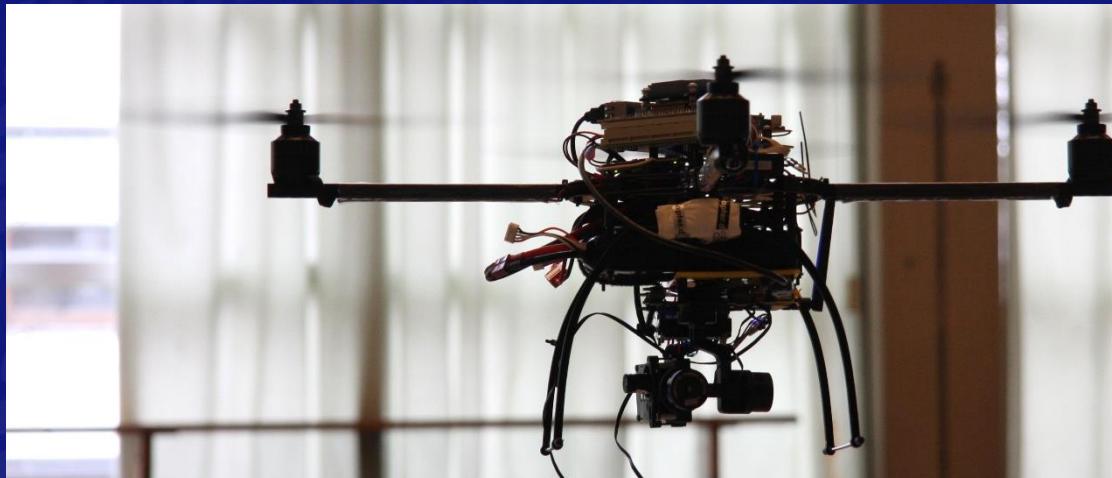


## The Multi-Rotor Avionics and Payload Computer System



Sören Schreiner, M.Sc. – OFFIS e.V.

