

# The Open Dynamic Robot Initiative Project



JNRH2020

Thomas FLAYOLS  
LAAS Gepetto - June 25, 2020

# What is the ODRI project ?

- A collaborative project between MPI Tübingen, NYU and LAAS
- Transparent actuation modules with low ratio gearboxes + brushless motor
- Easy-to-build robots, heavily documented
- Dynamic, light and cheap
- Free and open source design

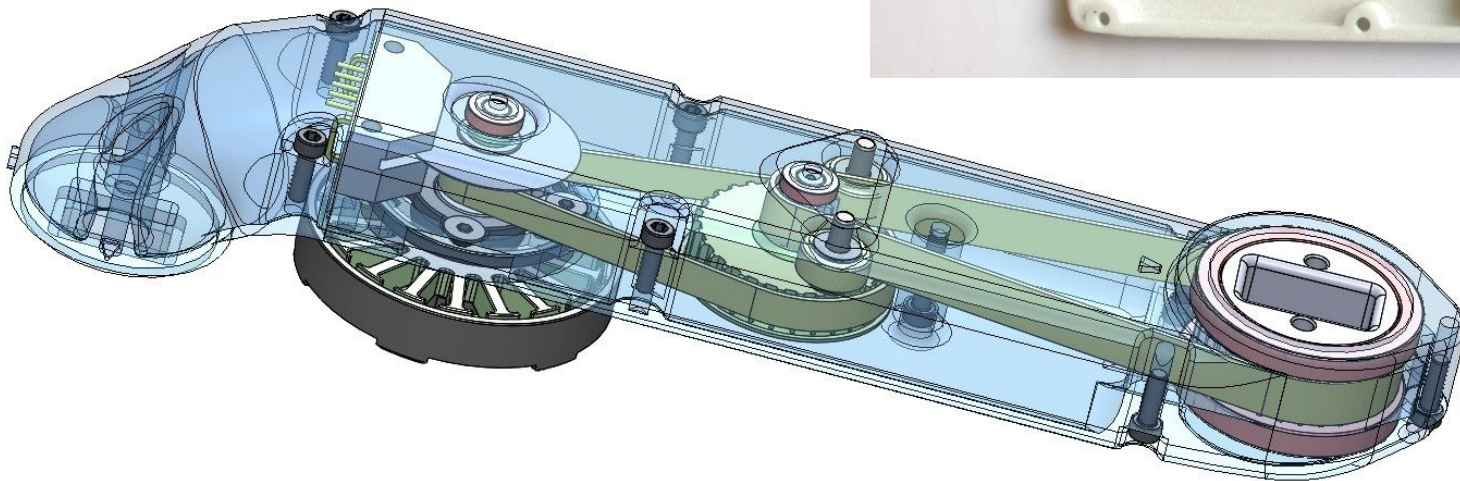
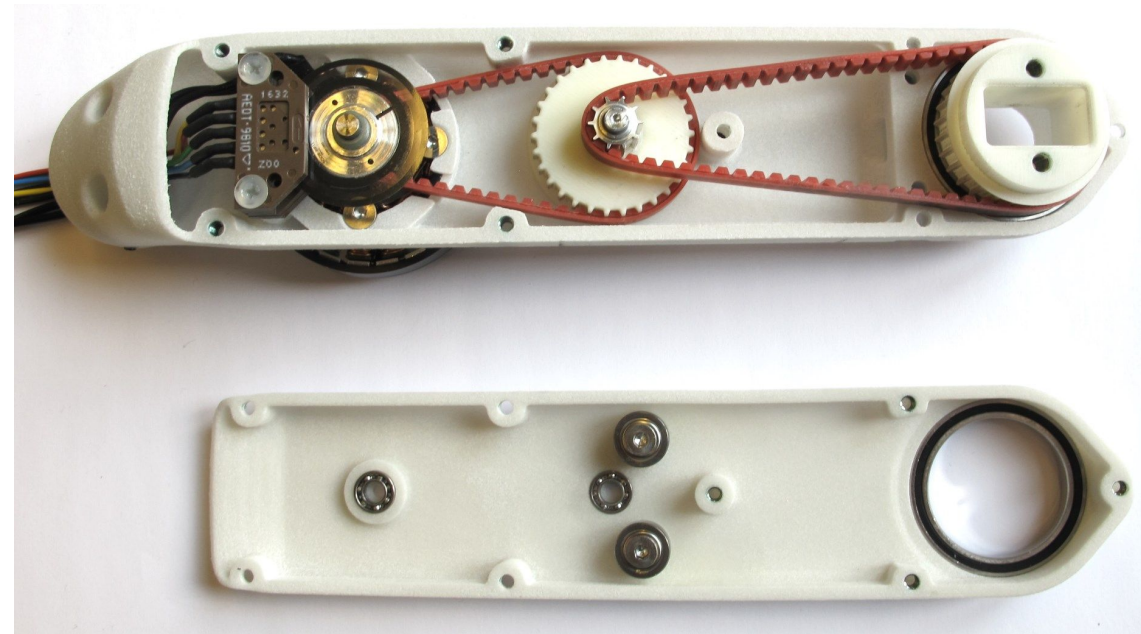


- Presentation of the Open Dynamic Robot Initiative Project
- The actuation modules
- The robots
- Motions demos
- Control architecture
- Custom electronic and communication link
- Field oriented motor driver evolution
- Research work lead at LAAS
- Future plans for this project

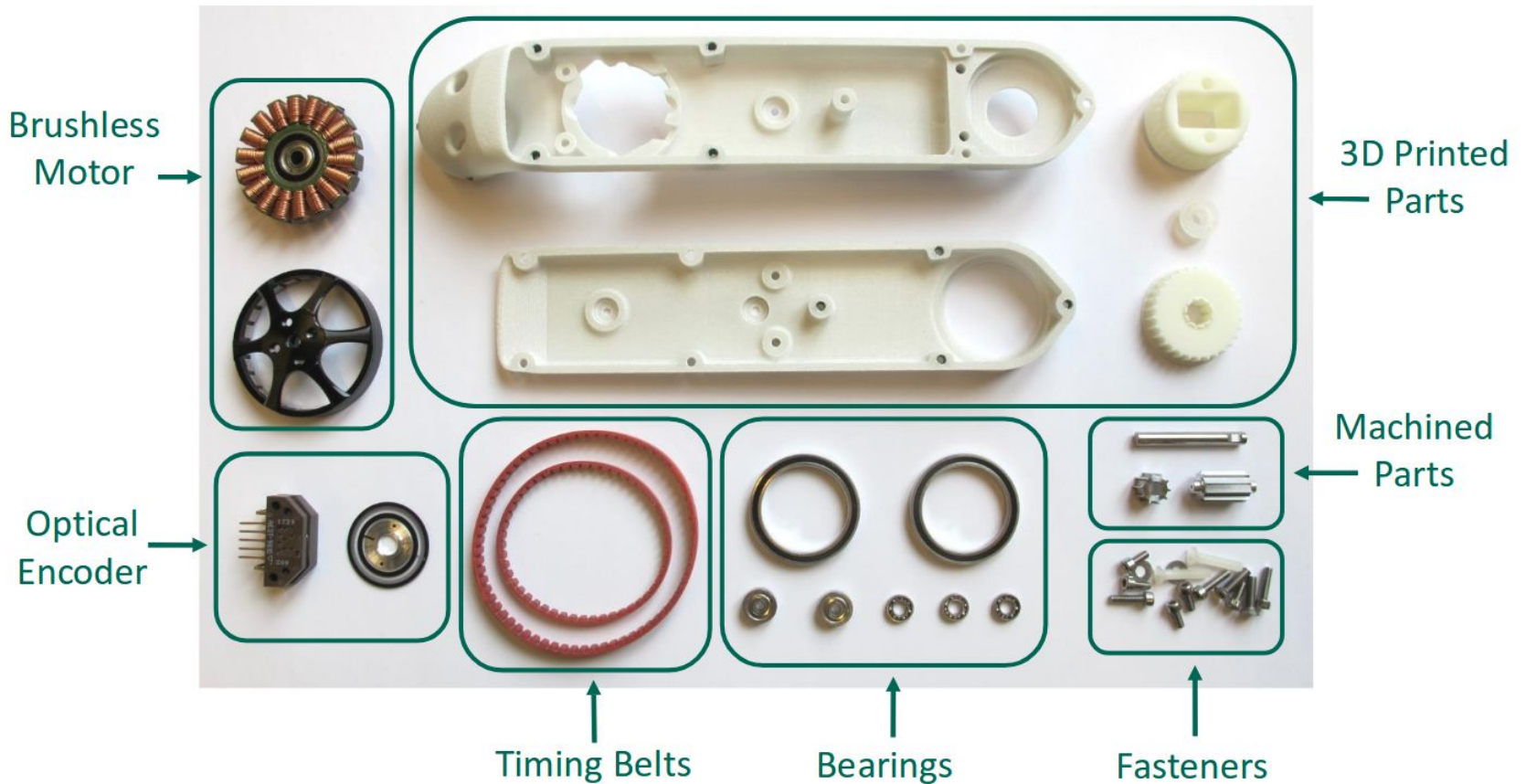


# Actuation module

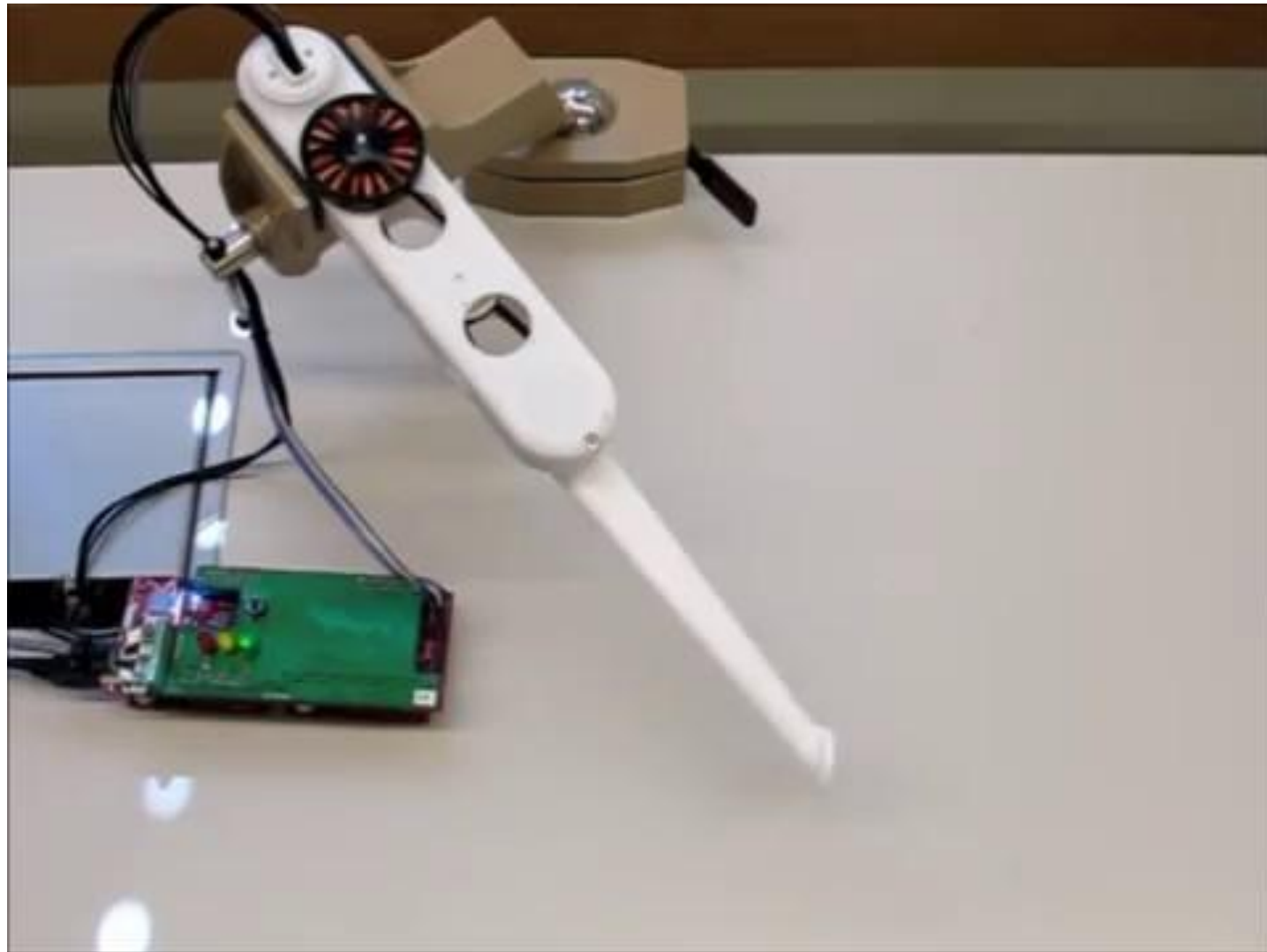
Length 160mm  
 Mass 150g  
 Torque 2.5Nm at 12A  
 Gear r. 9:1



