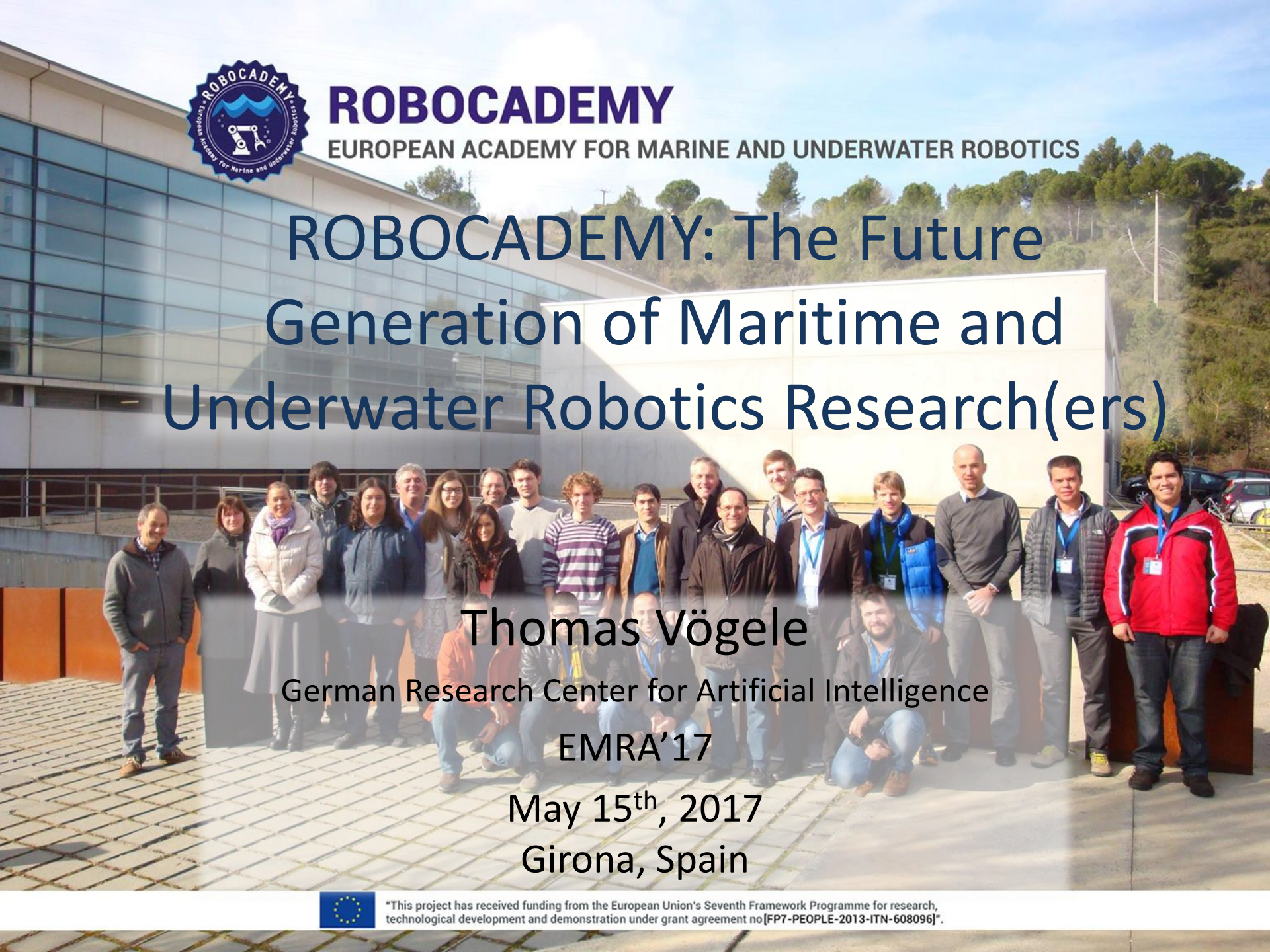

ROBOCADEMY

EUROPEAN ACADEMY FOR MARINE AND UNDERWATER ROBOTICS

# ROBOCADEMY: The Future Generation of Maritime and Underwater Robotics Research(ers)


Thomas Vögele

German Research Center for Artificial Intelligence


EMRA'17

May 15th, 2017

Girona, Spain


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# The ROBOCADEMY Initial Training Network