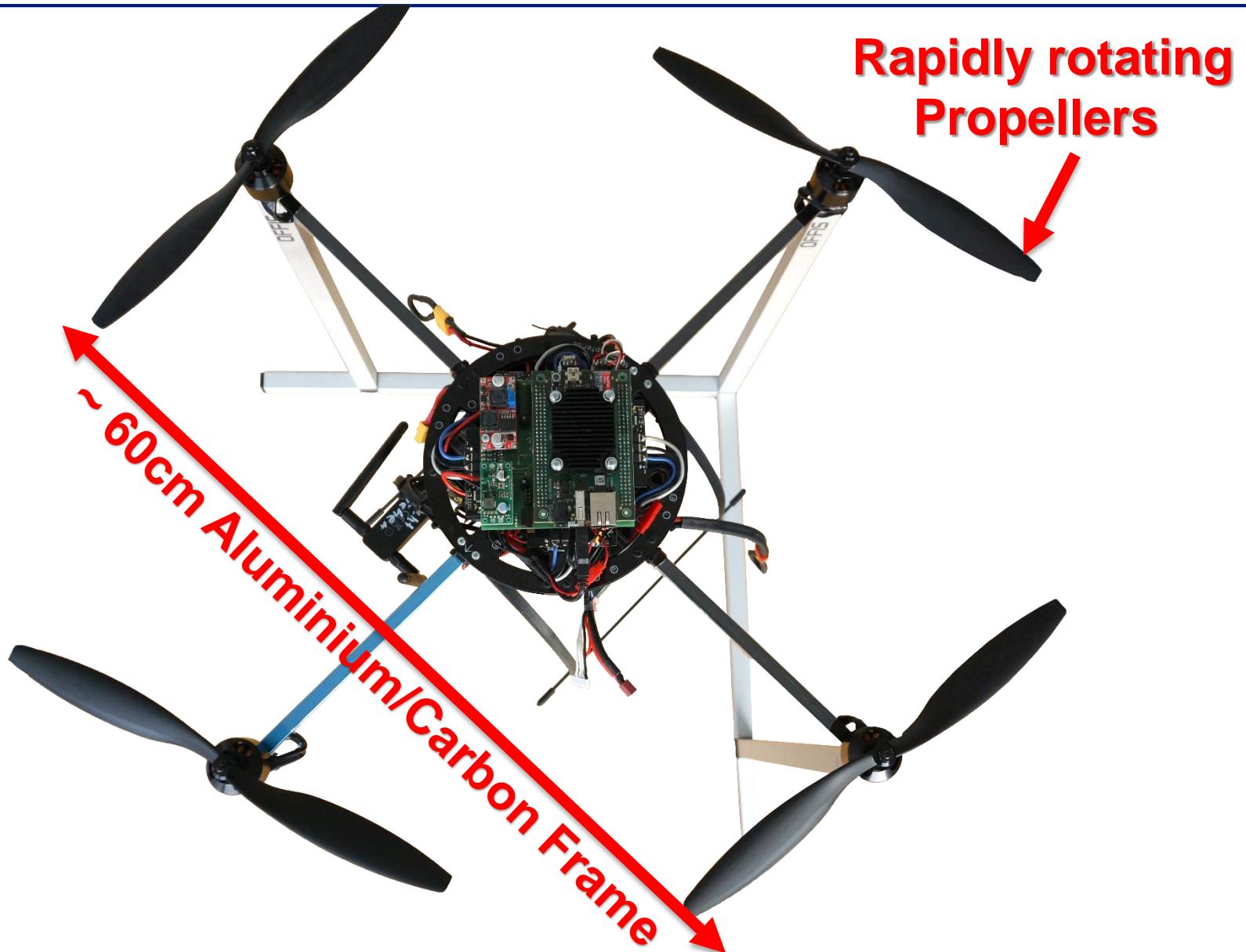
## ► 2 Multi-rotor system demonstrator



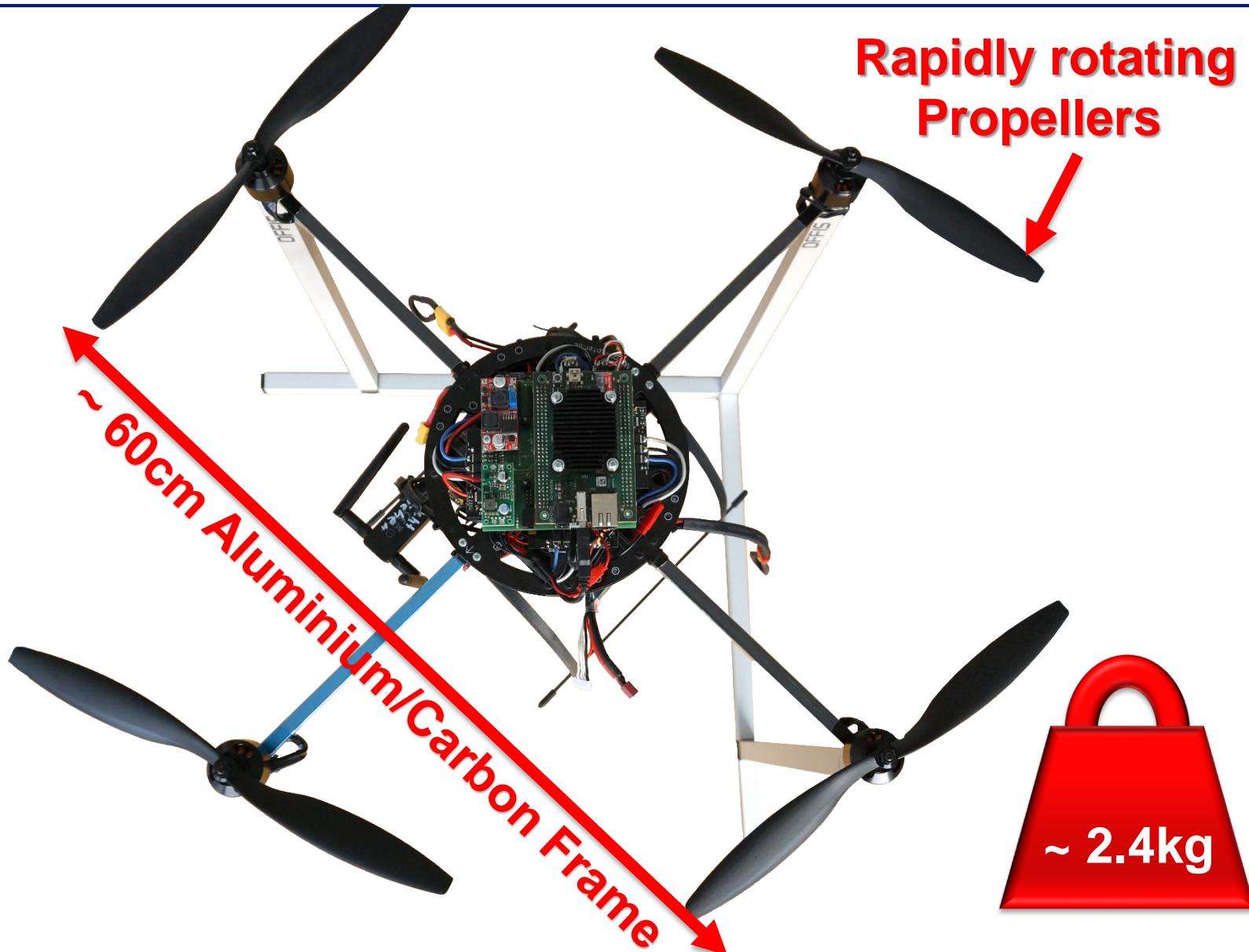
## ► 2 Multi-rotor system demonstrator



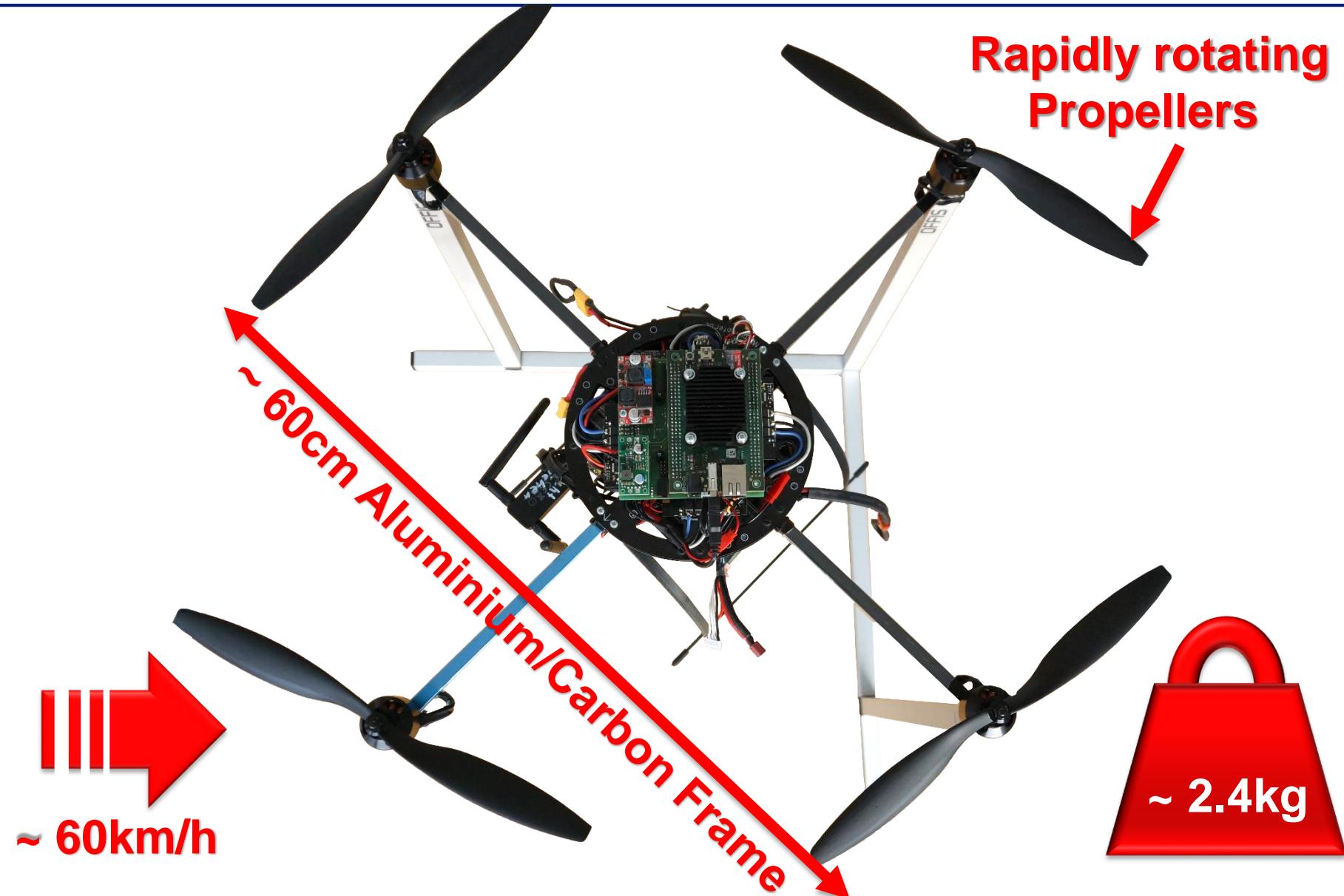
## ► 2 Multi-rotor system demonstrator



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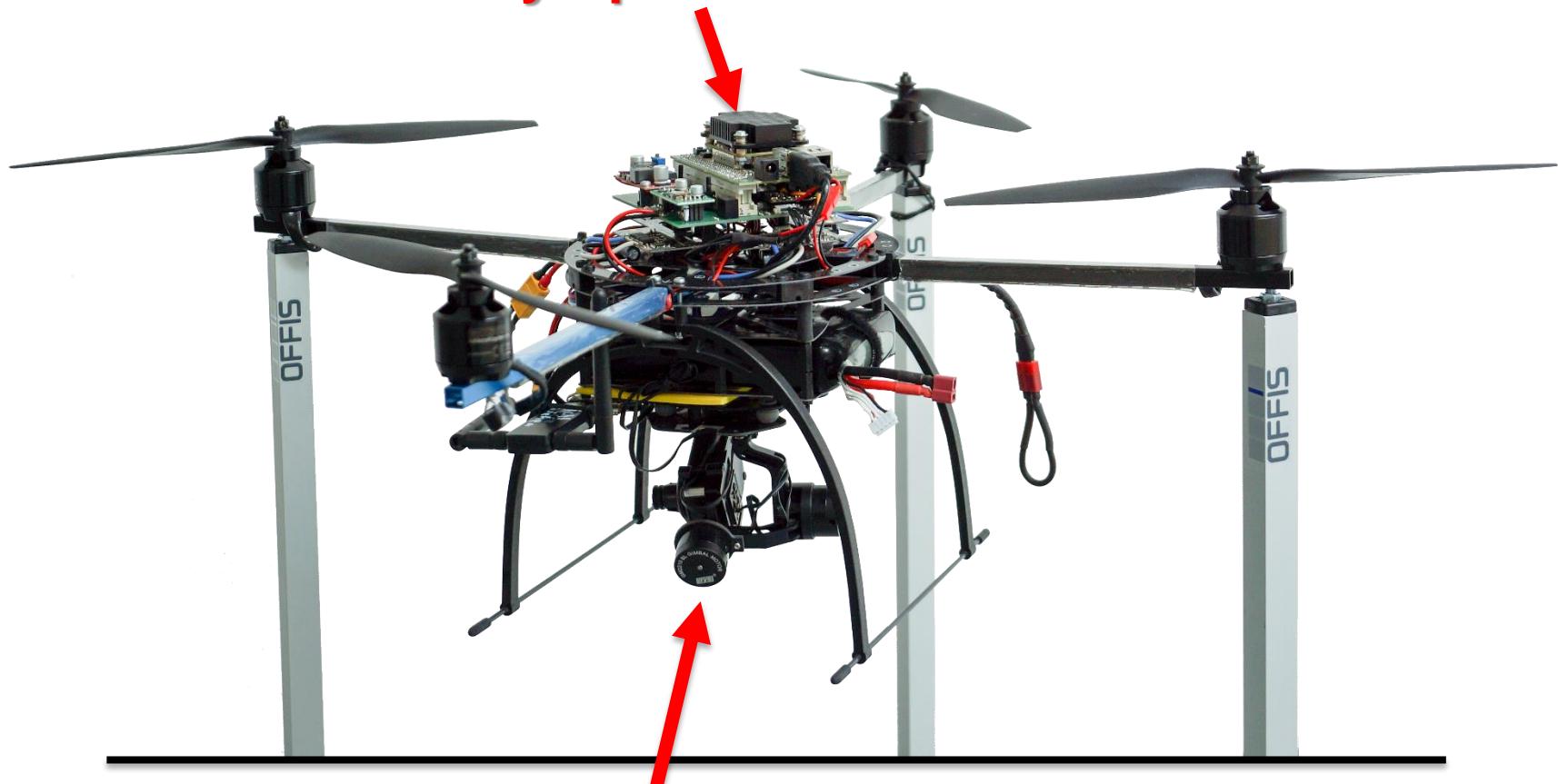
### ► 3 Multi-rotor system demonstrator



