The Polish Aviation Industry

Potential and prospects for development

November 2024

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The better the answer.
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Contents

Engineers from GE Aerospace Poland and Avio Polska contributed to the development, tests, and certification of the Catalyst™ engine, the first turboprop engine fully designed and made in Europe.

Foreword

Dear Readers,

I am handing over to you this report entitled "The Polish Aviation Industry. Potential and prospects for development", commissioned by the Association of the Polish Aviation Industry. This report is the result of the work of an expert team led by EY.

The aviation industry is an important element of the national economy. Currently, it comprises over 100 diverse entities, including global aviation manufacturers, small and medium-sized enterprises and significant scientific and research centers in Europe. The industry employs over 32,000 workers, which translates into more than 64,000 additional jobs in other branches of the economy. Every PLN 1 million of value added generated by the aviation industry leads to PLN 1.8 million of value added in other sectors of the economy. The value of the aviation industry's revenue in Poland in 2022 was PLN 14.5 billion. It is worth emphasizing that 87% of the revenue was export driven. As a result, the activities carried out by the industry's players have had a significant impact on strengthening the economy and enhancing the country's security and defence.

We are aware that maintaining this potential requires continuous development and following new trends, taking into account the needs of the economy and society. This is reflected in the expenditures allocated by aviation industry entities for research and development, averaging 4.3% for the period 2018-2022.

A significant challenge for the entire aviation industry is the low-emission transformation while simultaneously increasing the industry's competitiveness. The aviation industry currently faces a pivotal moment. Decisions taken now will have a significant impact on the condition and position of the Polish aviation industry in the long term.

This report comes at an opportune moment. On the one hand, it summarises the situation of the aviation industry in Poland, pointing out its importance for the socio-economic development of the country. On the other hand, it focuses on growth prospects, showing that we are ready to embrace the new challenges. Their implementation provides an opportunity to strengthen the position of the aviation industry both domestically and on global markets, and can thus contribute to further economic and social development in Poland.

We believe that this study can serve as a basis for developing strategic decisions regarding the support of the industry in the near and distant future.

I encourage you to engage with this report as well as to discuss the future of the aviation industry in Poland and worldwide.

dr inż. Paweł Stężycki
President of the Association of the Polish Aviation Industry

Abbreviations

APU	Auxiliary Power Unit
ARC	Aeronautics Research Consortium
ASD	AeroSpace and Defence Industries Association of Europe
R&D	Research and development
UAV	Unmanned Aerial Vehicle
COP	Central Industrial Region (Polish: Centralny Okręg Przemysłowy)
EASA	European Union Aviation Safety Agency
EDF	European Defence Fund
EREA	Association of European Aeronautical Research Institutions
EUR	Euro
FENG	European Funds for Smart Economy Programme
FERS	European Funds for Social Development
FMTC	Future Mid-Size Tactical Cargo
G2B	The sales formula between the government and the business sector (Government to Business)
G2G	The intergovernmental formula for government-to-government sales (Government to Government)
GUS	Central Statistical Office of Poland (Polish: Główny Urząd Statystyczny)
IFAR	International Forum for Aviation Research
IoT	Internet of Things
IT	Information Technology
LuFo	German Aeronautical Research Programme (German: Luftfahrtforschungsprogram)
MRO	Maintenance, Repair and Overhaul
SMES	Small and medium-sized enterprises
NASA	The United States National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organisation
NCBR	National Centre for Research and Development (Polish: Narodowe Centrum Badań I Rozwoju)
NGF	New Generation Fighter
OEM Manufacturer	Original Equipment Manufacturer

PARP	Polish Agency for Enterprise Development (Polish: Polska Agencja Rozwoju Przemysłu)
PBS	Applied Research Programme
GDP	Gross domestic product
PKWiU	Polish Classification of Goods and Services
PLN	Polish zloty
POIR	Smart Growth Operational Programme
PPP	Poland's industrial policy
PRL	People's Republic of Poland
RCS	Effective radar reflectivity area
R&D	Research and Development
RP	Republic of Poland
SAF	Sustainable Aviation Fuel
SAMAS	Remotely Piloted Systems
SESAR JU	Single European Sky ATM Joint Undertaking
AI	Artificial intelligence
SP	Aircraft
ME	Military equipment
Polish Armed Forces	Armed Forces of the Republic of Poland
TOKAT	Transfer of Knowledge and Technology
TRL	Technology Readiness Level
EU	European Union
USD	US dollar

Summary

Modern AW-149 battlefield support helicopter produced and developed by PZL-Świdnik.

A strong domestic aviation industry is of strategic importance for the economy and national security. Based on modern technology and innovation, it creates jobs for skilled workers and drives scientific development, influencing the country's economic growth. Leading European countries actively support the technological development of their own aviation industries.

Polish aviation industry is more than
100
companies

Employment
in the aviation industry is more than
32
thousand employees

Average annual growth of the Polish aviation industry between 2018 and 2022 amounted to more than

10%

Every
PLN 1 million

of value added generated by the Polish aviation industry leads to the creation of nearly

PLN 1.8 million

of value added in other/economic sectors

Recommendations

- Development of the Polish aviation industry around key existing specialisations
- Building a position in aviation technologies of the future
- Linking the achievement of national security goals with the development of the aviation industry
- Creating conditions that allow for the implementation of the entire R&D process in Poland
- Creating a system to secure the human resources required by the industry
- Maximizing development opportunities by supporting the development of technologies and products at every stage of implementation
- Creating a strategy for the aviation industry within the framework of an Industry Contract between the government administration and industry representatives

Summary

Today, the Polish aviation industry comprises more than 100 companies, that conduct extensive activities across all phases of the product lifecycle: from research and development, through the production of components and entire products, to post-sales service and maintenance. This dynamic industry includes small and medium-sized enterprises as well as large corporations, which closely collaborate and grow at an average rate of more than 10% annually (between 2018 and 2022), but above all involve more than **32,000 employees generating an annual output of PLN 14.5 billion**.

Today, the Polish aviation industry is closely integrated into the global market, and its international character is primarily built through the strong position of local companies in the value chains of the largest players in the global market. The development of the value and supply chain is achieved by incorporating small and medium-sized enterprises operating in the country. **Poland hosts key production plants, research centers, and service facilities for several leading aircraft manufacturers.** Companies in the domestic aviation industry are working in partnership to position Poland as the default partner in manufacturing, maintenance and research services for advanced products. To effectively ensure the creation of an optimal environment and a coherent strategy for building market strength, the industry has consolidated into industry organizations that represent their common interests.

Compared to the rest of the economy, **companies in the aviation industry stand out above all for their systematic growth, skilled and experienced workforce as well as innovation**. Together, these three factors enable broad participation in research and development projects and the ability to tackle challenges related to low-emission aviation, Industry 4.0, and unmanned aerial vehicles. To maintain this growth and align with upcoming trends, **the industry must make the best use of available industrial development tools**. Their availability and skilful utilisation have a decisive impact on the location of new production, research and service facilities, as they provide lasting benefits for the economy. This is confirmed by case studies of leading companies in the Polish aviation industry, which share their experiences and are described in more detail in the report.

The strategic importance of the aviation industry to the economy is not surprising. According to the study, it should be noted that **PLN 1 million of value added generated by the aviation industry leads to nearly PLN 1.8 million of value added in other sectors of the economy**. Similarly, employing one worker generates nearly 2.5 jobs in other parts of the economy. Few other industries can boast a similar impact on economic development. Additionally, the aspect of security provided by the local aviation industry is significant, as it continuously works on dual-use technologies.