- ROBOCADEMY funded by EU in **Marie Curie** Programme (H2020)
- Project started 01.01.2014, duration 48 months
- Total budget: 3,6 Mio €
- 13 ESRs („early stage researchers“) from 6 EU member states and 7 non-EU states
- 10 Partners from 6 member states


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# The ROBOCADEMY Consortium


ViCOROB
Computer Vision and Robotics Research Institute

National Oceanography Centre
Natural Environment Research Council

GRAALtech

German Research Center for Artificial Intelligence GmbH

Universitat de Girona

TALLINNA TEHNIKAÜLIKOOL
TALLINN UNIVERSITY OF TECHNOLOGY

ATLAS ELEKTRONIK
A joint company of ThyssenKrupp and Airbus DS

S&T organization
Centre for Maritime Research & Experimentation

CSL
National Technical University of Athens
Control Systems Lab

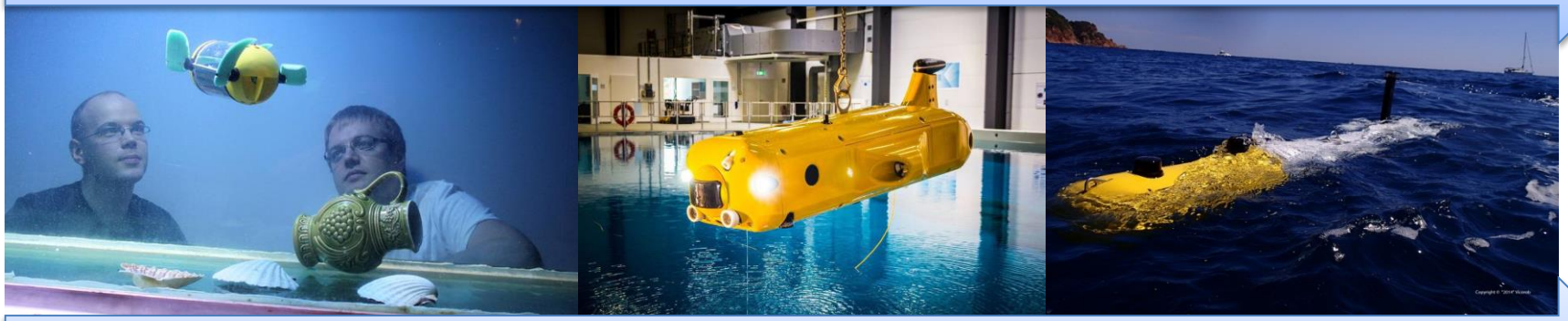
Ocean Systems Laboratory
Heriot-Watt University Edinburgh

seebyte
A Bluefin Robotics Company

**Industry – SMEs – Research - Universities**

# ROBOCADEMY Objectives

**O1: Advance State-Of-The-Art in UW Robotics**



**O2: Train Specialists in Underwater Technology**

**O3: Create a European Network of Competence Centers**

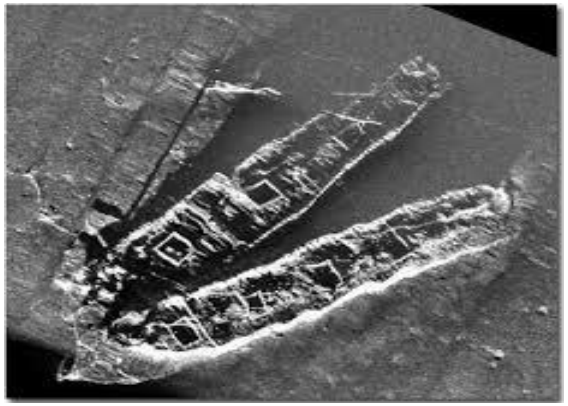
# Scientific Rationale for ROBOCADEMY

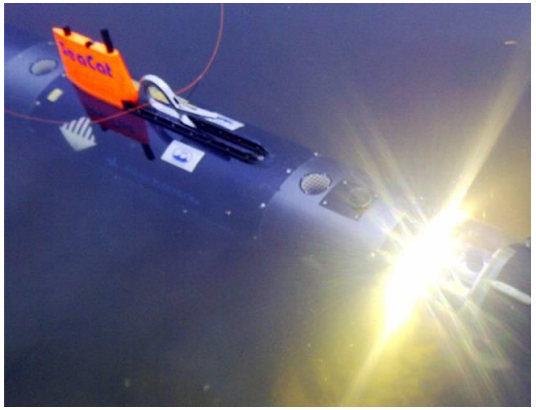
## Three Action-Lines for Long-Term Autonomy