## Avionics based on Xilinx Zynq 7020 MPSoC

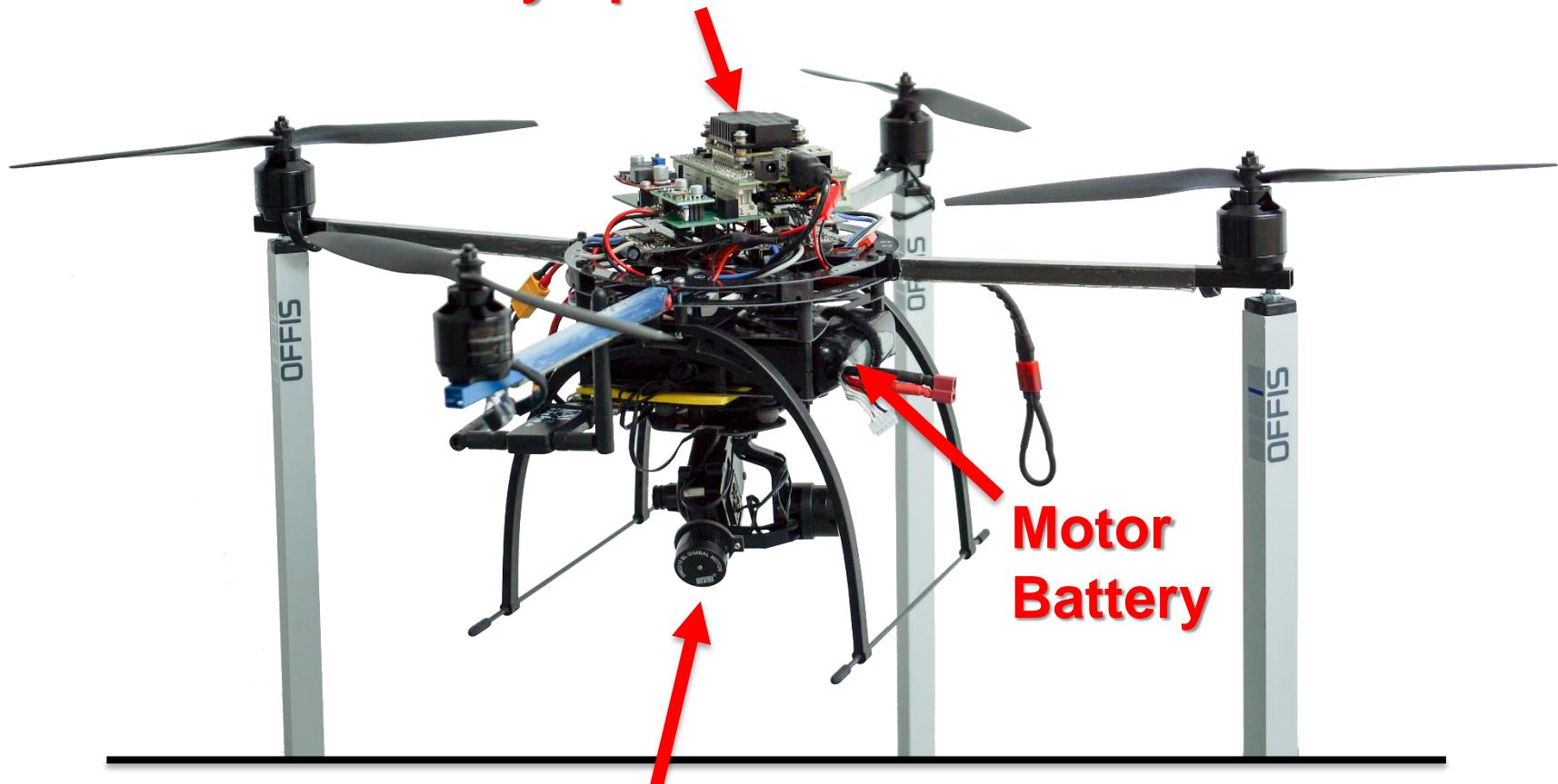


**Avionics based on Xilinx  
Zynq 7020 MPSoC**



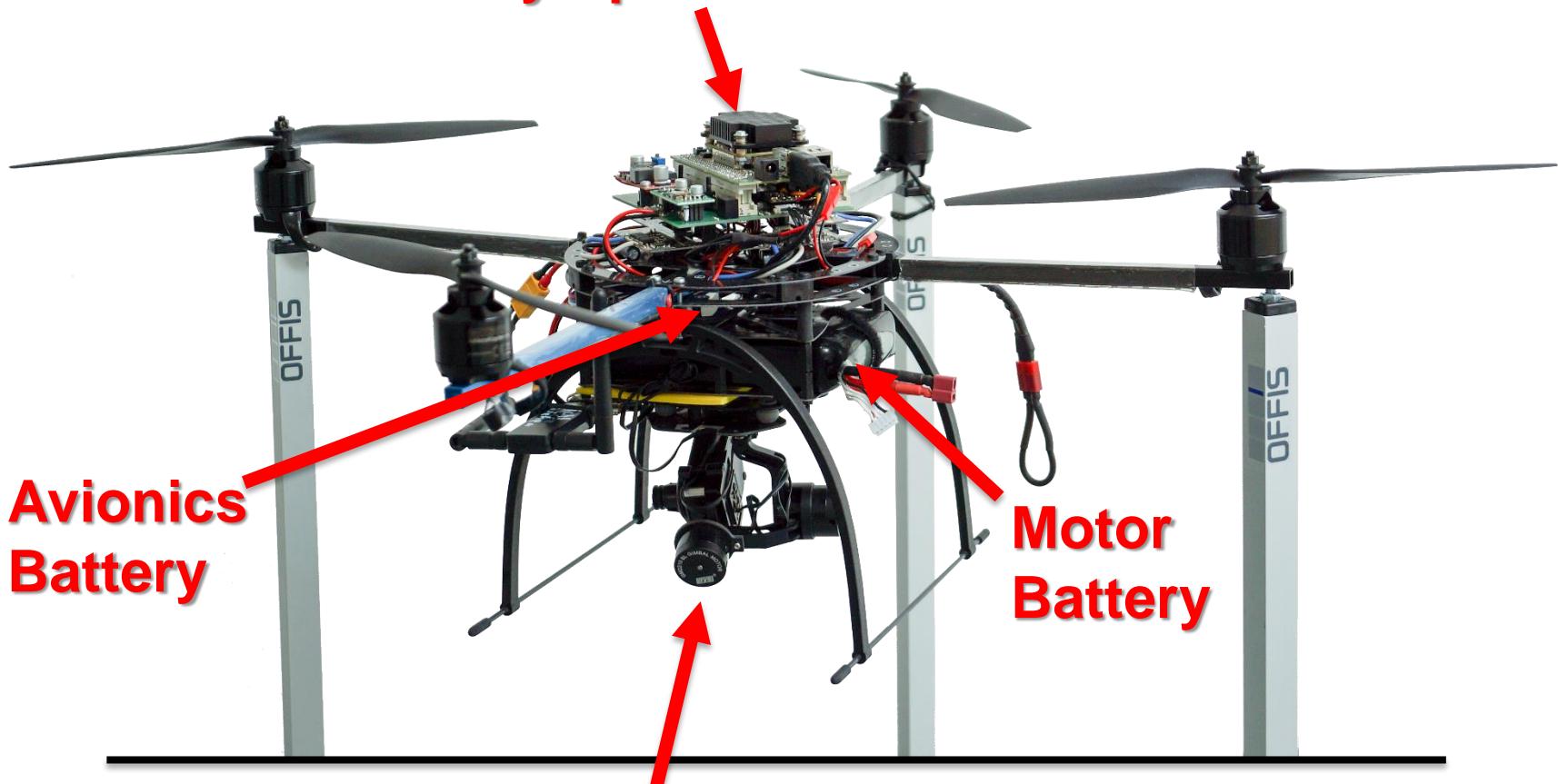
**HD Camera mounted on  
3 Axis Gimbal**

