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AMTECH

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Development of an aviation aerospace mechatronics technician curriculum

Project Result 2

Executive summary of findings and results

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1. Scope and scale of the research: an introduction to contents available for readers

In January 2022, the AMTech consortium launched a detailed and in-depth research aimed at mainstreaming and stock-tacking relevant trends and dynamics regarding the aviation industry with a special focus on the drone sector.

In consideration of the specific target groups of the project (and people as well as organisations which might potentially benefit from the publication of this document), partners focused their research efforts on SMEs, teachers and trainers of the VET sector and their needs especially to the new operation context: specifically, our objective was to investigate quantitative and qualitative indicators in regards to curriculums for the aviation industry and their focus (or not) on the new drone sector in Europe and all countries represented by the partnership (Germany, Italy, Latvia, Poland and Spain); highlight further challenges, skill-gaps and need assessments; extrapolate new and/or established opportunities for training and education in the drone sector for employers and employees.

This cross-national research took six months and collected relevant inputs and results from both secondary and primary resources. In fact, partners carried out the mapping activities from two different fronts of analysis: on one hand, the project partners looked at reliable and trustworthy literature sources published by international and national institutions; on the other hand, they also conducted a survey with the specific goal to collect meaningful insights from the target groups from all over Europe on the topic of the project.

The report is structured as follows:

- PART A – comprehensive presentation and executive summary of key findings from literature reviews conducted by the project consortium. The results are organised per country and are available in all languages formally represented by the AMTech partnership.
- PART B – collection of all reports finalised by partners and presented to readers in their integral form (only available in English).
- PART C - Table resuming results emerging from the survey (only available in English).

The key findings from the analysis are instrumental to inform the further implementation phase of the project which includes the development, testing and finetuning of the education material to be developed within the AMTech project. Thanks to the research activities conducted throughout the considered period, the project partners have been able to stock-take training areas that seem to be more crucial than others to help the target groups regarding the training needs when working with drones. This is an opportunity for better effectiveness and efficiency and students are more prepared when entering the labour market.

2. Presentation of key findings: a comprehensive overview

In the following paragraphs, the readers will have the opportunity to familiarise with the most important outcomes as highlighted by each partner in reference to their geographical context of reference (Europe for IHF asbl; Germany for Centrum für Innovation und Technologie GmbH and DroneMasters Academy; Italy for IDP European Consultants; Latvia for Kuldiga Technology and Tourism School, Poland for Nowa Sol VET school and Spain for IWS).

These outcomes pertain to critical need-assessment and skill-gaps identified by the project partners. For a detailed showcase of qualitative and quantitative trends and dynamics pertaining

to the aviation industry with the specific focus on the drone sector, the readers are invited to refer to the consolidated country reports in PART B.

European Union

The industry of unmanned aircraft systems (like drones) is expected to represent a powerhouse for the employability, innovation and development of the EU aviation and aeronautics industry. Industrial application of drones benefits a wide cohort of sectors (agriculture, energy, public safety, e-commerce, mobility, etc), with significant spill-over effects for entrepreneurs operating within these markets.

Despite the great technology advancements observed in the timeframe of the past ten years, further R&D efforts are needed to enhance the value that the drone industry can generate for end users. Most of potential industrial applications are still in an early stage of experimentation, with the public opinion still divided on concerns for privacy and safety.

The work of regulators is aimed at easing the social acceptance of this new phenomenon, without posing excessive burden to the innovation paths traced by the many new organisations operating in the unmanned aircraft sector. Competitive outlooks for businesses in the drone industry are bright and very promising, but on the other hand the sector might risk of reaming devoid of professional profiles that allow for the great technological effectiveness of this new state of art technology.

The analysis carried out in the report concerning the European level is aimed at assessing in a concise and comprehensive format the training needs informing the design, structure and following learning outcomes of the curriculum for aerospace mechatronic technicians. The references extrapolated from literature are somehow indicative of what this curriculum should look like at VET level, what could be the knowledge and skills detained by such professional profile, etc. Most of the effort was invested into interpreting and decoding data to meld an archetype that is still in the making.

Data and resources collected allowed have allowed to systemize an ideal curricula framework for drone maintenance-related operations that could fit indeed the professional profile seek by this project, and the needs of training and education providers. The outline of this theoretical framework for education and training provided by IHF is divided into three training areas that, based on our assessment, are intrinsically related to the Human Factor of unmanned vehicles, hence strategically relevant for capacity building experiences: know-how of hardware, understanding of software, attitude to multifunctionality.