**A1. Disturbance Rejection:**
Improve robot-control to mitigate the effects of highly-dynamic environment (currents, swell, moving objects, …)

**A2. Perception:**
Enable UW vehicles to fully perceive and map their environment.

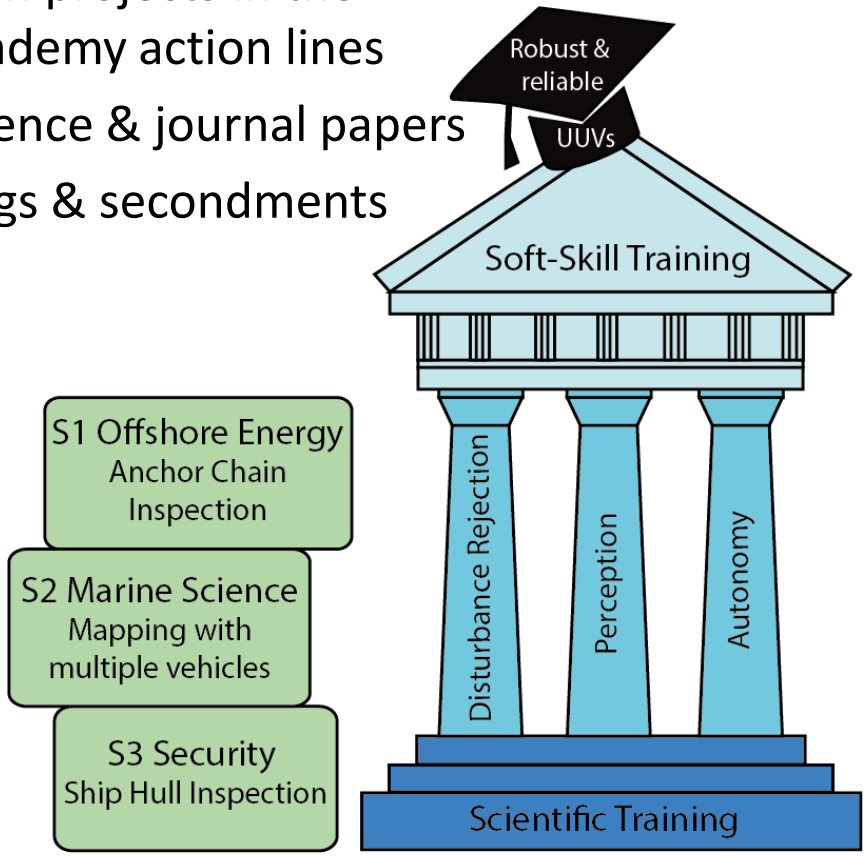
**A3. Autonomy:**
Provide a level of decisional autonomy that enables safe navigation and long-term autonomous operation.

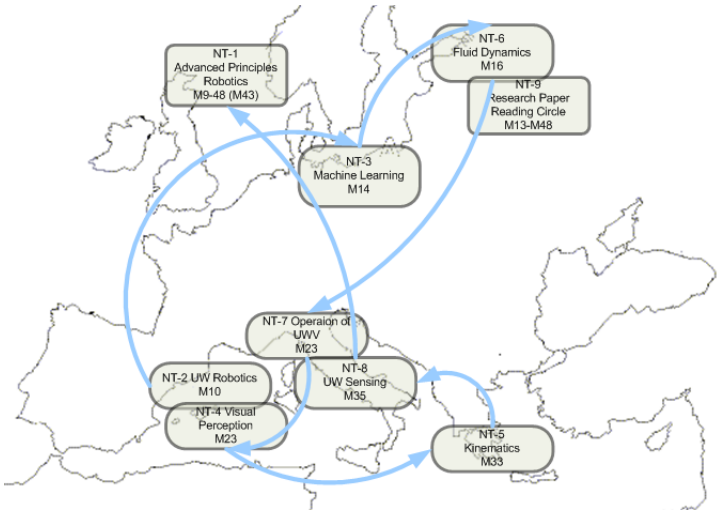





# The ROBOCADEMY Structure

- PhD projects as interrelated research projects in the Robocademy action lines
- Conference & journal papers
- Trainings & secondments



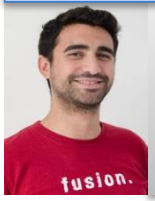




Scientific training and soft-skill courses organized by the project partners at the host-locations.

