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

Training Kick-off

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.

Agenda

- 08.30-09.00 Gathering
- 09.00-10.15 Introduction of AERO-TRAIN project
- 10.15-10.30 Short break
- 10.30-11.15 Being an AERO-TRAIN ESR
- 11.15-12.30 Speed dating (hybrid)
- 12.30-13.30 Lunch together
- 13.30-14.30 Team building exercise for ESRs + Supervisors alignment meeting (in parallel)
- 14.30-15.45 Training presentation
- 15.45-16.00 Short break
- 16.00-18.00 Supervisory Board + ESR committee (in parallel)
- 18.00 - Social gathering

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Introduction by participants

1 minute about yourself (all)

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What is AERO-TRAIN?

- **MARIE SKŁODOWSKA-CURIE ACTION**
  - Innovative Training Network (ITN) ➡ Fills a capacity/skill gap in the industry
    Fills a technological gap
- **4,1 M EUR**
- **16 Organizations: 7 Academic, 3 RTO, 2 SME, 4 Enterprises**
- **15 Early Stage Researchers**

Project Information

AERO-TRAIN
Grant agreement ID: 953454

Status
Ongoing project

Start date 1 January 2021
End date 31 December 2024

Funded under
H2020-EU.1.3.1.

Overall budget
€ 4 108 492,80

EU contribution
€ 4 108 492,80

Coordinated by
DANMARKS TEKNISKE UNIVERSITET
Denmark

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Why AERO-TRAIN?

- Motivation:
  - Ageing infrastructures require inspection and maintenance
  - Inspection, Repair and Maintenance Market to hit 60B USD by 2027
  - To date, this work is mostly done by human
  - The work environment is dangerous and access by human can be difficult and costly





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AERO-TRAIN challenge

Using aerial robots for both inspection AND maintenance can be a cost and a life saver.

However:

- Aerial robots are not very good at using tools and interacting with the environment
- It can be hard to recognize the class of a damage from just a screen or a picture
- Aerial robots are difficult to manoeuver, and often require several expertise in an operation

Table 21: Number of occupational accidents related to maintenance activities in selected European countries (data from EUROSTAT)

		2003	2004	2005	2006
Spain	Total	792,565	766,460	780,433	769,657
	Maintenance operations	136,608 **17%**	107,068 **14%**	107,014 **14%**	105,886 **14%**
Belgium	Total	No data	No data	72,541	74,868
	Maintenance operations			15,292 **21%**	14,567 **19%**
Austria	Total	88,790	88,397	85,500	86,326
	Maintenance operations	3,002 **3%**	3,027 **3%**	2,808 **3%**	2,722 **3%**
Finland	Total	58,498	58,123	62,959	63,462
	Maintenance operations	11,103 **19%**	10,688 **18%**	11,810 **19%**	11,993 **19%**
Italy	Total	599,711	588,151	564,167	551,659
	Maintenance operations	60,856 **10%**	80,621 **14%**	72,458 **13%**	71,977 **13%**

European Agency for Safety and Health at Work, 2010

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AERO-TRAIN challenge

Furthermore…

…who knows how to “pilot” an aerial manipulator?

There is a competency and human resource gap to be filled, to ensure that this technology can be used effectively by the industry.

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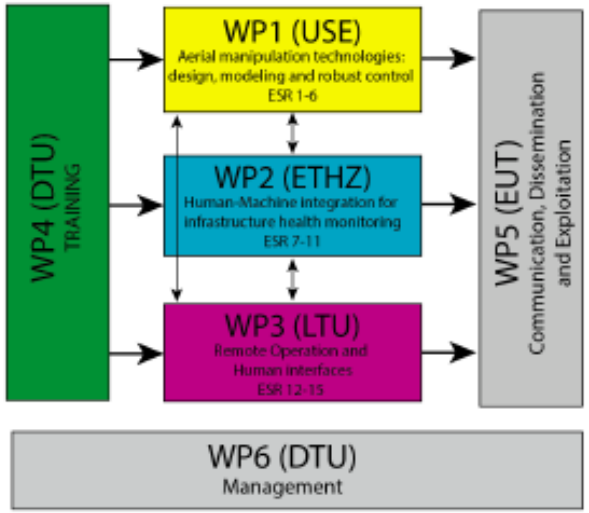
AERO-TRAIN approach

