Metacontrol for ROS2 Systems

Carlos Hernandez, TU Delft

ROS-Industrial Conference

December 10 2019, Stuttgart

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Autonomous robots

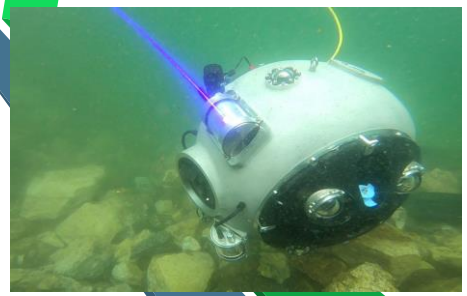
RobMoSys

Wizards of ROS: Willow Garage and the Making of the Robot Operating System

How a small band of Silicon Valley engineers started a global robotics revolution

By Evan Ackerman and Erico Guizzo — IEEE SPECTRUM

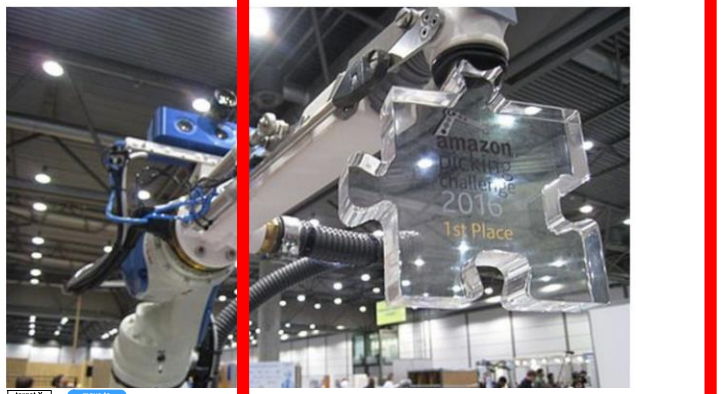
ROS.org

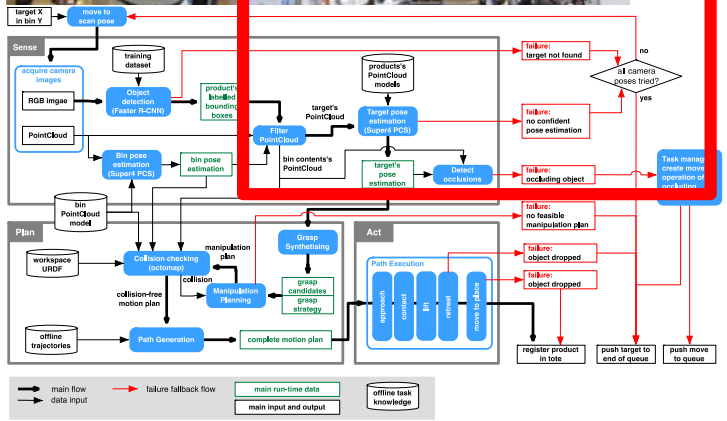


Team Delft Wins Amazon Picking Challenge

Year two of the Amazon Picking Challenge results in robots that are much, much closer to taking over for humans