www.robocademy.eu

# ROBOCADEMY Results

## ESR01: Bilal Wehbe




Topic: Efficient UUV Simulation
Publications: 3 Conference Papers
Thesis Submission: Autumn 2017

## ESR02: Samy Nascimento

Topic: Adaptive Fault Detection
Publications: 2 Conference Papers
Thesis Submission: 2018

## ESR03: Mariia Dmitrieva

Topic: Biosonar for Object Characterization
Publications: 2 Conference Papers
Thesis Submission: 2018

# ROBOCADEMY Results

## ESR04: Mariela de Lucas

Topic: Persistent Long-Term Autonomy
Publications: 2 Conference Paper
Thesis Submission: 2018

## ESR05: Juan Fran Perez

Topic: Flow Sensing
Publications: 13 Conference Papers 3 Journal Papers
Thesis Submission: Mid 2017

## ESR06: Klemen Istenic

Topic: Optical Mapping and Change Detection
Publications: 3 Conference Papers 2 Journal Papers
Thesis Submission: Autumn 2017

# ROBOCADEMY Results

## ESR07: Georgios Salavasidis

Topic: Long Range Navigation with Low Power
Publications: 2 Conference Papers
Thesis Submission: 2018

## ESR08: Diogo Machado

Topic: Optical Mapping and Disturbance Rejection
Publications: 2 Conference Papers
Thesis Submission: 2018

## ESR09: Shahab Heshmati

Topic: Control for Disturbance Rejection
Publications: 4 Conference Papers 3 Journal Papers
Thesis Submission: Mid 2017

# ROBOCADEMY Results

## ESR10: Veronika Yordanova

Topic: Planning to Optimize Object Recognition
Publications: 1 Conference Paper 2 Journal Papers
Thesis Submission: Mid 2017

## ESR11: Thomas Guerneve

Topic: Auto Tuning for Changing Payloads
Publications: 3 Conference Papers
Thesis Submission: Mid 2017

## ESR12: Matias Valdenegro

Topic: Object Recognition with Multiple Platforms
Publications: 7 Conference Papers
Thesis Submission: Mid 2017

# ROBOCADEMY Results

## ESR13: Youssef Essaouari

Topic: Co-operation for 4D Mapping
Publications: 1 Conference Paper
Thesis Submission: 2018

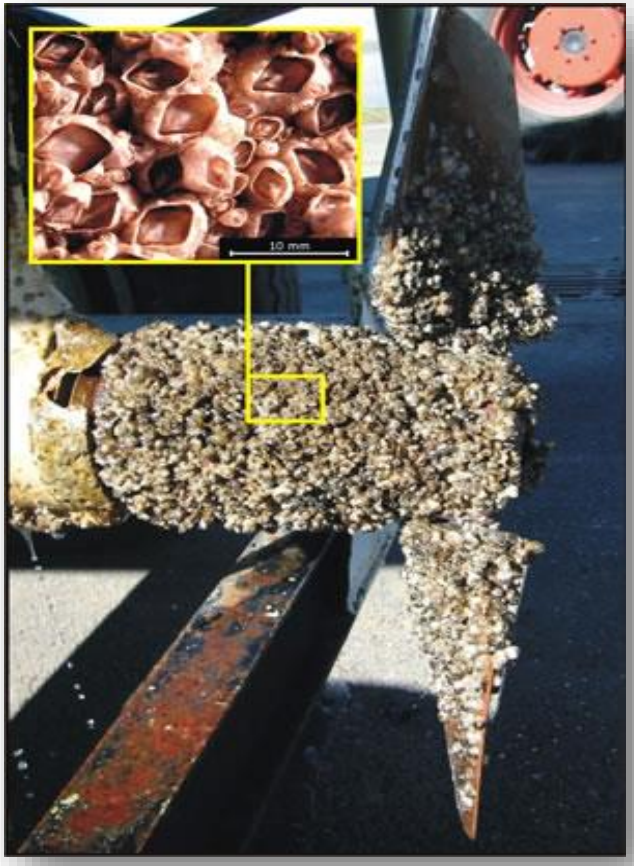
## ESR02: Samy Nascimento

# Adaptive Fault Detection

Objective: Develop machine learning-based method for **automated Fault Diagnosis** of AUV exposed components

- Online condition monitoring to **improve self-awareness** of the vehicle
- Autonomous evaluation of **component degradation**

Supervisor: Frank Kirchner (DFKI)