- A research program on:
  - Key technological gaps required to unleash the “drones as robots”
  - 3 main research pillars
    - The drone capability to perform actual tasks
    - The perception system supporting the human
    - The human-in-the-loop as a remote, teleported operator
  - A Grand Challenge as a pilot demonstrator in a relevant use case



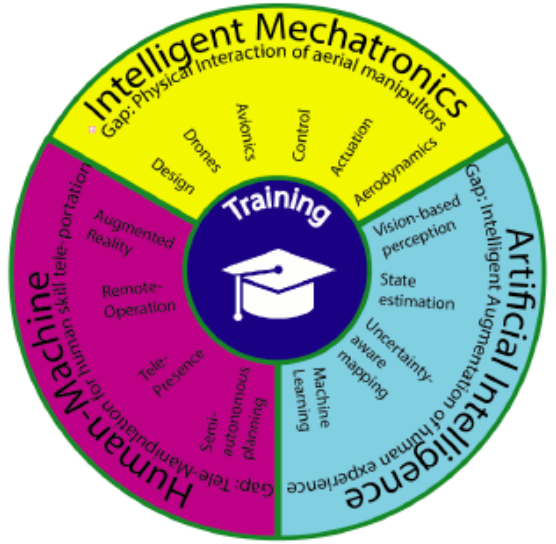


Figure 1.1.2: Interdisciplinarity of the research and training network

#	WP Title	LB #	SM	EM	Activity Type[1]	LB SN	ESR #
1	Aerial manipulation technologies: design, modeling and robust control	3	5	42	Research	USE	1,2,3,4,5,6
2	Human-Machine integration for infrastructure health monitoring	4	5	42	Research	ETH	7,8,9,10,11
3	Remote Operation and Human interfaces	2	5	43	Research	LTU	12,13,14,15
4	Training	1	1	48	Training	DTU	All
5	Dissemination and Exploitation	6	1	48	Outreach	EUR	All
6	Project Management and Coordination	1	1	48	Management	DTU	ESR Repr.

Table 1.1.1: Work Package4 (WP) List – LB=Lead Beneficiary, SM = Start Month, EM = End Month, LB = Lead Beneficiary, SN = Short Name

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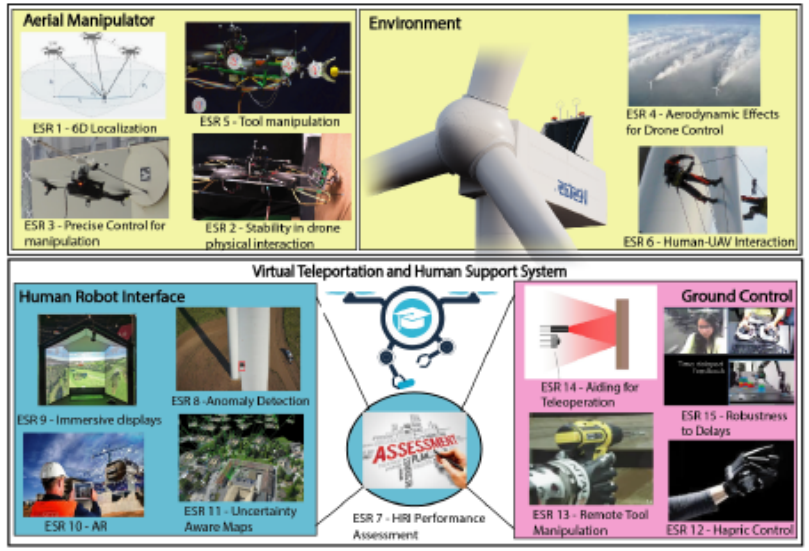
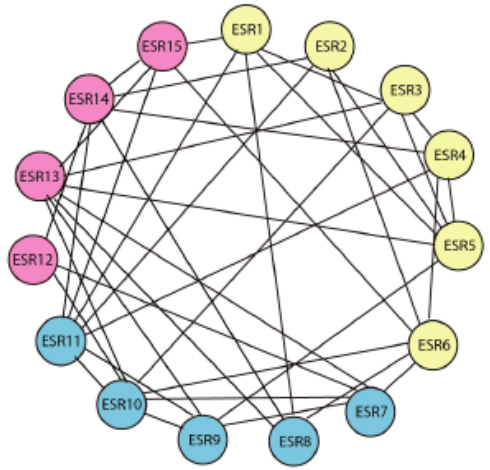
AERO-TRAIN approach