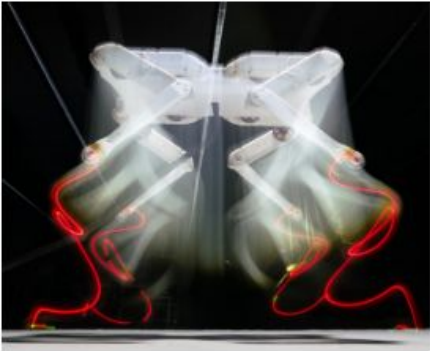

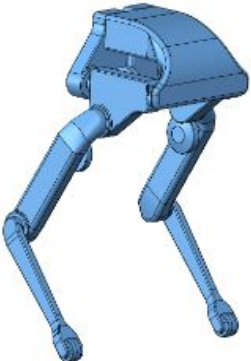

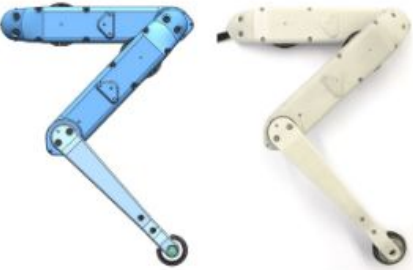
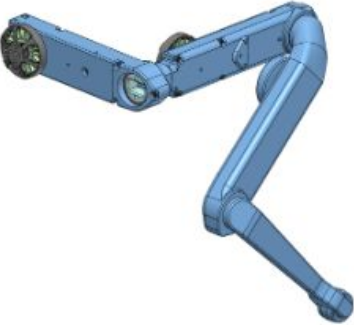
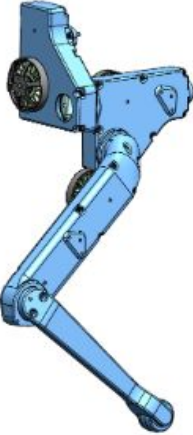

# Actuation module



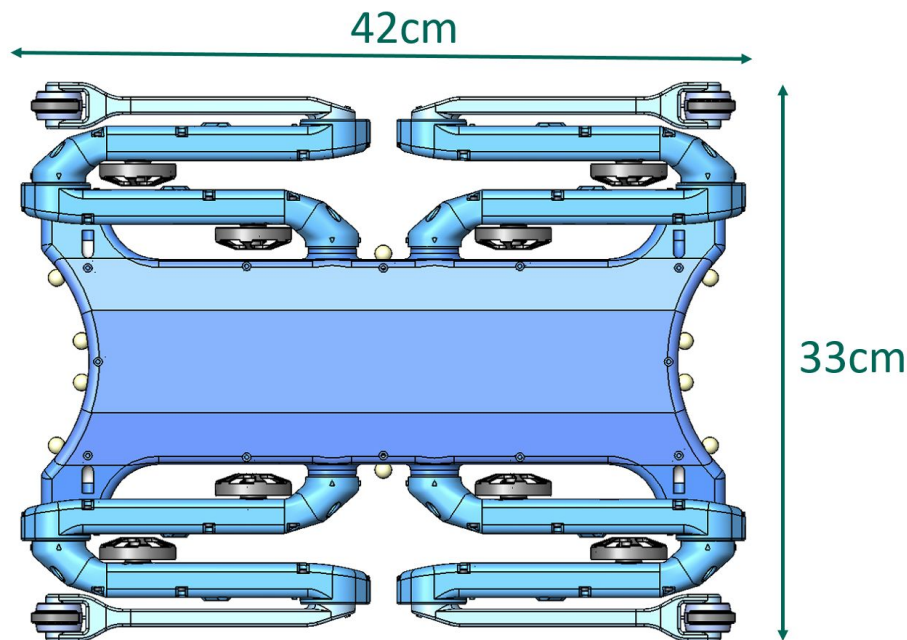
# Actuation module



# The Robots

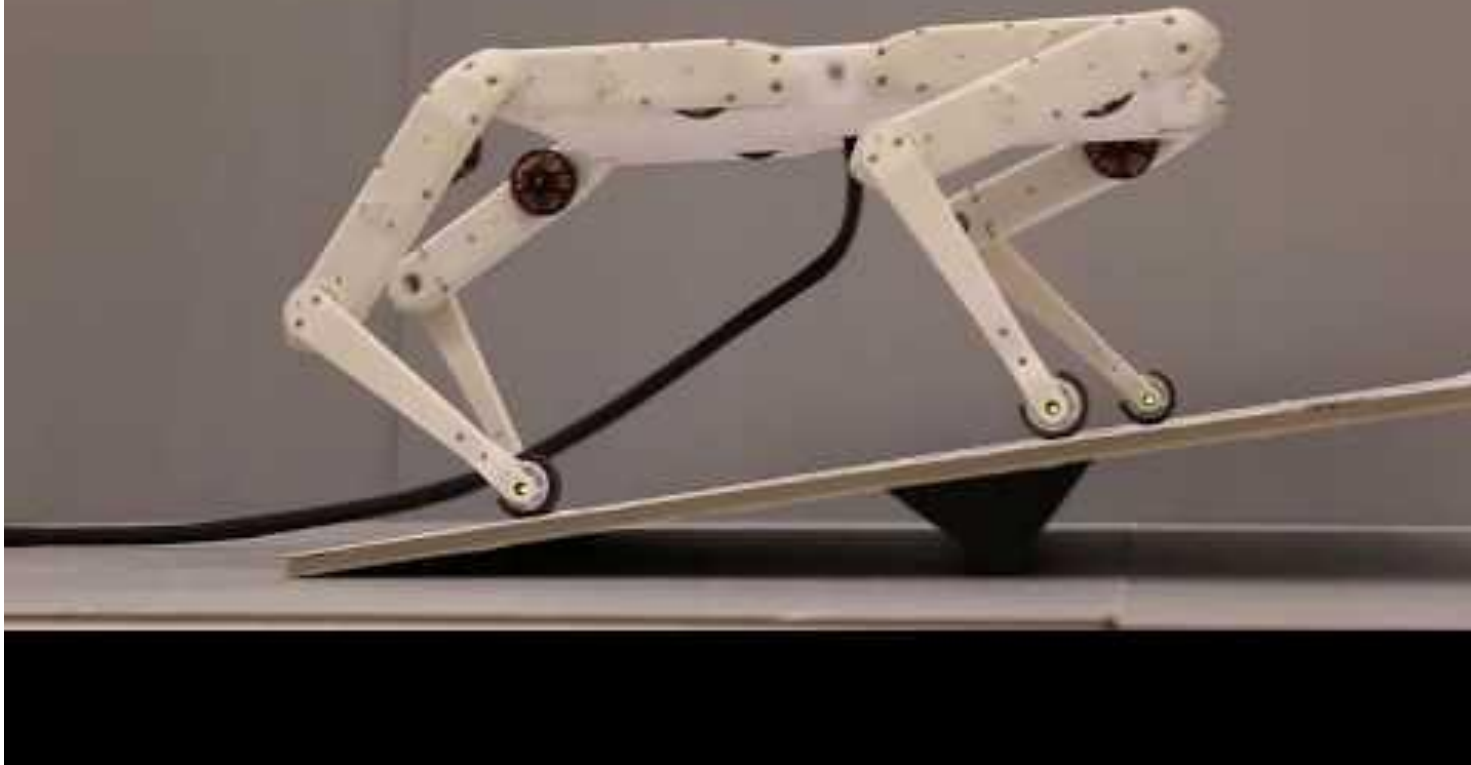
<p><b>Quadruped 8dof</b></p>	<p><b>Quadruped 12dof</b></p>	<p><b>Biped 6dof</b></p>	<p><b>TriFingerEdu</b></p>
			
<p><b>2dof Leg</b></p>	<p><b>3dof Leg</b></p>	<p><b>Biped Leg</b></p>	<p><b>FingerEdu</b></p>
			

