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# ROBOTIZED SERVING OF AUTOMATED WAREHOUSE

TRINITY Use Case demonstration by BME

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[www.trinityrobotics.eu](http://www.trinityrobotics.eu)

# Agenda

- Introduction
- System design
- Hardware infrastructure
- Software infrastructure
- Cyber-security
- Mobile robot motion control module

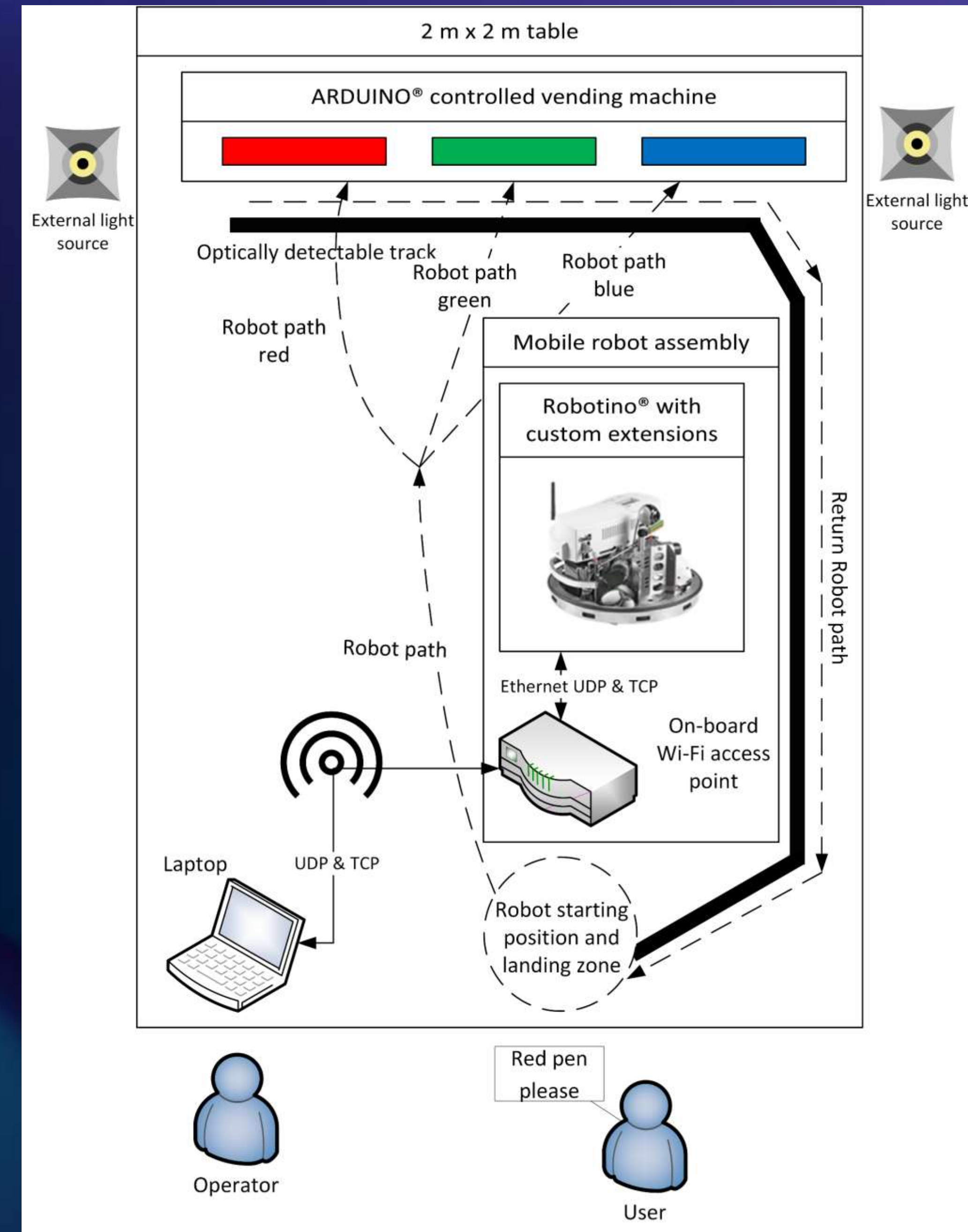
# Introduction

- Fully functional, scaled-down, table-top model of an automated warehouse served by an omnidirectional mobile robot.
- Used as an attraction in exhibitions.
- The goal is to demonstrate the capabilities of mobile robots in intralogistics.