**Avionics based on Xilinx  
Zynq 7020 MPSoC**



**HD Camera mounted on  
3 Axis Gimbal**

**Avionics based on Xilinx  
Zynq 7020 MPSoC**



**HD Camera mounted on  
3 Axis Gimbal**

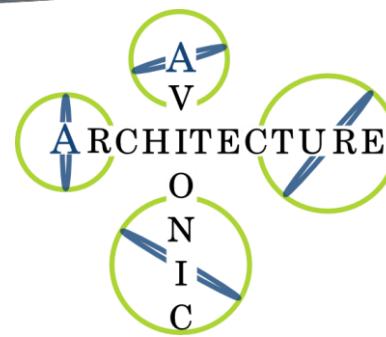
### ► 3 Multi-rotor system demonstrator



### ► 3 Multi-rotor system demonstrator

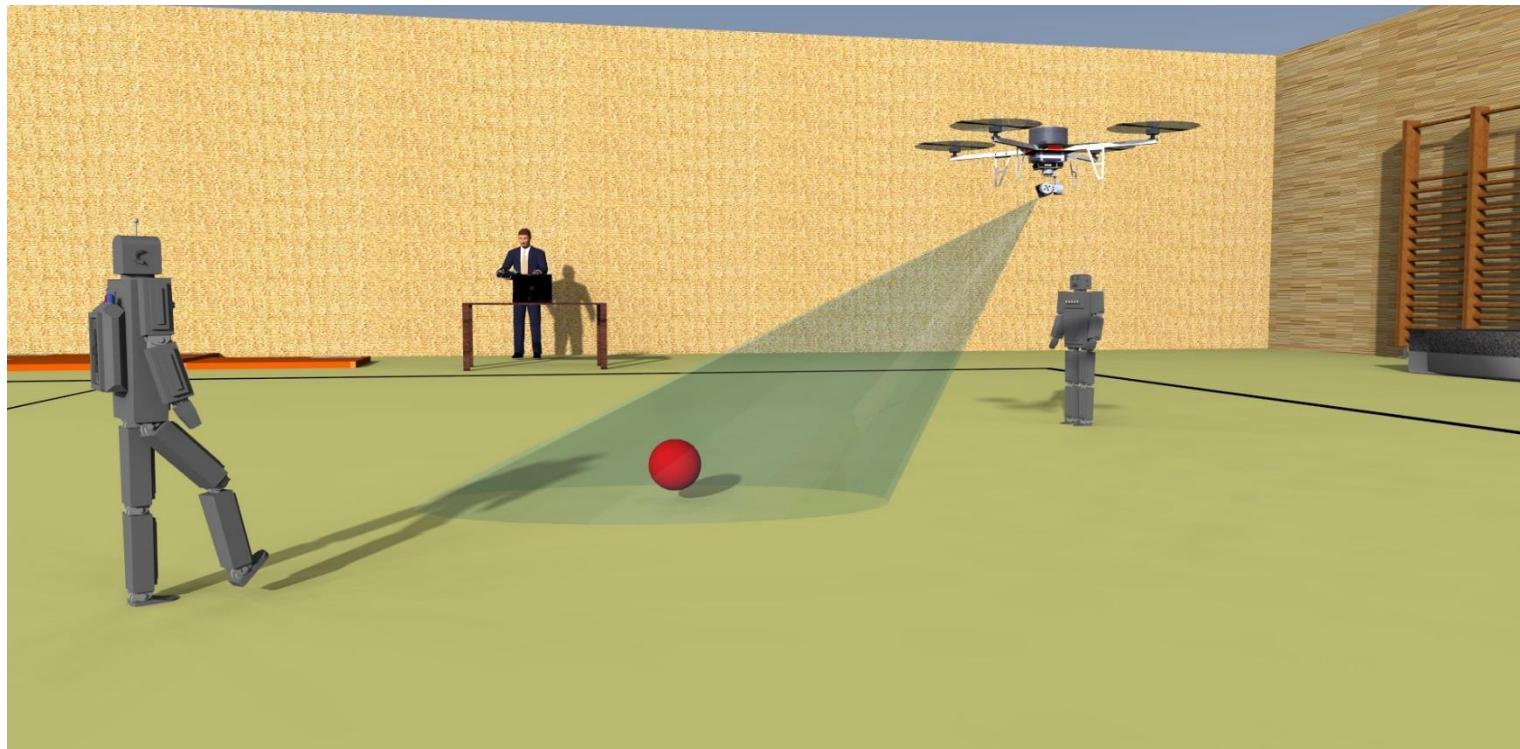


Avionics developed and  
assembled by Students of the  
University of Oldenburg



in their master's project group

## ► 4 Multi-rotor system's mixed-critical use-case

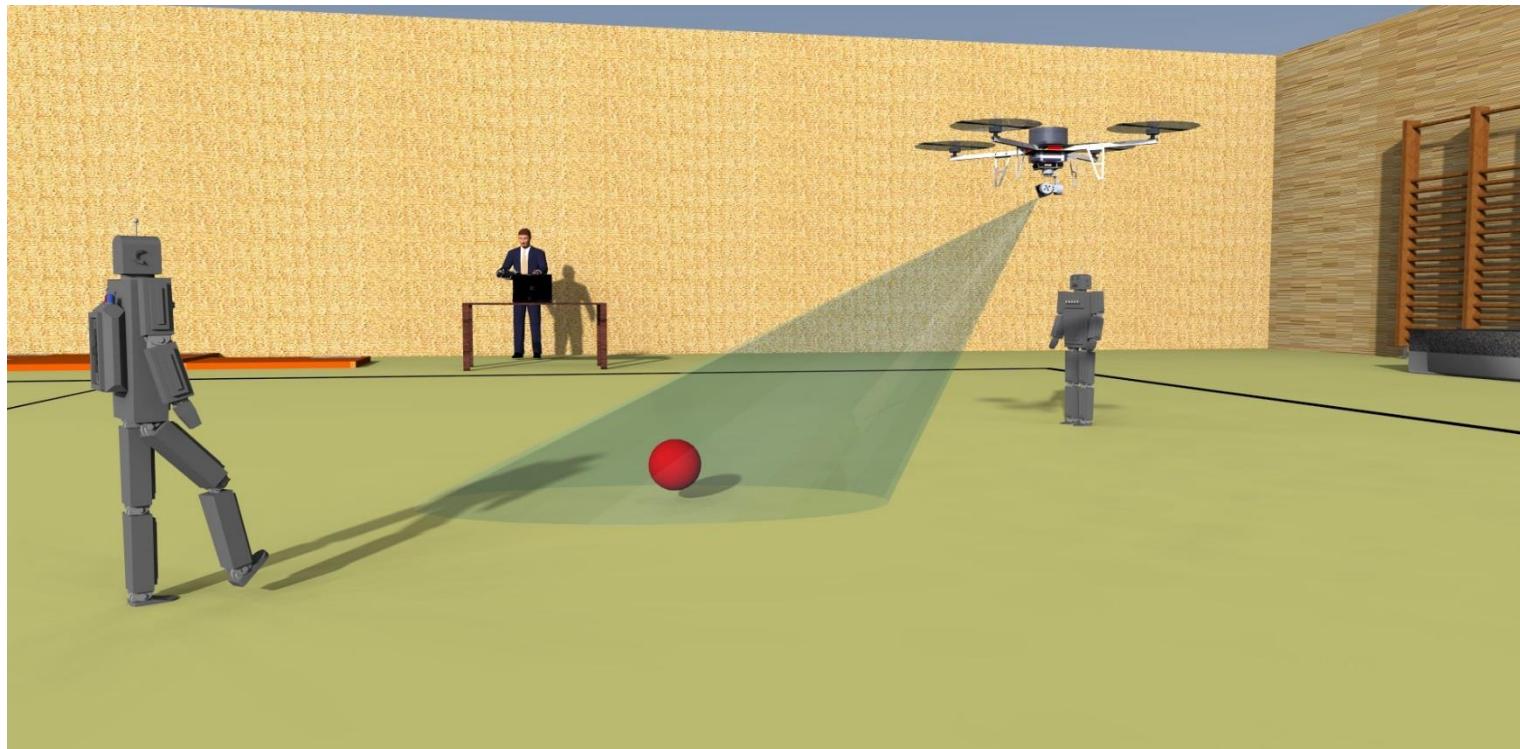


- Shoot robo soccer games with on-board camera
- Use of a single chip avionics based on Zynq 7020

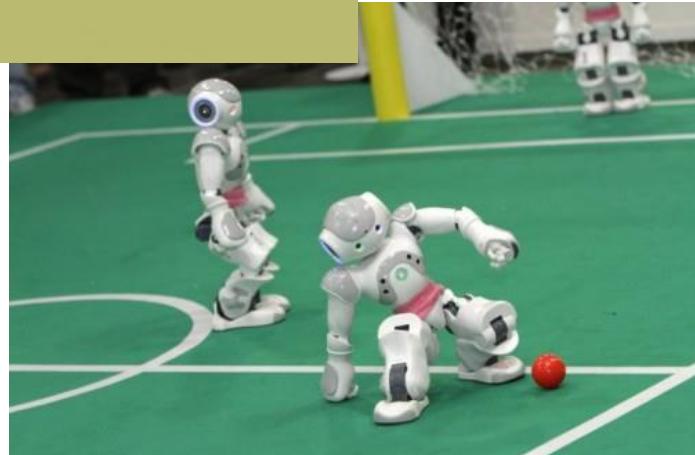


Source: [www.robocup2010.org](http://www.robocup2010.org)

## ► 4 Multi-rotor system's mixed-critical use-case

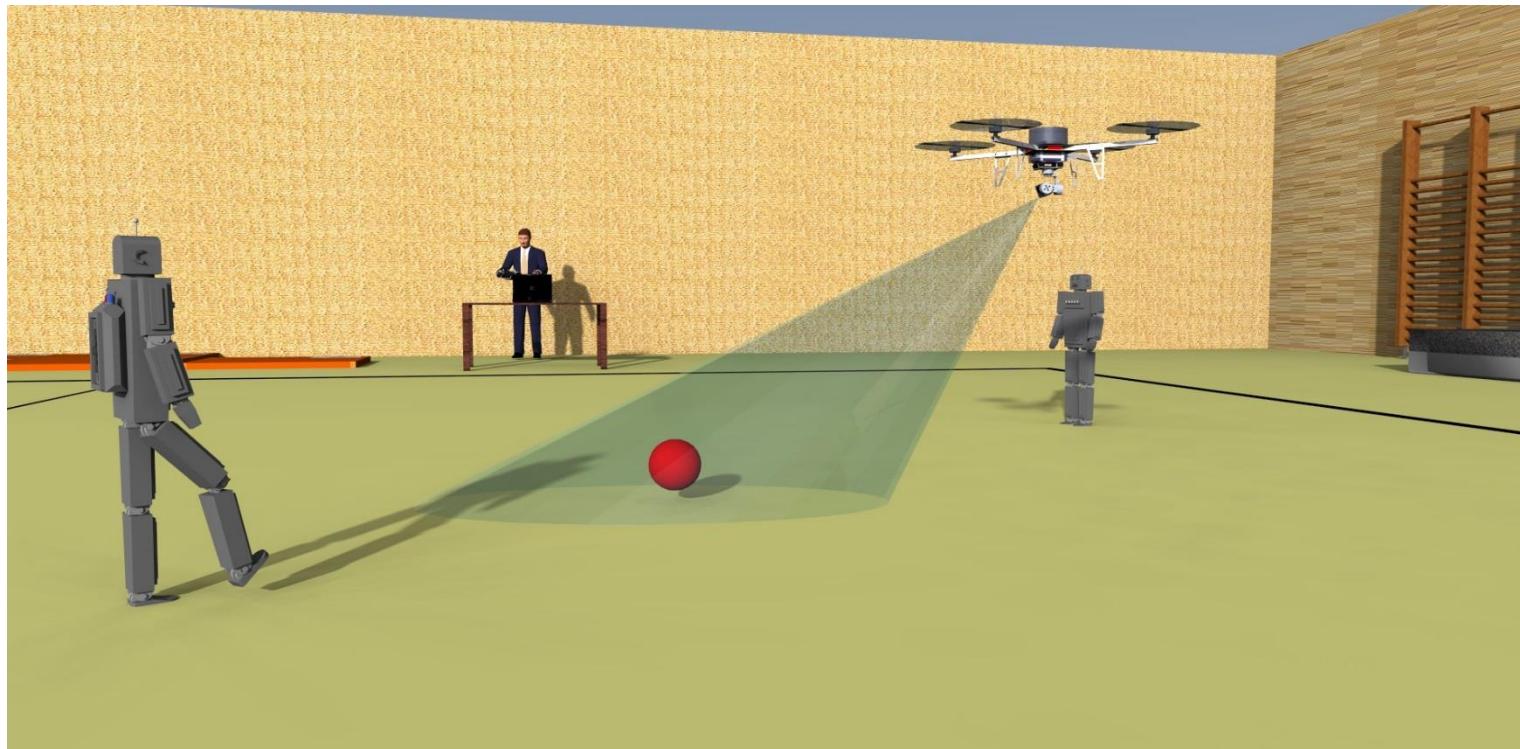


- ▶ Shoot robo soccer games with on-board camera
- ▶ Use of a single chip avionics based on Zynq 7020
- ▶ Two main tasks:

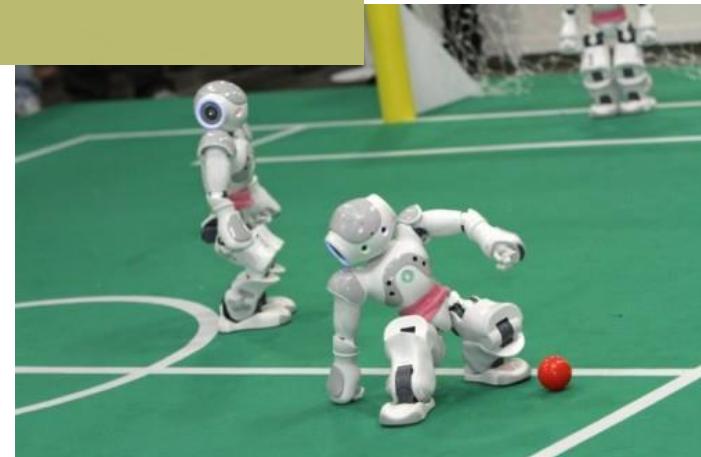


Source: [www.robocup2010.org](http://www.robocup2010.org)