Germany

The German aviation and aerospace industry has enjoyed unprecedented success over the last two decades. Since the mid-90’s, industry revenues have more than quadrupled - to over 40 billion EUR in 2018. Today, the sector belongs to the country’s most innovative and best-performing industries.

Industry analysts forecast that between 30 to 35 thousand new aircrafts will be put into service in the next 20 years to meet increasing global aviation demand – leading to a new golden age of aviation. With increasing demand for air travel and rising passenger counts, the industry is witnessing a sudden upsurge in disruptive technologies from companies willing to grab the market through innovation in services and customer experience. One of the innovations driving the aviation industry is ‘Electrification’. As per industry experts’ electrical power and propulsion systems will lead the way for Advanced Air Mobility (AAM), enabling silent short and vertical take-off and landing capabilities while lowering emissions and reducing fuel consumption (Rolls Royce,

2022). Alongside electrification, new materials and composites – as well as changes to overall aircraft design (e. g., retrofit with winglets) – are helping increase fuel efficiency levels through reduced weight and improved aerodynamics.

From smart manufacturing ("INDUSTRIE 4.0") to the airline planning cycle revolution and the dawn of in-flight connectivity – the digital revolution is having a significant effect on the aviation and aerospace industry. IT solutions will penetrate all aspects of airline production and operation (including maintenance and engineering, ground, and in-flight operations). In addition to that ongoing technological specialisation leads to the outsourcing of systems - such as avionic electronics - and the design and production of aircraft structures.

With all these industry transformations, it is evident that the workforce of tomorrow that designs, manufactures, operates, maintain and services these systems/platforms will require new skills. Since technology and industry standards evolve so rapidly, manufacturers themselves need to help shape and educate the next generation of workers. With interest in the trades still lagging, aerospace companies need to leverage public interest in space and drive enrolment in vocational studies. Interest in aviation and aerospace manufacturing could overflow into other sectors, with skills translating directly to other sectors. Aviation and aerospace manufacturers could help end the labour shortage that has impacted the industrial sector for more than a decade.

Manufacturers' involvement in vocational and educational training already takes many shapes, but there are unlimited ways to support education in the different sectors. The most direct way is building relationships with the local trade, vocational and technical schools, especially ones offering programs relevant to the manufacturers' industry or needs. Also, an involvement of government and educational institutions cannot be ruled out as their participation in providing resources and funds would be detrimental to the success of such a program.

In Germany, 10.300 workers are primarily employed by drone companies. The service market category is where most of the workforce is engaged (80 %). This primarily refers to those who use hardware and software in the course of their employment to perform tasks for other businesses, but it also covers those who work in fields like research and development, maintenance and repair, and consulting. Employees of companies whose primary business is unrelated to drones but where specific employees oversee drone-related duties are also included in this segment.

One of the biggest challenges that Germany currently faces is the lack of skilled workforce to take up jobs related to electric aircrafts and unmanned aerial systems (UAS), like drones. Since these novel platforms are foundational based on new technologies arising from different engineering disciplines such as electrical engineering, materials technology, electro-chemical engineering, computer science, information technology, machine learning, artificial intelligence (AI), etc. the educational curriculum needs a major overhaul.

Italy

The Italian unmanned aircraft systems (UAS) industry is characterized by dichotomous trends. Based on latest analysis from the Italian Drone Observatory of Polytechnic of Milan, a top-notch research centre at national level, the inhibitors/drivers model for this industry includes five key distinctive variables: evolution of legislation, organisations' culture and internal competences (i. e., referred by this report as "Human Factor"), networking and external collaboration with Stakeholders and other groups of interest, technology maturity, gathering, collection and processing of data. The lack of regulation compared to technologies, frequent changes in the normative outlook, and last but not least, the overall lack of understating from the demand side of concrete potentialities and benefits that this technology is able of guaranteeing seem pretty recurrent discussions among businesses and sectors' operators.

Worthy to mention is also the fact that the unmanned aircraft systems industry is populated for the very most by microenterprises, that despite their very high innovation driven culture, they deal with the same identical challenges typically faced by any other small enterprise regardless of their occupied sector (i. e., internationalisation, networking and access to finance, even by alternative credit means).

