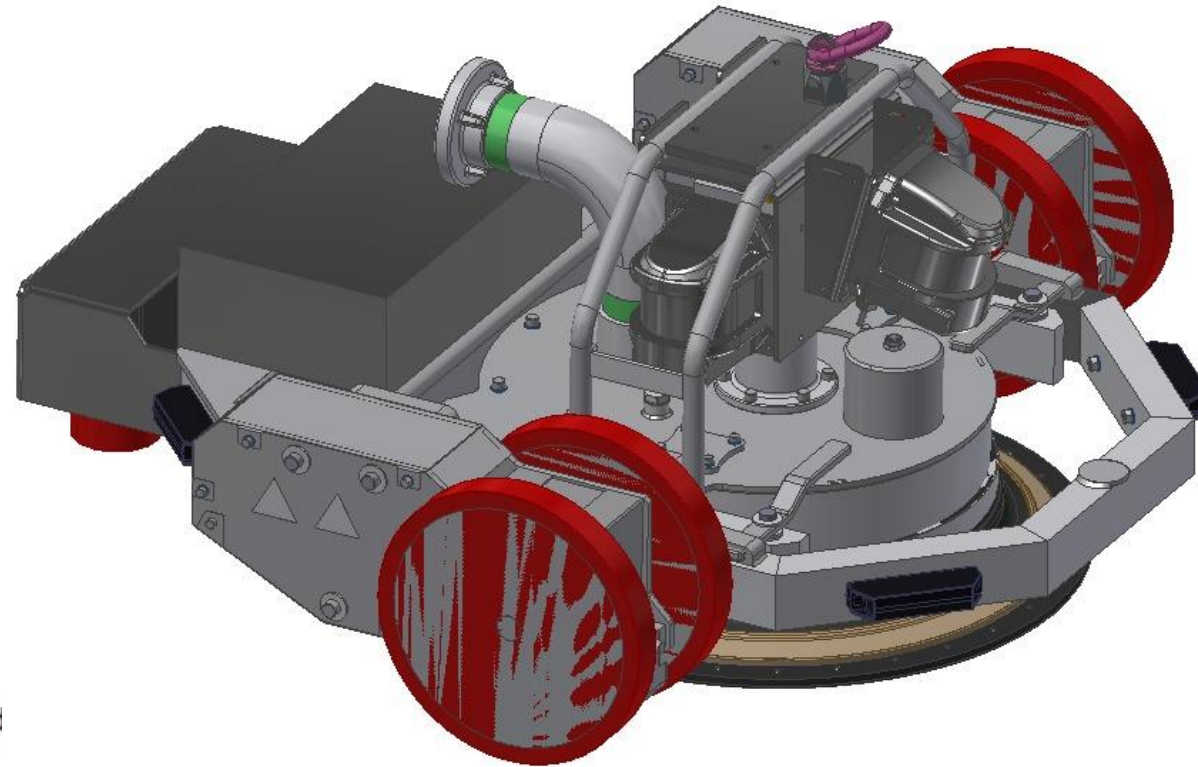
[Get Detail](#) [Select All](#) [Reset](#)

#	Summary Nr	Event Date	Report ID	Fat	SIC	Event Description
<input type="checkbox"/>	102389.01	01/13/2018	0626700	X		Employee Was Found Inside A Container And Was Unresponsive
<input type="checkbox"/>	101665.01	12/15/2017	0418400	X		Employee Collapses In Oxygen Deprived Tanker Car And Is Kill
<input type="checkbox"/>	101290.01	12/05/2017	0830500	X		Employee Loses Consciousness While Cleaning A Tank And Is Ki
<input type="checkbox"/>	101252.01	12/02/2017	0625700	X		Employee Is Found Unresponsive And Later Dies
<input type="checkbox"/>	101416.01	12/02/2017	0625700	X		Employee Is Found Unresponsive While Cleaning Tank And Later
<input type="checkbox"/>	99352.015	08/15/2017	0420600			Employee Is Cleaning Tank And Faints
<input type="checkbox"/>	95042.015	04/25/2017	0627510			Employee Is Burned By Acid Released During Tank Cleaning



1. Tank dimensions:
  - Tank diameter 12 – 58 meter,
  - Tank height 15 – 30 meter;
2. Ferro and **non-ferro** surface
3. 2-4 manholes in tank, each 19”
4. Ceiling fixed, **internal floating or external floating**
5. Vertical and **bottom** cleaning
6. **Several in- and external features**
7. In- **and outside** cleaning
8. **Atex classification and certification**