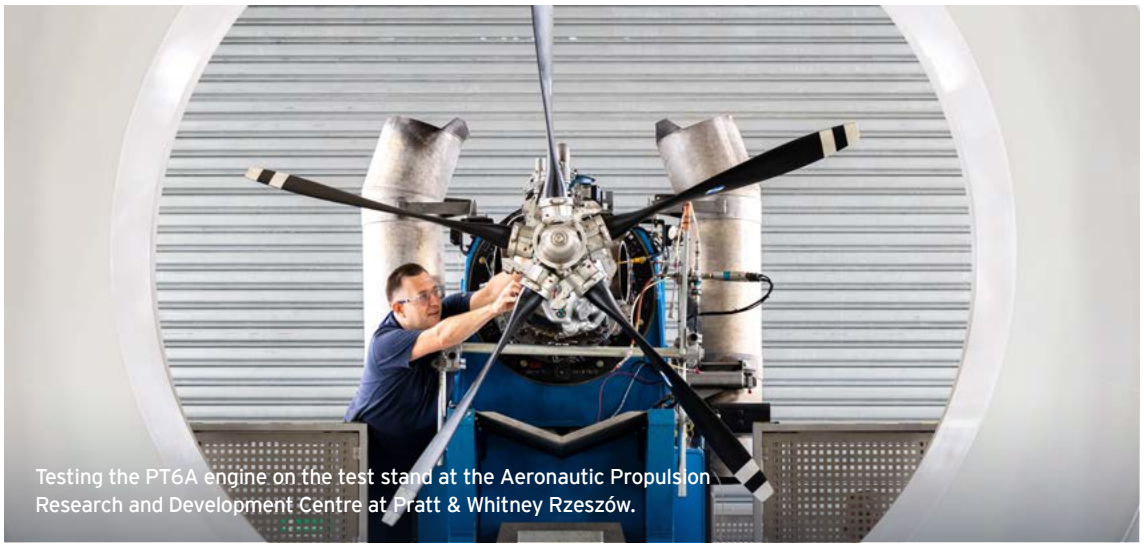
Most developed countries have seen the benefits of protecting and supporting the development of their own aviation industries. The best European practices of leading economies in this industry, such as the United Kingdom, France and Germany, demonstrate a systematic and multi-level approach to actively shaping and supporting the development of the aviation industry. Similarly, in Poland, continuous cooperation and an active government approach to supporting the development of the aviation industry are needed.

What tomorrow has in store for the Polish aviation industry depends on the actions taken today. Faced with new challenges, the report identifies seven key recommendations for the Polish aviation industry. These will undoubtedly help it achieve its full potential. Among the recommendations, the following are particularly important:

- focusing on key areas of competence;
- capacity building in areas of technology of the future;
- leveraging the potential of military procurement to achieve national security goals; and
- creating a system that supports product development in Poland at all stages of the R&D process and securing the workforce that forms the foundation of the industry.

Alongside the above, it is important not to forget to **maximise development opportunities by supporting technologies and products at every stage of implementation**. It is crucial to include all the aforementioned areas **in a coherent strategy for the aviation industry within the framework of an Industry Contract**.

The Industry Contract, which is an agreement resulting from the dialogue between the government administration and industry representatives, **can be an instrument that helps systematise actions and plan support mechanisms for the industry**. The government plays a strategic role here, as the predictability of support mechanisms and open dialogue with ministries is key to the implementation of an effective industrial policy. The discussions held so far prove that the Polish aviation industry is ready for this step – **agreeing a tailor-made Contract, including a strategy for the development of the aviation industry that will serve the economy, industry and society**. Such a prepared foundation will enable our industry to continue its development, increase its impact on the country's economy and become a key player in the global value chain.



Testing the PT6A engine on the test stand at the Aeronautic Propulsion Research and Development Centre at Pratt & Whitney Rzeszów.

1

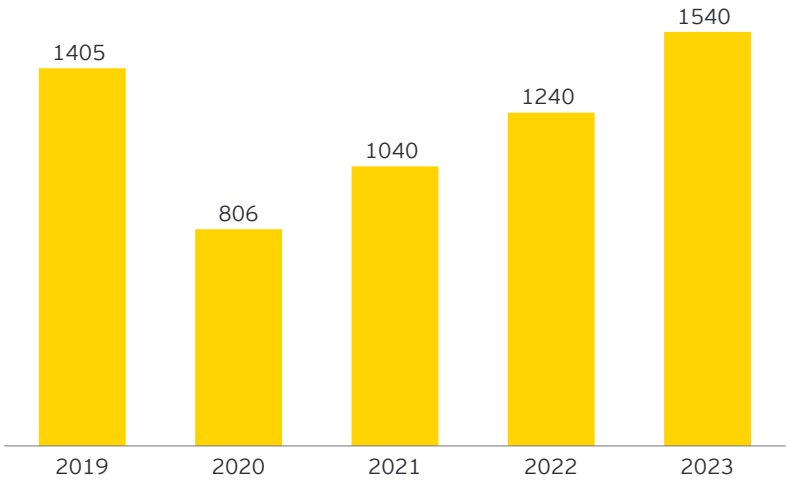
Aviation industry

There are currently more than 5,000 Black Hawk helicopters in service around the world with a total of more than 14 million hours flown. The photo shows the S-70i variant manufactured at PZL Mielec.

Introduction

The incredible ease and speed of moving around the world owed to airplanes and helicopters have forever changed the rules of the game in passenger and cargo transportation. The prospect of instant reductions in travel time from one place to another, along with previously unknown possibilities of reaching almost every corner of the earth[1] have led to an unprecedented development of aviation, making it one of the most attractive and promising sectors. Continued growth and the need for security in air transport has made it one of the most innovative industries of the global economy. Few other industries can boast such systematic and impressive development, spanning nearly 100 years.

Chart 1. Number of aircraft produced



The global COVID-19 pandemic hampered aircraft production, but by 2021 the market had begun to recover.

Source: Statista database

1 The use of aircraft has increased the efficiency of medical, firefighting and other rescue-related operations.

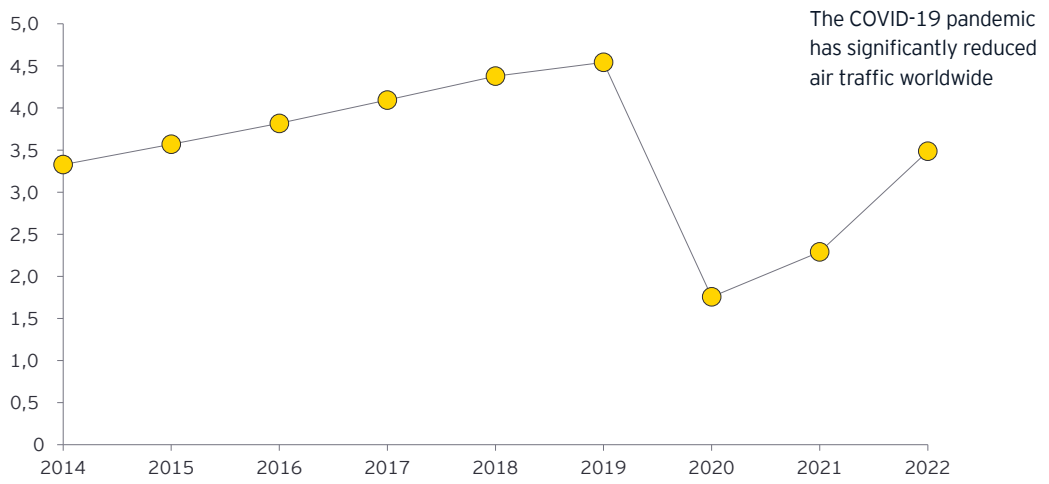
Polish helicopter Sokół ("Falcon") designed and manufactured in PZL-Świdnik, used in mountain rescue operations.