- A training program on:
  - Advanced technologies for infrastructure inspection and maintenance
  - Aerial Robotic technologies
  - Regulations and end-user requirements

- 15 research projects, each addressing a technological gap related to drone (and related) technologies (AI, AR/VR, remote operation, control of physical interaction, human-in-the-loop, …)





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AERO-TRAIN approach

Public

- 3 training schools
- 1 summer school
- 3 Integration weeks and one Grand Challenge in real environment
- A final conference

Intra-network:

- Academic and non-academic courses
- 3+ secondments for each ESR
- Several activities and seminars

	Overview of the main Training Events & Conferences (cf. details in the following tables)				ECTS	Lead Partner	Month
	Reference	Science-based	Transferable skills	Other			
1	Research training	Individual research projects + Secondments to both academic and industrial partners			-	All	7-42
2	Local courses	Scientific and transferable skills courses provided locally by universities Industrial training and transferable skills provided locally by companies			-	All	7-42
3	Conferences	International Scientific Conferences			-	All	7-42
4	Kick-off event	Kick-off; Training plan review; Recruitment. "PhD supervision" course to align supervisors			-	DTU	1
5	Training School 1 (TS1) (Seville) 5 days	**SC1** Unmanned Autonomous Systems **SC2**: 3D and Virtual Reality **Workshop W1** **Technology TT1** **Keynote: Vijay Kumar**	**TC1**: Intellectual Property Rights (IPR) **TC2**: Ethics and Social Responsibilities for Scientists **TC3**: Scientific Writing	• ESR Committee nominates 3 ESRs to the SB (sec. 3.2.a). • ESRs present research plan. • Team-building activities	6	USE	10
6	Training School 2 (TS2) (Copenhagen) 5 days	**SC3**: Convex Optimization **SC4**: Advanced Nonlinear Control **Workshop W2** **Technology Training TT2** **Keynote: David Anisi**	**TC4**: Project Management **TC5**: Time Management	• ESRs present posters on research plan • ESRs present their CDP • Identification of additional collaborations and synergies	5	DTU	16
7	Training School 3 (TS3) (Luleå) 5 days	**SC5**: Recursive estimation **SC6**: Advanced image processing **Workshop W3** **Technology Training TT3** Summer school preparation Kick-off **Keynote**: Basil Weibel	**TC6**: The Entrepreneurial Analysis of Engineering Research Projects, followed by pitch preparation for Startup competition. **TC7**: Grant Writing	Mid-term review ofprogress	4	LTU	24
8	Summer School (Zurich) 5 days	Aerial robotics and AI Summer Schools (open to external participants) **Use cases**: companies present technologies and use cases for the O&M industry and the Grand Challenge will be executed as a demonstrator			2	ETH, ENI ESR	40
9	Hands-on events (UNINA)	Integration weeks and Grand Challenge			3	UNINA, ENI	20,28, 36,40
10	Final Conf. (Copenhagen) 2d	Open to external participants. Teams present main research results.	Invited experts' talks; Open public meeting with Press	Discuss new grants and collaboration	-	All	48

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AERO-TRAIN Consortium

16 organizations:

- 7 universities
- 3 RTO
- 2 SME
- 4 Enterprises

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Where to find us

Website: https://www.aerotrain-etn.eu
LinkedIn: https://www.linkedin.com/company/aerotrain
Twitter: @AEROTRAIN2020

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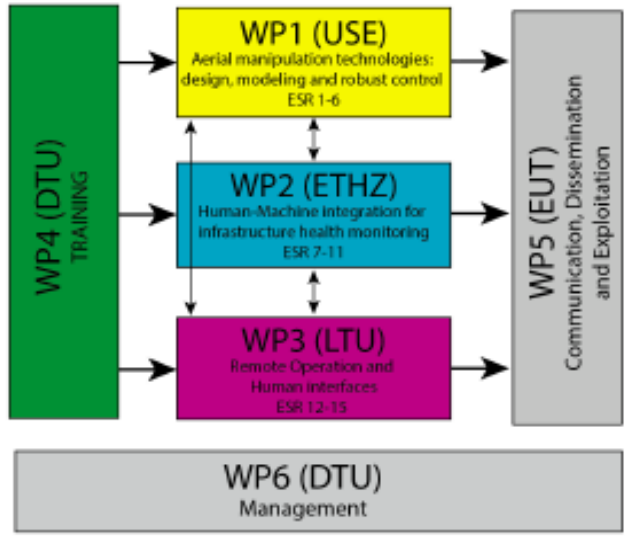
AERO-TRAIN Research project