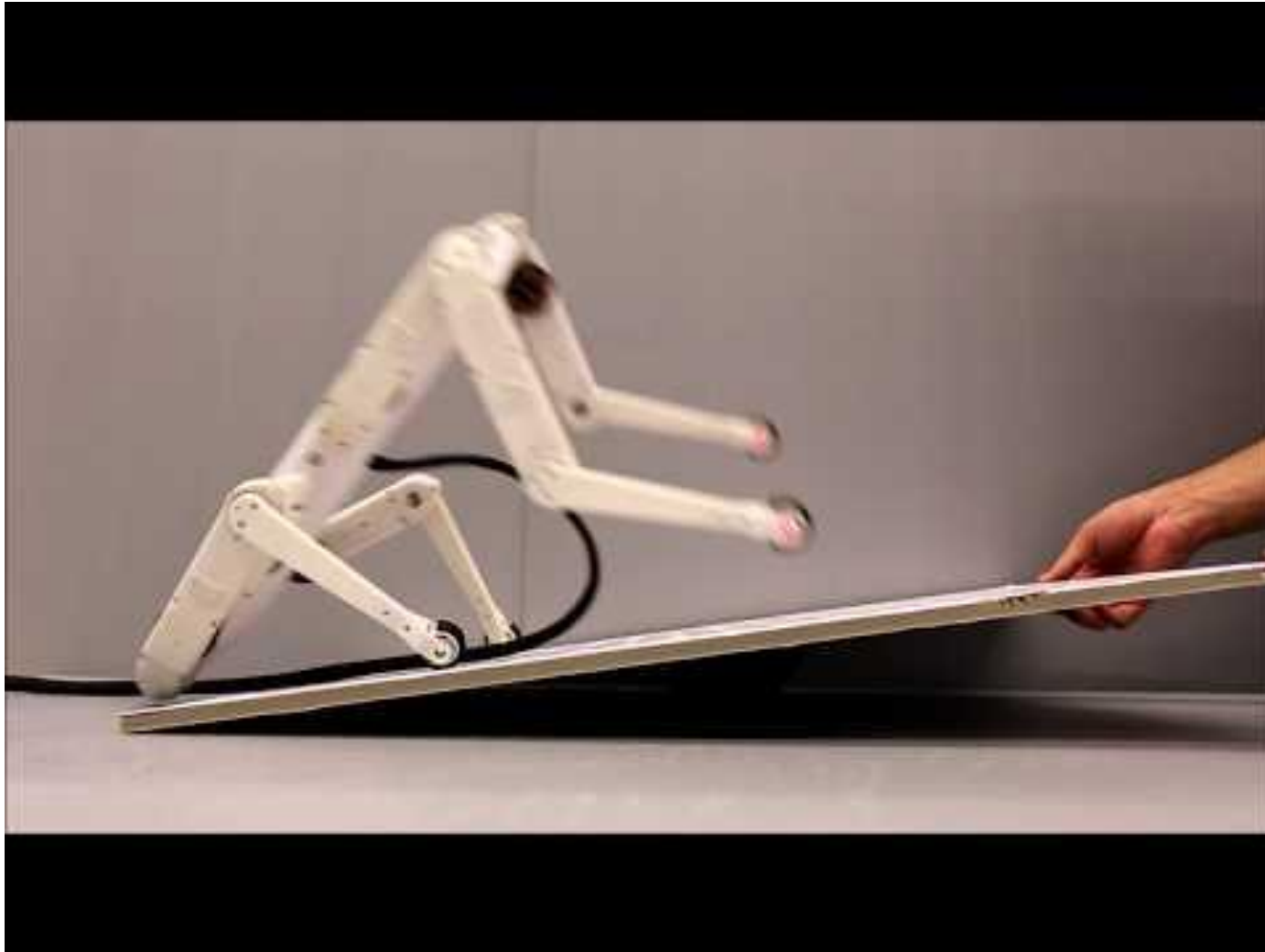
# Solo 8 - The first legged prototype



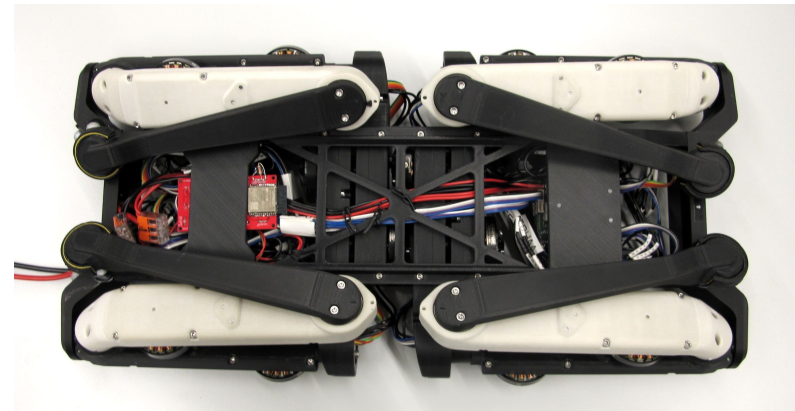
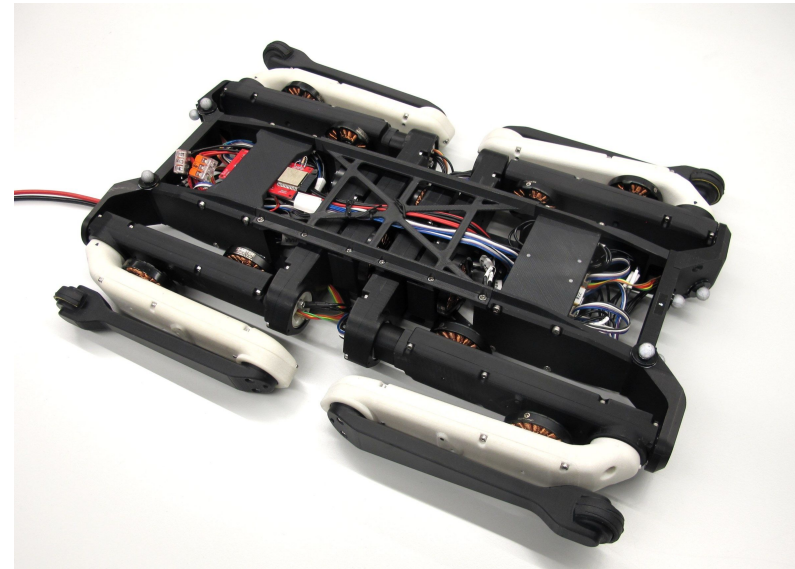
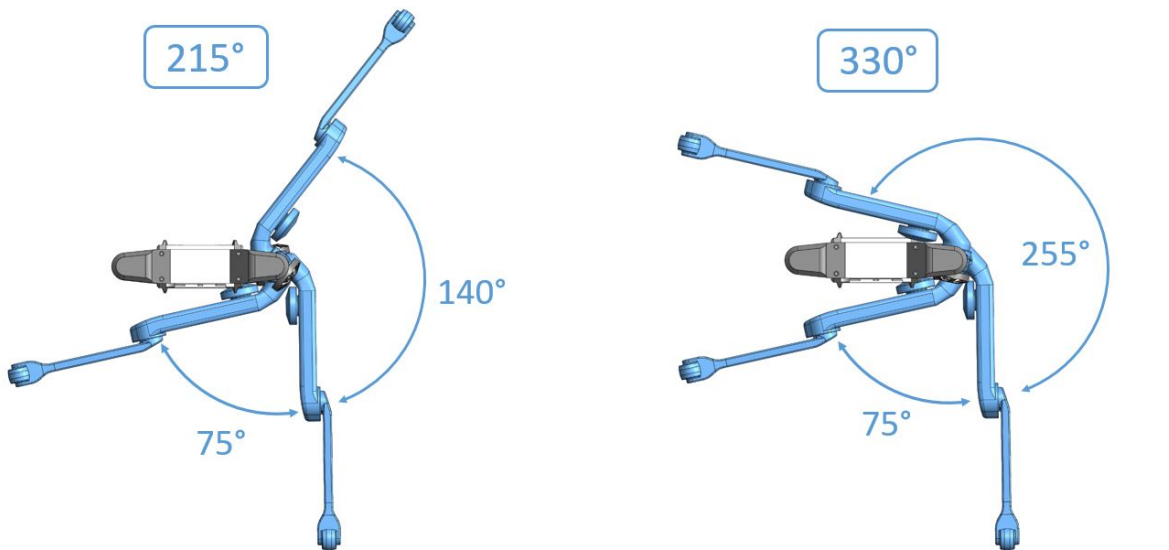


Slow walk on unknown terrain  
(kino-dynamic planner + proposed controller)