The growing global demand for civil aviation services and the versatile use of aircraft in the security and defence sectors have shaped the modern aviation industry. It is characterised by continuous technological progress, including the pursuit of ongoing improvements in efficiency and the introduction of further technical enhancements that increase the safety of the operations carried out. Modern aircraft are complex structures with a very intricate value chain, requiring multi-stage and international cooperation. Original Equipment Manufacturers (OEMs), which include producers of components, modules, systems and the aircraft themselves, play a dominant role in the aviation industry value chain. This chapter serves as an introduction to the concept of the aviation industry and aims to present its structure and main development conditions.

Defining the aviation industry

The basic segmentation of the aviation industry indicates a market division by application into civil and military aircraft, and by product into transport, special and general aviation. Alternatively, there is also a functional division into equipment manufacturers and entities providing maintenance and repair services, known as MRO (Maintenance, Repair and Overhaul) services[2].

Chart 2. Number of airline passengers worldwide (billion)



Source: World Bank database

The development of the aviation industry, particularly the civil segment, is closely linked to the activities of air carriers, who have built a very strong and still growing market over the past few years. This is evidenced not only by the increasing number of airline passengers (see Chart 2), but also by the expansion of the worldwide airport network (and, in Poland, the mega-airport project situated between Łódź and Warsaw). Innovations and technologies generated in the military segment continue to have a significant impact on the development of the civil segment – this is where jet engines, advanced navigation and aviation safety standards were first introduced. For more on this, see the case study *The role of military equipment procurement in building industry capabilities* on p. 128.

2 For the purposes of this report, it should be emphasised that the players in the aviation industry do not include airlines because, despite their obvious connection to aircraft, their main activity is the transportation of people and goods.

The aviation industry is characterized by a complex structure. It is a network of many interconnected entities that collectively provide a full range of services and products necessary for the production, maintenance and operation of aircraft, such as passenger and military airplanes, helicopters, gliders, unmanned aerial vehicles, aerostats, satellites and other flying devices[3].

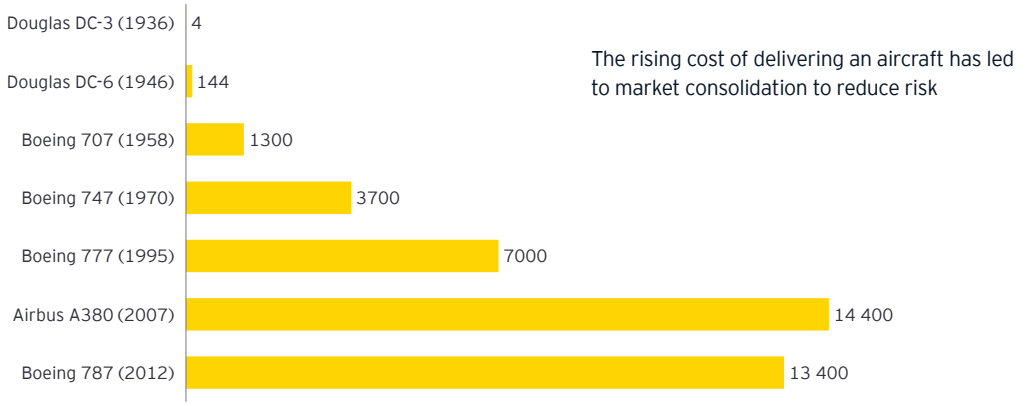
In 2021, the value of the global aviation industry production was USD 300–400 billion, and by 2031 the market is expected to grow to USD 500–600 billion[4]. Despite challenges such as the global COVID-19 pandemic, which limited some of the world's air traffic, and increasingly stringent environmental regulations, further growth of the aviation industry is inevitable.

The aviation industry is highly concentrated, meaning that most of the revenue is generated by a relatively small number of companies – the end manufacturers. This industry has significant entry barriers, the key ones being high costs and safety requirements, which affect the long-term process of conducting research and development, building prototypes and meeting certification requirements.

However, the implementation of these activities does not guarantee mass production, the delivery of the final product to the market or the achievement of economies of scale that give an advantage to existing players in the market. These market constraints have led to the consolidation of the industry and the emergence of natural leaders in specific market segments, creating a model similar to an oligopoly, where a few entities dominate by producing comparable products. The main reason for the merger of aviation industry entities was the need to reduce the cost of developing new technologies and products. At present, only very large companies are able to bear the cost of long-term research and development to culminate in a new product, and pursuing new ventures with a partner or in consortia allows for sharing the investment risk.

As a result, in the aviation industry, a small number of entities generate the majority of revenue from the sale of aircraft, while a large number of collaborating suppliers of materials, components and modules, as well as entities providing R&D services, operate within the supply chains, collectively enabling the creation of aircraft.

Chart 3. Passenger aircraft project cost in (million) USD in 2004



Source: J. Bowen, The Economic Geography of Air Transportation: Space, Time, and the Freedom of the Sky, London 2010

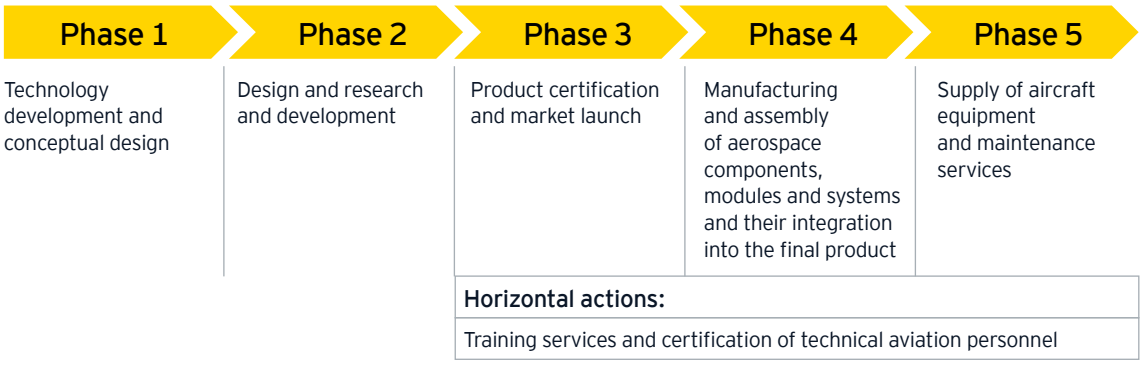
3 The definition of aircraft remains open, as new aircraft, e.g., flying taxis, are constantly being developed and may be an important market segment in the future.

4 Polaris Market Research (2022), Aircraft Manufacturing Market Size Global Report 2022–2030; Allied Market Research (2023) Aircraft Manufacturers Market.

