EUROPEAN ROBOTICS FORUM


# AErial RObotic TRAINing for the next generation of European infrastructure and asset maintenance technologies

## The AERO-TRAIN Training program

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie Grant Agreement No 953454.

# Outline

- Overview of the training
- Training events
- Network-wide training
- Quality assurance



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# Overview of the training

**Objectives of the training:**

The goal of the AERO-TRAIN training is to deliver a high-level education, and skill training in the field of aerial robotics for inspection and maintenance, together with a personalised training and career development plan for the ESRs.

Within the training, our objectives are:

- To ensure collaboration and create synergies among the ESRs
- To provide knowledge and competences on core topics of aerial robotics for inspection and maintenance
- To provide an ecosystem for the ESRs, that enables creativity while ensuring delivering of down to earth results.
- To provide the ESRs with valuable skills that can be adopted in any job context



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# Overview of the training

**Training structure:**

- **Network-wide Training** including individual research projects, secondments, joint training schools providing knowledge and skills relevant to all ESRs, conferences,
- **Local Training** including scientific and transferable skills courses relevant for ESRs' individual needs as well as ECTS requirements at their local host or at the awarding degree partner for the "industrial ESRs", and
- **External Training** such as visits, conferences, tutorials and summer/winter schools outside the network.

**Training elements:**

- **Training through research**: To create a platform of mobility and training of young researchers by means of tailored individual research projects, including secondments within the Network
- **Scientific courses and training**: To enhance the attractiveness of a career in front-line areas of industrial research and innovation, we provide a structured training program encompassing mandatory scientific courses specifically designed for AERO-TRAIN ESRs, which cover a portfolio of disciplines relevant for the project and the ESRs.
- **Transferable skills training:** special courses as well as seminars will be organized by the consortium. Beyond these, each ESR will attend local courses within each university. The ESR's engagement in key management roles will provide the experience needed to become a future group leader in industry or academia.



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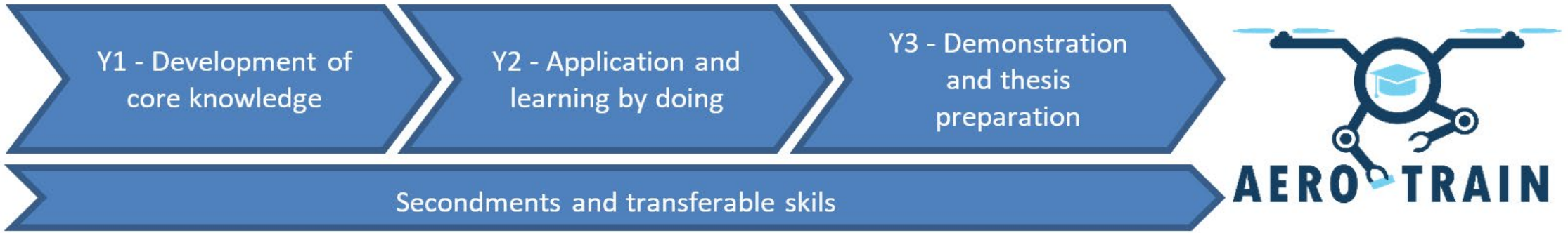
# Overview of the training



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# Overview of the training

| | Overview of the main Training Events & Conferences (cf. details in the following tables) | | ECTS | Lead Partner | Month |
|---|---|---|---|---|---|
| 1 | **Kick-off event** | Kick-off; Training plan overview; "PhD supervision" course to align supervisors | - | DTU | 10 |
| 2 | **Training School 1 (TS1)** (Seville, 5 days) | **Topic: Aerial manipulation technology**<br>Duration: 5 days of school + 2 weeks of assignment<br>Examination: written report on practical exercise | 2-3 | USE | 14 |
| 3 | **Training School 2 (TS2)** (Copenhagen, 5 days) | **Topic: Aerial Robots in an Uncertain World**<br>Duration: 5 days of school + 2 weeks of assignment<br>Examination: written report on practical exercise | 5 | DTU | 18 |
| 4 | **Training School 3 (TS3)** (Luleå, 5 days) | **Topic: Deployment of Aerial Robots**<br>Duration: 5 days of school+2 weeks of assignment<br>Examination: written report on practical exercise | 5 | LTU | 22 |
| 5 | **Summer School** (Zurich, 5 days) | Aerial robotics and AI Summer Schools (for external participants) | - | ETH, ENI ESR | 42 |
| 6 | **Hands-on events** (Naples) | Integration weeks and Grand Challenge<br>**Use cases**: Companies define use cases for the O&M industry, which will be used by ESRs for the demonstration at the Grand Challenge. Integration weeks serve as hands-on preparation events for the Grand Challenge. | 6 | CATEC, EUT, TAU, UNINA, ENI | 26,30, 34,38 |