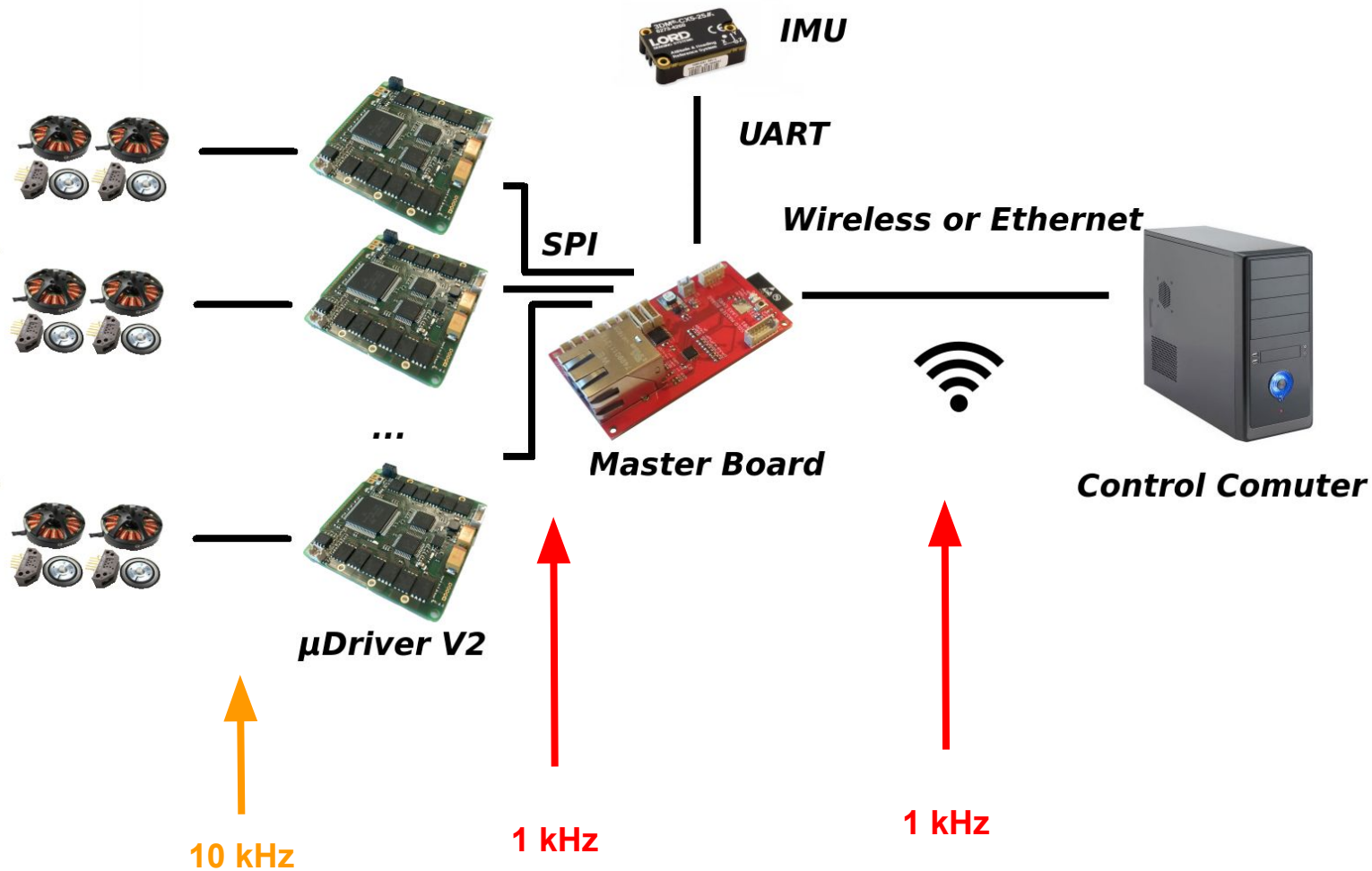
# Solo 12 - Update version



# Solo 12 - Update version

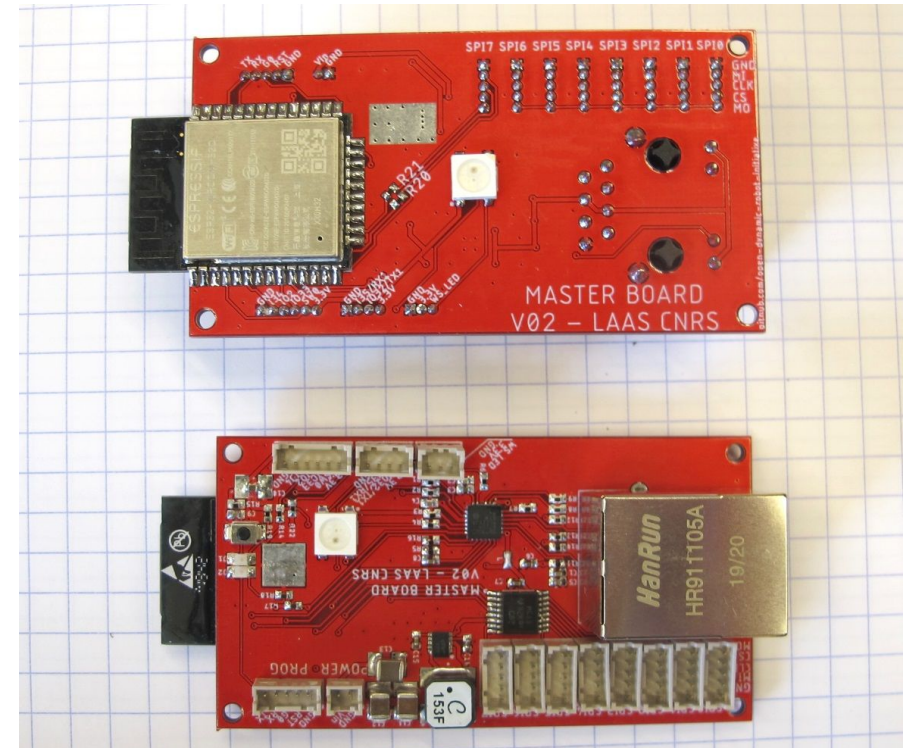


# Control architecture



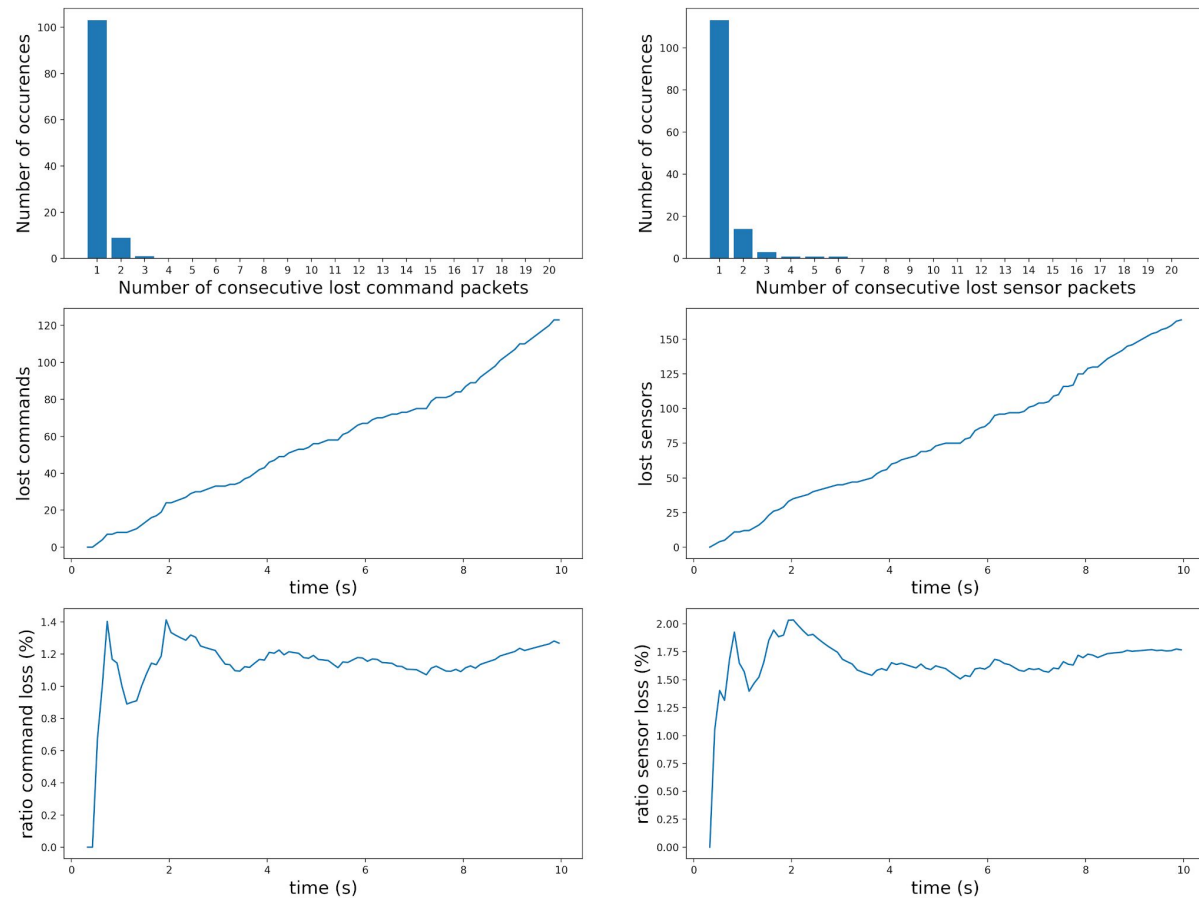
## Master Board

- Open source/hardware
- Synchronous RT com with up to 16 actuators, IMU, ...
- Wired or Wireless com with RT control PC
- 1Khz control loop
- Onboard safety procedures
- room for user code..



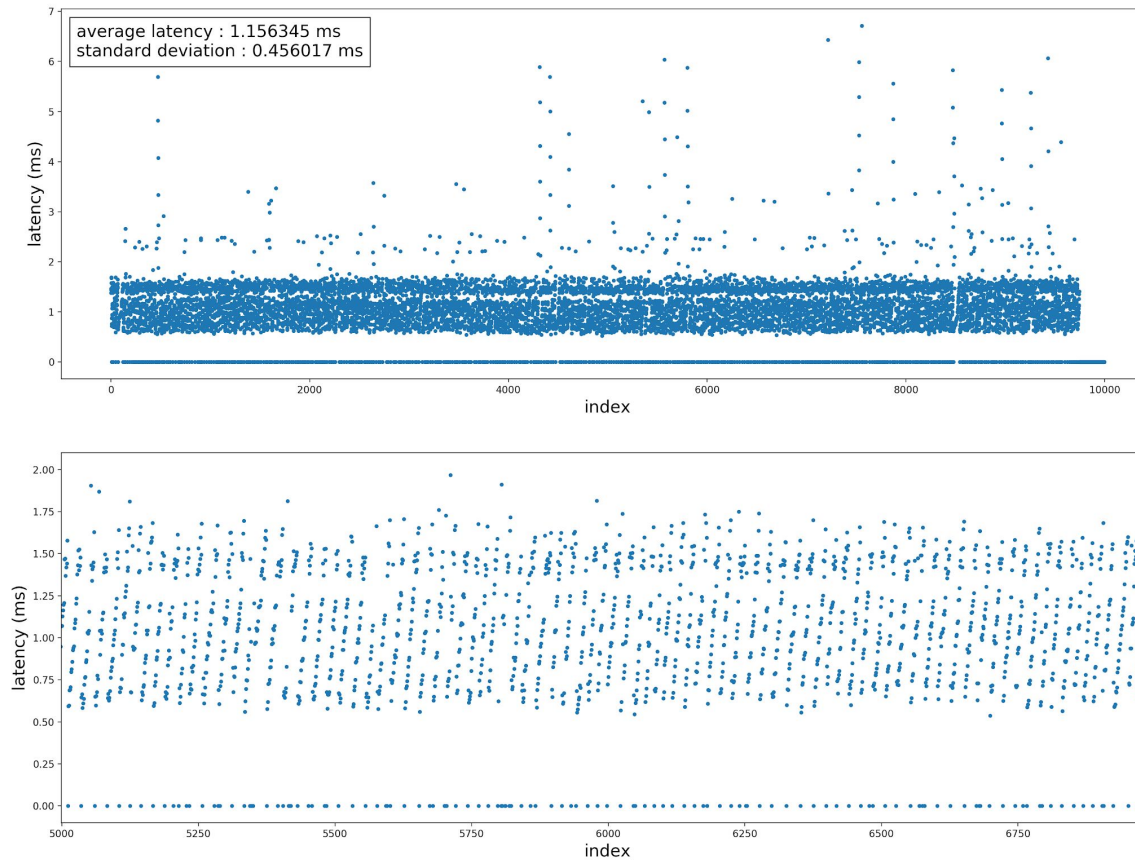
Wifi statistics : channel 14

## Master Board



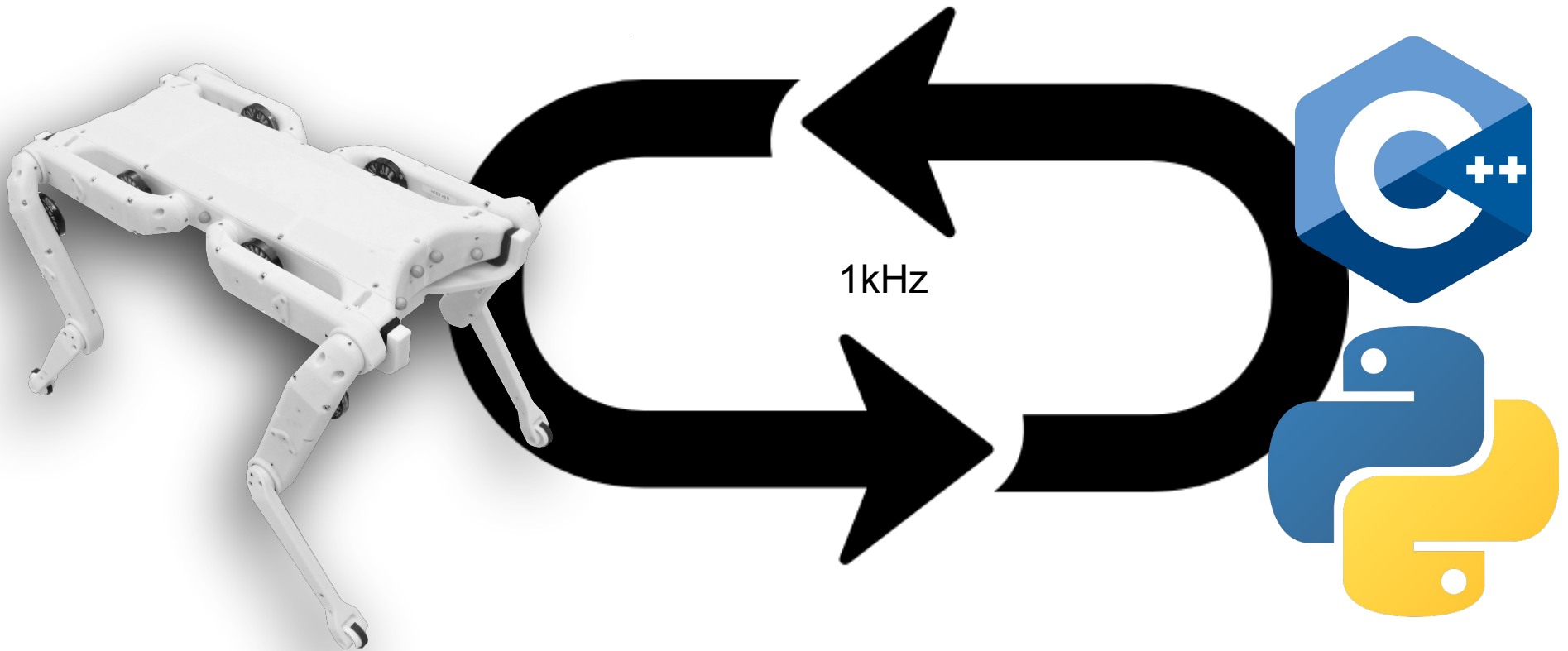
# Custom electronic and communication link