Aviation industry value chain

The value chain of the aviation industry encompasses all stages of work that lead to the production and maintenance of an aircraft, ensuring its continuous airworthiness throughout its entire operational life. Therefore, the aviation industry includes entities that participate in any element of the value chain of aviation products:

Figure 1. Aviation industry value chain



Some entities within the aviation industry possess extensive competences and operate in more than one part of the aviation industry's value chain. This is particularly true for the largest aircraft manufacturers, who develop their products, manufacture key parts themselves and provide post-sales support.

The world's largest aircraft manufacturers – Airbus, Boeing, Lockheed Martin, Embraer or Leonardo[5] – are present at every stage of the aviation industry's value chain. However, these entities do not manufacture all modules or systems of the aircraft. In parallel and under similar principles, aircraft engine manufacturers such as Pratt & Whitney, GE Aerospace, Safran Technologies or Rolls-Royce operate. These entities supply this key module of the aircraft and are responsible for the entire value chain in their area.

It should also be noted that the aviation industry intersects with other sectors. Some aviation technologies not only have dual applications – civil and military – but also meet the needs of other industries, such as the automotive, energy or advanced materials sectors. For this reason, the aviation industry should be understood broadly and may include entities whose activities are partially related to other sectors.

5 These entities operate in both the civil and military segments.

Value chain explained on the Boeing 787 Dreamliner example

To better understand the typical value chain in the aviation industry, it is illustrated using the example of the development and production programme of the Boeing 787 Dreamliner passenger aircraft.

Its innovation lay in the extensive use of composites in the airframe construction (over 50% of the aircraft's weight, compared to no more than 20% in earlier designs) and its novel electrical architecture. Excluding the early technology development phase (achieving Technology Readiness Levels 1-3 – more information in the box below: Technology Readiness Levels (TRL), the transition from concept to market introduction of the new aircraft took 10 years. However, this time can be significantly longer for technologies with even higher levels of innovation or breakthroughs, such as electrification or hydrogenation.

Technology Readiness Levels (TRLs)

Technology Readiness Level (TRL) is a scale used to measure the technological maturity of solutions on their way to market implementation. The TRL consists of nine levels (depending on the maturity level of the technology: 1–9):

1. Start of research
2. Finding opportunities to use technology
3. Research to validate the concept
4. Laboratory verification of the technology
5. Testing in an environment that simulates real conditions
6. Tests of the prototype under near-real conditions
7. Prototype tests under operational conditions
8. Demonstration of the final technological form
9. Technology ready for implementation.

Source: Industrial Development Agency

The TRL levels guide a product through its entire lifecycle, from research (preliminary, feasibility and technological) to the demonstration of the finished product and its preparation for market entry.

In the entire lifecycle of the discussed Dreamliner aircraft, five phases of the value chain can be distinguished. Thus, the process of developing the aircraft up to the point of delivery to users is as follows:

Phase 1

Technology development and conceptual design

In the first phase of new product development, the company invests heavily in research to develop breakthrough technology critical to the product. This research takes 8–12 years to complete.

After achieving an appropriate level of technology readiness that allows for proof of product feasibility (i.e., reaching TRL 4-5), the conceptual design materializes. This design is used to gauge market interest and make preliminary estimates of order volumes, which are crucial for deciding whether to launch the programme. In the case of the Dreamliner, this stage lasted over three years from the start of conceptual work in 2001 to the public announcement of the programme in April 2004.

For the product to be commercially successful, the technological advancement behind it must provide the user (in this case, the airline) with at least 15-20% savings. Otherwise, the product will not find enough buyers, and the development costs will not be recouped. The Dreamliner, compared to its predecessor, offered future users about 20% savings in operating costs, primarily due to lower fuel consumption. Developing the technology that ensured such a technological leap cost the manufacturer over USD 32 billion.

Phase 2

Design and development

The design and development phase is a key phase where innovation materialises and the future of the aviation industry takes shape. This phase of the value chain includes research and development (from TRL 5 to TRL 9), engineering and design. Research work is largely carried out by companies' internal R&D departments and research centres, often in collaboration with academic institutions. Since the largest entities in the aviation industry are private companies, it should be noted that most R&D work in the aviation industry takes place in the private sector. An important element of this stage is securing confirmed orders for future aircraft and selecting the first operator (launch customer), which was the Japanese airline ANA for the 787.

In the case of the Dreamliner, the design and development phase lasted over five years and concluded with the maiden flight in December 2009.

Phase 3

Product certification and market launch

All aircraft components, starting from fasteners, must meet safety standards both individually and as part of the entire mechanism. Unlike many other industries, aviation is heavily regulated in terms of safety and product certification. Meeting these requirements is a prerequisite for the product to be approved for use in civil airspace. This approach, along with a consistent international system, has led to an unprecedented improvement in operational safety in history. This has been crucial in further popularizing aviation as a means of transport.

In the case of the Dreamliner, certification tests lasted two years and concluded with the issuance of the airworthiness certificate in August 2011. The following month, the aircraft was delivered to its first user and subsequently entered the flight network in October 2011.

Phase 4

Manufacturing and assembly of aerospace components, modules and systems and their integration into the final product

The next phase of the value chain is based on previously designed and certified[6] solutions and consists of the production and assembly of aviation components, sub-assemblies and systems into the final product – the aircraft.

Aircraft production is a complex and intricate process, with various stages occurring simultaneously in many factories around the world. The manufacturer of the Dreamliner aircraft outsourced most of the production of parts and systems to companies in Japan, Italy and the United States[7], while the main integration site for the aircraft remained Boeing's home facilities in South Carolina[8]. The integration stage itself does not take long. For the first Dreamliner, the integration of the entire aircraft took seven weeks. According to the manufacturer's plans, this time was to be reduced to six days[9] after the production of the next 100 units.

Aviation industry products very often remain in production for more than 50 years. For the Dreamliner's predecessor, the 767, serial production began in 1982 and continues to this day (expected to reach a minimum of 45 years). Even so, this is not a record compared to the 737 model, which has been in production for more than 55 years. The same is expected for the Dreamliner, which was the first newly designed passenger aircraft in the manufacturer's portfolio in over 10 years and enjoys significant market interest.

Because a particular aircraft model sells for several decades, there is a continuous demand for a wide range of components, modules and systems that make up the aircraft throughout this period. This allows for the creation of durable production chains and the guarantee of specialized jobs.

6 All aircraft components must be certified for the design and manufacturing process.
7 https://www.reuters.com/article/us-boeing-787-idUSN2136064220070522 (access: 10 February 2024).
8 Previously the main plant was a facility in Everett, Washington, due to cost-cutting, production was relocated in 2021.
9 https://www.reuters.com/article/us-boeing-787-idUSN2136064220070522 (access: 10 February 2024).

Phase 5

Supply of aircraft equipment and maintenance services

The final phase of the value chain is the delivery of the aircraft to the customer. From this point onwards, it is used by the operator to provide services, primarily for the transportation of passengers and cargo. The operation of flights generates demand for maintenance and technical support services. These include maintenance, repairs and upgrades of aircraft and their systems, known as MRO services. These services are essential for keeping the fleet in proper technical condition and operational readiness.

MRO services are not only about checking the aircraft after a flight and performing basic inspections, but also periodic (e.g., every four or eight years) comprehensive inspections of the entire aircraft. These inspections aim to diagnose the condition of the entire unit and can take up to several months. For passenger aircraft like the Dreamliner, the simplest maintenance services are performed at airports, while major inspections are conducted only at dedicated service facilities. Only organizations with the appropriate certifications can provide maintenance and technical support services.