By Evan Ackerman — IEEE SPECTRUM





Why Robots and Humans Struggled with DARPA's Challenge

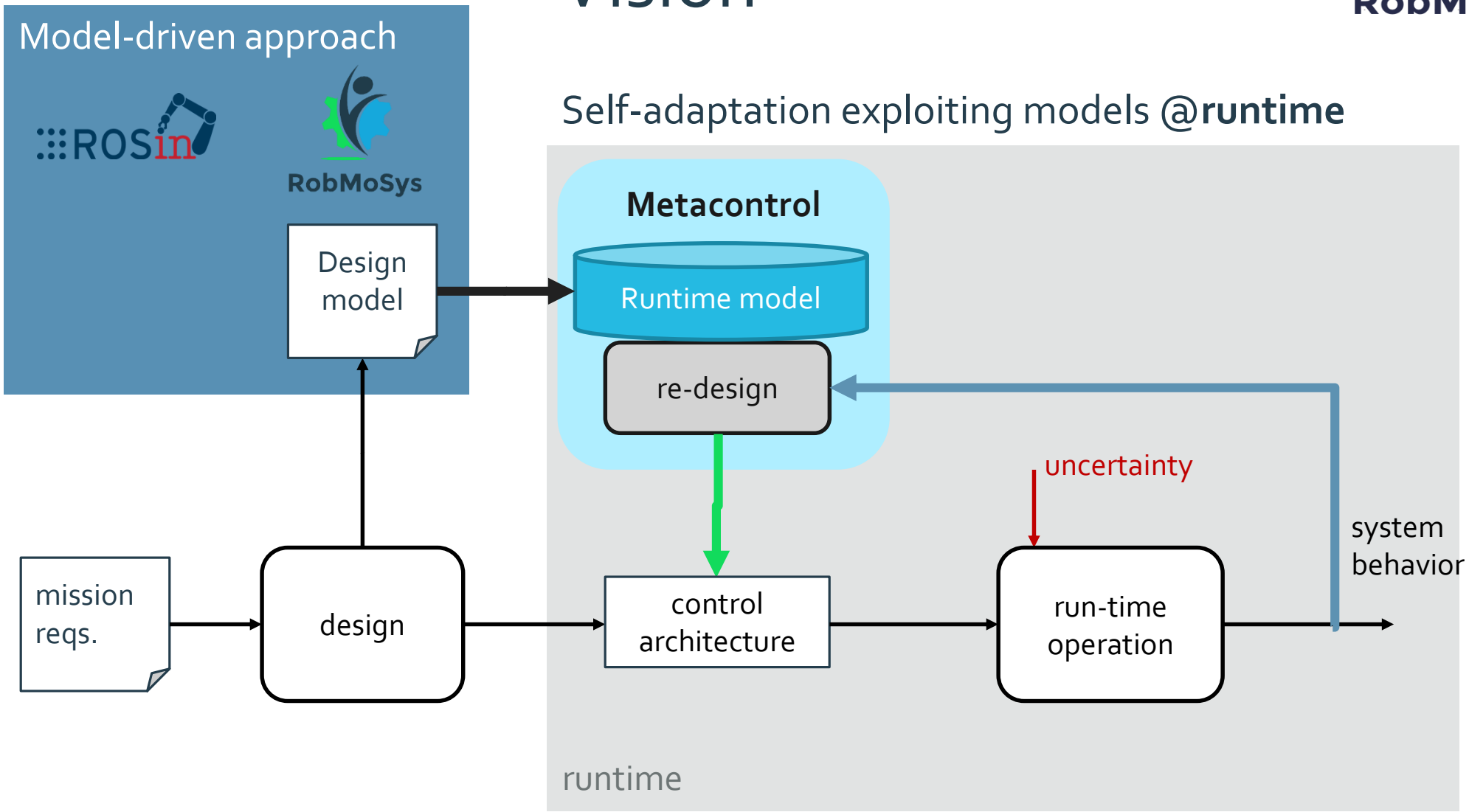
MIT Technology Review

From Kohlbrecher et al. Human-robot teaming for rescue missions: Team ViGIR's approach to the 2013 DARPA Robotics Challenge trials. Journal of Field Robotics, 32(3):352–377, 2015.

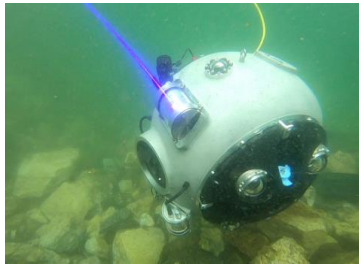
Outline

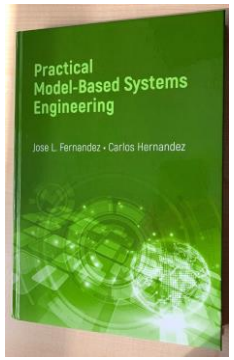
1. *Vision*
2. *Objectives*
3. *Approach*

Vision


Model-driven approach
ROSin
RobMoSys
Design model
Self-adaptation exploiting models @**runtime**
Metacontrol
Runtime model
re-design
uncertainty
system behavior
mission reqs.
design
control architecture
run-time operation
runtime