# System design

- Based on an omnidirectional mobile robot equipped with three omni-wheels.
  - Kiwi drivetrain
- The automated warehouse is modeled by a pen vending machine operated by a microcontroller.
- The vending machine has 3 slots for holding 3 differently colored pens
- Serving one pen at a time.



# Hardware infrastructure

- FESTO Robotino®
- Uniquely designed parts
  - Workpiece tray,
    - Bent sheet metal part accommodating the workpiece during the wending process.
  - ARDUINO® controlled vending machine,
  - Proximity switch holder,
    - Bent sheet metal part holding in place a factory standard optical proximity switch accessory to detect the proximity of the wending machine during the final approach.
  - Optically detectable path
    - Painted or glued tape.
- Commercially available parts
  - 4 m<sup>2</sup> wooden flooring,
  - Two standard light sources on a tripod,
  - Laptop with Microsoft Windows® operating system.

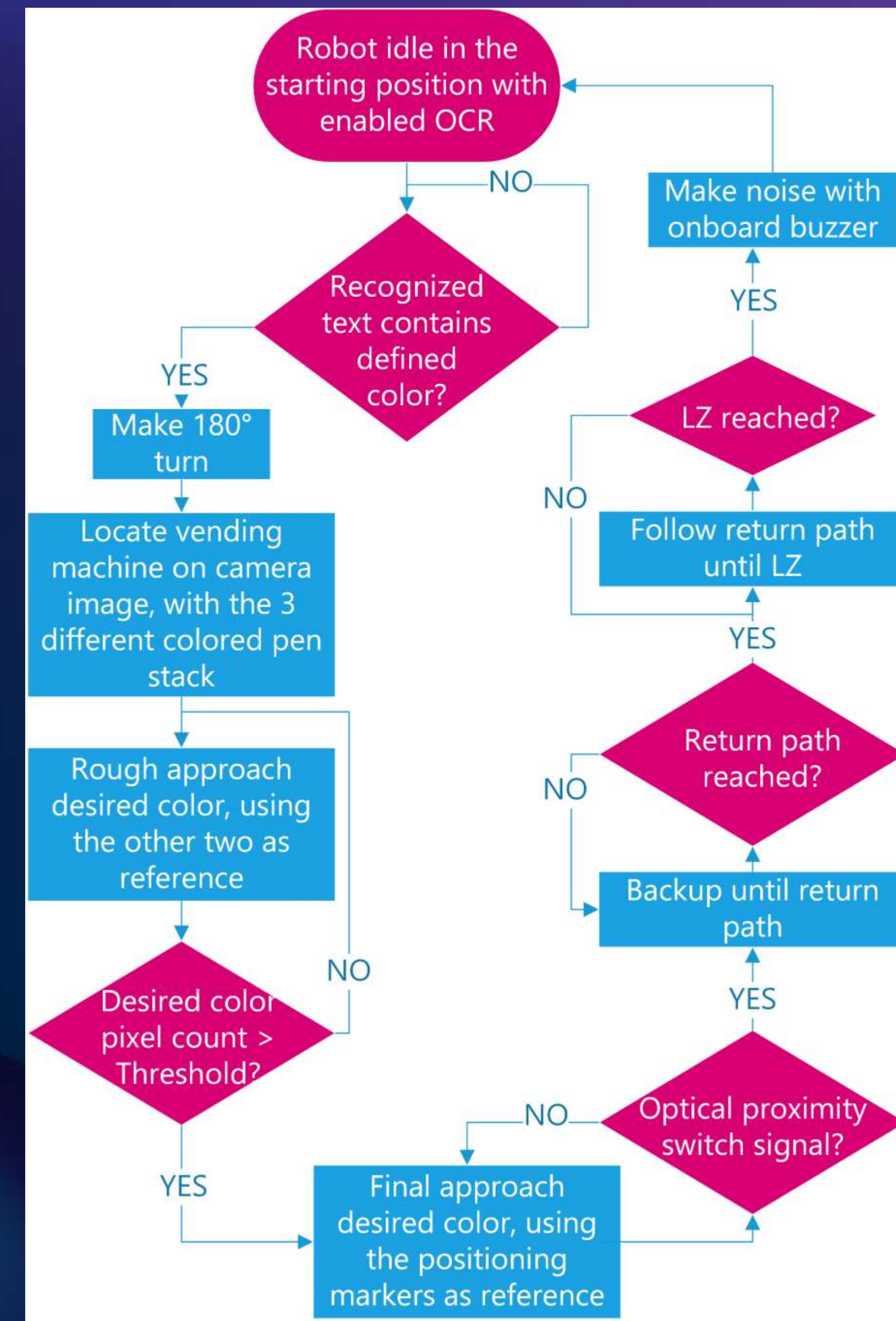




# Software infrastructure

- The complete robot control software is made with National Instruments LabVIEW™ graphical programming language