The example of the Dreamliner aircraft illustrates how the combination of all elements of the aviation industry value chain together creates an environment that enables the creation of a complete aircraft, its sale and efficient operation. Read more about the challenges of the development process of another aviation product in the case study *Commercial success in a fuel reduction technology Project* on page 22.

Currently, except for specific military products, it is not common practice worldwide to locate the entire supply chain in one place. By default, the supply chain is spread across the globe and decisions to build competences in a particular location are made based on an assessment of local skills, experience, investment environment and investment security. Polish companies are part of this system and carry out work at every stage of the aviation product lifecycle.

The next chapter introduces the concept of the Polish aviation industry, its main features, strengths and weaknesses.

The high level of availability of the M28 Bryza aircraft fleet in the Polish Air Force is guaranteed by efficiently carried out maintenance works at the manufacturer – PZL Mielec.

Case study

Commercial success in a fuel reduction technology project

The GTF engine of the PW1000 series, in the production of which the Pratt & Whitney plants in Kalisz, Niepołomice and Rzeszów are involved.

Company name:	**Pratt & Whitney Rzeszów**
Name of completed project:	Advanced manufacturing techniques for aircraft gear – "INNOgear"
Institution / programme under which funding was provided:	NCBR / INNOLOT / INNOgear
Total project value / own financing / funding:	PLN 54 million / PLN 27 million / PLN 27 million
Project period:	2013-2018[10]

The main objective of the project with the acronym INNOGEAR was to develop an innovative FDGS (Fan Drive Gear System) for the GTF Geared TurboFanTM turbine engine and its production method. The gearbox developed and put into production by Pratt & Whitney Rzeszów, which was the subject of the project, allows for a significant reduction in the aircraft's fuel consumption, noise generation, CO_2 and NO_x emissions. The introduction of the FDGS gearbox into the GTF engine architecture enabled, among other things, an increase in fan diameter, and consequently, the engine's bypass ratio, without generating excessive noise. This represents a significant advancement in the efficiency of aircraft engines, thereby contributing to the development of the entire sector. It is estimated that the innovative engine design could serve the market for at least 50 years, further emphasizing the long-term value of this investment.

10 After the annexation – originally the programme was due to end in 2017.

The implementation of the entire FDGS gearbox project – not just the part funded by the INNOGEAR programme – began in the mid-1990s and concluded nearly 30 years later with the introduction of the GTF engine to the market. This process illustrates the long-term nature of investment in aviation, requiring continuous commitment to transition from the technology development phase to commercial success, which in this case took about 20 years.

The economic value of the project is also very favourable. Expenditure on the INNOGEAR project amounted to PLN 54 million, 50% of which was funding from the National Centre for Research and Development (NCBR). The total revenue generated from the commercialisation of the project results, already in the first two years after its completion, reached PLN 573 million. It is expected that the innovative product will generate up to PLN 3.5 billion in revenue within the first 10 years of its market introduction, part of which will return to the state budget in the form of paid taxes.

The collaboration and involvement of scientific units from across the country, established during the project, are also significant. Pratt & Whitney continues to work with these units on its current in-house research and development efforts and other projects

The success of the INNOGEAR project demonstrates how strategic support can generate economic benefits and contribute to the emergence of technologies in Poland that have the potential to revolutionise the aviation industry, as well as create sustainable, highly-specialised jobs.

Planetary gearbox fan drive for the GTF engine of the PW1000 family produced and tested in Kalisz and Rzeszów.

2

The Polish aviation industry

Acceptance test of the APU engine for the B787 Dreamliner at Hamilton Sundstrand in Rzeszów, a company owned by Pratt & Whitney.

The Polish aviation industry can be defined in various ways, for example, based on its position in the global supply chain, product classification or the origin of capital. For the purposes of this report, the Polish aviation industry is defined as a collection of entities based in Poland and engaged in the provision of services and products necessary for the production, maintenance and operation of aircraft. Thus, the Polish aviation industry also includes entities that are capital-dependent on global aviation giants but operate in Poland as separate legal entities.

Today, the Polish aviation industry comprises more than 100 companies, a large percentage of which belong to the SME sector. The activities of most of these companies focus on the provision of services, as well as the production of aircraft modules. In the case of unmanned aircraft and light aircraft in Poland, final products are also manufactured in Poland. Additionally, there is a significant number of entities whose operations are entirely dependent on or strongly linked to companies strictly within the aviation industry. However, it is the large entities that generate the vast majority of market revenues.

Polish aviation industry in numbers

100+
aviation companies, many more related

Production value:
PLN 14.5 billion
in 2022
(direct production)

Employment[11]
32,000
people

87%
export sales revenue

90.8%
market value generated by private operators

Percentage expenditure on R&D in the aviation industry
4.3%
on average in 2018-2022

Source: EY's own elaboration based on survey data

11 The number of employees includes employees of micro, small and medium-sized enterprises for 2024. The data was established in the course of work with SPPL.

The Polish aviation industry employs 32,000 people. This fact is not surprising, considering the opportunities offered by this industry: the chance for daily interaction with the latest technologies, employment in advanced production, research and development, or service facilities and the possibility of participating in the development of next-generation products. The aviation industry also offers attractive salaries. In 2022, an employee in this industry earned an average of PLN 7,100 gross, which is 13% – or PLN 800 – more than the national average.

The majority of employees working in the Polish aviation industry have a university degree (56% of employees) or vocational training[12] (42%). This confirms that the aviation industry largely generates highly skilled jobs. In the Polish aviation industry, the majority of employees (over 57%) are production workers, with one in four of them working as production engineers. A further 13.6% of employees are involved in research and development. This means that one in seven employees in the Polish aviation industry is involved in research and innovation!

Chart 4. Employment structure in the Polish aviation industry by job position (%)

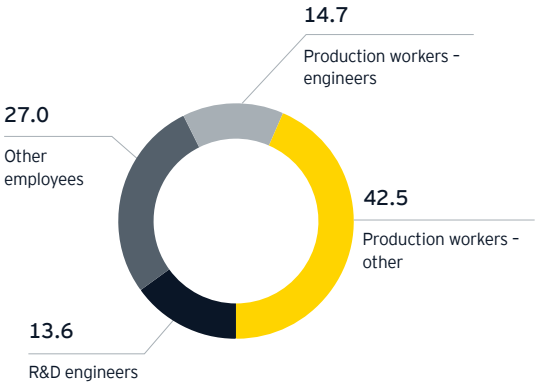
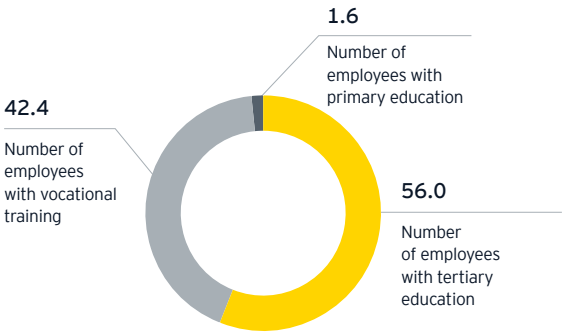


Chart 5. Employment structure in the Polish aviation industry by educational level (%)



Key:

Production workers – engineers

Production workers – other[13]