References

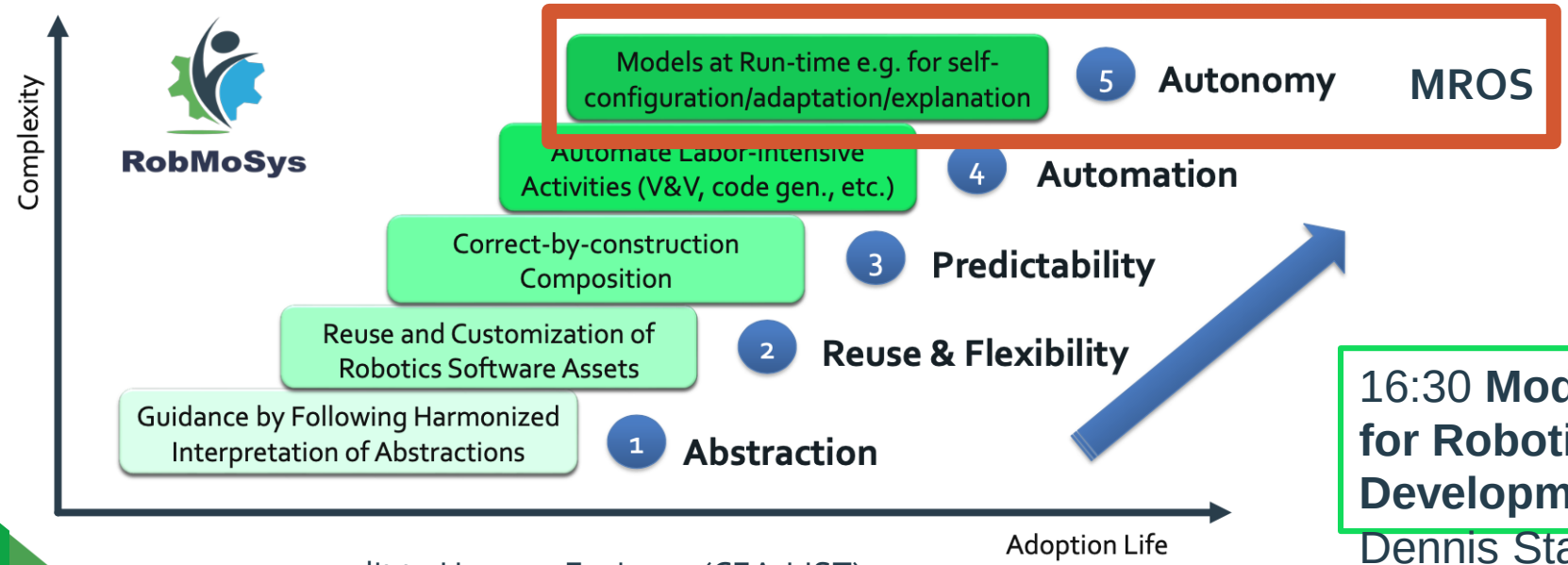




- C. Hernandez et al. *A self-adaptation framework based on functional knowledge for augmented autonomy in robots*. Integrated Computer-Aided Engineering, 2018.
- C. Hernandez et al. *Meta-control and self awareness for the ux-1 autonomous underwater robot.* In Fourth Iberian Robotics Conference, ROBOT'19
- J. L. Fernandez-Sanchez and C. Hernandez. *Model-based Systems Engineering. A practical approach with examples. 2019*

MROS: a **RobMoSys** Integrated Technical Project

- MROS: **Towards an EU Industrial Digital Platform for Robotics**
  - Partners from EU projects ROSIN and OFERA, funded and coached by RobMoSys
- **RobMoSys**: Composable Models and Software for Robotic Systems
- RobMoSys **Model-Driven Approach**



credit to Huascar Espinoza (CEA-LIST)

16:30 **Modeling and Tooling for Robotics Software Development**
Dennis Stampfer, HS Ulm

Objectives

O1: meta-modeling solution for **reliable** robot skills through **architectural adaptation** @**runtime** with clear separation of concerns for task, contingency and system handling.