Wifi communication latency





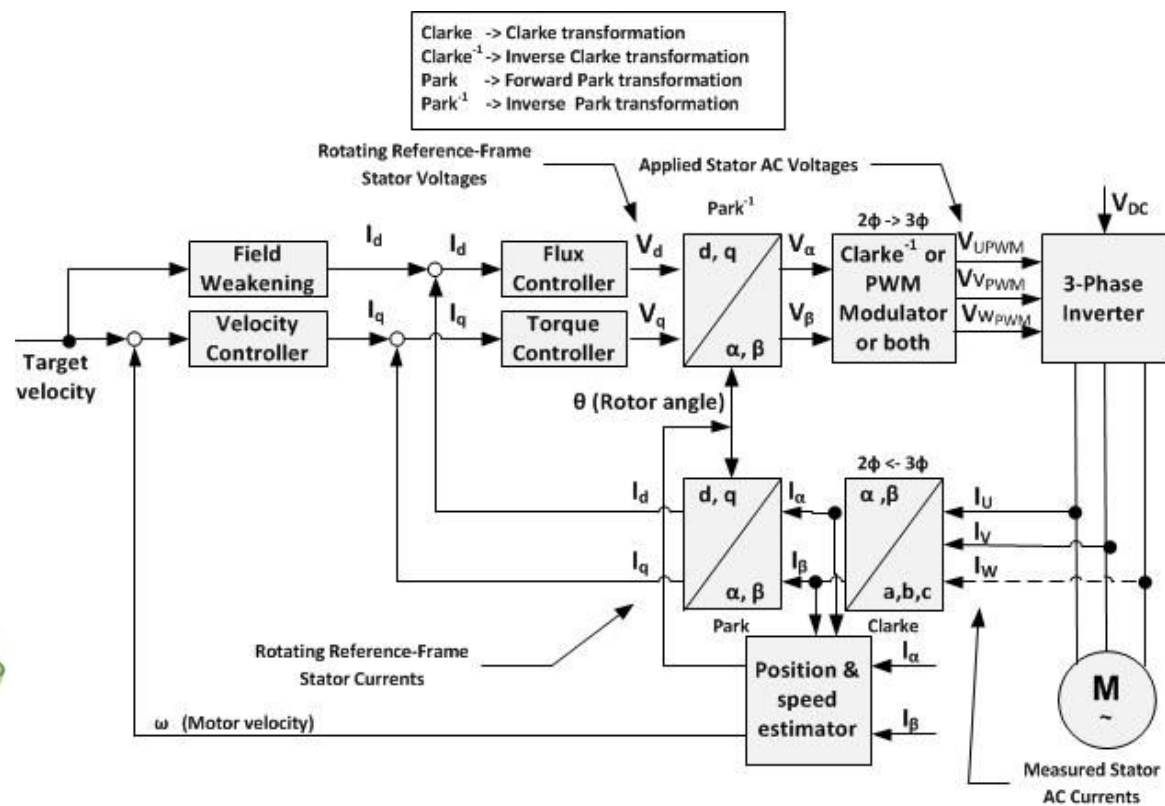
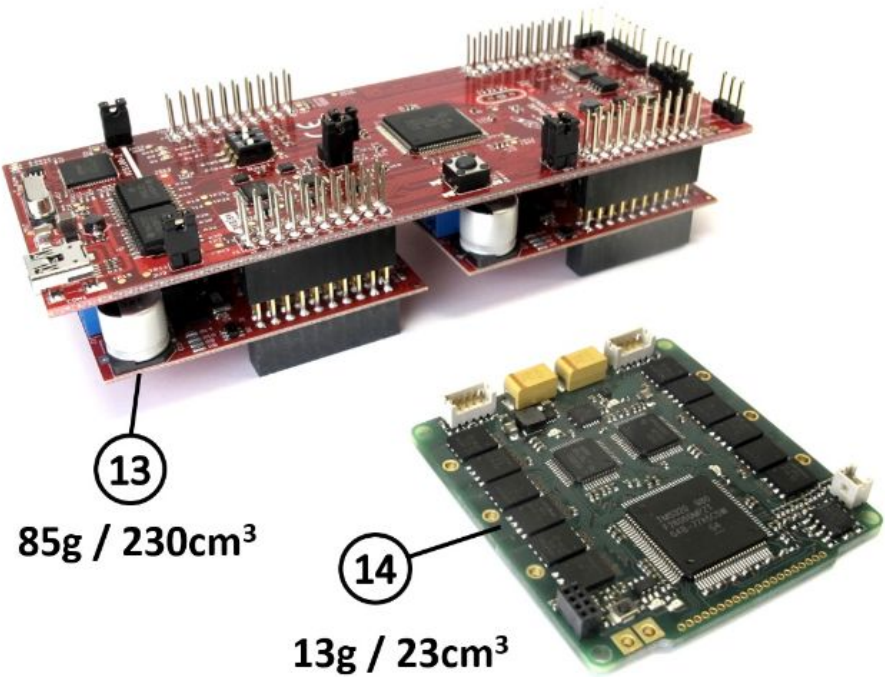
Simple SDK to control the robot from a distant computer



# Custom electronic and communication link

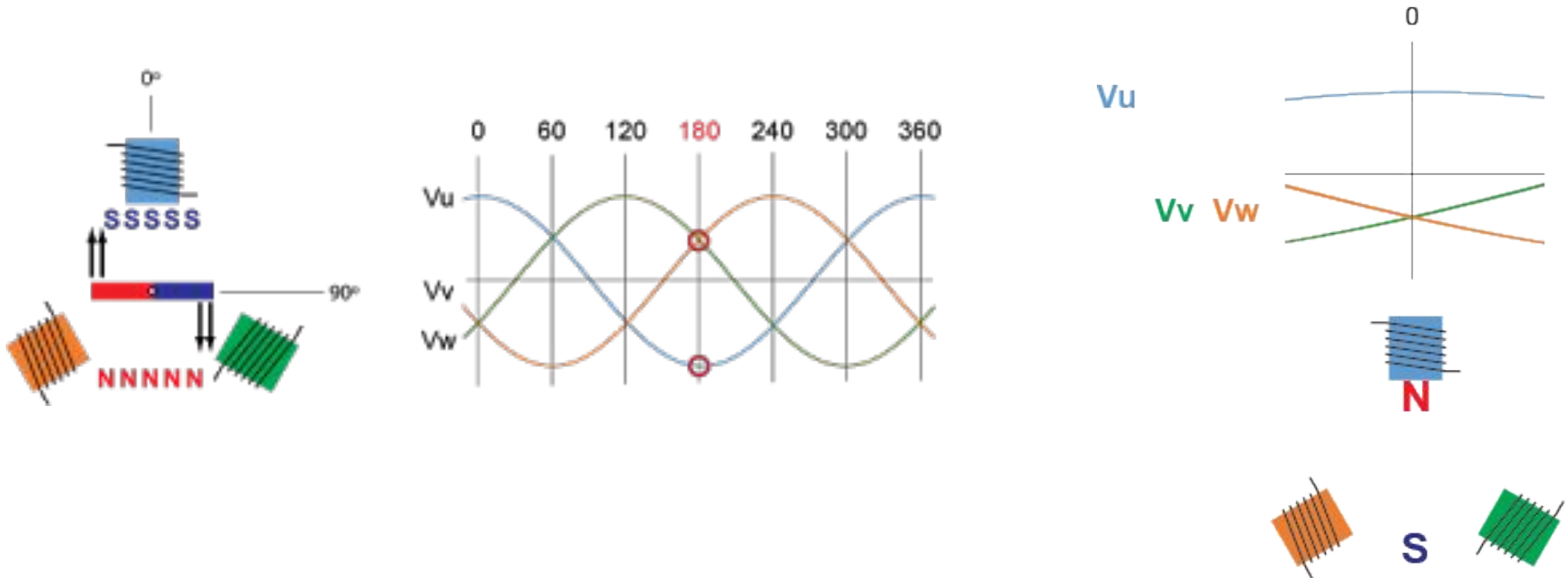
## Motor driver: microDriver

- Open source/hardware
- Off the shelf / Custom PCB
- Field Oriented Control of 2 motors
- 1kHz CAN and SPI interfaces