## ► 4 Multi-rotor system's mixed-critical use-case



- ▶ Shoot robo soccer games with on-board camera
- ▶ Use of a single chip avionics based on Zynq 7020
  - ▶ Two main tasks:
  - ▶ 1. Flight algorithms (**safety-critical**)
  - ▶ 2. On-board video processing (**non-/mission-critical**)

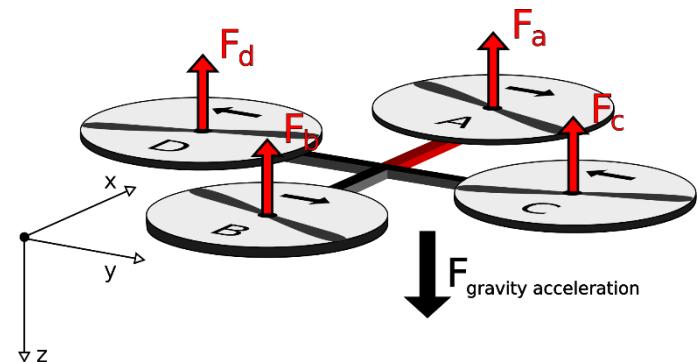


Source: [www.robocup2010.org](http://www.robocup2010.org)

## 5 Task description

### ► Safety-critical flight algorithms

- ▶ Sensor processing
- ▶ Remote control processing
- ▶ Attitude and altitude controller (standard PID)
- ▶ **Failure → System will crash**



### ► Non-/Mission-critical object detection

- ▶ Video grabbing from camera
- ▶ Object detection
- ▶ Adjustment of camera gimbal to follow object
- ▶ **Failure → Quality of Service**

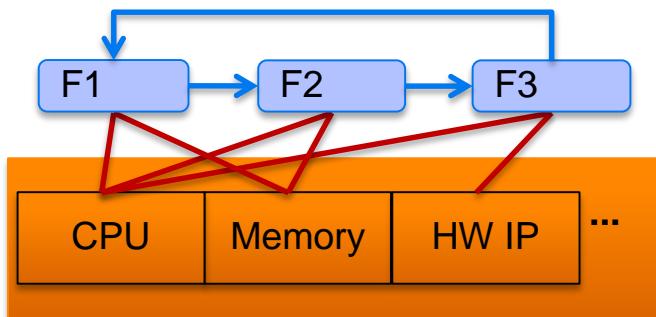


### ► Safety-critical task has to be separated by the architecture to avoid all influences through other tasks

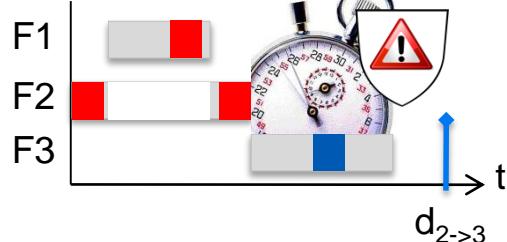
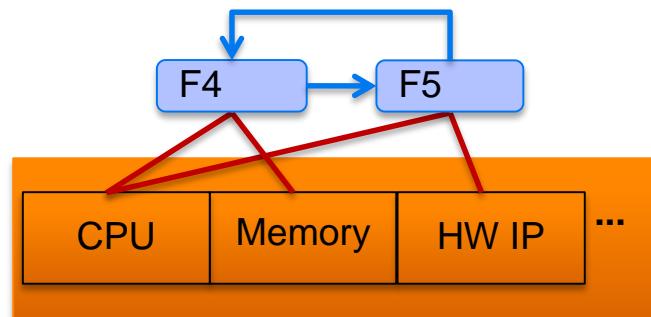
# 6 State-of-the-art mixed-critical system design

- ▶ Fully distributed with dedicated HW/SW platforms for different criticalities

## Safety-critical flight algorithms

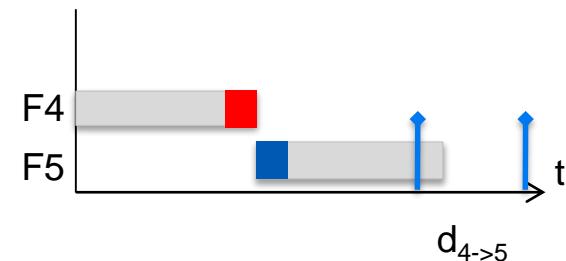


## Non-/Mission-critical object detection



Application 1

- Hard deadline  $d_{2 \rightarrow 3}$
- No power constraint
- No temperature constraint



Application 2

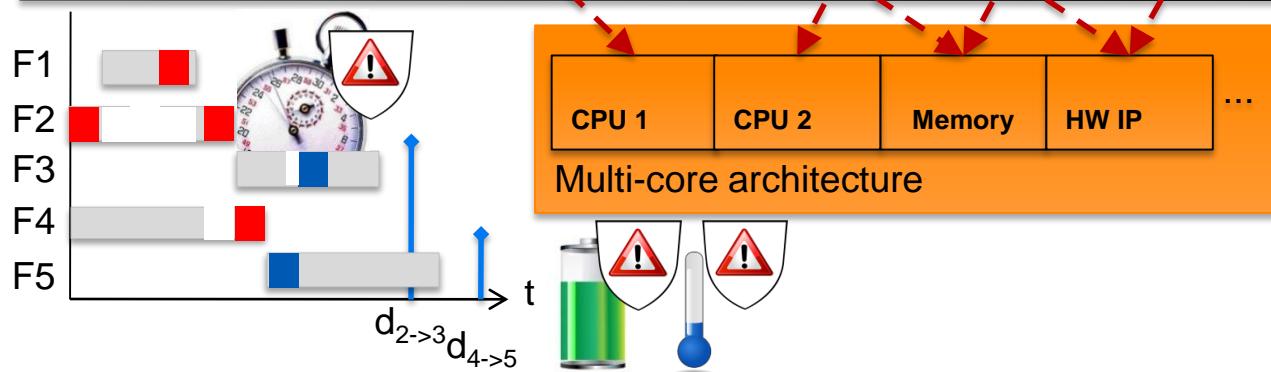
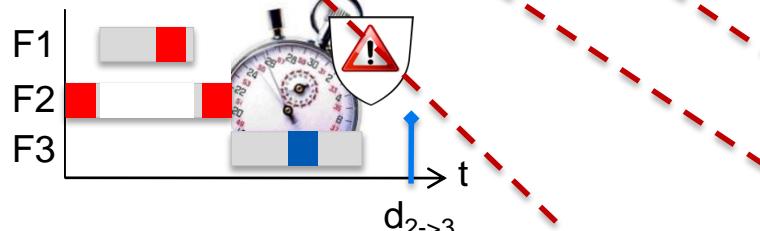
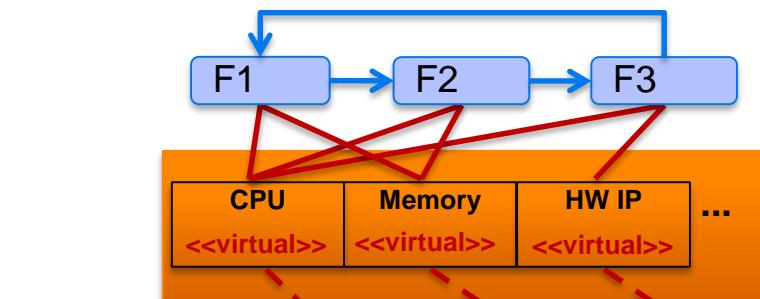
- Soft deadline  $d_{4 \rightarrow 5}$
- Hard power constraint
- Hard temperature constraint

- ▶ Extra-functional properties Timing, Power & Temperature

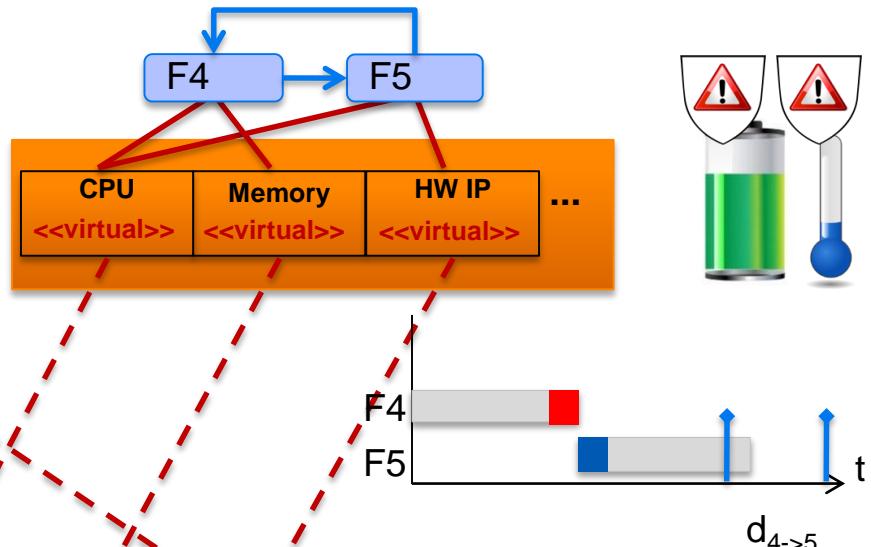
## 7 Mixed-critical system design

- Temporal, spatial, power and temperature segregation for mixed-critical control applications

### Safety-critical flight algorithms



### Non-/Mission-critical object detection



- running
- block/susp.
- shared var.
- comm.