R&D engineers

Other employees[14]

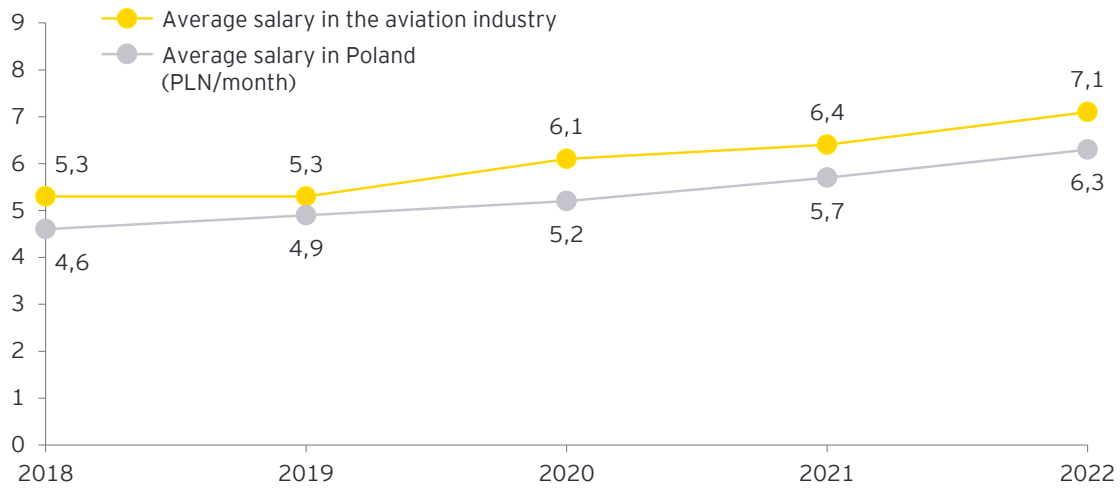
Source: EY own elaboration based on survey data, Central Statistical Office

12 For the purposes of this report, people with vocational education include those with a technical school diploma and those with a basic vocational education.

13 A group of workers directly involved in the production process, such as machine operators, assembly workers, welders, etc., who are not production engineers.

14 Other employees include administrative, financial, marketing, sales, customer service, etc. personnel who are not directly involved in the production process or in carrying out research and development work.

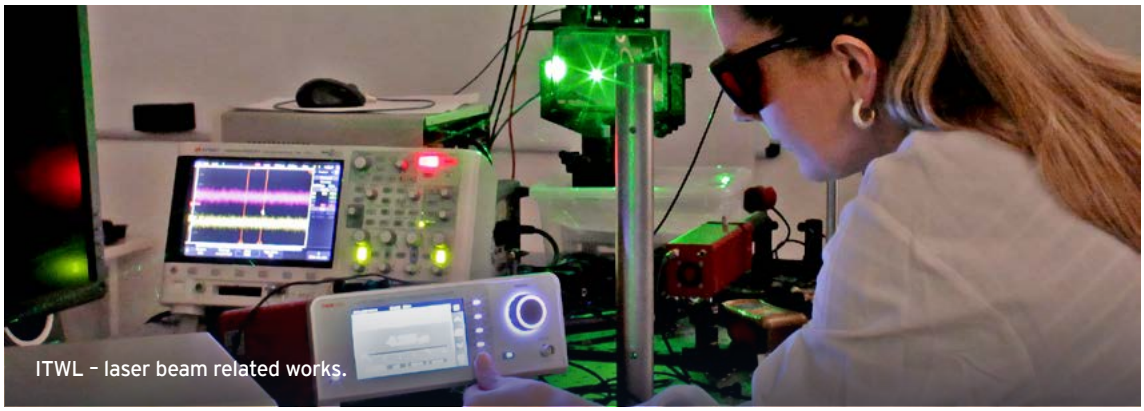
Chart 6. Average salary in the Polish aviation industry versus the country (PLN thousand/month)



Source: EY own elaboration based on survey data, Central Statistical Office

The flagship of the Polish aviation industry is the Aviation Valley cluster – the largest aviation cluster in this part of Europe. It brings together aviation-related stakeholders from across Poland. Most of them are located in the southeastern part of the country, where more than 90% of the industry's production potential in Poland is concentrated[15]. The industry was founded on the basis of Poland's interwar aviation tradition and has developed since the transformation period with the investment support of global aviation industry giants.

Alongside the Aviation Valley, there are also aviation clusters and associations operating in Silesia, Lublin, Pomerania[16], Mazovia or Greater Poland. The activities of the industry are coordinated by industry organisations with a significant role played by the Polish Aviation Industry Association. Its representatives represent the industry in international bodies[17] related to the aviation industry.


ITWL – laser beam related works.

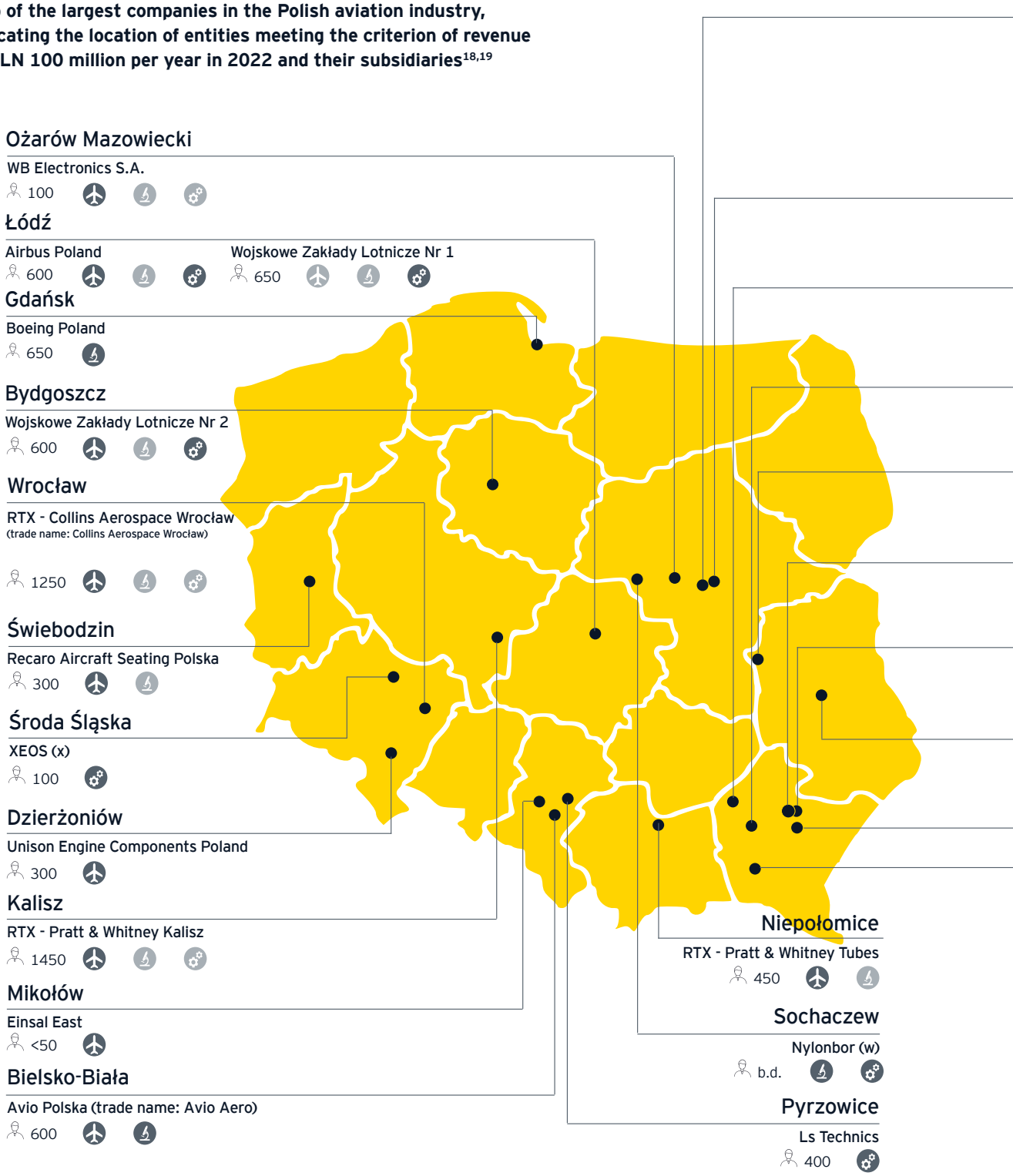
15 https://magazynprzemyslowy.pl/artykuly/polski-przemysl-lotniczy (access: 10 February 2024).