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# Training Schools

## Description of training schools.



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# Training Schools

**Training School 1 (TS1) – USE**

**Training Event type:** School

**Expected date**: M14, starting from Jan 2021

**Title:** Training School on Unmanned Aerial Systems for Inspection and Maintenance

**Description of main theme**:

The course provides theoretical knowledge and hands-on experience on design, control, planning, navigation, and state estimation for Unmanned Aerial Systems and aerial manipulators for Inspection and Maintenance.

**Learning Objectives**:

This school will focus on providing the students with an overview of the technologies involved in the design, development and operation of UAVs and aerial manipulators and insights on implementing models, controllers and state estimators for UAVs in simulation.

**Evaluation**:

ESRs will be assessed based on a report focusing on home and practical assignments.

**Credits**:

2-3 ECTS



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# Training Schools

## Training School 1 (TS1)

### List of lecture topics:

- UAS systems: platforms, architectures, applications
- Design of UAVs
- Estimation and localization
- Control of UAVs
- Autonomous functions, planning, collision detection and avoidance
- Aerial physical interaction
- UAV simulation models and frameworks
- Ground stations
- On-site experimentation
- UAS regulations and integration in airspace

### Knowledge:

Students attending this training school will learn:

- Basics of design, control, perception and state estimation
- Basics of navigation, planning, obstacle avoidance and physical interaction
- Hands-on experience on design, simulation and operation of UAVs

### Competences and skills:

Students completing the course will be able to:

- Select UAV configuration and architecture for specific applications
- Select sensors for state estimation and localization
- Implement simplified models and controllers for the UAV
- Simulate estimation and control of UAVs



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# Training Schools

**Training School 2 (TS2)**

**Training Event type:** School
**Expected date:** M18, starting from Jan 2021
**Title:** Training School on Autonomous systems working in uncertain environments

**Description of main theme:**

Autonomous systems working in real-life environments (out of the lab) must deal with uncertainties originating from the lack of precise measurements, unknown and unexpected disturbances, unstructured and dynamic environments.

**Learning Objectives:**

This school will focus on learning methodologies for taking these uncertainties into account when developing guidance, navigation and control algorithms for autonomous systems. The school will furthermore provide insights on human in the loop approaches for human-AS collaboration.

**Evaluation:**

ESRs can choose to be assessed based on a written exam or on a short report focusing on  a home assignment.

**Credits:**

2 ECTS or 5 ECTS, depending on the type of examination chosen by the ESR.



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# Training Schools

## Training School 2 (TS2)

### List of topics:

The lectures provided within this training school will cover topics related to:

- Motion planning for aerial robots
- UAV State estimation
- Adaptive control of uncertain non-linear systems
- Bio-inspired control for robotics
- Avionics and onboard sensors for autonomous aerial robots
- UAV perception

### Knowledge:

Students attending this training school will learn:

- Sensing for autonomous aerial robots fundamentals of vision-based perception
- Concepts of onboard state estimation using different sensors
- Basics of motion planning and representation under uncertainty
- Adaptive and bio-inspired control methods for control under uncertainties

### Competences and skills:

Students completing the course will be able to:

- Select proper avionics and sensing technologies for autonomous aerial robots
- Implement estimation algorithms based on multiple sensor modalities
- Represent the world model and being able to plan a motion under uncertainties
- Implement and test control approaches for robustness against unknown disturbances