Current use case  
Medium term  
Long term



Working pressure max. 3000 bar  
Flow rate approx. 50 l/min  
Coverage up to 70m<sup>2</sup>/hour

Working Ø: 374mm  
Number of nozzles: 16  
Nozzle type: P or T (Type P recommend)

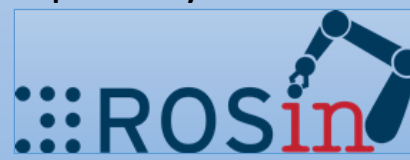
Travel speed: max. 7 m/min  
Turning circle: <2m  
Weight: 112 kg



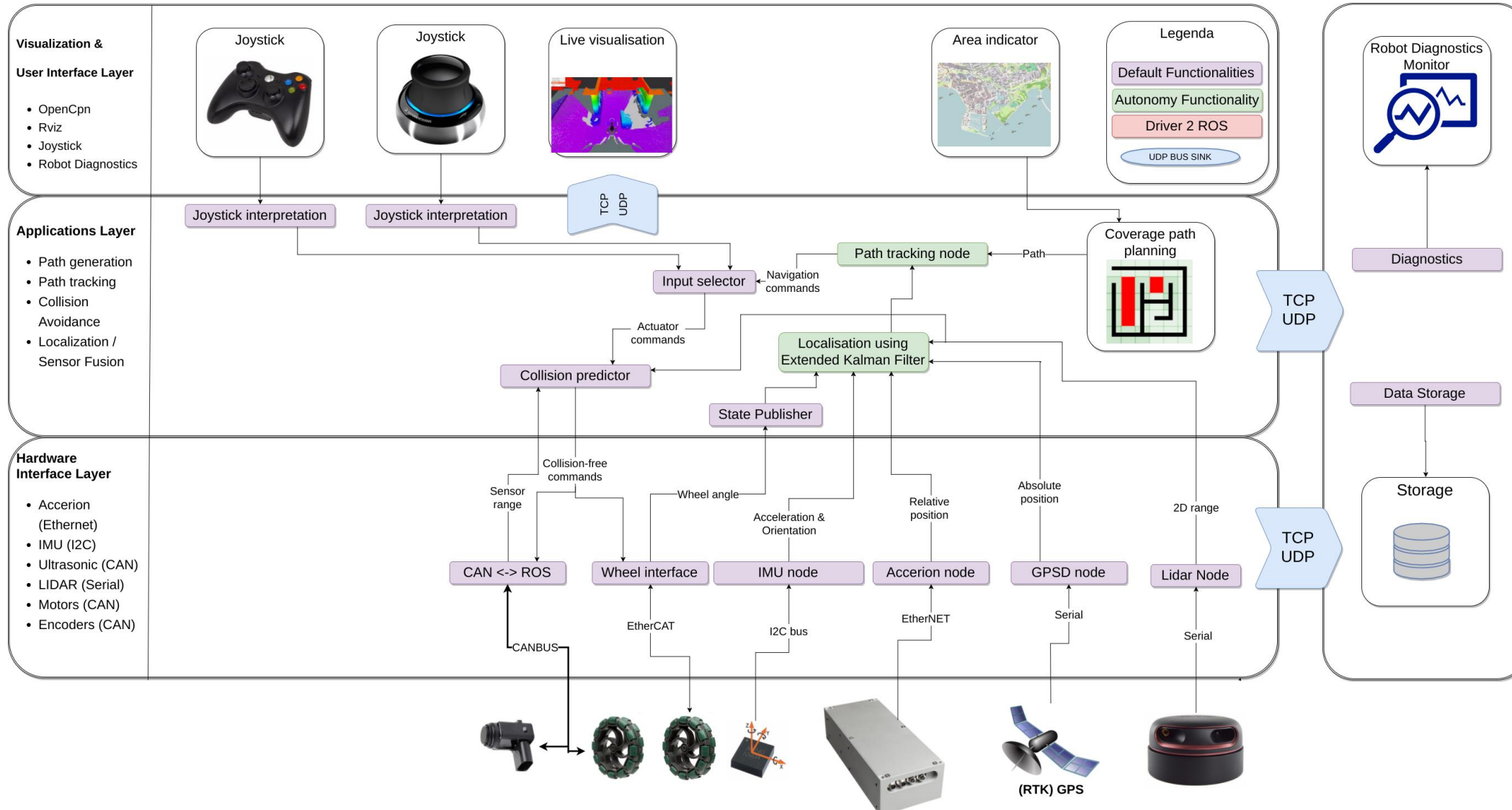
### OS Architectural choices

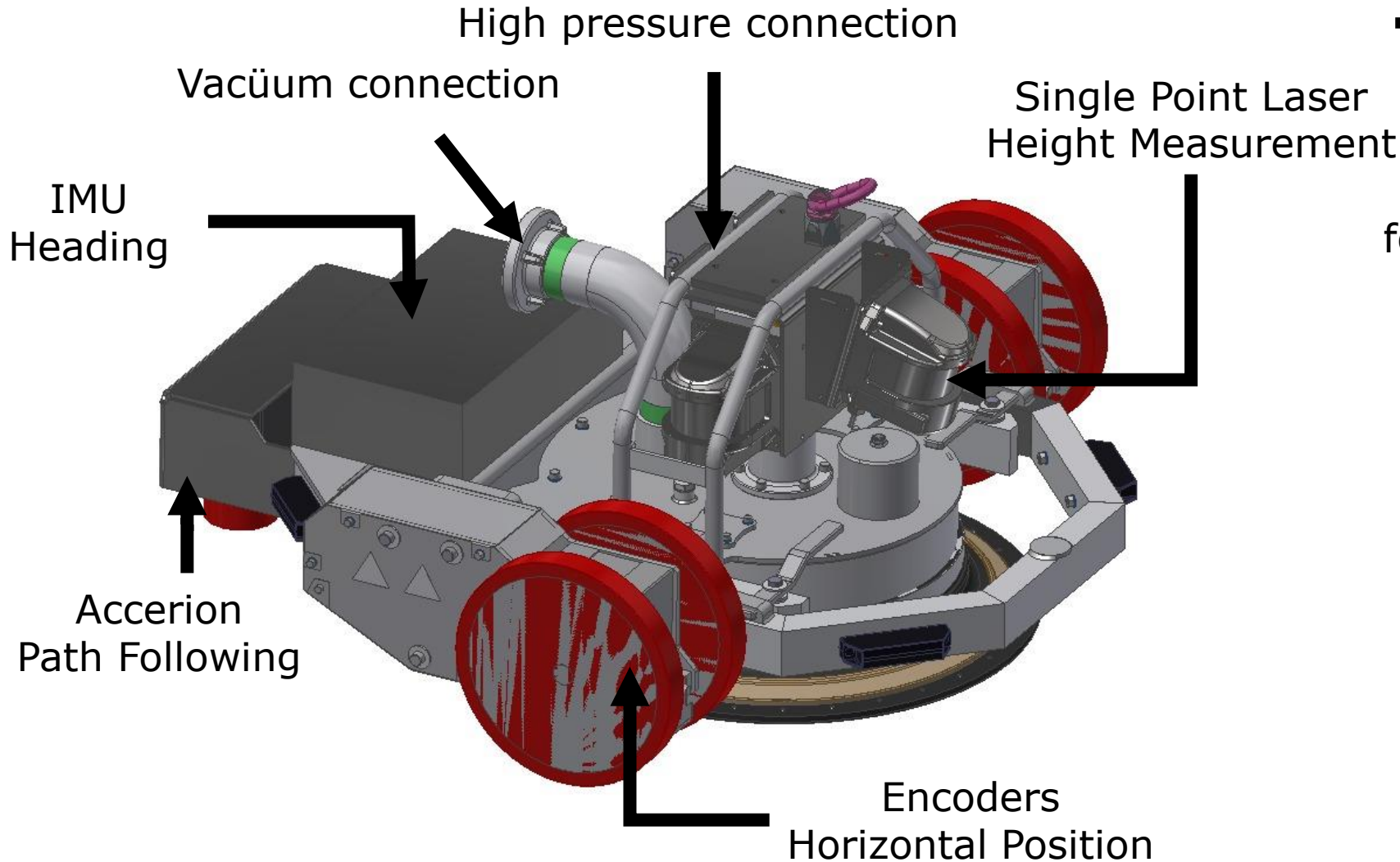
CTQ	Gebruikte software platform						
	In house development	Matlab Simulink	ROS	ROS-Industrial	ROS 2.0	Orocos	Microsoft Robotics Developer Studio
Time to Market, Dev't effort	-	+	+	0	0	0	-
Ease of use (simulation, diagnostics, debuggir	0	+	+	+	0	+	+
Standardized/traction solution	-	+	+	0	0	-	-
Software costs	+	-	+	+	0	0	0
Hardware costs	+	0	+	0	0	0	0
Quality assurance, robustness	0	+	0	+	0	0	+
IP ownership	+	-	0	0	0	0	0
SUM Total	1	2	5	3	0	0	0