O2: Implementation for the **ROS2 Navigation** in an industrial pilot case.

O3: Demonstrate the value of **ontologies** for reasoning with **models@runtime** in the context of RobMoSys.

Pilots: **Navigation**

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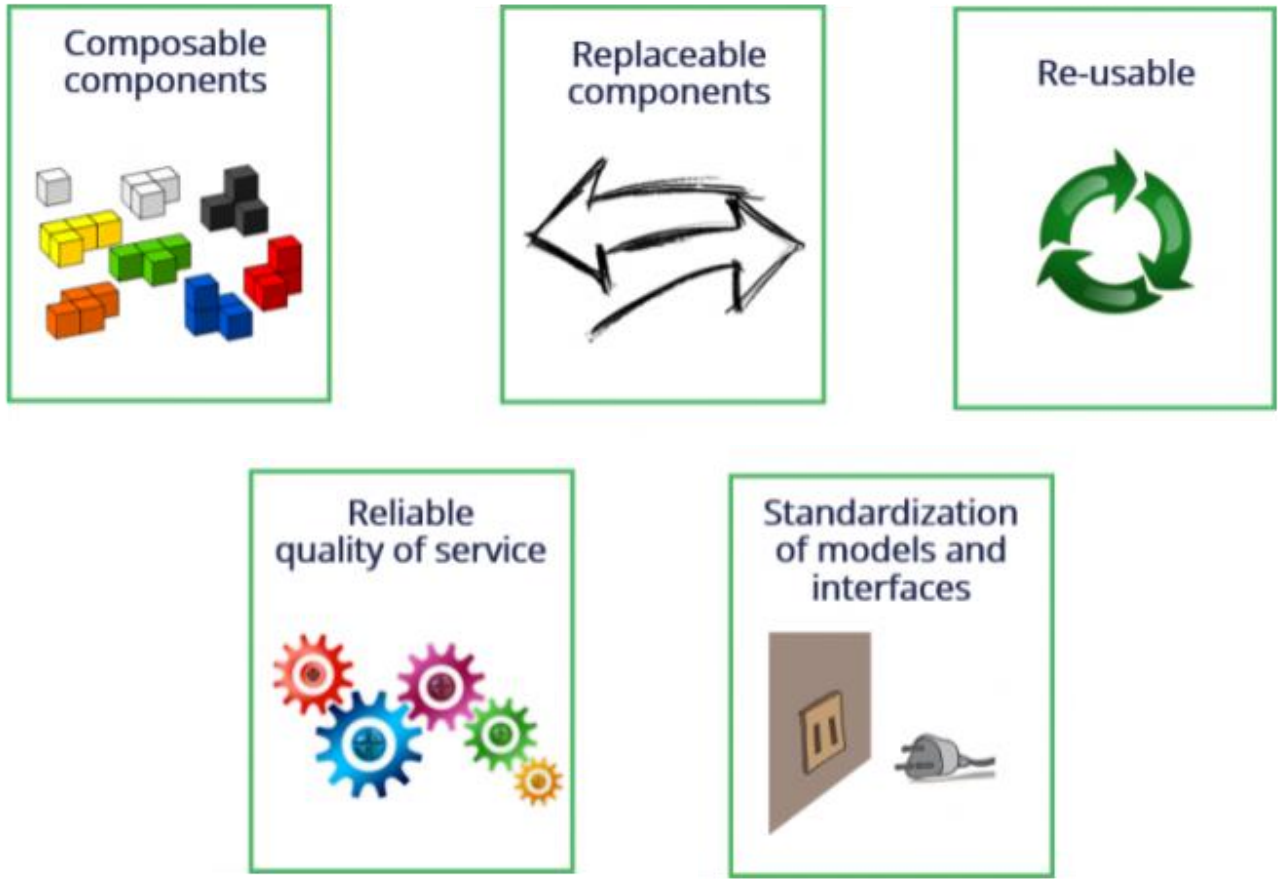
- **ROS2** Navigation stack
- **Two platforms -** varying task requirements: *transport*, *approaching*, *exploration*…
- Improved **reliability** and **autonomy**