uDriver

## What is a FOC controller ?

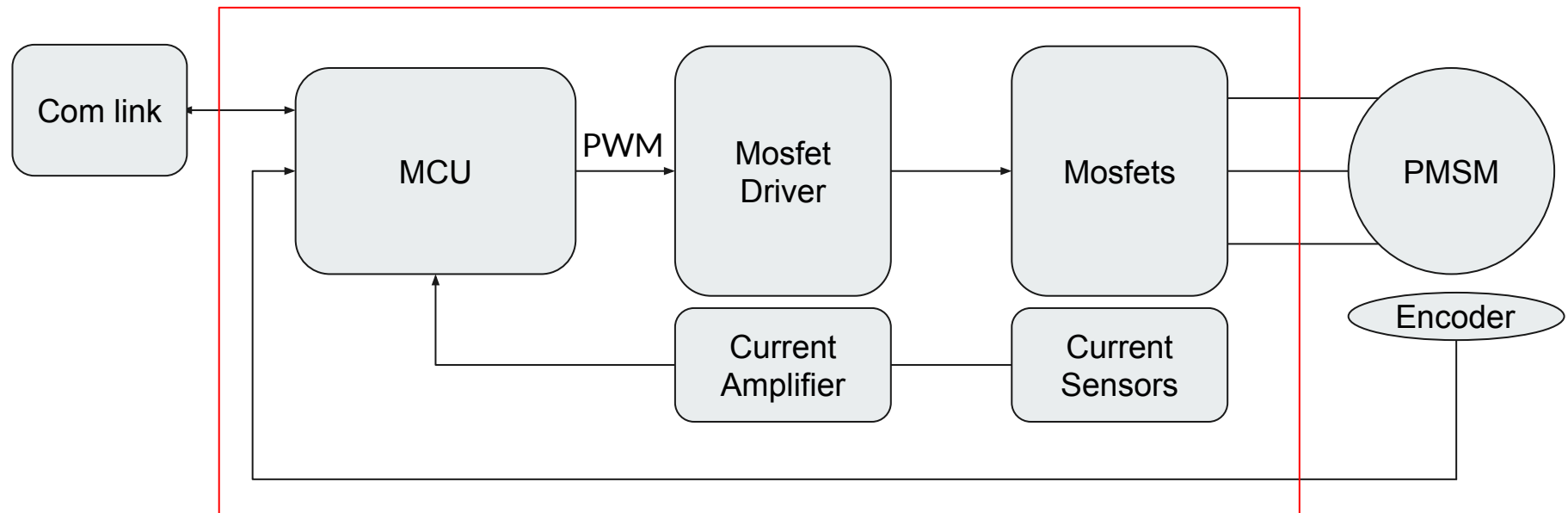


Images: roboteq

uDriver

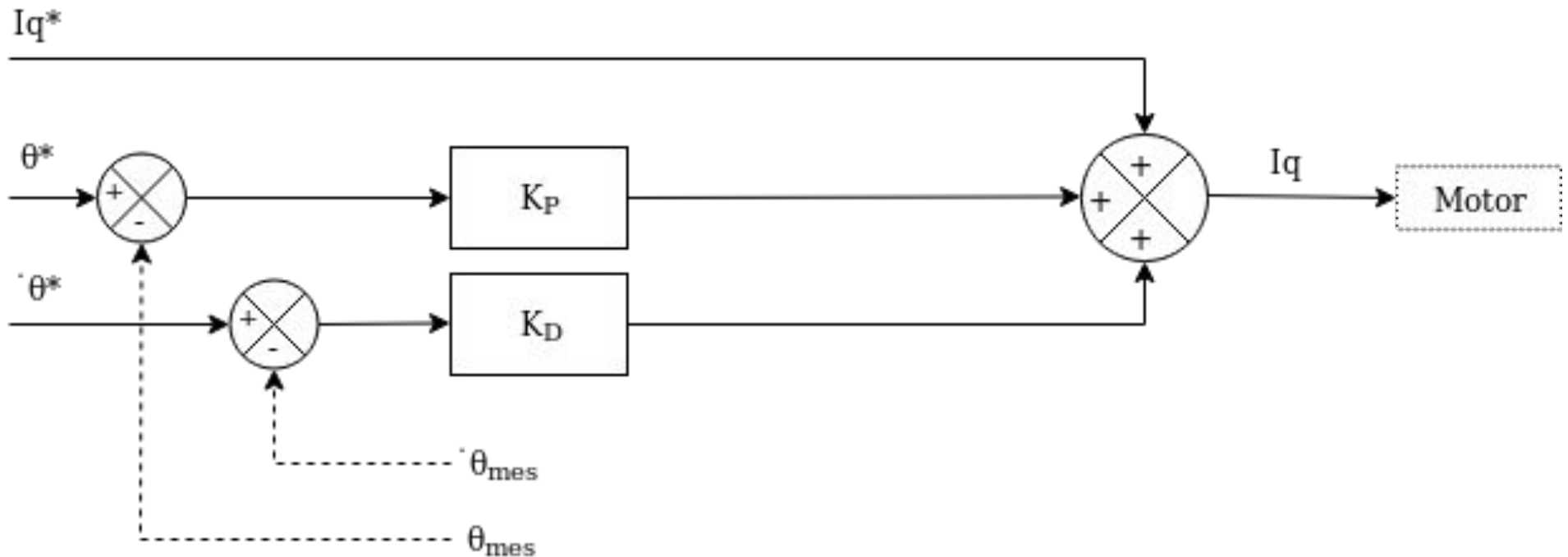
## What is a FOC controller ?

MCU + Mosfet Driver + Current sensor and amplifier + Mosfet



uDriver

Running at 10 kHz :



# Custom electronic and communication link

uDriver:

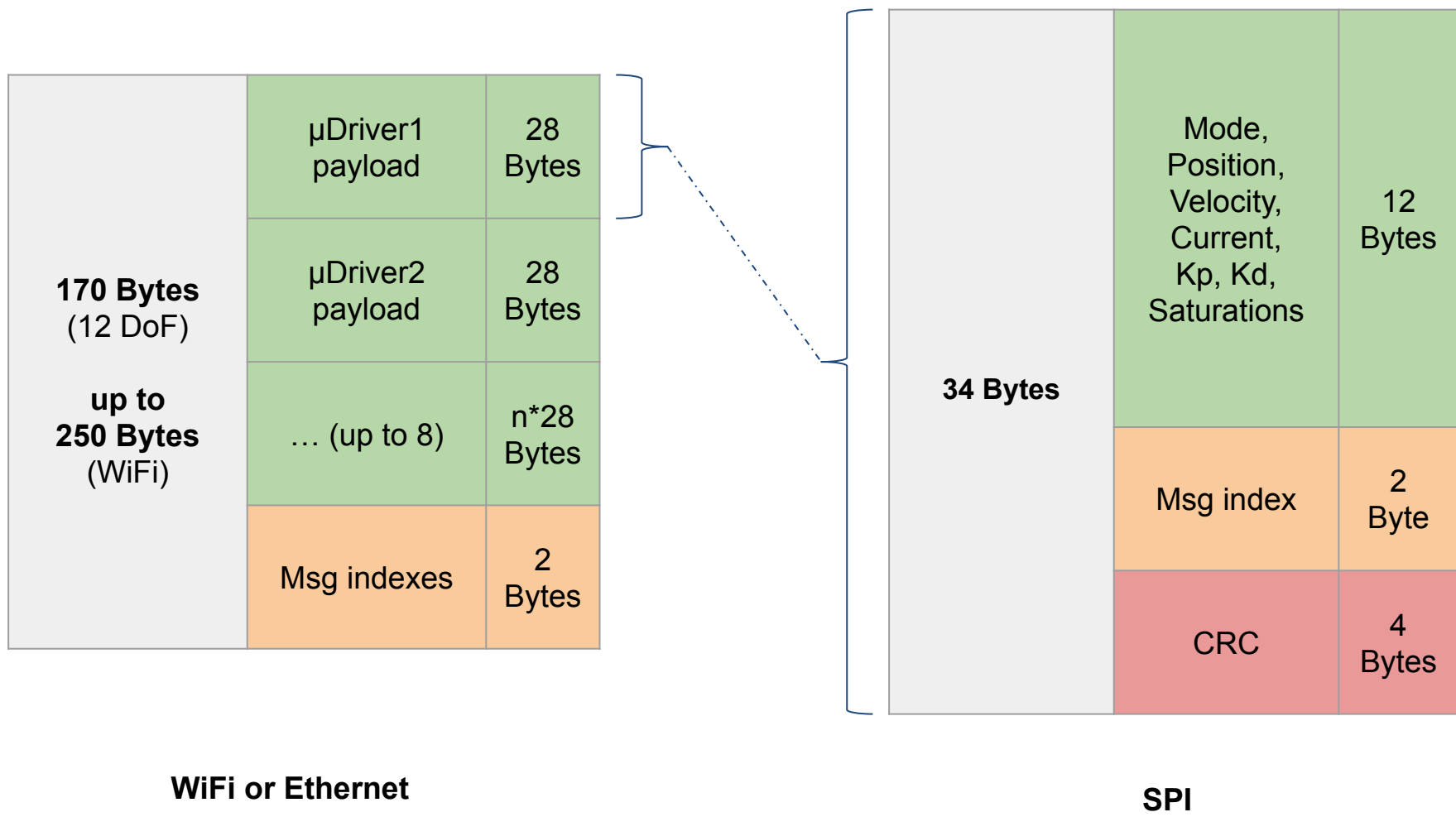


TMS320F2838x		Temperatures		125C	125C Q100
<b>Connectivity</b>		<b>Processing</b>		<b>Actuation</b>	
Connectivity Manager (CM) Access	C28x Access	C28x™ DSP core 200 MHz	C28x™ DSP core 200 MHz	16x ePWM Modules (Type 4) 32x Outputs (16x High-Res)	
10/100 Ethernet	FSI: 2x Tx, 8x Rx	FPU64	FPU64	Fault Trip Zones	
CAN-FD	2x McBSP	TMU	TMU	3x 12-bit DAC	
UART	4x UART	VCRC	VCRC	<b>Sensing</b>	
SSI	4x SPI	CLA core 200 MHz Floating-Point Math	CLA core 200 MHz Floating-Point Math	4x Analog to Digital Converters 16-bit Mode, 1.1 MSPS, 12 differential or 24 single-ended channels	
I2C	2x I2C, 1x PMBus	<b>Memory</b>	<b>Memory</b>	12-bit Mode, 3.5 MSPS 24 single-ended channels	
EtherCAT™		512 KB Flash	512 KB Flash	8x Windowed Comparators w/ Integrated 12-bit DAC	
USB MAC & PHY		44 KB RAM	44 KB RAM	8x Sigma Delta Filter Modules	
2x CAN 2.0B		128 KB RAM Shared		Temperature Sensor	
<b>System Modules</b>		26 KB RAM Shared for IPC		3x eQEP	
3x 32-bit CPU Timers per C28x CPU		2x Security Zones		7x eCAP (2x HRCAP)	
192 Interrupt PIE per C28x CPU		Boot ROM		<b>Configurable Logic Block</b>	
Watchdog Timer		ROM Tables		8 Tiles	
Missing Clock Detection		6-ch DMA		Position Manager: Flexible Absolute Encoder Interface	
<b>Power &amp; Clocking</b>		2x EMIF			
2x 10 MHz OSC		<b>Debug</b>			
Ext OSC Input		Real-time JTAG			
		Real-time Analysis and Diagnostic unit (ERAD)			