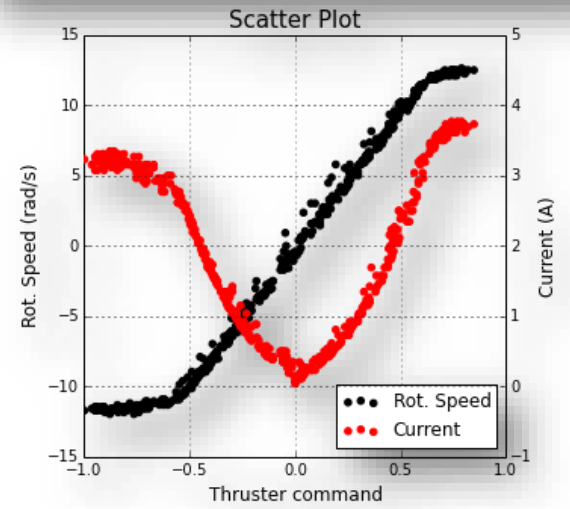



Biofouling growth on a propeller.

# Adaptive Fault Detection

Methodology:

- For UW thrusters, experimental **collection of data** on speed, electric current for
  - nominal operation (base case),
  - operation with one or both propellers removed
  - operation with simulated bio-fouling (silicone)
- Use machine learning (classifiers) to **learn characteristics of operational modes**
- Apply learned models to **identify and classify non-nominal behavior**

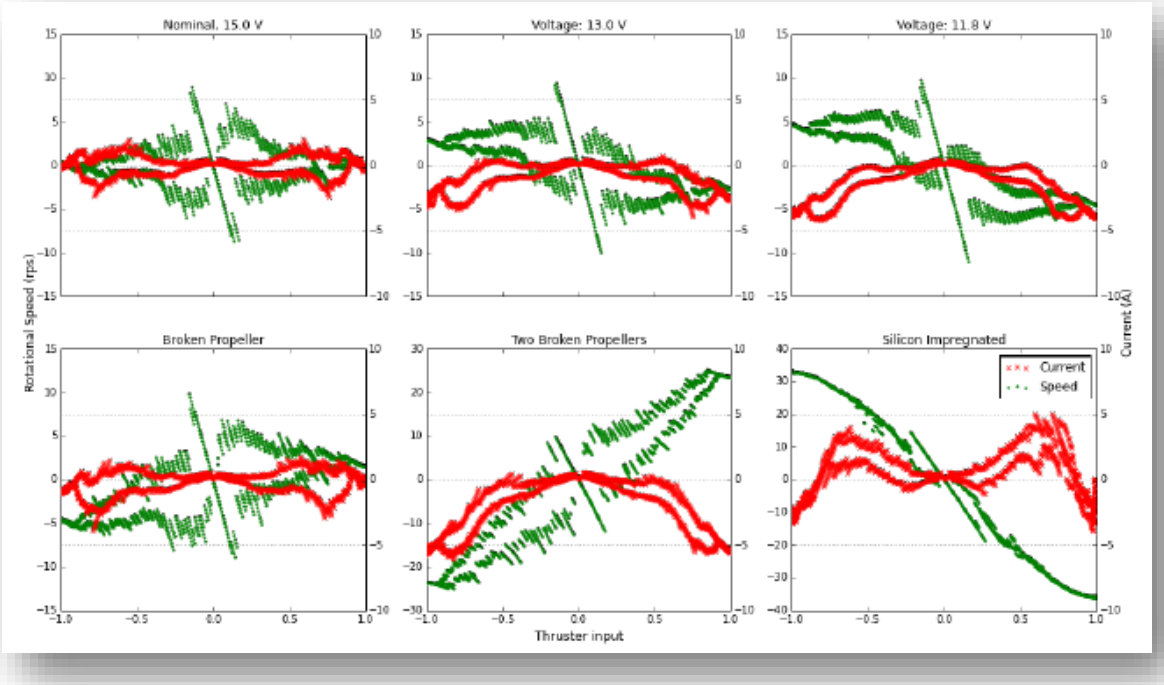



Fault detection of underwater thrusters.