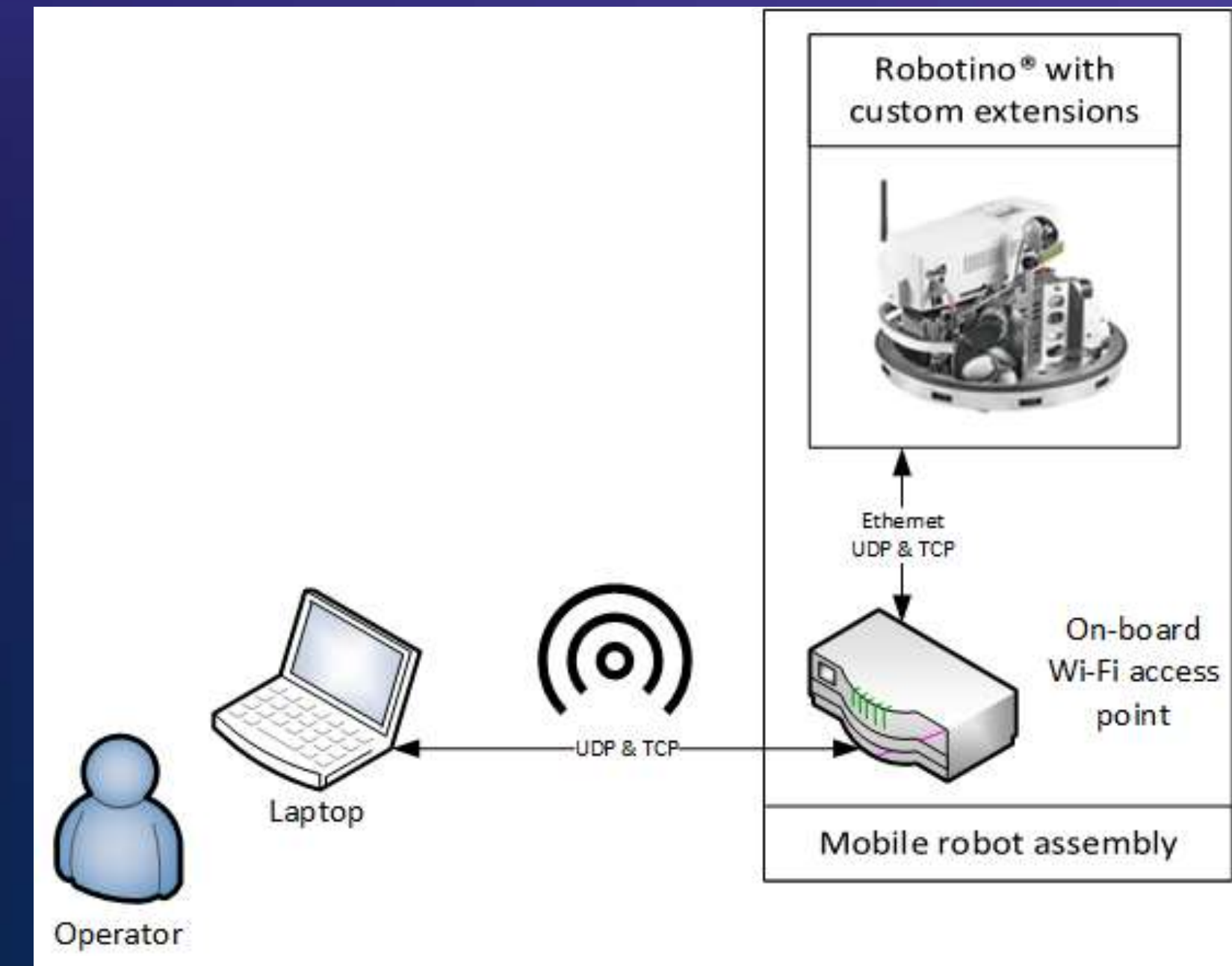
Legal disclaimer: LabVIEW™ is a trademark of National Instruments. This publication is independent of National Instruments, which is not affiliated with the publisher or the author, and does not authorize, sponsor, endorse or otherwise approve this publication.