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# Training Schools

**Training School 3: LTU, Sweden**

**Expected date:** M24, starting from Jan 2021
Title: Training School on Autonomous Aerial Field Robotics

**Description of main theme:**

- Field experimental actives such as designing and planning an experiment, sensor configurations, and data collection, processing and analysis
- Focus on infrastructure inspection and maintenance

**Learning Objectives:**

- How to successfully conduct experiments outdoors
- Focus on the practical implementation aspects of UAV control, navigation, state estimation and computer vision methodologies

**Evaluation:**

ESRs can choose to be assessed based on a written exam or on a short report focusing on  a home assignment.

**Credits:**

2 ECTS or 4 ECTS, depending on the type of examination chosen by the ESR.



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# Training Schools

**Training School 3 (TS3)**

## List of topics:

The lectures will cover practical aspects of the topics related to:

- Computer vison and Image processing
- Sensor fusion techniques
- Communication techniques and limitations
- Positioning
- Field experimentation
- Data collection and analysis

## Knowledge:

Students attending this training school will learn:

- Plan carry-out and evaluate experiments
- Adapt to the real environmental setup
- Asses the performance of the experiment based on the obtained results and data
- Gian experimental mindset and how to deal with practical problems

## Competences and skills:

Students completing the course will be able to:

- Participate professionally in experimental activities in the field
- Professionally disseminate methodology and result
- Work in teams on practical project assignment
- Prepare towards the upcoming activities within the project and grand challenge



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# Integration Weeks and Grand Challenge

- Team up the ESRs into 4 groups
  - Each group is homogeneous regarding the skills as much as possible
- Four use cases
  - The four use cases create the Grand Challenge (GC)
- Each group is matched to a use case
- The ESR will develop their individual plan with an eye on the assigned final use case
- The Integration Weeks (IWs) serve the GC
  - The IWs are a sort of ”gym” to collaborate with the ESRs of the team and reach preliminary achievements in a lab-controlled environment



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# Integration Weeks and Grand Challenge

## IW1 @ Eurecat Technology Center (Barcelona)

### Facilities

- Electronic and mechatronic workshops
- Fast prototyping lab
- Indoor arena (8*5*3m)
- Support labs: collaborative and industrial robotics, Perception and Cognition, Augmented reality, etc
- Plenty of offices and meeting rooms

### Possible use cases

- Tunnel-like structures

Indoor Arena




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# Integration Weeks and Grand Challenge

## IW2 Catec explanation of facilities, possible use cases, technology training

**CATEC indoor testbed**

- 15x15x5 m space
- Vicon 6D pose system
- ROS compatible

**Possible use cases**

- Refinery scenario
- Others (curved surface/tanks, single pipe, etc)



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# Integration Weeks and Grand Challenge

## IW3 TAU explanation of facilities, possible use cases, technology training



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# Integration Weeks and Grand Challenge

- **USE CASE 1**
  - The drone (not necessarily equipped with an aerial manipulator) should carry out on-site measurements of pipes and other structures, even with the presence of curvatures. The drone is telemanipulated with a shared-autonomy architecture.
- **TEAM**
  - **ESR 2**
  - **ESR 15**
  - **ESR 7**



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# Integration Weeks and Grand Challenge

- **USE CASE 2**
  - The drone (equipped with an aerial manipulator) should carry remote and physical human-robot interaction. The aerial manipulator is then employed as a support for the human operator. For instance, the aerial manipulator can share the same human operator's workspace, or it can bring the operator a tool, and so on.
- **TEAM**
  - **ESR 3**
  - **ESR 6**
  - **ESR 13**



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# Integration Weeks and Grand Challenge

- **USE CASE 3**
  - A team of aerial manipulator is teleoperated for transporting task (*i.e.*, a bar that must be mounted somewhere) or for some installation tasks (*i.e.*, placement of an element that requires the use of two aerial manipulators)
- **TEAM**
  - **ESR 5**
  - **ESR 10**
  - **ESR 14**
  - **ESR 12**



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# Integration Weeks and Grand Challenge