ROS

- + proprietary nodes
- + 
- + continuous testing







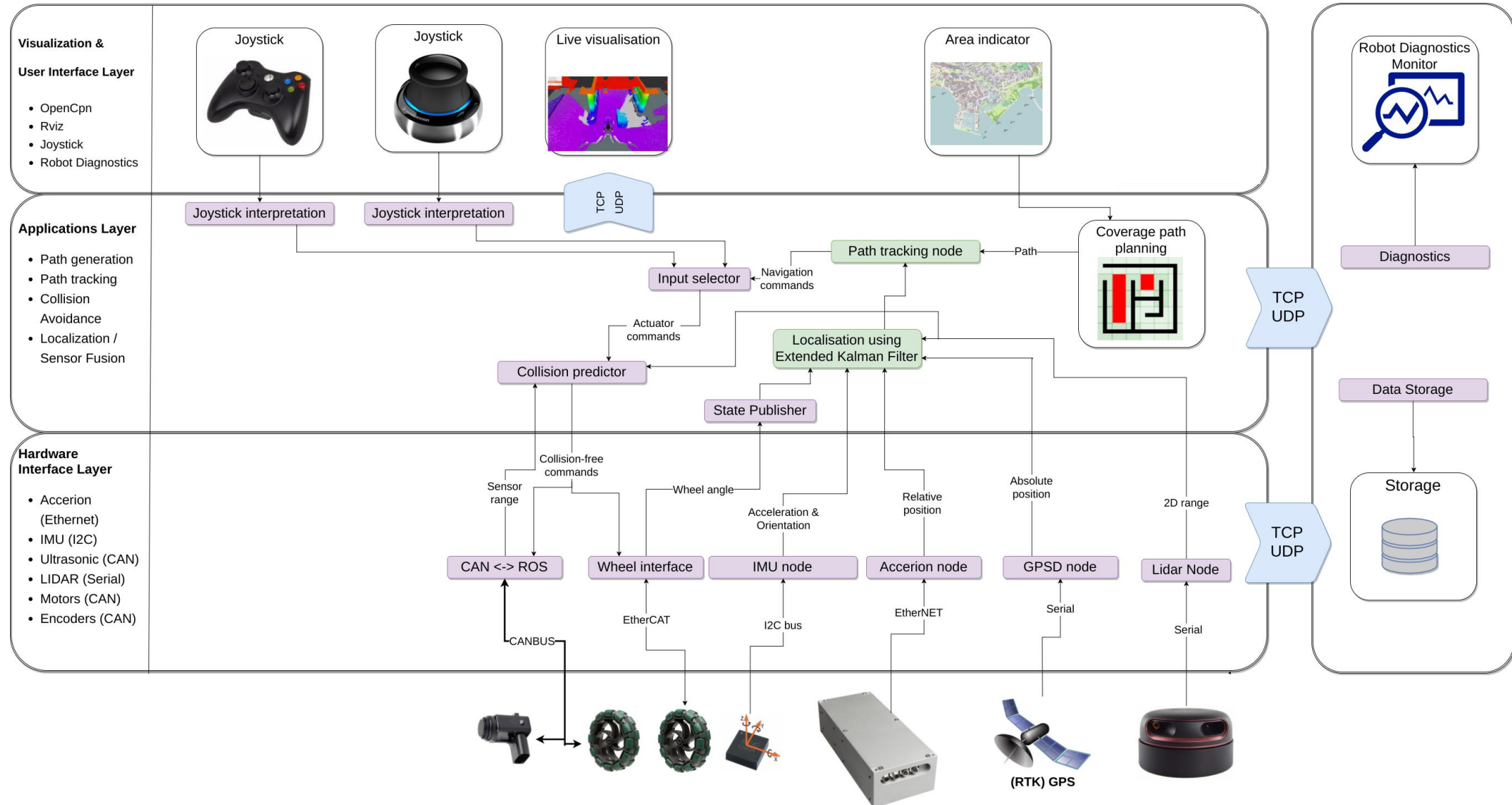