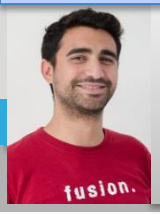
# Adaptive Fault Detection

Results

- More than **23.000 data sets** were created for training
- Six classes could be **clearly distinguished**
- Several **classifiers were tested**
- SVM achieved 0.85 precision
- Next: use **recurrent neural networks** (for dynamic temporal behaviour)



## ESR01: Bilal Wehbe



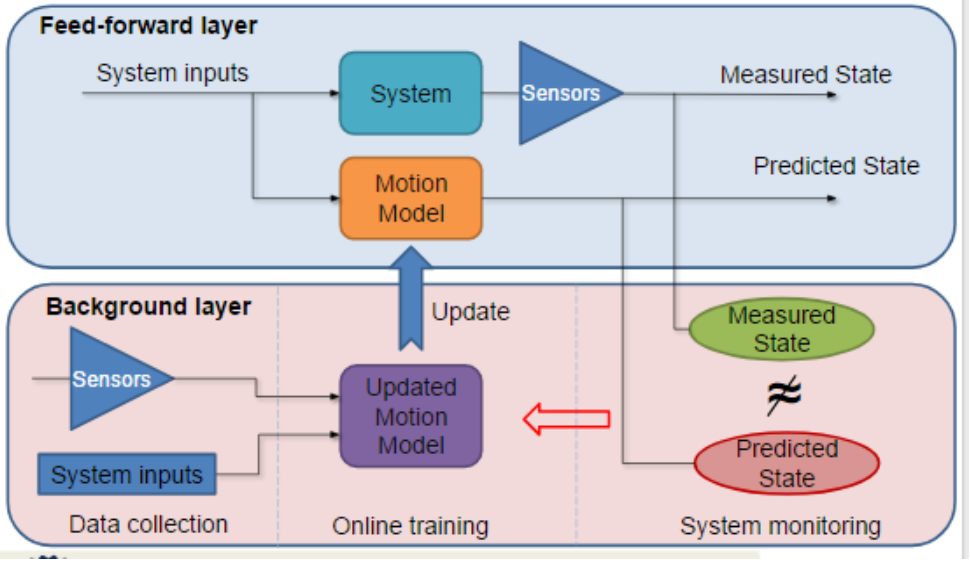

# Efficient UUV Simulation

Motivation: Design framework to **estimate robust motion models** for underwater vehicles, **detect and identify model failures** under changing environmental/internal conditions, **adapt models** and recover from errors.

Supervisor: Frank Kirchner (DFKI)

Method:

- Learn motion dynamics in background layer and predict state with motion model
- Compare measured state (sensor data) with predicted state (motion model)




- Detect discrepancies between measured and predicted state
- Use machine learning to update motion model / learn the motion dynamics.

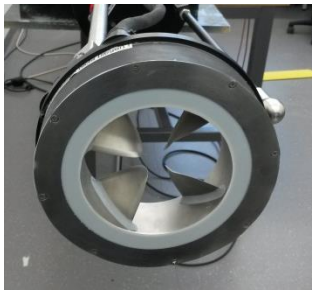

# Efficient UUV Simulation

Data collection:

- Thrust = $K\omega|\omega|$

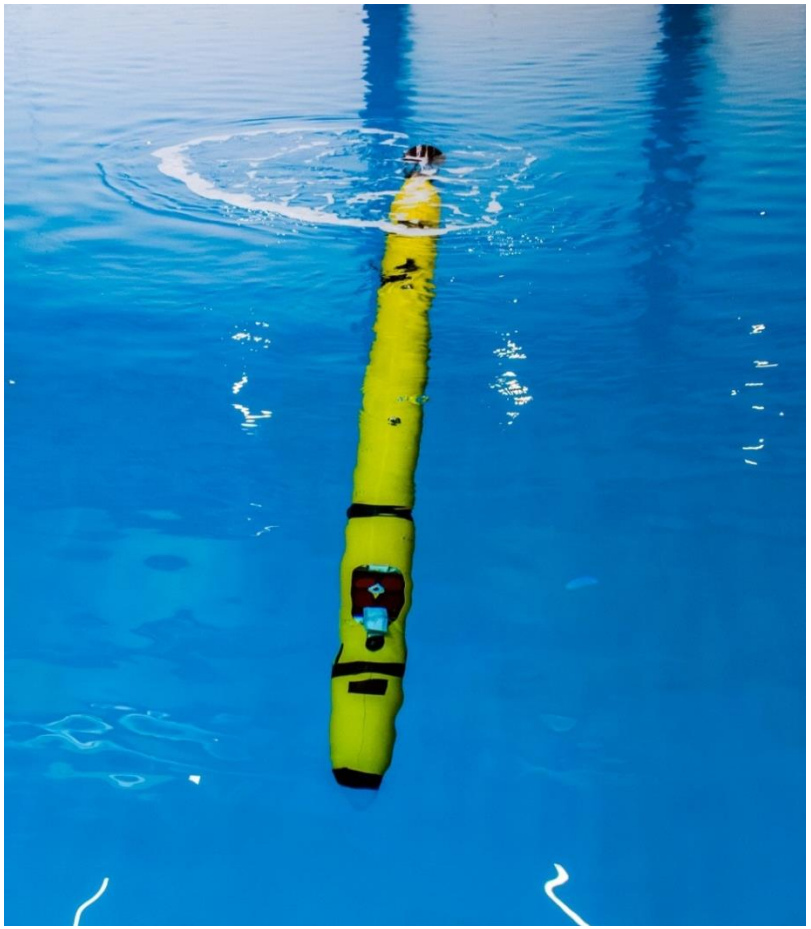
  Torque = $Thrust \times d_c$

  rpm / rate: 100 Hz



- Linear velocity:
  DVL / rate: 5 Hz

- Angular velocity:
  FOG / rate: 1000 Hz

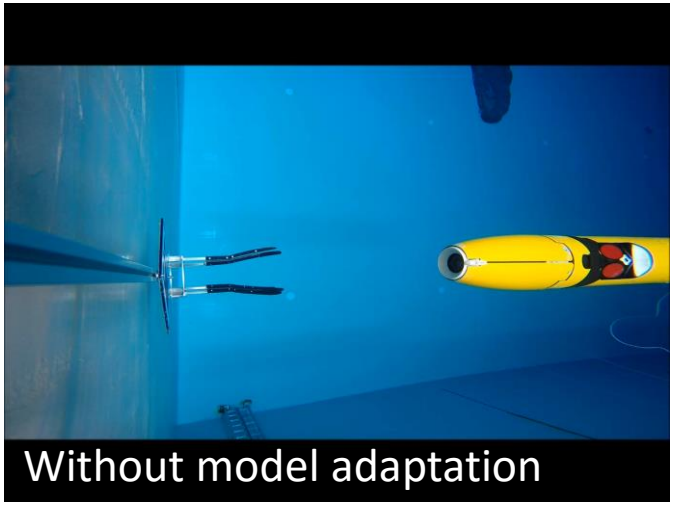



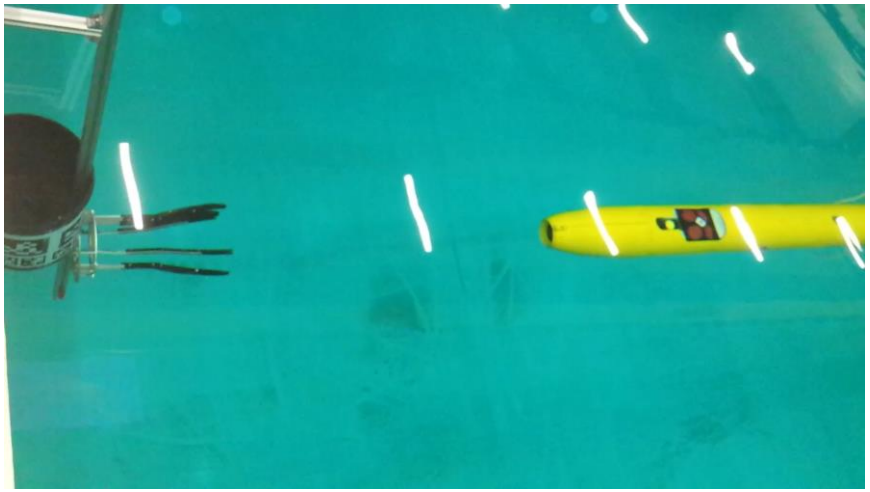
Leng AUV

## ESR01: Bilal Wehbe


# Efficient UUV Simulation

- Several machine learning methods were tested.
- Nonlinear regression methods shows better performance than traditional least squares
- Robust model prediction in the case of drop-outs of DVL measurements
- Application in practical systems (e.g. docking of Leng)