# 8 Xilinx Zynq 7020 overview

## ► Processing System

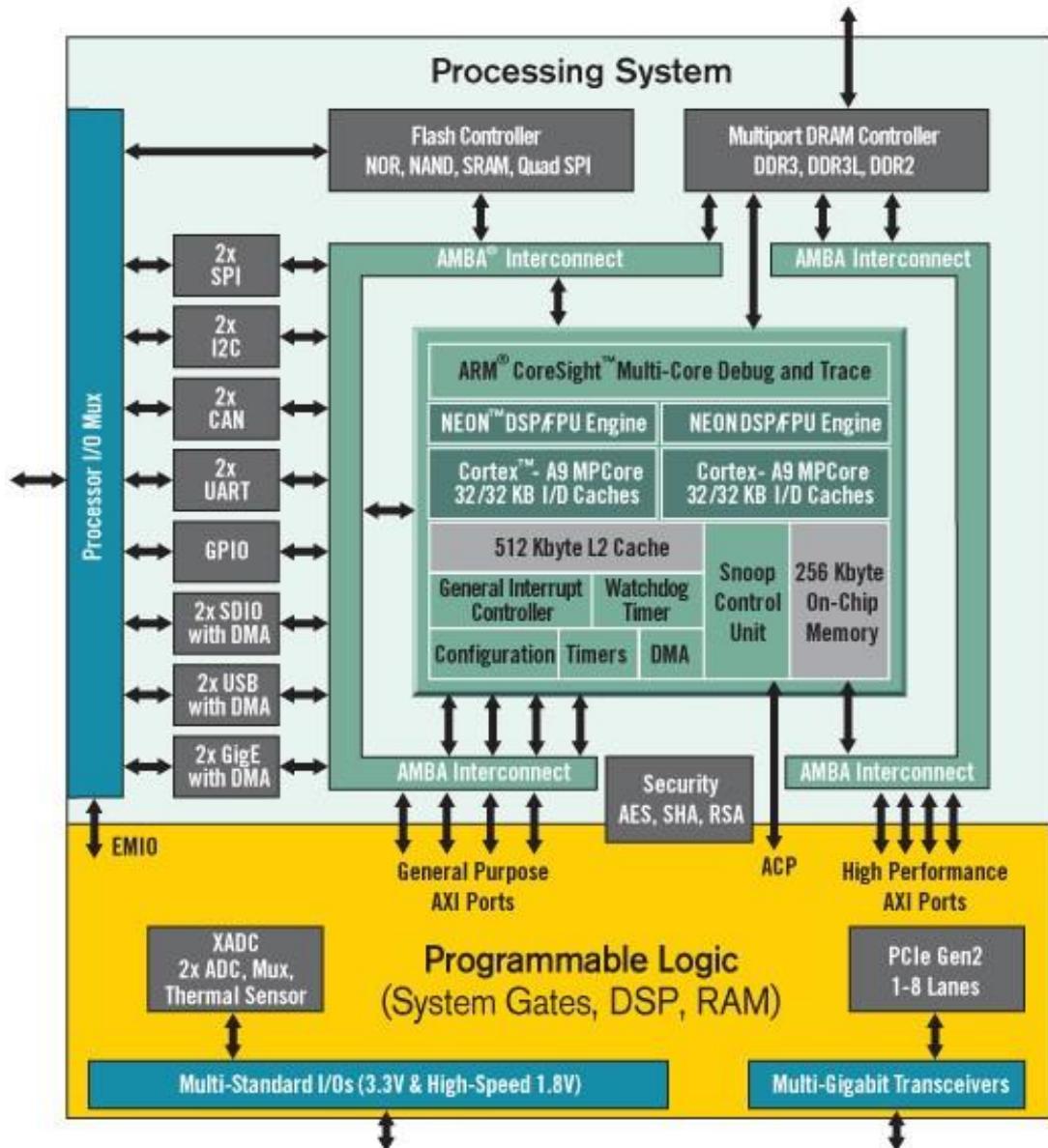
- ▶ Dual ARM Cortex A9
- ▶ 866MHz
- ▶ Standard interfaces available

## ► Programmable Logic

- ▶ Implementing own or IP hardware (further needed interfaces, processing elements, etc.)
- ▶ 85.000 Logic Cells

## ► Great for exploring architectures for mixed-criticality systems in consideration of extra-functional properties

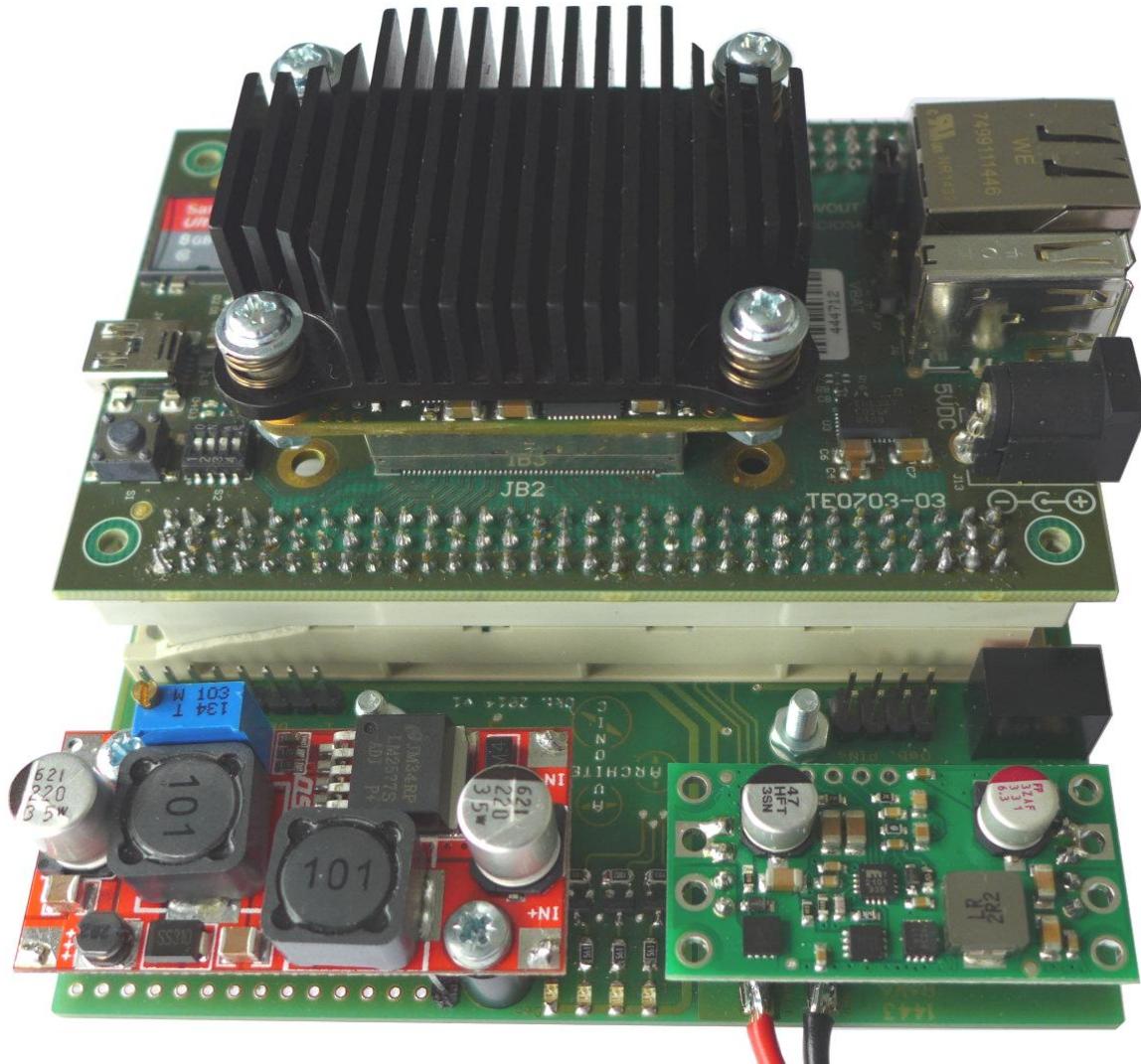
- ▶ (Near future: Zynq UltraScale+)



Source: [www.xilinx.com](http://www.xilinx.com)