But despite all of these, the Italian unmanned aircraft systems industry shows also great potentials for innovation, development and employability. Official stats from the Polytechnic's observatory confirm indeed that the drone sector is recovering very rapidly from COVID's crisis and it is forecasts margins of high competitiveness and profitability.

In the context of this report, IDP looked specifically into training and education opportunities available among legislation and existing literature for the aviation aerospace mechatronics technician, a professional profile that is not still defined at formal level but identified by the project's background as of instrumental valorisations for the outreach of the sector.

Compared to capacity building for drone pilots, the training and education resources for drone operators and technicians, let alone aviation aerospace mechatronics technician seem nowhere to be found in literature, or to better say, in a compiled, institutionalised and structured framework of common reference for interested parties. This is mainly due to the high fragmentation of technical/regulatory requirements that exists within the sector, and influenced by the industrial application of drones, the specific sector to which this application is in force, and field specific regulatory frameworks.

Nonetheless, besides few coordinates' indicative of the technical skills and knowledge that should be possessed by such profiles, IDP provided for a theoretical model of curricula centred as well on attitudes and qualitative features that should be applied to this profession and are instrumental for further employability opportunities.

Latvia

The Latvian aeronautics industry is a small sector with big opportunities and exporting vocation, whose technological developments are incorporated into other sectors of activity present in our daily lives. Especially the drone industry is at the beginning in the country.

The aeronautical industrial activity in Latvian is mainly concentrated in private sectors, or big companies where the only one is AirBaltic. The sector is characterized by very few large companies and medium-sized companies but a much larger number of small companies. There aro no current data regrading to drone industry as an industry in Latvia. Some factories are based on defence markets, and some are based on private follower for sport activity, some for shows.

Training in the aeronautical industry in Latvia is mainly based on the AirBaltic needs, and the teaching of specialists for their company. AirBaltic made some cooperation with local vet schools. In the private sector it mainly teaches the training how to pilot a drone and the law where can it be piloted. With a few exceptions, no training is offered in electronics, mechanics or mechatronics fields.

As a result of this situation, when we turn directly to the UAV sector, we find that one of the main problems for employers is that they cannot find qualified personnel due to the lack of specific training. In conclusion, we can highlight good overall aeronautical training, especially in the VET ecosystem. But in the specific sector of drones and unmanned aircraft, the training is mainly focused on the operation of the aircraft, ignoring other fundamental elements to train a good professional such as electronics, computer science, assembly, etc.

Poland

The legitimacy of the project's implementation is confirmed by the analyses presented in the report of the aviation market in Poland, especially the drone market, which is characterised by high growth dynamics. Drones, as a tool, as a system should be looked at in three levels.

The first is the equipment itself, its design, the use of the latest materials, power systems. And this is where the huge challenge of building educational, technical and service facilities comes in. Just as in the aviation industry the process of design, construction, maintenance of continued airworthiness and eventually repair is clearly regulated by international aviation laws, so too in the case of drones, whose presence will become more and more common in peoples living space, the oversight of their creation and servicing must be bound by legal standards. This is due to the need to ensure high safety standards. Hence, the development of technical education in this area is considered essential.

The second aspect is the question of using IT solutions and artificial intelligence. The idea behind drones is their autonomy, which allows them to be used to their full potential without the constant presence of a human. BSP flights are possible in visibility and out of sight of the operator. In particular, the development of solutions that allow drones to be used as autonomous units, reacting to each other, learning the management system represents the greatest opportunity for the widespread use of drones. The use of artificial intelligence (AI) for the creation of these systems is therefore becoming essential.

The third pillar is the area of application. Transport, monitoring, entertainment or military use are just some of the areas where drones are finding their place. The development of technology and, above all, the development of new, efficient and long-lasting power systems for drones will allow for their full application, which is difficult to predict today.

It could be said that the only limit to the use of drones is our human imagination. It is not a new flying device, but a completely new technical plane with applications that are still difficult to foresee. The use of drones can dramatically change the approach to their use in, for example, urbanised spaces, in broadly defined services for the public strongly changing the quality of life of the population.

Spain

The Spanish aviation and aeronautics industry is a sector with high-added value and exporting vocation, whose technological developments are incorporated into other sectors of activity present in our daily lives.

The aviation and aeronautical industrial activity in Spain is mainly concentrated in Airbus products, complemented by participation in Boeing, Embraer, Bombardier and Sikorsky programs, among others. The sector is characterized by very few large companies, with a larger number of medium-sized companies and a much larger number of small companies. In Spain, there are 436 companies with EN9100 certification, distributed among 670 production centres. SMEs represent 96 % of the companies in the sector, and 15 companies have more than 250 workers.