16 The Lublin Cluster of Advanced Aviation Technologies is located in the Lubelskie province, while the Silesian Aviation Cluster was established in Silesia.

17 Among other things in the organisations ASD, EREA, IFAR.

History of the Polish aviation industry

Map of the largest companies in the Polish aviation industry, indicating the location of entities meeting the criterion of revenue of PLN 100 million per year in 2022 and their subsidiaries[18,19]



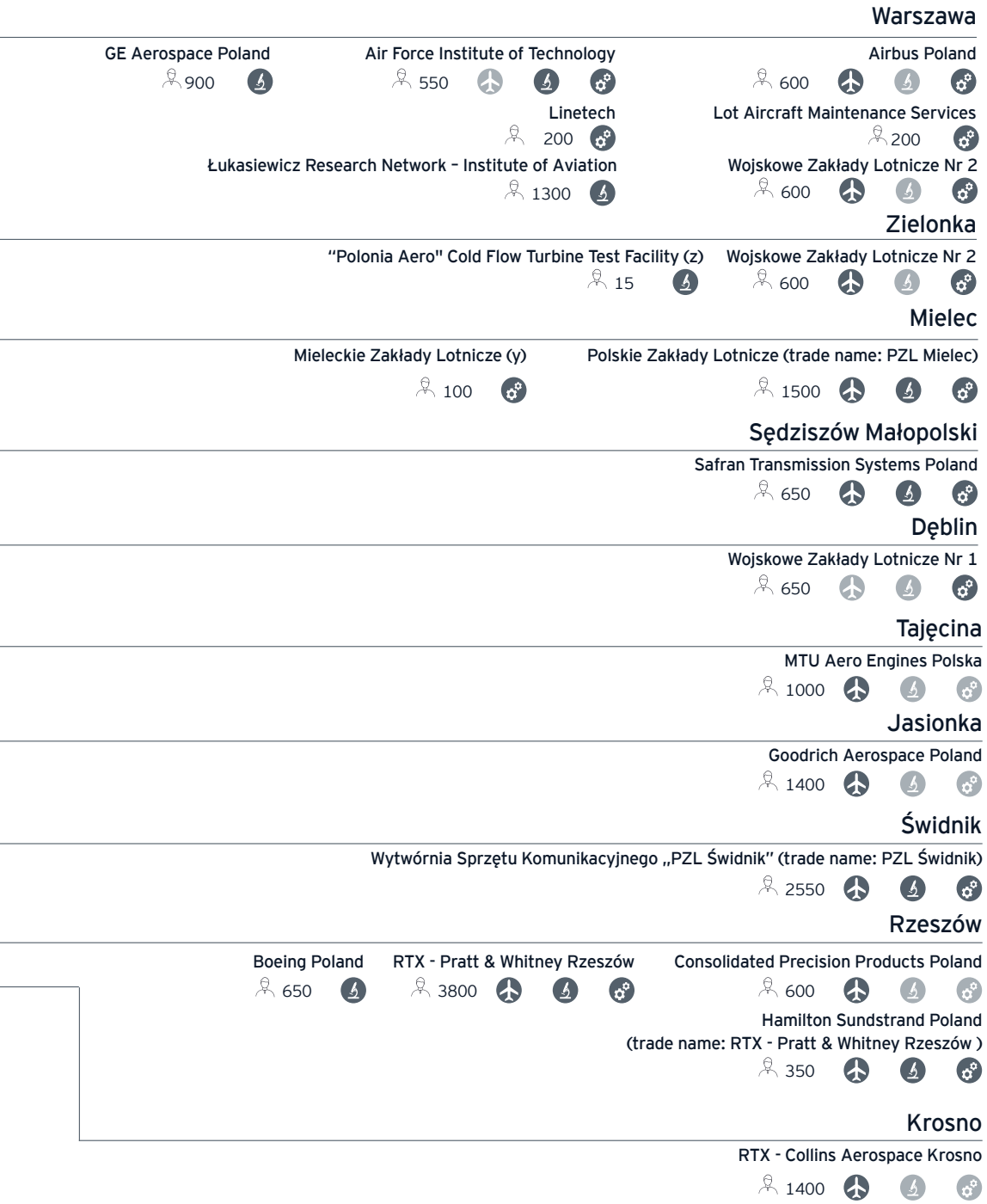
18 Subsidiaries belonging to the aviation industry whose owner meets the income criterion. The map shows only those entities meeting the criterion of revenue of PLN 100 million per year in 2022 and their aviation subsidiaries.

19 For companies that have several locations (e.g. WZL-2), the employment presented refers to all locations combined.

Key:

Number of employees (2022) · Production · R&D · MRO · Main activity · Partial scope of activities

Currently, the Polish aviation industry consists of over 100 entities, with one in four being a large company generating over PLN 100 million in annual revenue. However, before the industry reached this size, it went through a long development path.



w – subsidiary of the Air Force Institute of Technology
x – subsidiary of GE Aerospace Poland and Lufthansa Technik
y – subsidiary of the Łukasiewicz Research Network – Aviation Institute
z – subsidiary of Wojskowe Zakłady Lotnicze Nr 2 and Avio Aero

Source: Survey data, data from the eKRS system, data from company websites, press releases

The beginnings of the Polish aviation industry trace back to the need to maintain the aircraft of the Air Force of the Second Republic of Poland and the establishment of the Centralne Warsztaty Lotnicze (Central Aviation Workshops, CWL) in Warsaw (later transformed into Państwowe Zakłady Lotnicze (State Aviation Works, PZL). The plant quickly jumped up the value chain and began designing its own aircraft. The initiative of the 1930s to establish the Central Industrial District (COP - Centralny Okręg Przemysłowy) on the territory of the former Lviv and Kielce, Lublin and Krakow provinces led to the establishment of further heavy industry plants and a number of energy investments, laying the foundations for the Polish aviation industry as we know it today.

Thanks to the COP, the Państwowe Zakłady Lotnicze in Mielec (now Polskie Zakłady Lotnicze sp. z o.o.) and the aircraft engine factory of the Państwowe Zakłady Lotnicze in Rzeszów (now Pratt & Whitney Rzeszów S.A.), which exists to this day, were established. Poland soon became an important European manufacturer of aircraft of its own design.