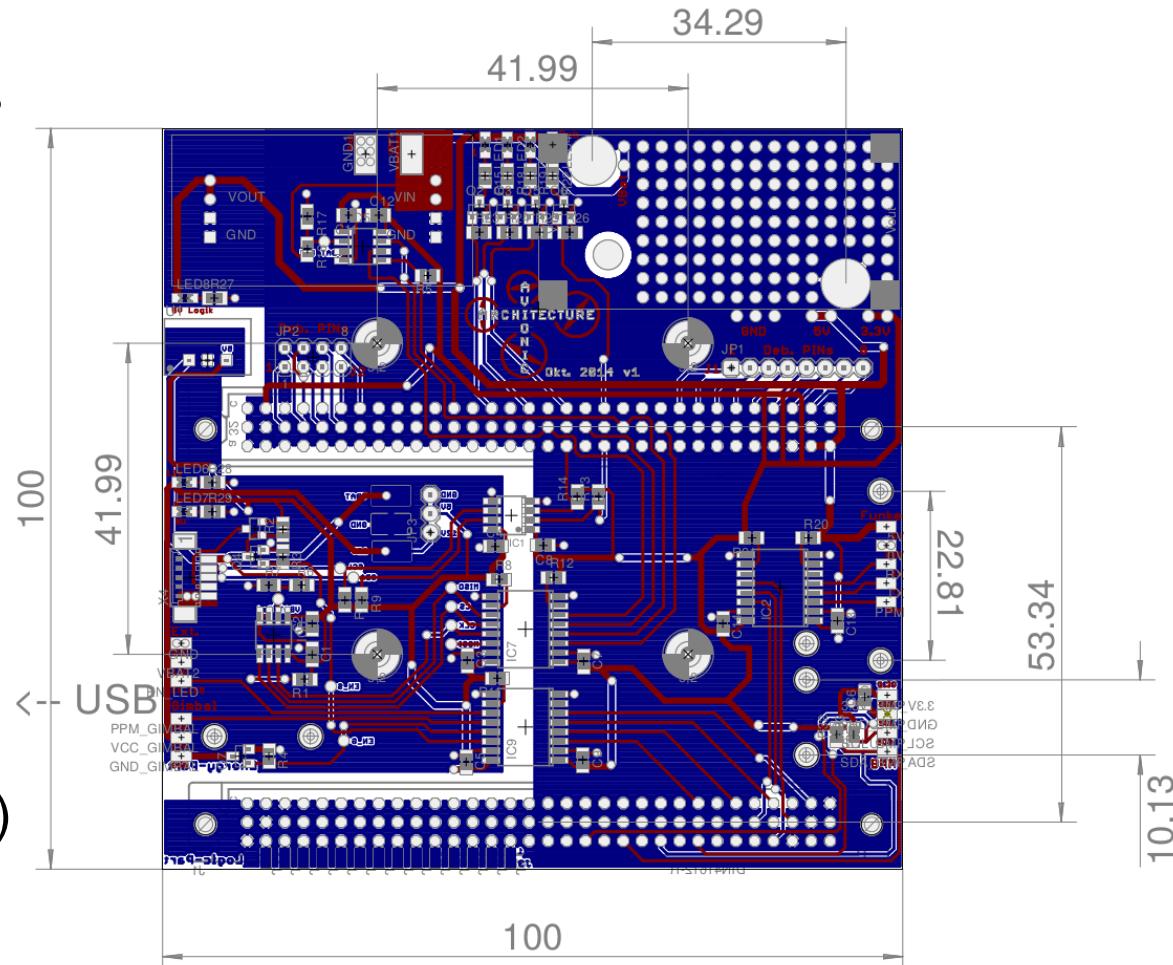
# 9 Avionics HW-architecture top-down

- ▶ Zynq industry board mounted on top of avionics
- ▶ Distribution board allows
  - ▶ Direct connection to sensors (accelerometers, gyroscopes, magnetometer, barometer)
  - ▶ Direct connection to motor drivers
  - ▶ Etc.
- ▶ Separation in two power domains (motor & avionics)
  - ▶ Since motors introduce much noise on the power lines
  - ▶ Avoid failure of Zynq