BOSCH

consumer mobile robot prototype

Impact


Composable components
Replaceable components
Re-usable
Reliable quality of service
Standardization of models and interfaces

KPIs

- KPOs: system **availability**, engineering **effort**, **cost** and **time** and platform **evolvability**.
- **KPI 1:** System reliable autonomy level
- **KPI 2:** Effort to develop an autonomous application
- **KPI 3:** Re-usability
- **KPI 4:** Extensibility
- **KPI 5:** Suitability of ontologies for RobMoSys metamodeling

Approach

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Meta-models

RobMoSys Task-plot metamodel

MROS TOMASys metamodel

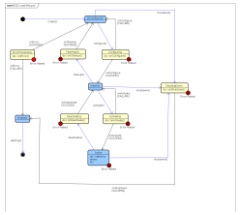
System Modes from micro-ROS

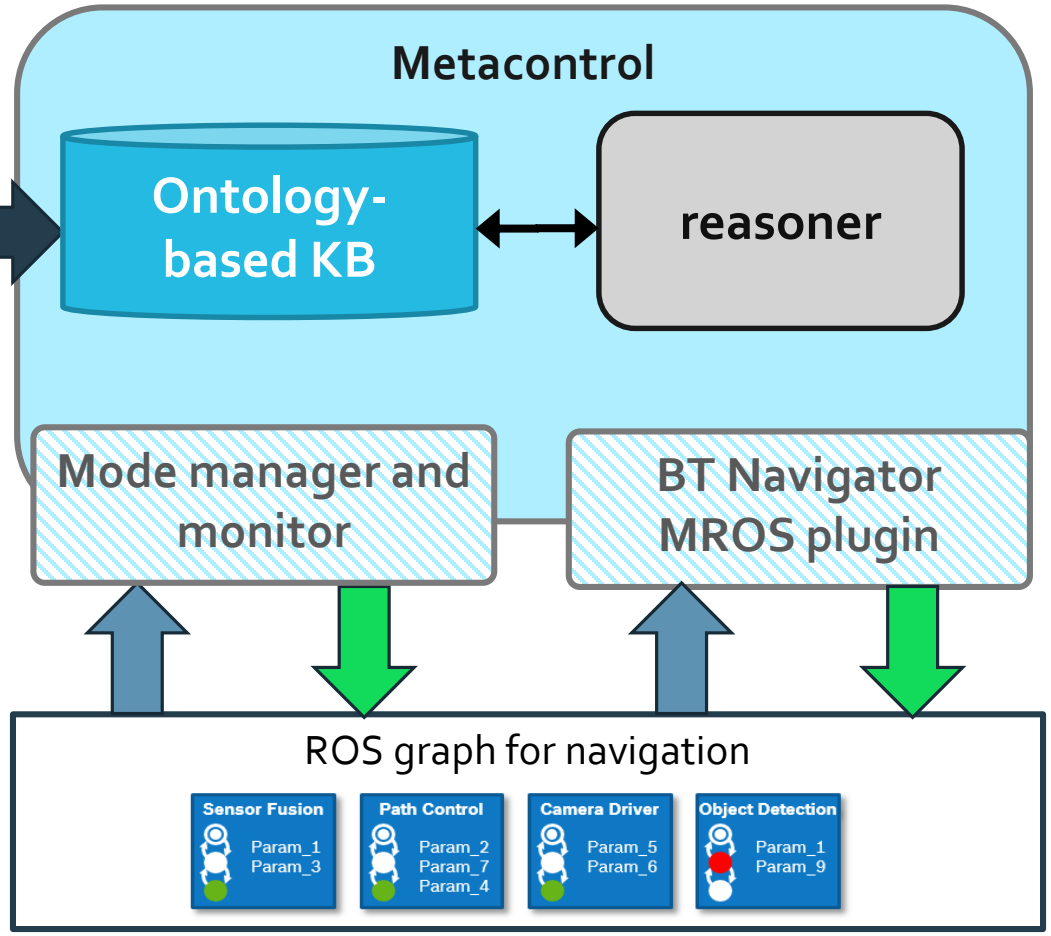
ROS 2 node Life-cycle from http://design.ros2.org