# Cyber-security

- Closed system with no need for access to the internet.



Vulnerabilities	Mitigation
Control laptop security: if the laptop is online for any reason	Completely prevent control laptop internet access
Wireless encryption	Already has WEP, will be changed to WPA
Wireless router security key issue	MAC address filtering on the wireless network. AP only accepts allowed MAC addresses
Interference caused to wireless communication	
DHCP service	Disabling the DHCP server, only fix IP addresses will be allowed
The qDSA protocol is open source and publicly available	
No encryption implemented in the qDSA protocol	
The mobile robot enables a secondary connection in spectator mode and sends the camera image and feedback messages to the spectator	

# Offered Modules

- Queued Message Handler (QMH) software architecture
- Robotino<sup>®</sup> communication
- Environment detection
- Mobile robot motion control

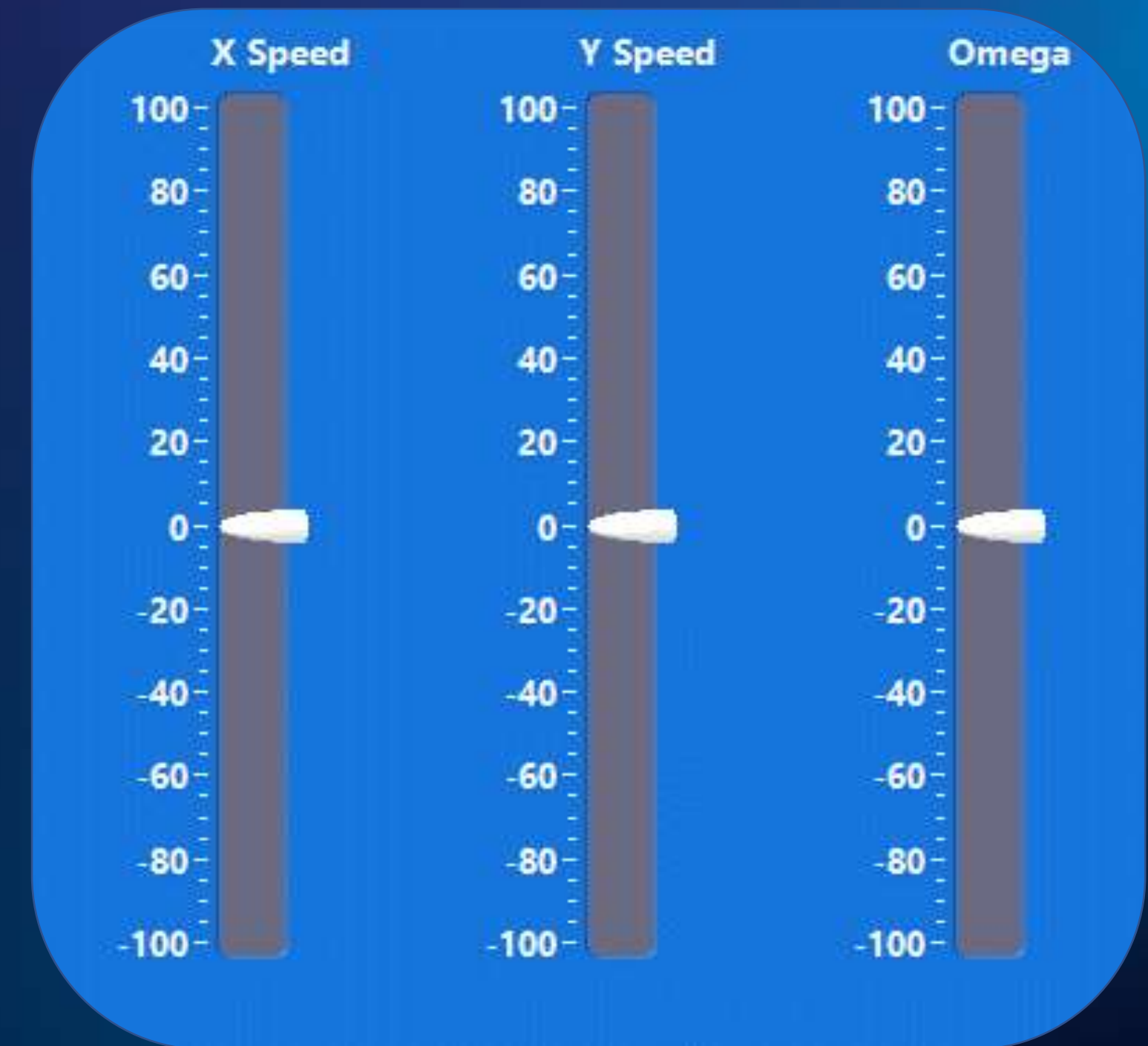
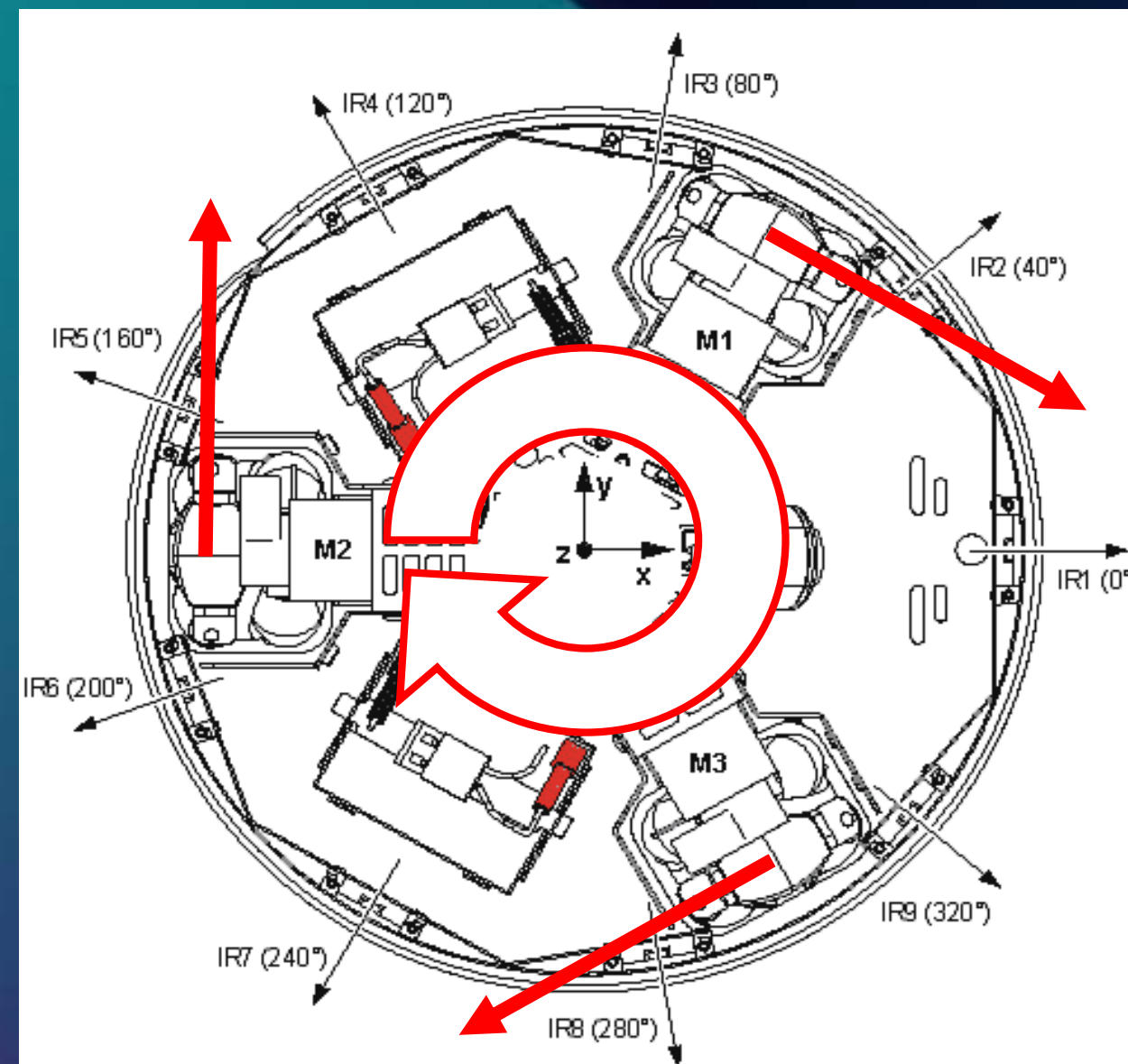
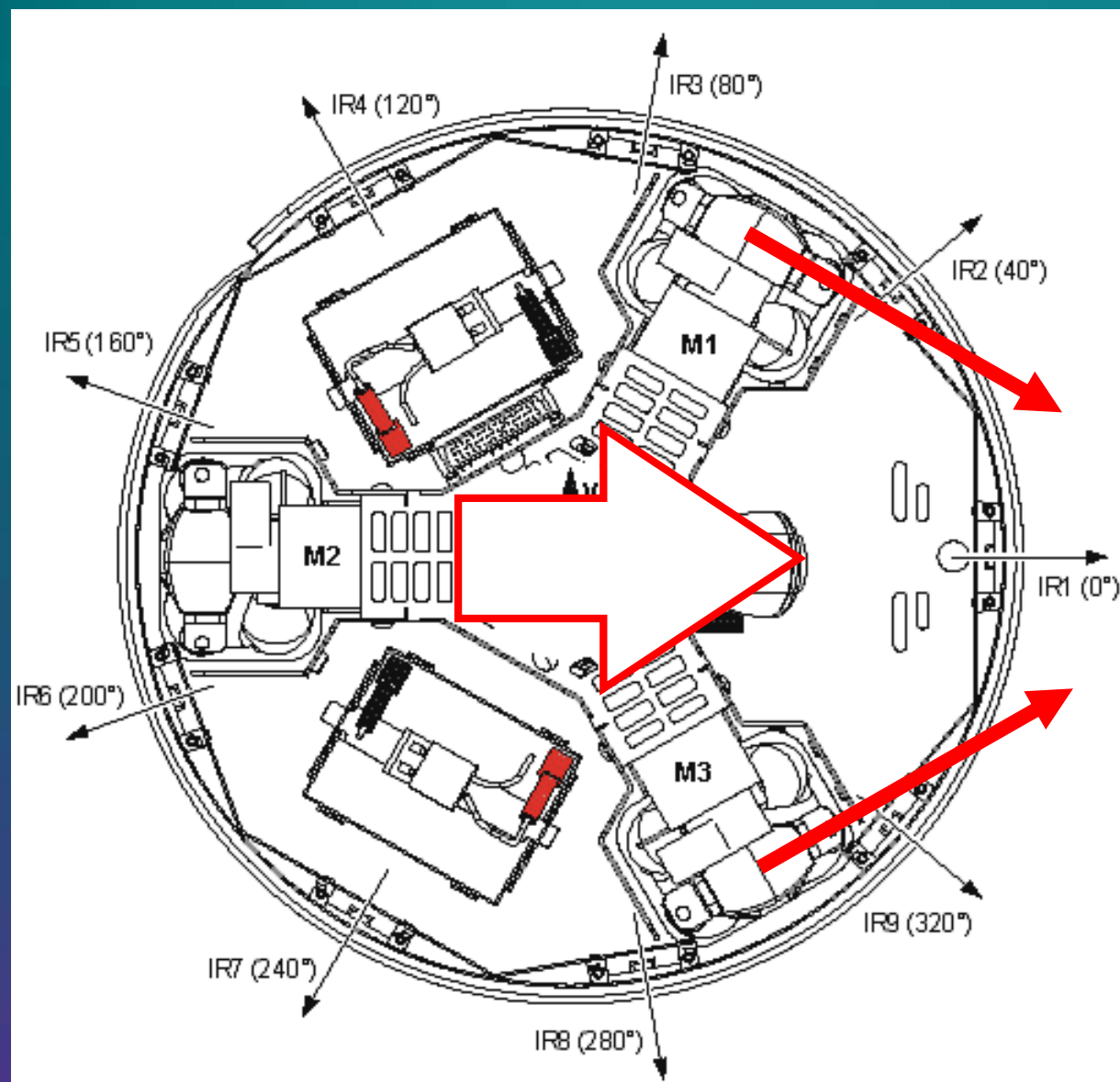


# Availability of Modules

- The Modules are available both in source code and as a standalone desktop application.
- Licensing
  - During TRINITY
    - GNU GPL v3 excluding LabVIEW
  - After TRINITY
    - For Open-Source projects
      - GNU GPL v3 excluding LabVIEW
    - For commercial applications
      - Availability and usage are based on a commercial license agreement with BME.

# Mobile robot motion control module

- Open-loop motion control
  - Perform different pre-programmed or time-controlled movement patterns





# Mobile robot motion control module

- Machine vision-based closed-loop motion control
  - Implement closed-loop motion control algorithms based on machine vision calculations executed on images



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## Thank you!

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