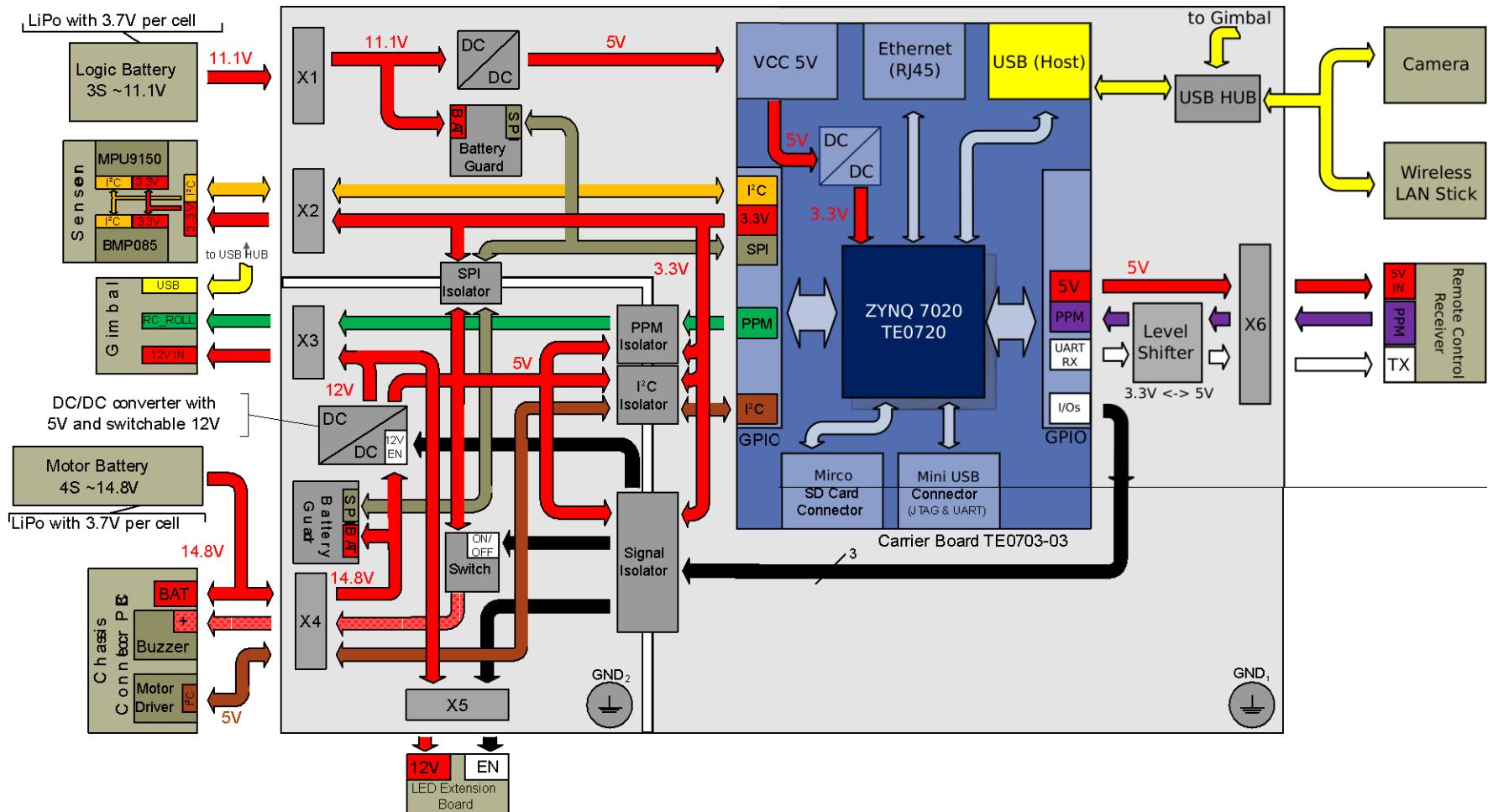


## 9 Avionics HW-architecture top-down

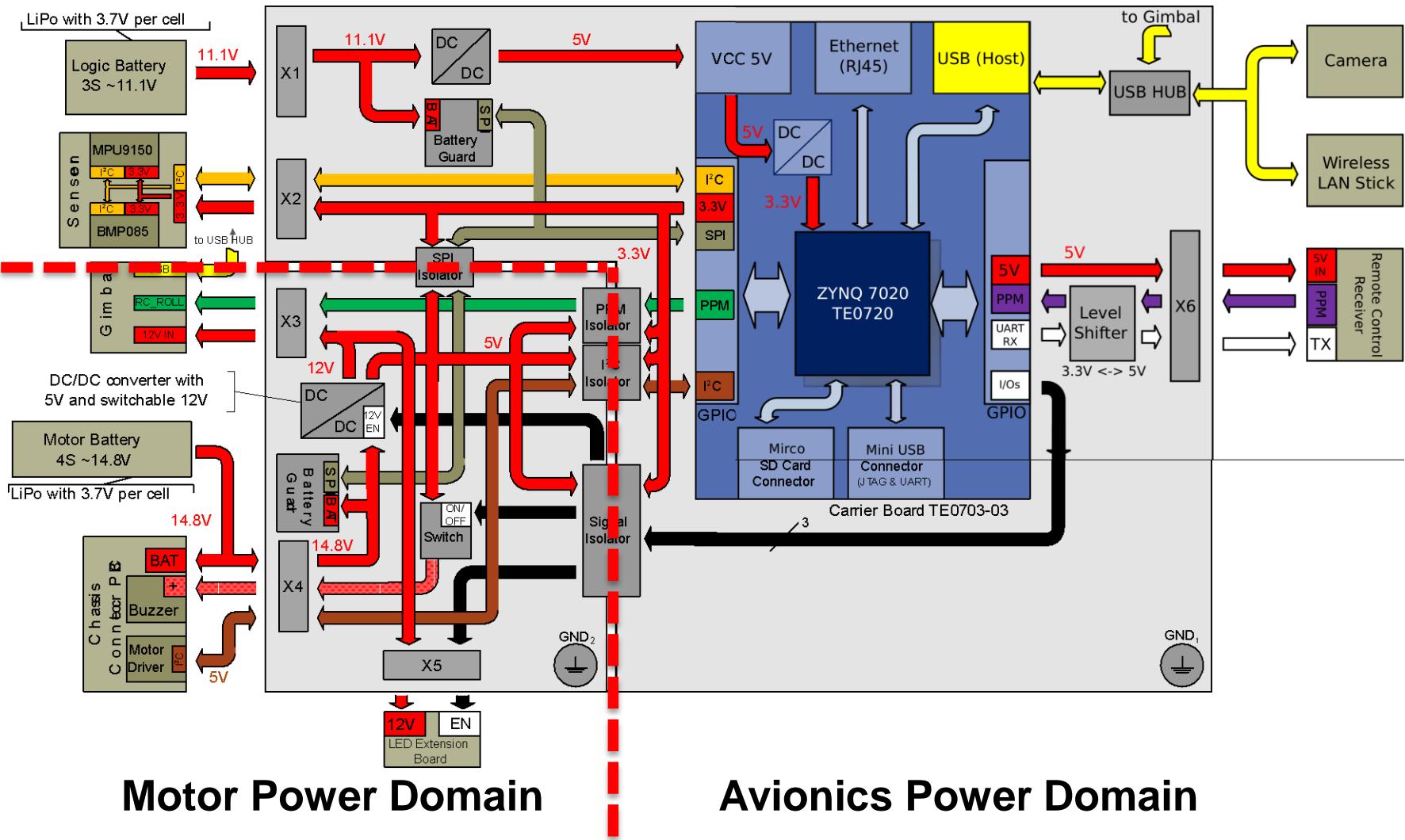
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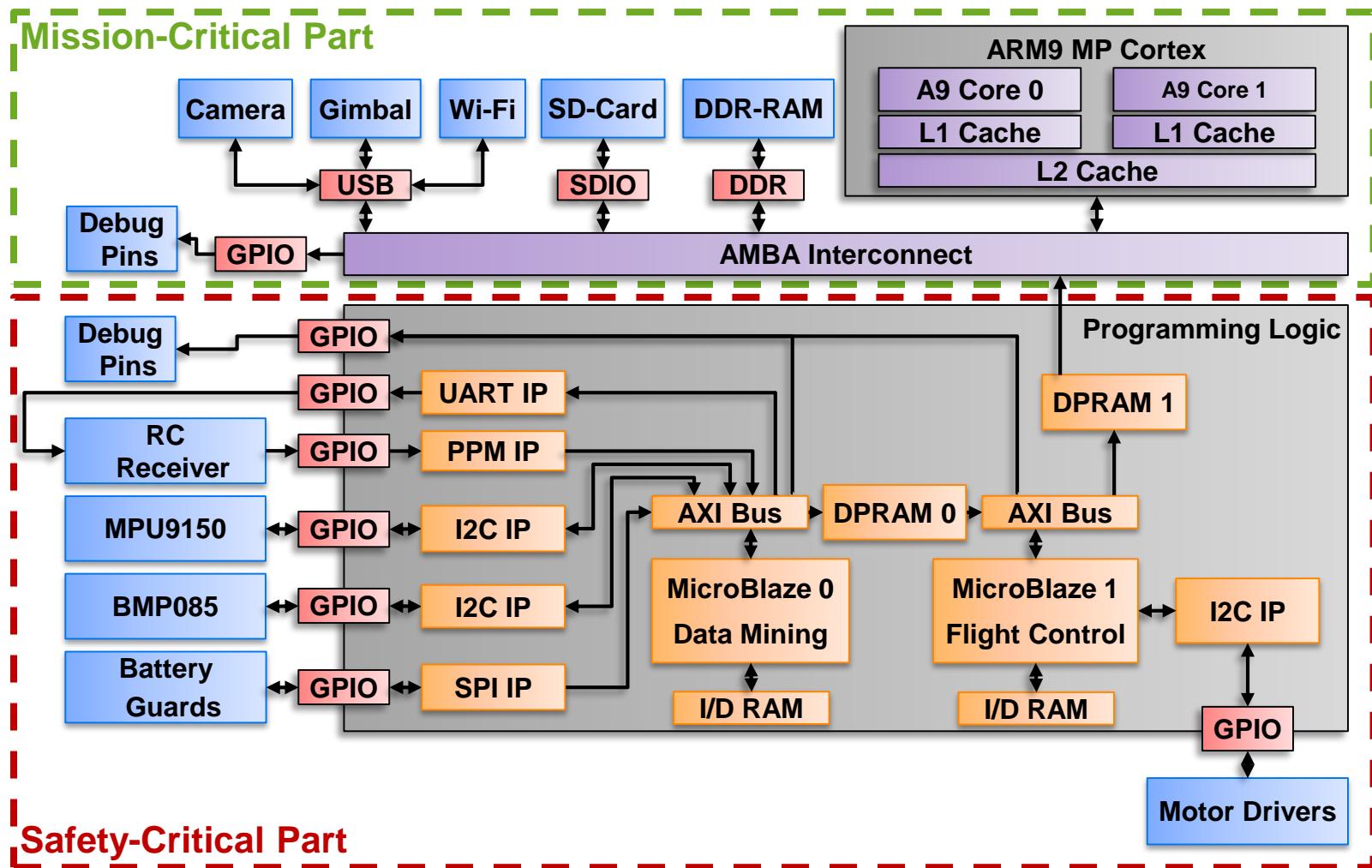
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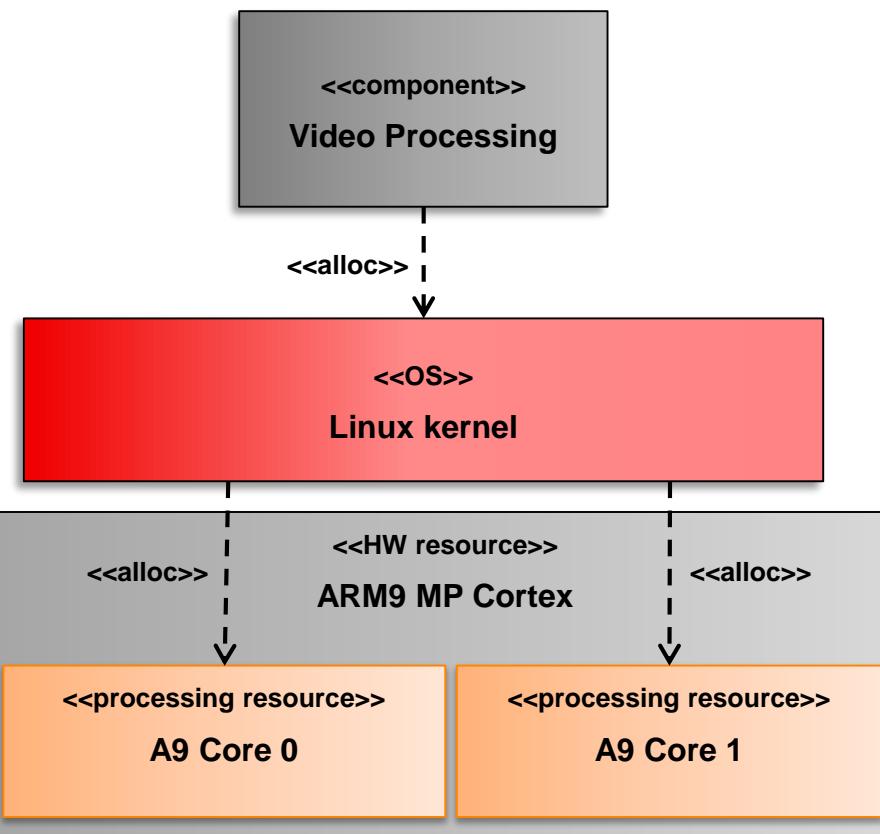
**Motor Power Domain**

**Avionics Power Domain**

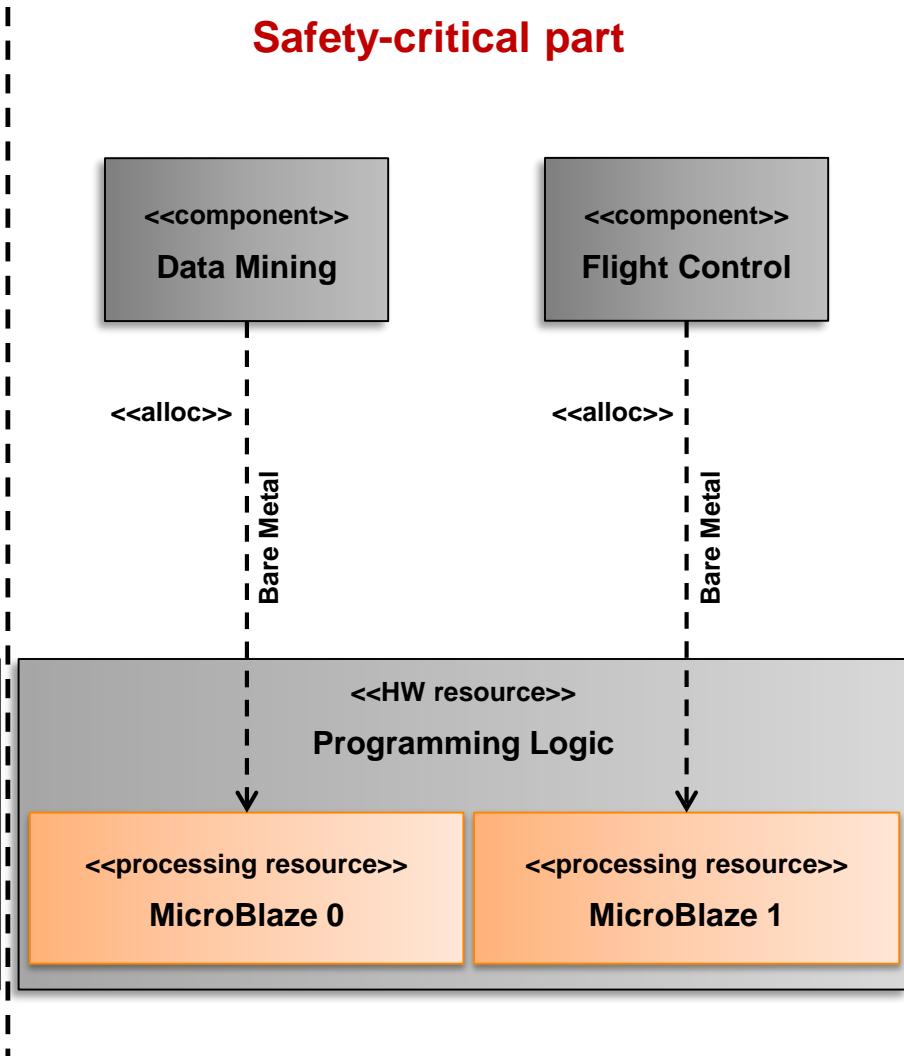
# 9 Avionics HW-architecture top-down



## Non/Mission-critical part



## Safety-critical part



# Thank you! Any questions?

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