System Behaviour

Functional Arch. model

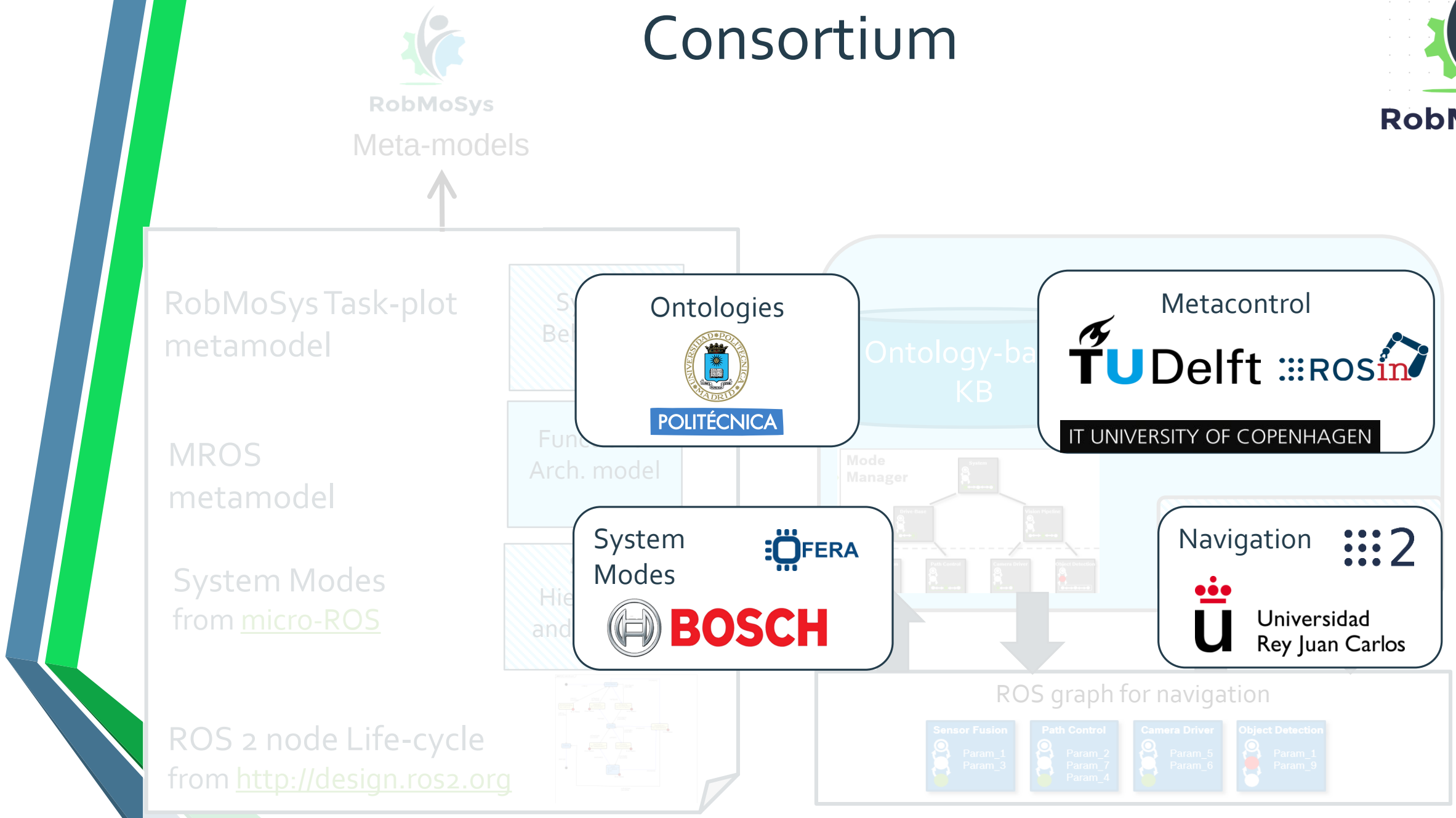
Sys. Hierarchy and Modes



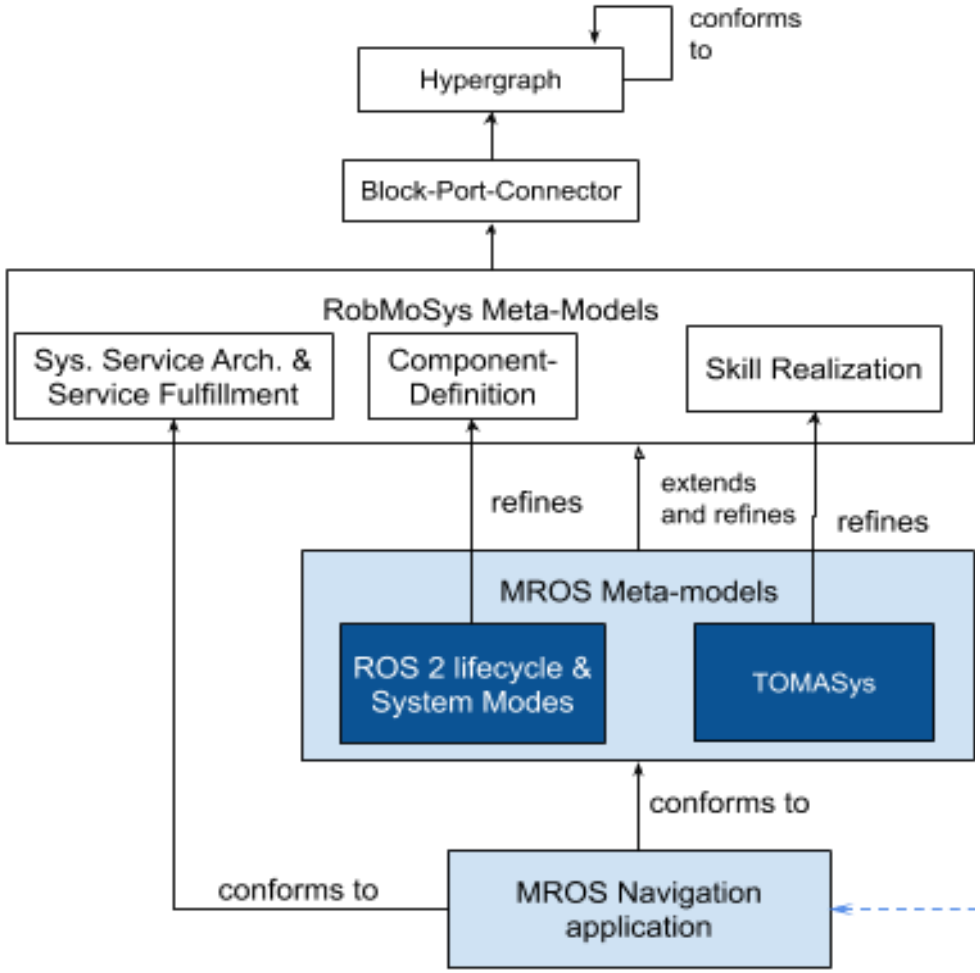


RobMoSys

Consortium


RobMoSys
Meta-models
RobMoSys Task-plot metamodel
MROS metamodel
System Modes from micro-ROS
ROS 2 node Life-cycle from http://design.ros2.org
Ontologies
POLITÉCNICA
Ontology-ba KB
Metacontrol
TU Delft
ROSin
IT UNIVERSITY OF COPENHAGEN
Mode Manager
System Modes
FERA
BOSCH
Navigation
2
Universidad Rey Juan Carlos
ROS graph for navigation
Sensor Fusion
Path Control
Camera Driver
Object Detection

MROS and RobMoSys metamodels



Tools for verification and validation

Wed 11:50 **ROS Model**
Nadia Hammoudeh Garcia, Fraunhofer IPA

To wrap up

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MROS: Metacontrol for ROS2 systems

- **models@runtime** to drive
- **architectural adaptation** for
- **reliable autonomy**

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Thanks!