The Spanish industry is currently present in all segments of activity; most of the aeronautical sector (76 %) works in "aircraft and structures", 11 % in "engines" and 12 % in "equipment and systems". A key differential from the rest of the European companies is that Spanish aviation and aeronautical companies contribute complementary to the turnover of the civil and defense markets.

Between 2014 and 2019, the overall evolution of the national defense and aerospace sector was always positive, to the point of being "the fastest growing industrial sectors in Spain". The civil aviation and aeronautics industry was the hardest hit by the Covid-19 crisis in 2019, due to the decline in demand for new aircrafts. The flights were suspended for much of 2020, leading to an overall decrease in production activities.

The sector's recovery depends on competitiveness, which will be achieved:

- dedicating great efforts to R&D&I
- investing in technology
- by maintaining the capacity to cover the entire course of an aircraft: conceptual phase, design, development, manufacturing, assembly, certification, sale and support of the product once in service.

Knowledge, training and investment in R&D&I are key to the development of the aerospace industry. Continuous training of qualified professionals is essential for the competitiveness of the industry.

Training in the aeronautical industry in Spain is mainly articulated through vocational training offered by the following programs:

- Aeromechanical Maintenance Training Cycle,
- Aeronautical Systems Structures and Installations Assembly Technician,
- Higher Technician in Aeromechanical Maintenance of Aircraft with a turbine engine,
- Higher Technician in Electronic and Avionic Aircraft Systems Maintenance.

These programs cover all types of subjects related to aeronautics but not directly related to UAVs. At the university in Spain, they also have aeronautics and aerospace degrees.

In the drone and unmanned aircraft systems sector, training is carried out by private academies and is focused almost exclusively on drone operation and navigating. With a few exceptions, no training is offered in electronics, mechanics or mechatronics fields. As a result of this situation, when we turn directly to the UAV sector, we find that one of the main problems for employers is that they cannot find qualified personnel due to the lack of specific training.

In conclusion, it can be highlighted that there is good overall aeronautical training in Spain, especially in the VET ecosystem. But in the specific sector of drones and unmanned aircraft systems, the training is mainly focused on the operation of the aircraft, ignoring other fundamental elements to train a good professional such as electronics, computer science, assembly, etc.

3. Final remarks and the way ahead

As mentioned already, the standardization of a curriculum for aviation aerospace mechatronics technicians is relatively complex due to the heterogeneity that there is in the many fields of application, the divergence that there is between each of the considered segment, and the technology-driven requirements from sector to sector.

Based on the assessment of the project consortium, resources available are still very much oriented on attitudes, skills and knowledge of pilots. Nonetheless, the reliability of the entire system that comprises the vehicle, the ground station, and communication equipment is intrinsically related to a human factor of which mechatronics technicians certainly belong to.

Evidence and findings suggest that this human factor can be break-down into three elements, and related sub-threads:

Hardware	Software	Personnel
Logistics and handling of typically extremely fragile components Assembly of electrical systems and safe storage of raw materials Robust, specialised and reliable knowledge of vehicle-specific elements and distinctive features Battery maintenance, and compliance with charging / discharging cycles and safety procedures Crisis / failure management Data management of flight history and recording of trends Data management of maintenance history of single components Basic understanding of alternative propulsion systems	Software management Monitoring and evaluation of vehicle performance Quick thinking on anomalous/ out-of-ordinary conditions Data gathering / data storage/ data management (and high quality of information)	Sensory and experience-based know how of vehicle performance Multiskilled-compliant attitude (i. e., combining knowledge of electric, mechanical and software engineering) In-depth understanding of the engineering features of the vehicle

On the basis of the findings, the next step will be the development of the training curriculum for the aviation aerospace mechatronics technician. Additionally, 6 training modules will be devloped during the project duration to support the topic of the curriculum. The topics of the training modules as plausible focus of interest have been distributed among partners based on each organisation’s specific background, know-how and expertise.

The training areas are confirmed as follows:

1. How to deliver digital training content through a digital training platform
2. Resources for Vocational Education teaching and training
3. How to engage students in online training
4. Theoretical training in the drone industry based on STEM subjects in vet education
5. Practical Application of STEM in Vocational Education
6. Introduction to UAS Technology & its Future