- Overarching objectives and structure in WP (3 WPs)



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WP1- Aerial manipulation technologies: design, modeling and robust control [Lead: USE, Months: 5-45]

- Objectives: [**A**erial **M**anipulators = AM]
  - Models and integrated mechatronic design of AM for robust control, precise and reliable aerial manipulation.
  - Design AM for manipulation of the environment, in highly uncertain and perturbed environments for realistic outdoor applications.
- 4 Tasks for AM (Keys: physical interaction, real scenarios uncertainties and disturbances)
  - **Modelling** the dynamics and air flow in free flight, near contact and in contact. (USE, ETH, UNINA) ESR3-4-5-6;
  - **Requirements** analysis for design: physical interaction with the environment in real application scenarios (uncertainties and disturbances) (CATEC, DTU, USE) ESR1-2-3-4-5-6;
  - **Design** considering innovations for physical interaction: variable stiffness actuators in (multi) armed AM, and including interaction with human (DTU, USE), ESR1-2-4-5-6-12-13-14;
  - **Control** & **perception** (low-level)**:** precise positioning and control to properly regulate interaction and risk of impacts with the environment (UNINA, WDF, DTU) ESR1-2-3-4-5-6-12-13-14-15
- 3 Deliverables: Modelling & control (M16); design (M26); tests in use case scenarios (M44)

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WP1- Aerial manipulation technologies: design, modeling and robust control [Lead: USE, Months: 5-45]

- ESR projects' introduction by supervisors:
- ESR2, Stabilization and control of aerial manipulators in contact with the environment for on-site measurements, UNINA
- ESR3, Full-body Control of an Interactive Aerial Robot, ETH
- ESR4, Aerodynamics-aware cognitive control of aerial manipulation of flexible objects, USE
- ESR5, High Force Tool Manipulation with Aerial Robots, DTU
- ESR6, Soft aerial robots physically interacting with humans and objects in the environment, USE

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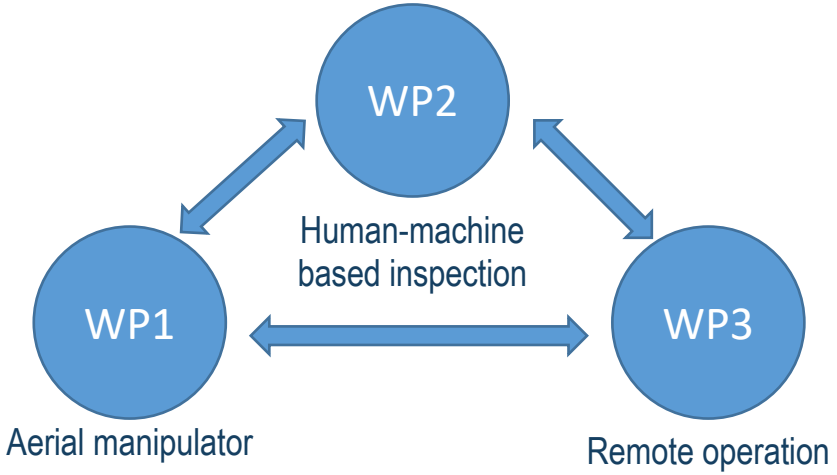
WP2

Title: Human-Machine integration for infrastructure health monitoring

Objectives: integrate human supervision into robotic inspection developing a remote inspection support system that interfaces the human operator and the robot

- Provide data to human operator to assess damages and take decisions (augmented reality, autonomous mapping)
- Provide results of inspection like detected failure points and unknown, novel or anomalous regions (anomaly detection, 3D reconstruction)
- human-assisted but machine-verified platform navigation and manipulation for discrimination of false positives (human in the loop path planning)



Scientific & Technological Challenges:
- HRI for remote inspections (ESR-7, EUR)
- detection of failures (ESR-8, DTU)
- augmented reality (ESR-9, TAU)
- human-in-the-loop path planning (ESR-10, LTU)
- dense and semantic mapping (ESR-11, ETH)

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WP2

ESR projects' introduction by supervisors:

- ESR7, Human-drone interaction performance assessment in aerial infrastructure inspection, EUT
- ESR8, Bio-inspired Learning approaches for Anomaly Detection and Condition Monitoring with Aerial Robots, DTU
- ESR9, Immersive displays maintaining ultra-realism and 3D visual cues, TAU
- ESR10, Augmented Reality for enhancing semi-autonomous Remote Aerial Manipulation, LTU
- ESR11, Uncertainty Aware Mapping and Control for Aerial Robots, ETH

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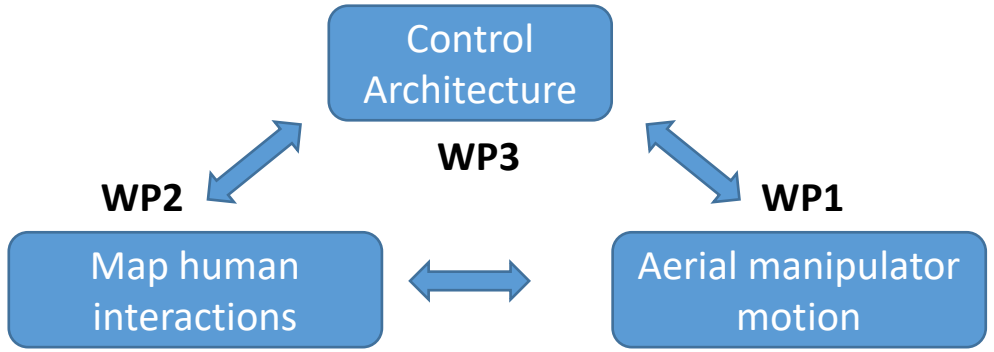
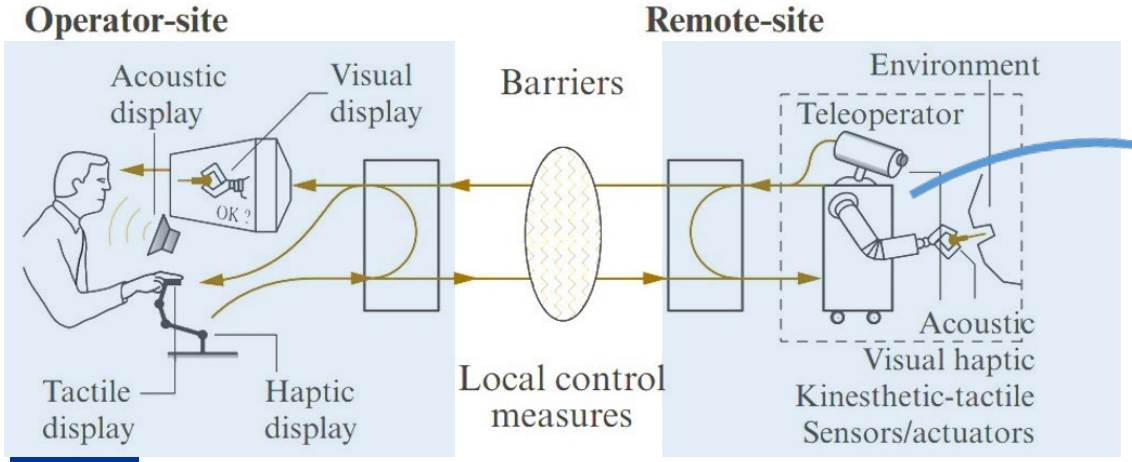
WP3 [Lead: LTU]

Title: Remote operation and human interface



- Objectives
  - Developing new tele-operation framework with visual and haptic feedbacks
  - Development of hardware for aerial manipulators and remote interface
  - Develop and test control algorithms to demonstrate the manipulation capabilities



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WP3 [Lead: LTU]

ESR projects' introduction by supervisors:

- ESR12, Haptic control for remote teleoperation of cooperative aerial manipulators, UNINA
- ESR13, Remote Control of Aerial Robots for Tool Manipulation, DTU
- ESR14, Advanced guidance and precise control of aerial robots for industrial inspections, CATEC
- ESR15, Drone based Robust Control Schemes against varying time delays, LTU
- ESR16, Connectivity and positioning for UAVs, ERI

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WP4 -Training [Lead: DTU]

- A training program built around a research project
- 15 ESR working on own research project
- Secondments and network-wide training
- Local training
- Courses

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WP4 -Training

- ESR projects' introduction by supervisors:
- **Stabilization and control of aerial manipulators in contact with the environment for on-site measurements**
- **Full-body Control of an Interactive Aerial Robot**
- **Aerodynamics-aware cognitive control of aerial manipulation of flexible objects**
- **High Force Tool Manipulation with Aerial Robots**
- **Soft aerial robots physically interacting with humans and objects in the environment**