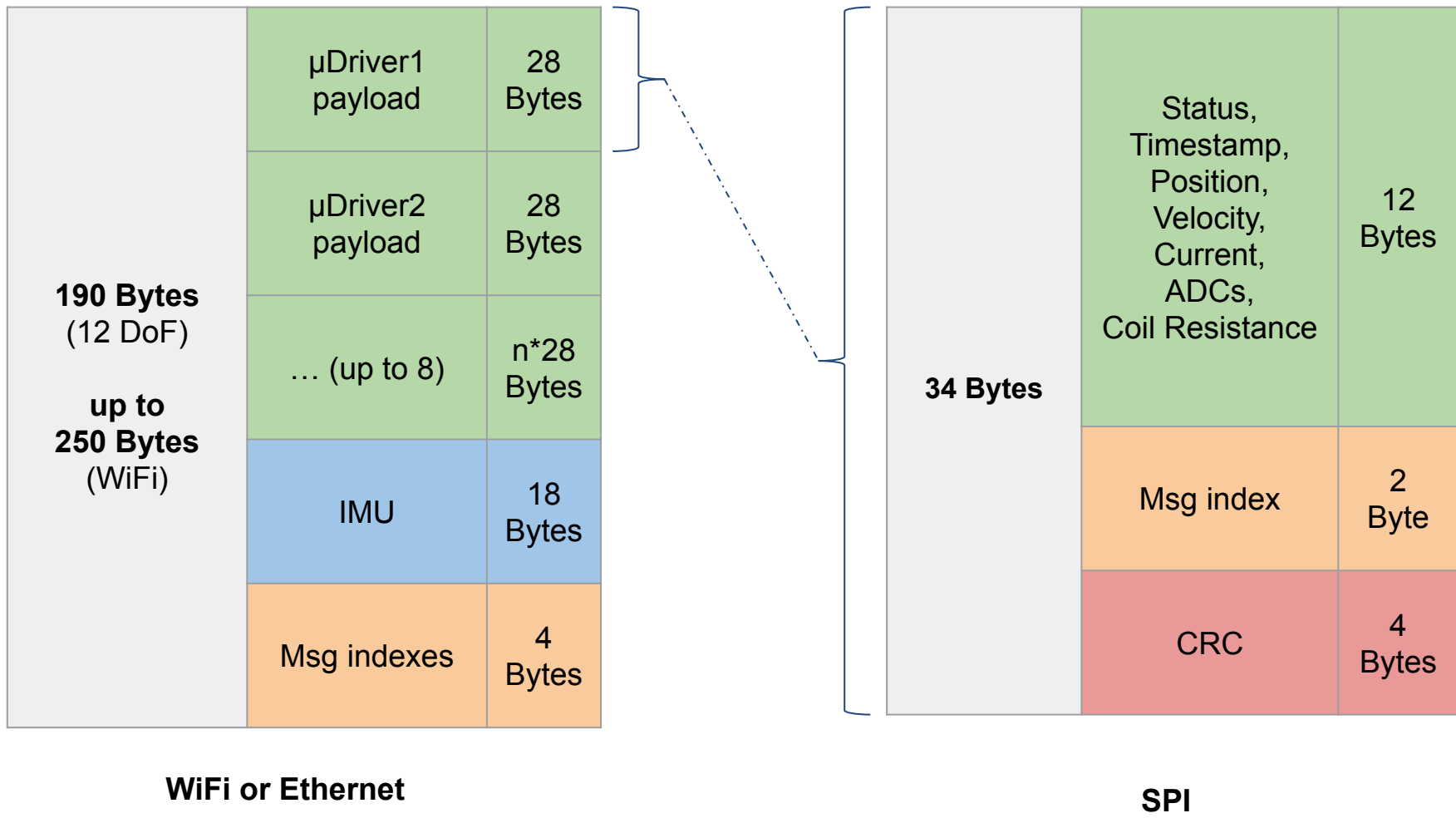
A major update is on its way!

- State of the art hardware
- Open source/hardware
- Scalable solution (power, size)
- Fast communication link

# Payload downlink (PC → μDriver)



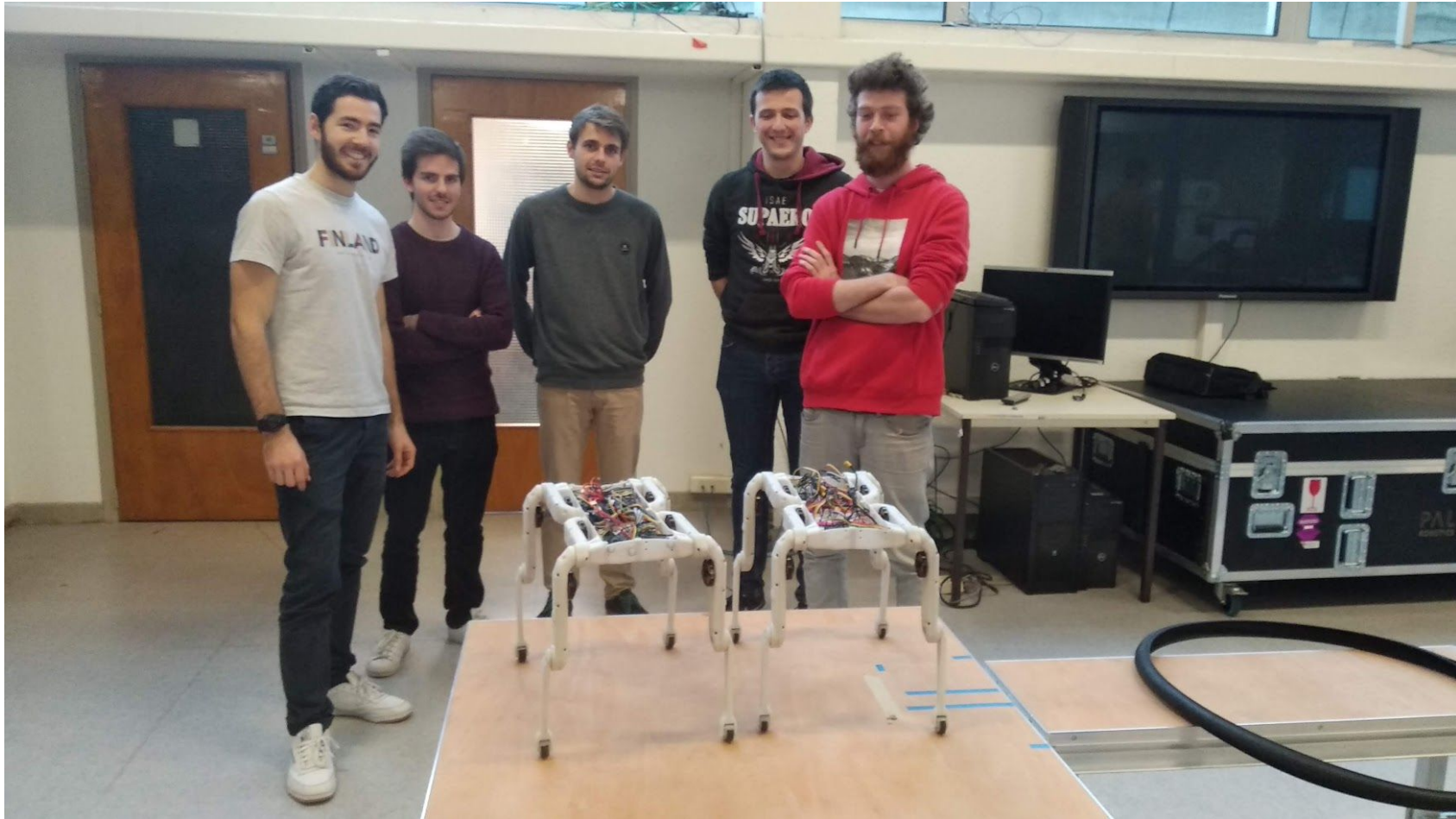
# Payload uplink ( $\mu$ Driver $\rightarrow$ PC)





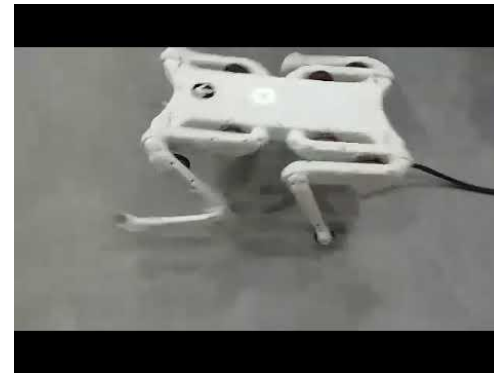
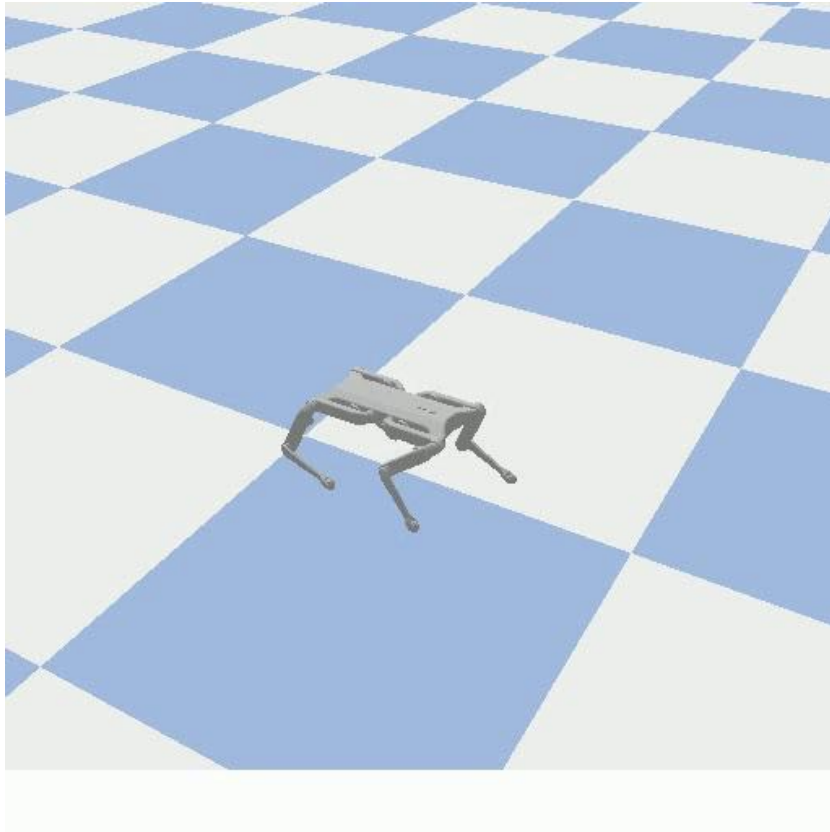
# Research project lead at LAAS

Assembly + Simple gait optimisation with Genetic Algorithm - ISAE student project  
Etienne Arlaud, Thibault Noël, Thomas Corbères, Marion Valette, Ethan Cherki, Jean-lou Quetin



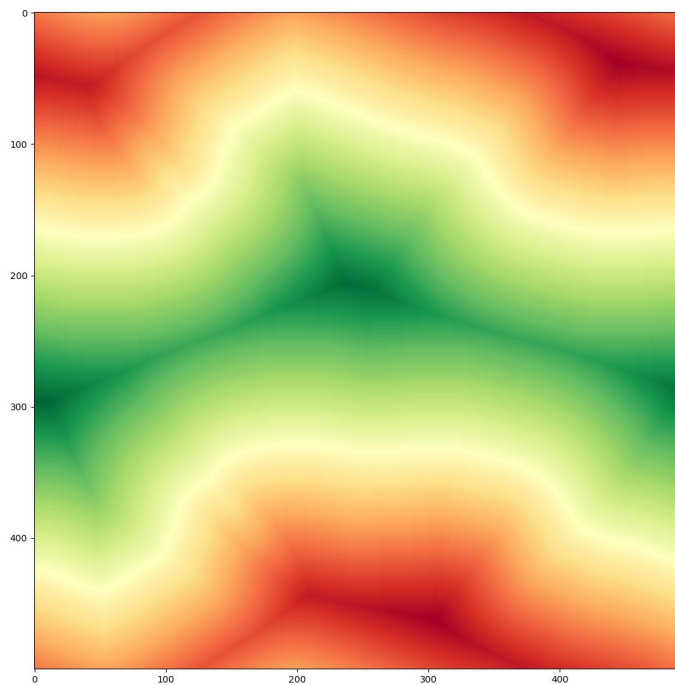
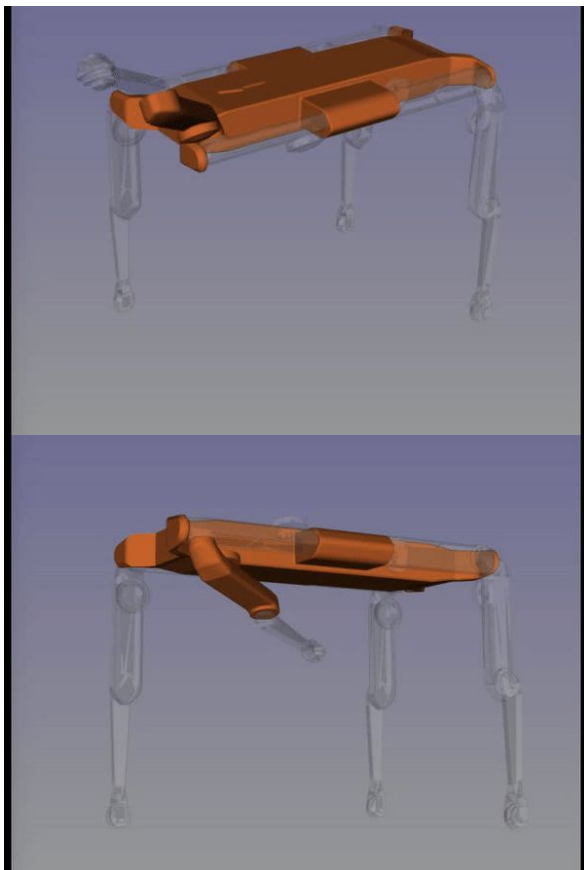
# Research project lead at LAAS