## Tankcleaner Concept

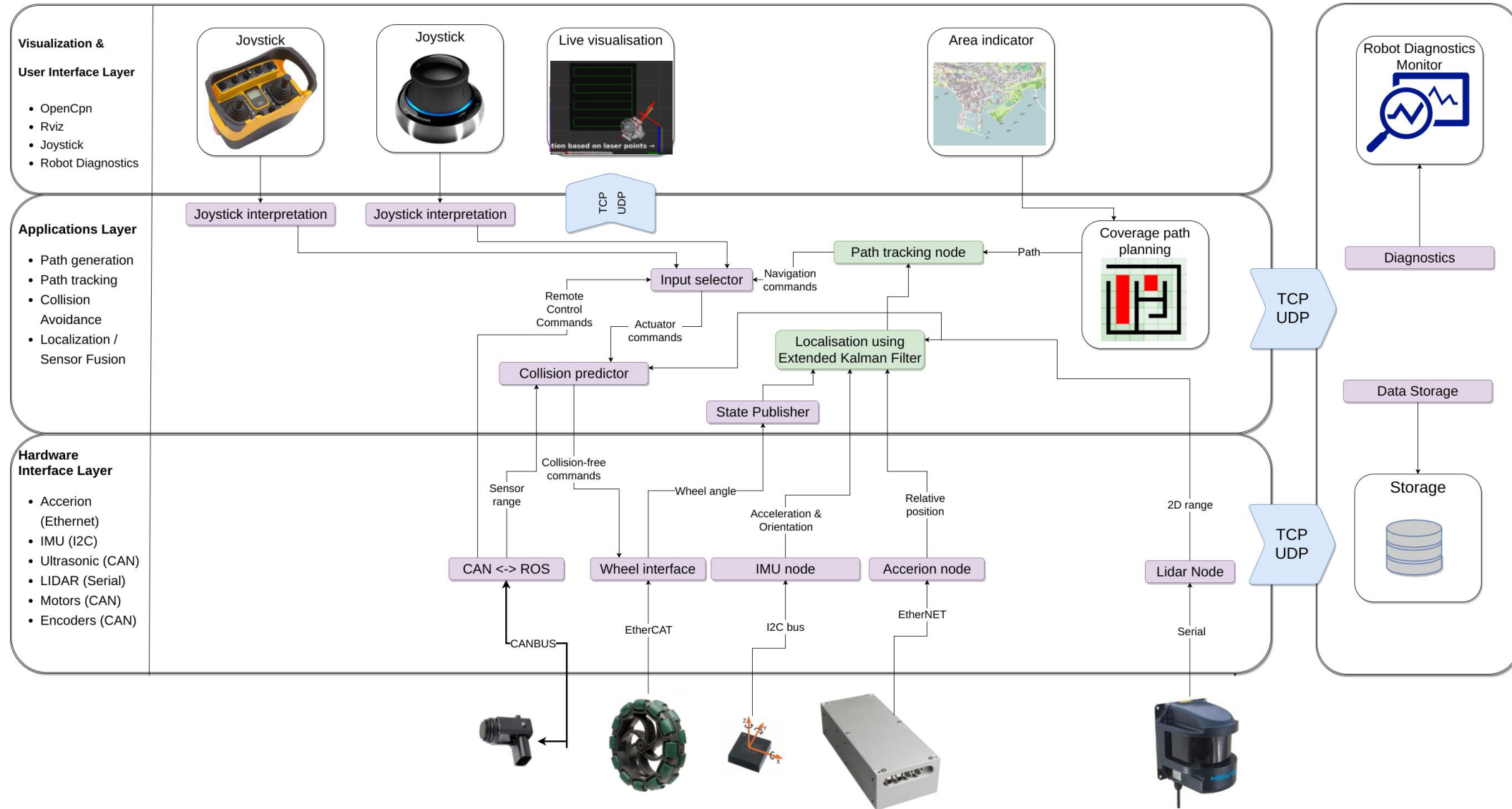
Magnetic-crawler platform for cleaning industrial tanks