Without model adaptation


With model adaptation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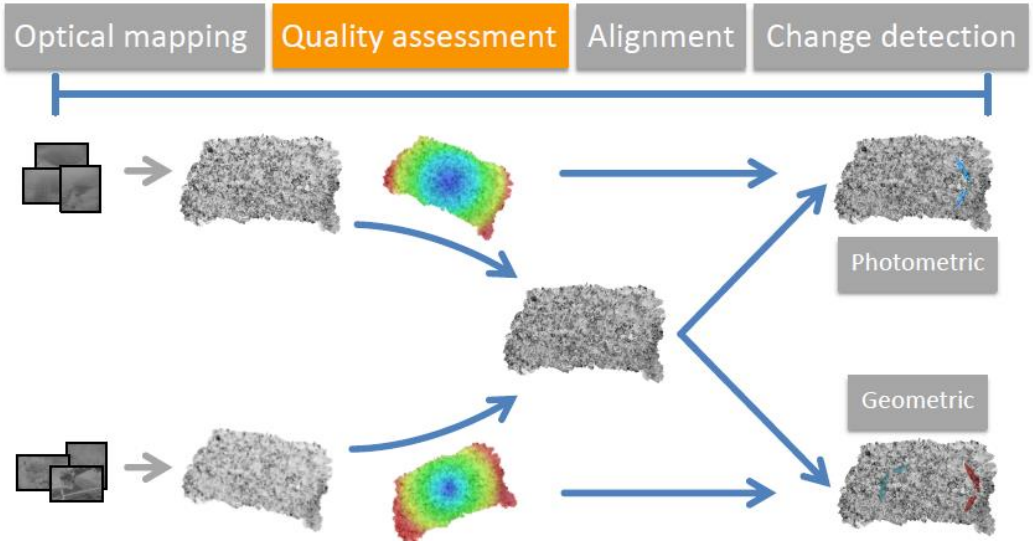
## ESR06: Klemen Istenic

# Optical Mapping and Change Detection

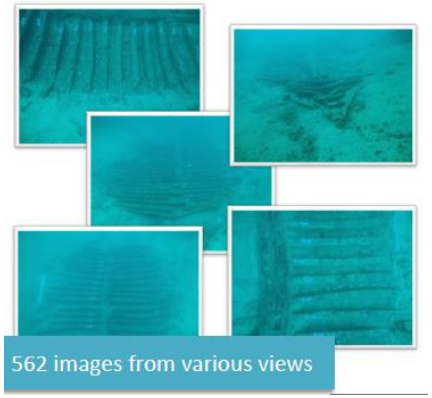
- Objective: Improve and develop new tools for **robust change detection** in multiple sequences of high resolution underwater imagery
- Supervisor:
  Rafael Garcia (UdG)



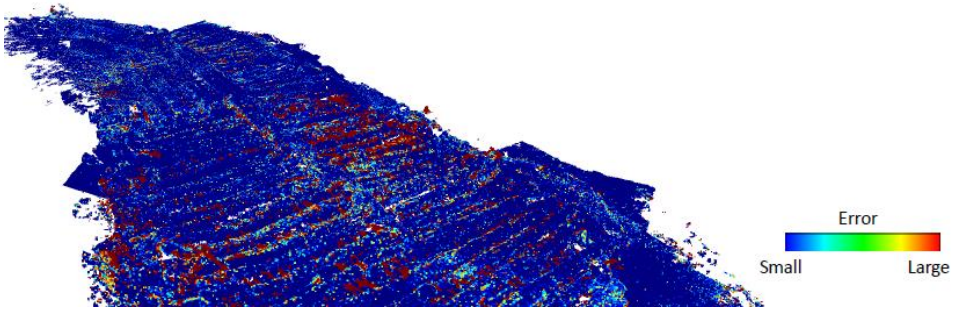
## ESR06: Klemen Istenic

# Optical Mapping and Change Detection

- **3D reconstruction** based on combination of many 2D images
- Good results for 3D reconstruction
- But depends on the quality of raw data, strategy applied in acquisition process
  - Rapid attenuation of light
  - Scattering effects
  - Non-uniform lighting
- Current focus: quality assessment




3-D Reconstruction



# Conclusions

- ROBOCADEMY managed to
  - assemble a multi-national group of high-quality young researchers
  - support a number of very interesting PhD studies
  - strengthen the ties between key academic and industrial players in UW research in Europe
- How to exploit the results of ROBOCADEMY?
  - Offer the ROBOCADEMY fellows attractive positions to keep them in Europe
  - Follow-up on the PhD projects to further push the SoA
  - Keep the network alive (joint projects, WS like EMRA, euRobotics TG UW Robotics)

# Thank you for Attention!

**For more Information on ROBOCADEMY:**

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