Project Coordinator

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AEROARMS Partners

- University of Seville, Spain
- Center for Advanced Aerospace Technologies (FADA-CATEC), Spain
- DLR, German Aerospace Center
- LAAS CNRS, France
- Consorzio C.R.E.A.T.E., Italy
- TÜV NORD, Germany
- Institut de Robòtica i Informàtica Industrial (UPC-CSIC), Spain
- ALSTOM Inspection Robotics, Switzerland
- ELEKTRA UAS GMBH, Germany
- SENSIMA Inspection, Switzerland

AEROARMS, AErial Robotic system integrating multiple ARMS and advanced manipulation for inspection and maintenance

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement - No 644271

www.aeroarms-project.eu

INNOVATION

AEROARMS proposes the development of the first aerial robotic system with multiple arms and advanced manipulation capabilities to be applied in industrial inspection and maintenance.
The objectives are:

- Research and development of **aerial manipulation** methods and technologies required to perform the **industrial inspection and maintenance.** This includes: improve the operational conditions and robustness of the existing aerial manipulation and the development of new methods and technologies of aerial manipulation systems with multiple arms, including bilateral manipulation, for future more complex inspection and maintenance tasks.

- Validation in the industrial environment of the technologies in the following applications: (1) **Installation** of **sensors** on remote components such as pipe works, fire flares or structural components, and (2) **deploying a mobile robotic system** permanently installed on a remote structure without costly and dangerous human operations.

VALIDATION AND IMPACT

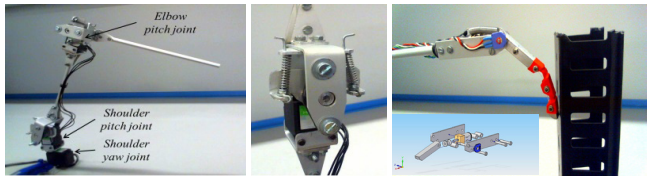
AEROARMS methods and technologies have a general interest to reduce costs (i.e. shut-downs) and/or to decrease the risk of dangerous human activities in inspection and maintenance including industrial plants with aerial facilities, power generation (thermal, wind, solar), offshore plants, electrical systems, infrastructures, support for decommissioning works or even indoor aerial inspection of big parts in manufacturing. AEROARMS pays particular attention to pipes inspection and maintenance at height in oil and gas industries. Operational aspects are being analysed by including the consideration of the ATEX directive and the Remotely Piloted Aircraft Systems regulations. The safety and risk mitigation analyses will be used in the preparation of the validation experiments. The gained expertise will be used in future certification activities.

AEROARMS FIRST RESULTS

- **Systems design and development**
  Design the aerial platforms taking into consideration: functional requirements, safety analysis, operational constraints and regulations. In parallel we have validated the most important design decisions by integrating the following proof-of-concept aerial systems to easily, and in a short time, validate the initial design assumptions.

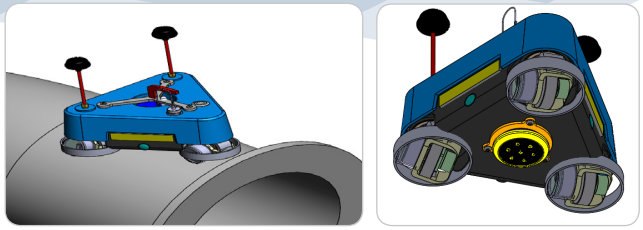
Lightweight Dual Arm System for Aerial Manipulation
Development and integration in octo-rotor aerial platforms of two 5-DOF, human-size, low weight and low inertia arms designed specifically for aerial manipulation applications. The motion of the arms can be coordinated in such a way that the reaction torques generated by one arm can be partially cancelled by the other arm just generating an opposite motion.

Lightweight Compliant Arm with Compliant Finger for Aerial Manipulation and Inspection



Novel fully-actuated aerial platforms: Fully actuated hexarotor with propellers individually tilted to generate user defined forces and torques in any direction.

New mobile robot deployable by aerial robots: Design of a new tri-wheel steerable and motorized robot of triangular shape, wireless operated mobile robot for remote Inspection of Industrial Piping Installations, with the main challenges of weight and size limitations and the steerability requirements.



Design of new sensors systems: Design and prototyping of UPEX, the first intrinsically safe ATEX eddy current instrument and design of an autonomous Eddy current module ("DAISY") for the TRI-wheel mobile robot.

- **Control of aerial robots with multiple manipulation means**
  The work has included: Development of a torque estimation system for bilateral aerial manipulation; Dynamic Analysis and Control of Tethered Aerial Vehicles; Studies on behavioural control based on task-priority inverse kinematics techniques; Visual servoing resilient towards poor or unknown internal calibration of the camera, and implementation in a hierarchical control law; Preliminary studies on visual servoing with an actively movable camera (second arm carrying a visual camera).

- **Aerial telemanipulation in inspection and maintenance**
  Preliminary studies on aerial telemanipulation using visual and force feedbacks.

- **Perception for robotic manipulation in aerial operations**
  The work has included: method to build an augmented map able to integrate information coming from visual place recognition, point clouds (provided by 3D cameras or lasers) and range-only sensors; Method to exploit aerial robot-beacon cooperation in order to improve SLAM efficiency and accuracy; Method to compute relative robot pose without 3D model (POP); and On-line and real time method to learn/recognize defects on pipes.

- **Planning for aerial manipulation in inspection and maintenance**
  Developing of planning methods for a system composed by a quadrotor, with a degree of freedom manipulator, considering the dynamic of the manipulator and the vehicle; and Developing a method to learn human hidden knowledge for improving path planning.