Assembly + Simple gait optimisation with Genetic Algorithm - ISAE student project  
 Etienne Arlaud, Thibault Noël, Thomas Corbères, Marion Valette, Ethan Cherki, Jean-lou Quetin

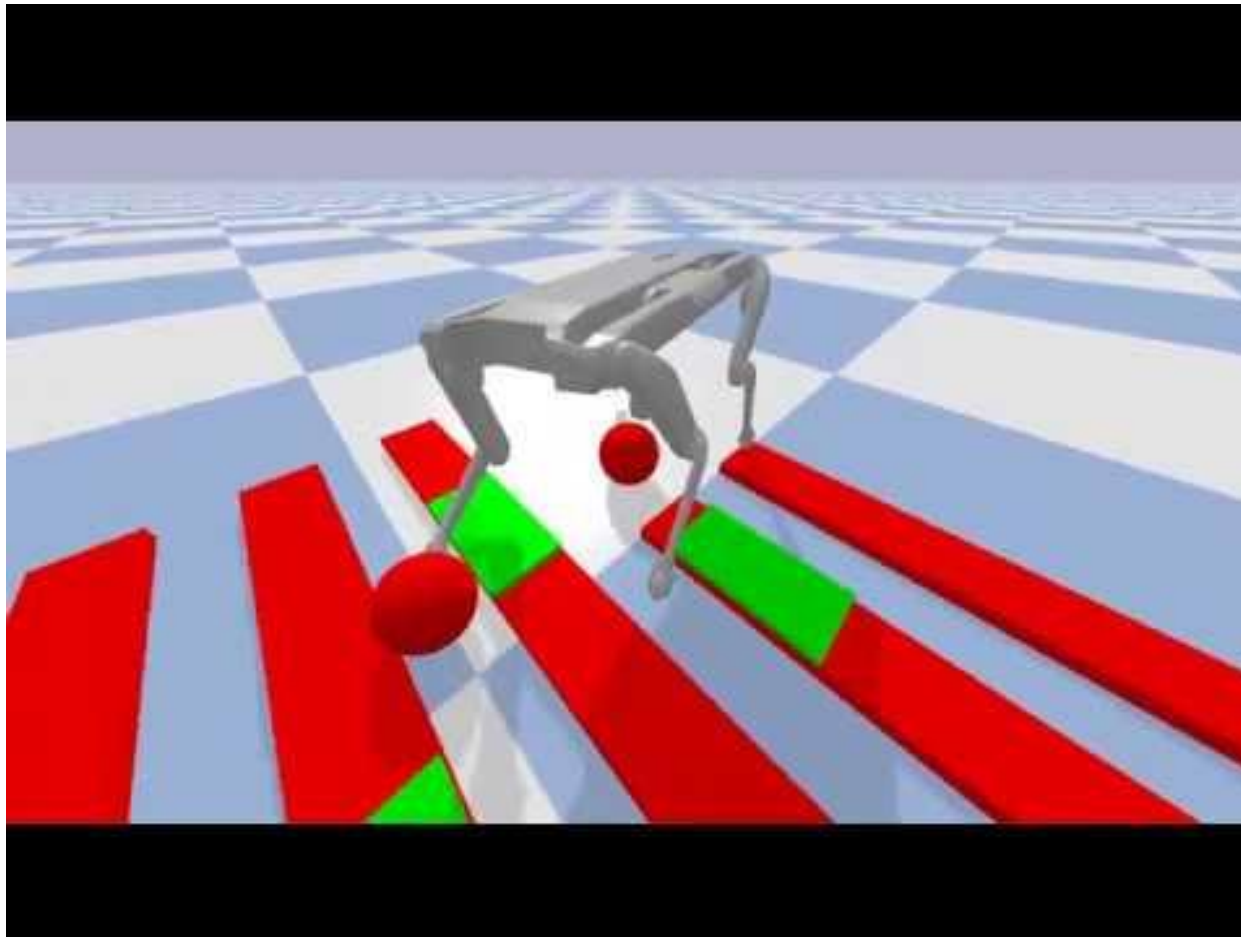
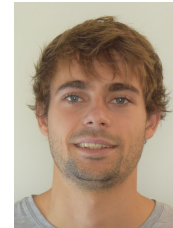




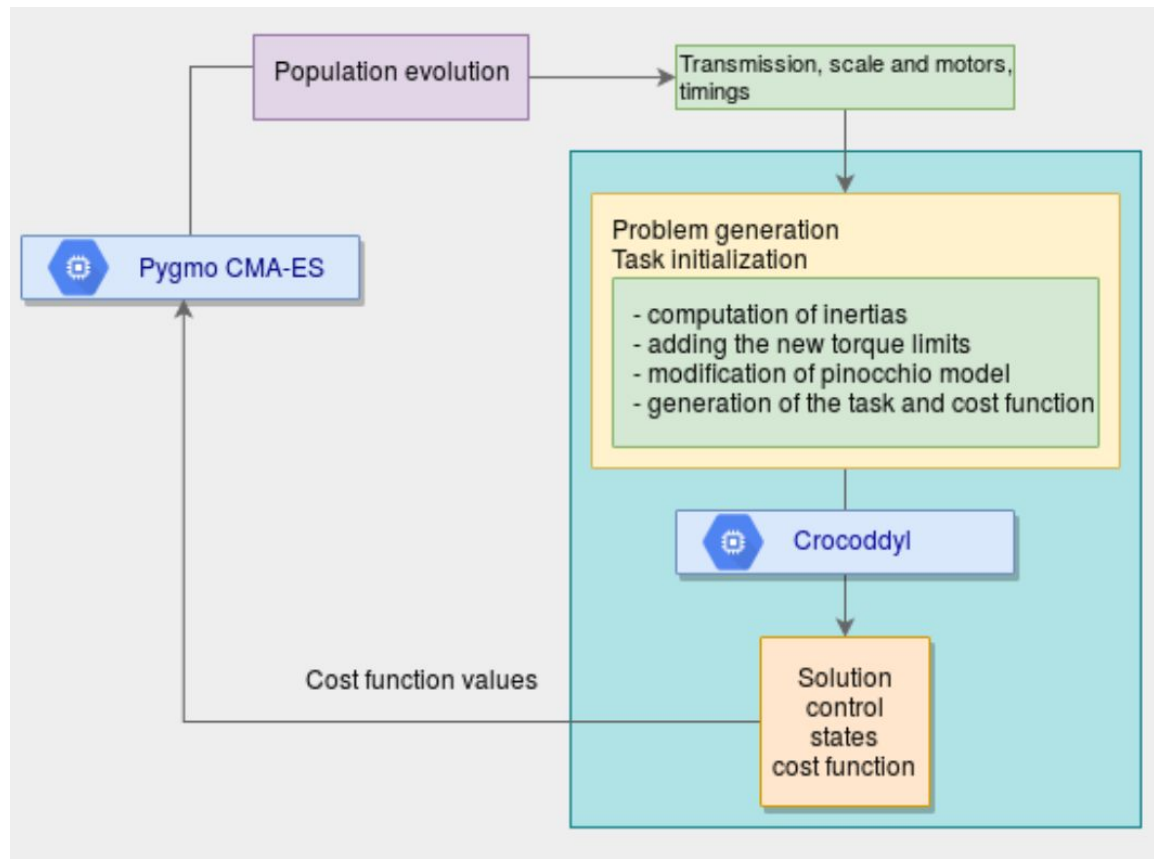
## Self collision detection and avoidance - Thibault Noel



Reactive walking controller - Pierre-Alexandre Leziart & Thomas Cobrère



## Co-design - Gabriele Fadini



For LAAS:

- Assemble and control solo 12
- Study the upscaling via codesign - Collaboration with PPRIM lab in Poitier
- Work on estimation
- Update and optimize motor control
- Embed power source

For other partners:

- Make the robot cheaper, find distributors for the robot?
- Use it as a didactical platform for academic
- ML, Control, biped...
- Compare control strategies from different teams

# Conclusion

Website

<https://open-dynamic-robot-initiative.github.io/>

Youtube channel

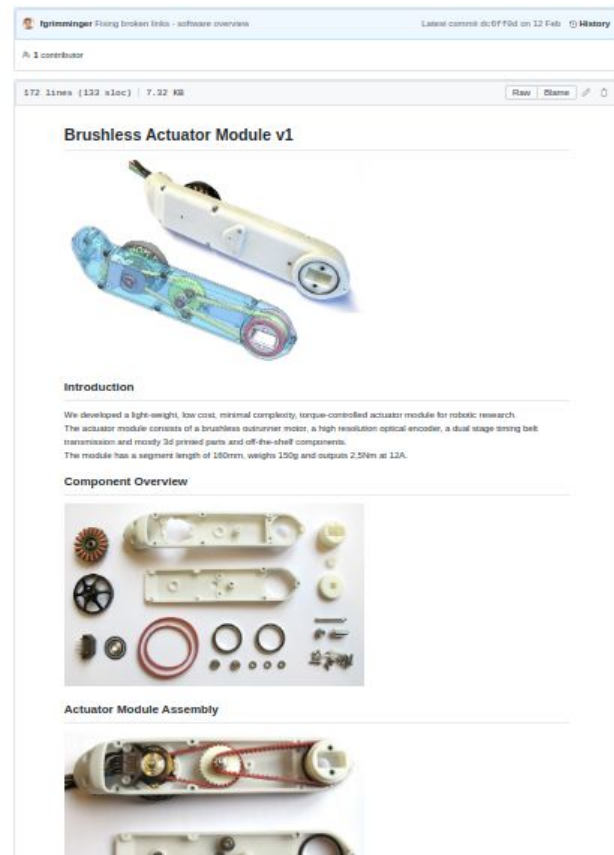
<https://www.youtube.com/channel/UCx32JW2oIrax47Gjq8zNI-w>

GitHub

<https://github.com/open-dynamic-robot-initiative/>

WhitePaper

F. Grimmering et al., "An Open Torque-Controlled Modular Robot Architecture for Legged Locomotion Research," in IEEE Robotics and Automation Letters, vol. 5, no. 2, April 2020



# Merci !