- **USE CASE 4**
  - The drones are employed for mapping the operating site and reconstruct the environment in simulation. This is useful to train and detect anomalies in the plant and similar.
- **TEAM**
  - **ESR 1**
  - **ESR 4**
  - **ESR 8**
  - **ESR 9**
  - **ESR 11**



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# Integration Weeks and Grand Challenge

- GC will take place at ENI (upstream Italian oil&gas facility)



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# ESR Summer School

**Sumer School: ETH, Switzerland**

**Expected date:** M42, starting from Jan 2021

**Objective:**

- **share both the scientific and technical knowledge** collected within the AERO-TRAIN consortium to the wider community
- **ESR learning new competences through the organization of the event**: from defining the program, choosing and inviting external speakers, to organizing and providing short practical classes themselves.

**Learning Objectives:**

- Organize and manage an event
- Define the logistics
- Define the scientific program
- Create and provide a lecture
- Disseminate and promote the event
- Outreach possible external speakers



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# Secondments

**Where to do the secondment?**

**Answer the question:**

**1) which skill, competence and/or knowledge do I need, to fulfill my:**

- **Project objectives**
- **Personal ambitions**

**2) which partner can give me that?**

**3) how much time do I need to get them?**

**Plan the Secondment together with your supervisor(s) and appointed mentor/supervisor at the seconding organization**



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# Common activities

**General explanation of common activities (workshops, journal clubs, ESR presentations, transferable skill training online sessions)**

- ESR meeting every 2 weeks, starting from (?):
  - journal clubs, ESR presentations, skill training online sessions)
- workshops
  - Organization at conferences
  - Workshps by the partners on technologies
- Transferable skill training (online, from 2022):



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# Transferable Skill training

| Course | Main learning objectives | Delivery method | When | Responsible |
|---|---|---|---|---|
| **Data Management Plan** | Understanding the importance and good practice of research data management | Webinar (2x4h) | Jan 2022 | DTU |
| **Scrum & Kanban (tentative)** | To understand and use the main tools of agile project management | Workshop (4h) | Oct 2022 | EUT |
| **Publication of Software and Code – Legal Aspects** | Understanding basic legal aspects to consider when publishing software | Webinar (2x2h) | Aug 2023 | DTU |
| **The Entrepreneurial Analysis of Engineering Research Projects, followed by pitch preparation for Start-up competition** | To rethink their research in business terms and to uncover and assess its market potential. | Online Workshop (2 days) | Jan 2024 | UNINA |



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# Quality Assurance

| Meeting | Month | Description |
|---|---|---|
| **Supervisor meeting** | At least twice a month | A supervisor, a co-supervisor and a non-academic mentor are appointed to each ESR. The PCDP is defined under the joint agreement of the ESR and the supervisors. The main supervisor will meet the ESR once every 2 weeks. The co-supervisor and non-academic mentor are informed on a monthly basis and meet the ESR no less than once every 3 months. |
| **PCDP first review** | Within 3 months after start of ESR | An initial PCDP is proposed and submitted for review to the Training & Career Development Committee, who assures (1) proper scheduling of secondments, trainings, local courses; (2) quality of the planned training in terms of synergistic training, complementary training and transferable skill training; (3) correct plan of ECTS. |
| **Mid-term evaluation** | M24 | The TCDC and the SB evaluate each ESR against the proposed PCDP and the expected outcomes. Comments are provided to the ESR for reviewing the remaining part of the PCDP and risk assessment. The TCDC and SB can request an update meeting with the ESR who did not satisfy the minimum requirements 3 months after the mid-term review. In case of an unsatisfactory update meeting, a negative evaluation is sent to the Doctoral School of the Host institution. |
| **Mid-term update** | M27 | Update meeting with an ESR upon negative evaluation of mid-term review. |
| **Final PCDP monitoring** | M32 | A final evaluation is then performed to monitor the progress of each ESR against the individual mid-term summary and the risk assessment. Milestones are set to monitor the progress and evaluate the overall project performances. |
| **Final report** | M42 | A final report will be submitted by the ESR to the SB and TCDC for an overall evaluation of training and project progress. |



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