<https://youtu.be/IFjjDOssTf8>









# Technologische ontwikkeling

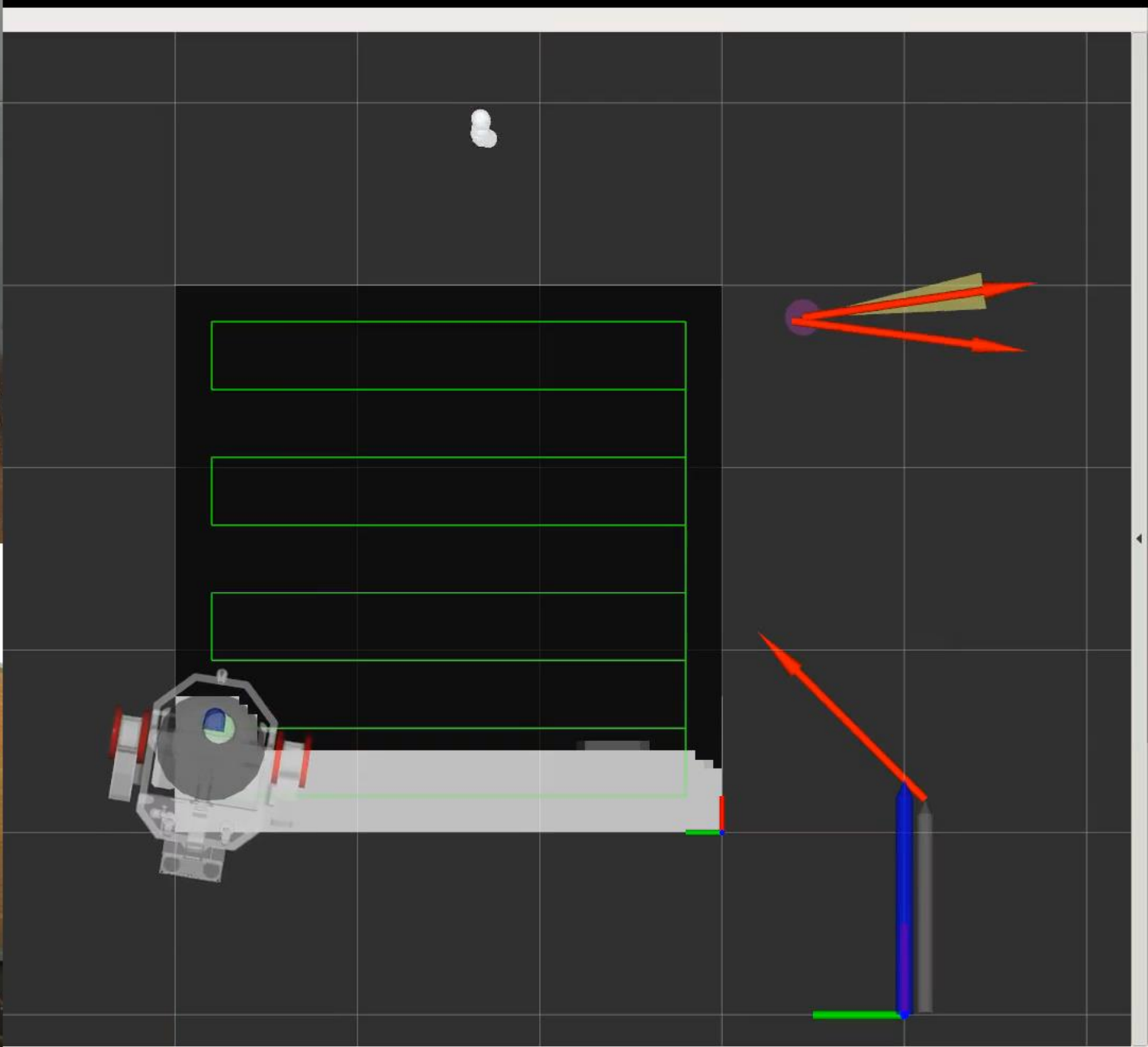
De testruns



**DERC**  
WATERJETTING

[https://youtu.be/4dMjt\\_Pj4og?t=4m8s](https://youtu.be/4dMjt_Pj4og?t=4m8s)





# De uitdagingen



Afschuiving van de wielen

[https://youtu.be/4dMjt\\_Pj4og?t=4m53s](https://youtu.be/4dMjt_Pj4og?t=4m53s)

# Compensating for wheel shear



# De uitdagingen



Afschuiving van de wielen

[https://youtu.be/4dMjt\\_Pj4og?t=4m53s](https://youtu.be/4dMjt_Pj4og?t=4m53s)

Onstabiele controllers

<https://youtu.be/58K4eyxeslY?t=35s>



30x

# De uitdagingen



Afschuiving van de wielen

[https://youtu.be/4dMjt\\_Pj4og?t=4m53s](https://youtu.be/4dMjt_Pj4og?t=4m53s)