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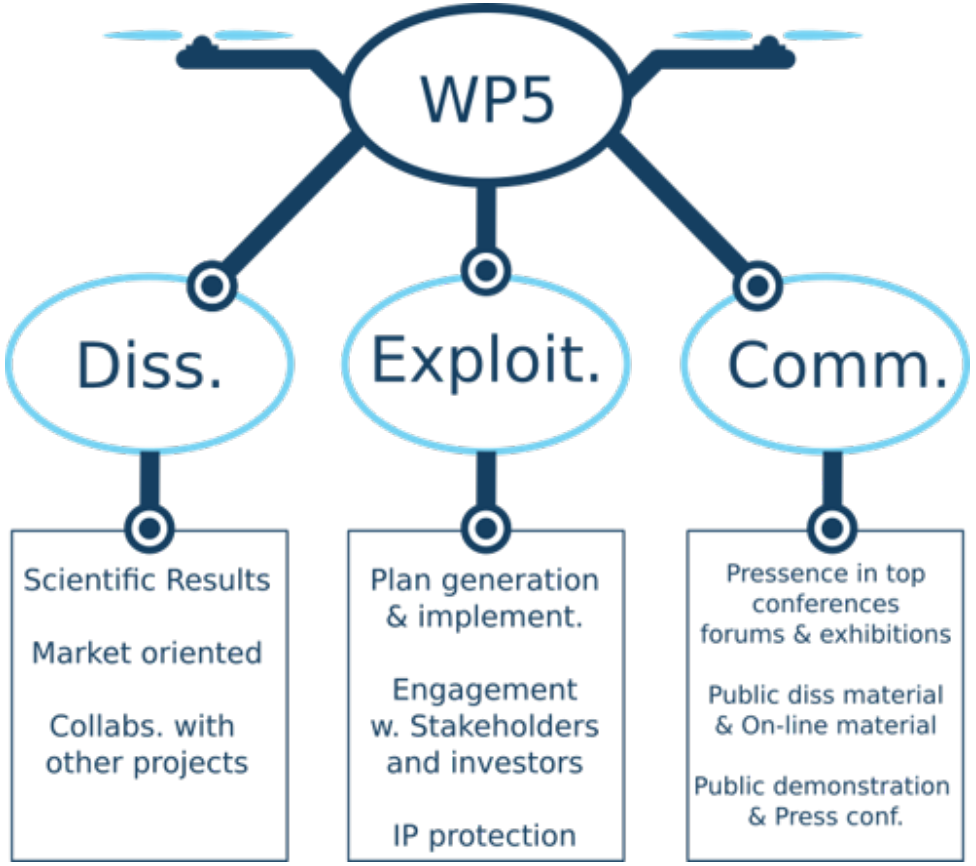
WP5 - Communication, Dissemination and Exploitation [Lead: EUT]

Objectives

(i) To disseminate the AERO-TRAIN results to the wide international network active in the field of infrastructure inspection, monitoring and maintenance.

(ii) To communicate results to the industrial sector, governance structures and politics, the wider public, media and the young generation.

(iii) To exploit the developed knowledge and IPR.



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WP5 - Communication, Dissemination and Exploitation

Tasks:

T5.1 Implementation of the Communication Plan (DTU+All)

T5.2 Dissemination of Scientific results and conclusions (DTU+All)

T5.3 Strategic Market-based Dissemination (EUR+All)

T5.4 Harmonization with other EU and Global Projects (CAT)

T5.5 Implementation of the Plan for Exploitation and Dissemination of Results (EUR)

Deliverables & Reports:

M2 D5.1 Website and social media interfaces available (DTU)

M10 D5.2 CP and PEDR (EUR+DTU)

M16 D5.3 Feedback collected from first public presentation and discussion tables; included in remaining outreach planning (EUR+DTU)

M30 D5.4 AERO-TRAIN support material and presentations available (CAT+DTU)

M46 D5.5 Final press release on AERO-TRAIN findings, attributed awards and all public relevant information (EUR)

M47 D5.6 Final Conference and Summary of Scientific manuscripts submitted (DTU)

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WP6 – Project management

- Preparation and submission of deliverables
- Coordination of overall activities
- Tracking and monitoring of progress
- Quality control
- Risk management

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