Onstabiele controllers

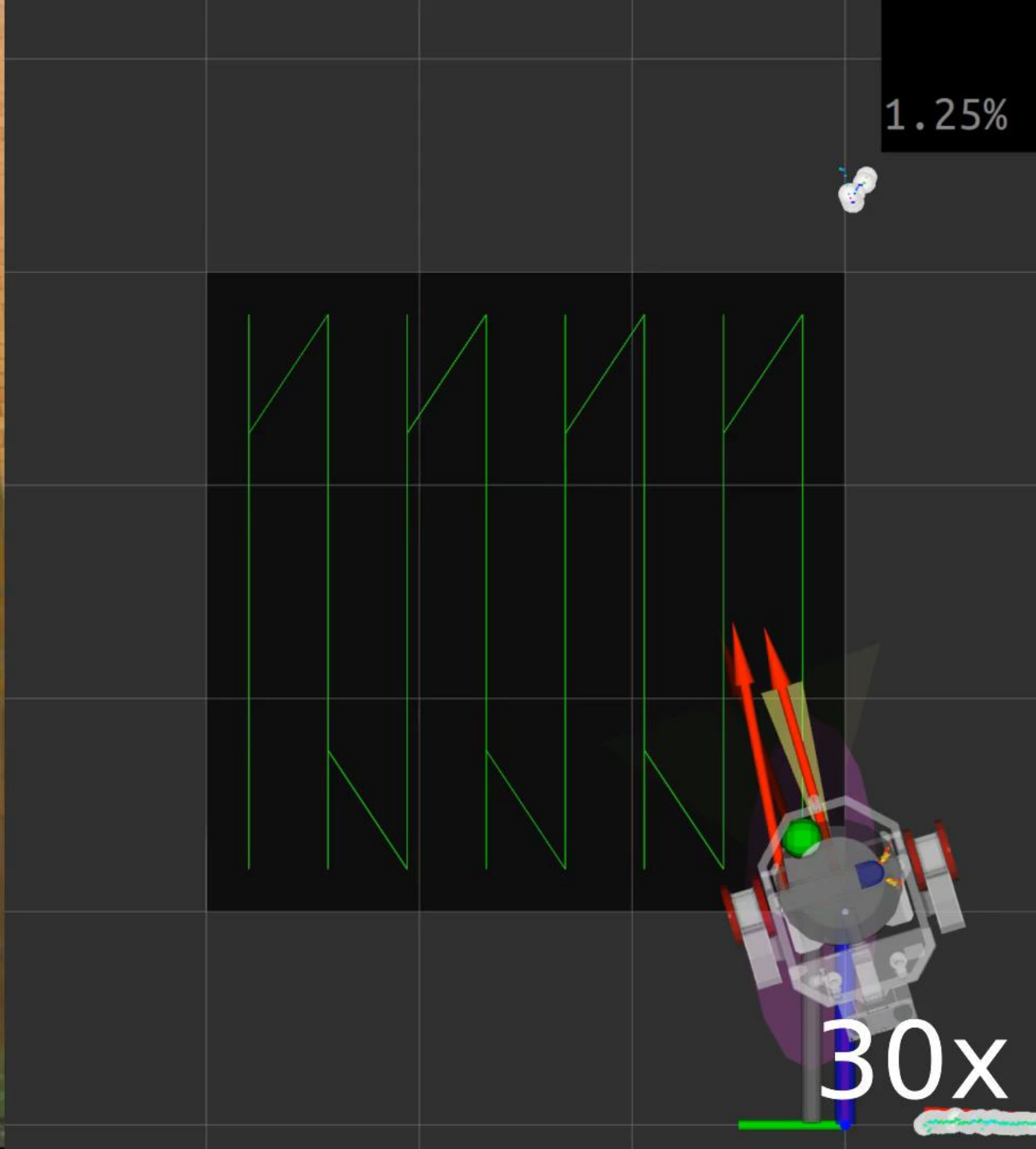
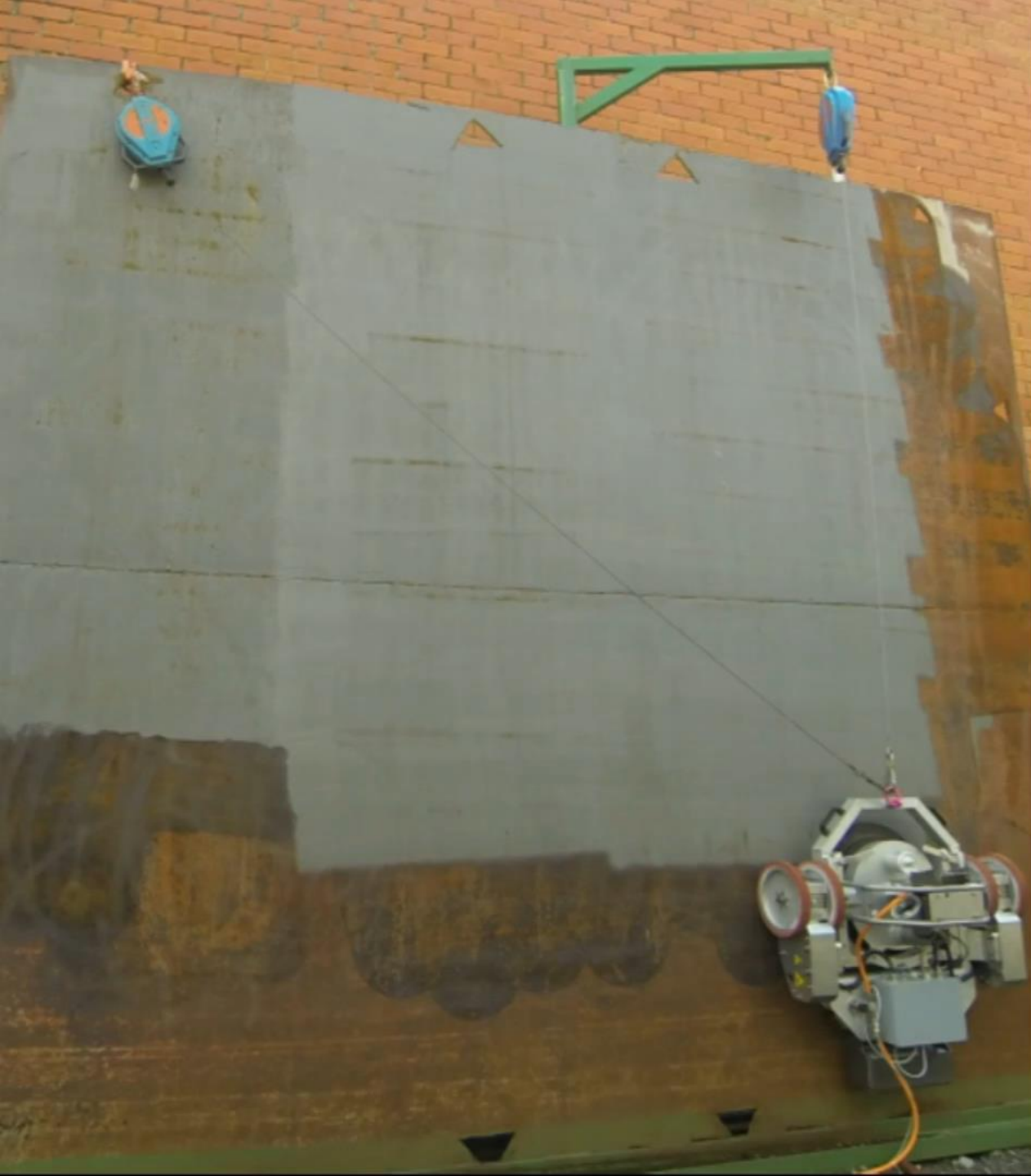
<https://youtu.be/58K4eyxeslY?t=35s>

Onbekende factoren

(klanten voorkeur voor verticale modus, waarschijnlijk met goede reden 😊)

<https://youtu.be/58K4eyxeslY?t=1m37s>







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# Backup slides



# Tank cleaning risk reduction

Tank cleaning is an extremely hazardous activity with many difficult to quantify variables. As a general rule, time spent by personnel inside a tank should be kept to a minimum.

Training is the key to safe working in a confined space and personnel engaged in such activities should be carefully instructed and trained in all safety systems and procedures.

A key element in minimising the risk is choosing an appropriate cleaning method. A number of semi and fully automated methods are commercially available. In any event, **there is no doubt that when implementing non-man entry cleaning systems many hazards are dramatically reduced and some even eliminated.**

- Dow is leading the industry in innovating new technologies to remove workers from higher-hazard activities in an effort to help achieve its 2025 target to “**eliminate fatalities**, reduce severe injury and illness incidents and maintain its total recordable injury and illness rate at industry-leading levels.” Examples include **implementing robotic highpressure water cleaning, robotics to eliminate the need for confined space entry**, drones to eliminate certain elevated work, and protection devices on aerial lifts.



# Track selection

	Direction	Vert. Position	Hor. Position	# Corners	Cabling	Total
Vertical, long tracks	+	--	+	+	++	3+
Vertical, short track	+	--	--	--	++	3-
Horizontal, long track	++	++	--	+	++	5+
Horizontal, short track	--	-	+	--	++	2-
Entire tank, spiraling	++	-	+	++	--	1+

# Sensor modalities selection

	Resolution	Precision	Risk	Abs	Rel	Angle	Position	Versatility	Price	Infrastructure	Total
Accerion	++	++	--	-	++	-	++	++	--	++	6+
<b>Encoders</b>	++	+	++	--	++	+	++	++	++	++	<b>14+</b>
Gravity sensor	++	-	++	+	+	+	--	++	++	++	10+
IMU	++	--	++	--	++	--	+	++	++	++	8+
UWB	++	++	--	++	++	++	++	++	-	--	9+
Visual	++	++	++	++	++	++	++	--	-	-	10+
Central 3D lidar	++	++	++	++	++	-	++	++	--	-	10+
<b>Single Point Laser</b>	++	++	-	++	++	-	++	++	++	++	<b>14+</b>