The period of the Polish People's Republic (PRL) brought the construction of specialized production plants, such as PZL Świdnik in 1951, and integration with Eastern markets. Polish manufacturers focused on Soviet designs, which was dictated primarily by politics. The economic transformation initiated in 1989 reduced contacts with the Soviet Union, the previous market and partner that determined trade relations with other partners, as it were, leaving Polish enterprises without growth prospects.

The 1990s were a time when the Polish economy was heading towards the West and modern technologies. However, for Polish aviation industry companies, it was a difficult period. The loss of previous markets and cooperative ties led to production limitations and partial shutdowns of capabilities.

Poland has faced this problem since the beginning of the transformation. With regard to the aviation industry in particular, there was a lack of vision for the future and a lack of equity to maintain and develop its potential. The way out of the deadlock was made possible, among other things, by the start of cooperation with Western aviation companies and ownership changes – the entry into Poland of international giants operating on global markets.

This process, particularly the phasing out of the previous product lines, could not be without controversy, but the total economic calculation shows the gains from such processes. The introduction of Western capital into Poland has brought many benefits, most notably the development and building of new local competences, the retention and growth of jobs and the creation of an aviation ecosystem attractive to international partners with access to large capital. Faced with a lack of capital of its own and the threat of permanent closure, cooperation with leading companies in the global aviation industry was the most favourable solution. This not only allowed the transformation of existing plants, but also attracted capital, which resulted in the establishment of completely new factories and construction offices. The process of tightening cooperation with the global aviation industry continues to this day.

During its over 100-year history, the Polish aviation industry has established itself as a reliable production partner and is now also an important research and development center for advanced aviation products. Today, the Polish aviation industry is strongly interconnected with global industries, primarily due to the established position of Polish companies in the value chains of key companies in the global market.

Small and medium-sized aviation companies

Until the economic transformation in 1990, there were no private companies operating in the aviation industry in Poland. The first ones appeared in the 1990s, but their number was negligible. It was not until the change of regime and the privatisation of Polish state-owned airlines, or parts of them, that the conditions for the development of Polish SMEs on the market were created.

Some SMEs had ambitions to develop their own products. Due to capital constraints, they chose to specialise in the design and production of ultralight and general aviation aircraft and their subassemblies (e.g., Ekolot[20], Flaris[21], Zakłady Lotnicze Margański & Mysłowski[22]). In recent years, SMEs have also been heavily involved in the booming unmanned aircraft sector (e.g., Eurotech[23]). More on this topic can be found in the case study *Developing SME cooperation in innovative technologies for aviation* on page 84.

Most, however, decided to engage in the production of aviation components. This did not happen automatically. To a large extent, the realization of this goal depended on the development policies of privatized entities that were already part of global aviation corporations. Those entities that adopted the philosophy of lean thinking from the very beginning actively supported Polish private SMEs, interested in starting aviation production and cooperating with Western corporations located in Poland.

Some of the SMEs that want to partner with large aerospace corporations have changed their production profile. Others were created from scratch with the intention of operating in the aviation industry. This was often possible when their founders already had extensive experience working in Polish or foreign aviation companies. However, the positive changes that have occurred have not yet led to a network of subcontractors based on domestic SMEs as extensive as in Western countries.

Nevertheless, Polish companies cooperating with the Polish-based plants of global aviation corporations already provide significant support and contribute greatly to making them more competitive in the global market. Increasingly, thanks to the cooperation already established in the Polish market, local SMEs, with the support of the foreign corporation branches located in Poland, are gaining the opportunity to establish fruitful cooperation with those corporations' plants located outside Poland and are making effective use of it.

20 KR-030 Topaz and JK-05 JUNIOR aircraft, KR-010 Elf motor glider.

21 Flaris LAR 01 aircraft (class: Hight Speed Personal Jet).

22 ORKA aircraft, MDM-1 FOX glider.

23 MJ-7 SZOGUN UAV (VERMIN air target imitator system), HASTA UAV developed in cooperation with the Łukasiewicz Research Network – Institute of Aviation.

Contrary to established stereotypes, it is the large players in the aviation industry who create the market and allow for its expansion, thereby providing space for smaller entities to integrate into collaborative networks. The durability of these relationships largely depends on the position of SMEs in the value chain of products manufactured by end manufacturers. One way to build a better position for SMEs in this regard is to increase their activity in R&D work on the development of new products and technologies (both their own and those carried out in cooperation). Some SMEs are taking on this challenge. They join as partners or subcontractors in R&D projects carried out by large companies and research institutes (for more on this, see the case study *Integrating companies through joint project implementation* on page 48). Few successfully take on the challenge of plotting and executing such projects independently, whether in terms of acquiring and developing new technologies or creating their own product.

Nevertheless, the lack of sufficient own capital resources and limited access to support funds are significant barriers for SMEs working for the aviation industry in undertaking such R&D activities systematically. The construction of accessible institutional support mechanisms will determine whether, in the long term, Polish SMEs will permanently build their position in the value chains of the aviation industry.

ITWL – JET-2 jet UAV on launch pad.

Case study

Building competence and positioning through participation in international projects

ITWL – Atrax UAV.

Name of entity:	**Air Force Institute of Technology**
Name of completed project:	Application of Structural State Surveillance to Remotely Piloted Systems (SAMAS)
Institution / programme under which funding was provided:	European Defence Agency
Total project value / own financing / funding:	PLN 13.3 million / PLN 0 million / PLN 13.3 million
Project period:	2017–2020

Instytut Techniczny Wojsk Lotniczych (The Air Force Institute of Technology, ITWL) **builds its competence through scientific and research, experimental and construction and technical-service work in aviation-related areas**. In addition to its work for its main client, the Polish Armed Forces, **the Institute participates in Polish and international projects** that enable the development of innovative technologies and further build the competence of Polish science.

In 2017, **The Air Force Institute of Technology joined the European SAMAS** project for the development of structural health monitoring (SHM) system technology and its demonstration in the form of a prototype system built on the "Hornet" ("Szerszeń") unmanned aerial vehicle. The project was aimed at creating a system that enables real-time diagnostics of composite structures carrying aerodynamic loads and subject to low-energy impact damage as well as ballistic damage. As part of the project, ITWL worked in a consortium with three other entities from Poland and Italy: Leonardo S.p.A., the Politecnico di Milano and Wojskowe Zakłady Lotnicze nr 1 S.A.

ITWL – Duch UAV.

The implementation of this project and others like it ensures that **a competitive advantage is maintained not only through the opportunity to work in an innovative area such as unmanned aircraft, but also through knowledge transfer**. with foreign partners in the SAMAS project, ITWL specialists could deepen their knowledge of monitoring the structural integrity of UAV used by the Polish Armed Forces, familiarise themselves with working methods and tools different from their own, and establish new scientific and business relationships.

ITWL's participation in such an important project under the supervision of the European Defence Agency constitutes proof that **the potential of Polish institutions is recognised by international institutions**. The Air Force Institute of Technology also represents Polish science in classified NATO projects. Participation in international projects not only improves the competence of the teams, but also promotes Polish entities internationally and opens up opportunities for building cooperation, including at subsequent stages of development work. The European Defence Agency recognised the need to extend the knowledge gained from the successful SAMAS project.

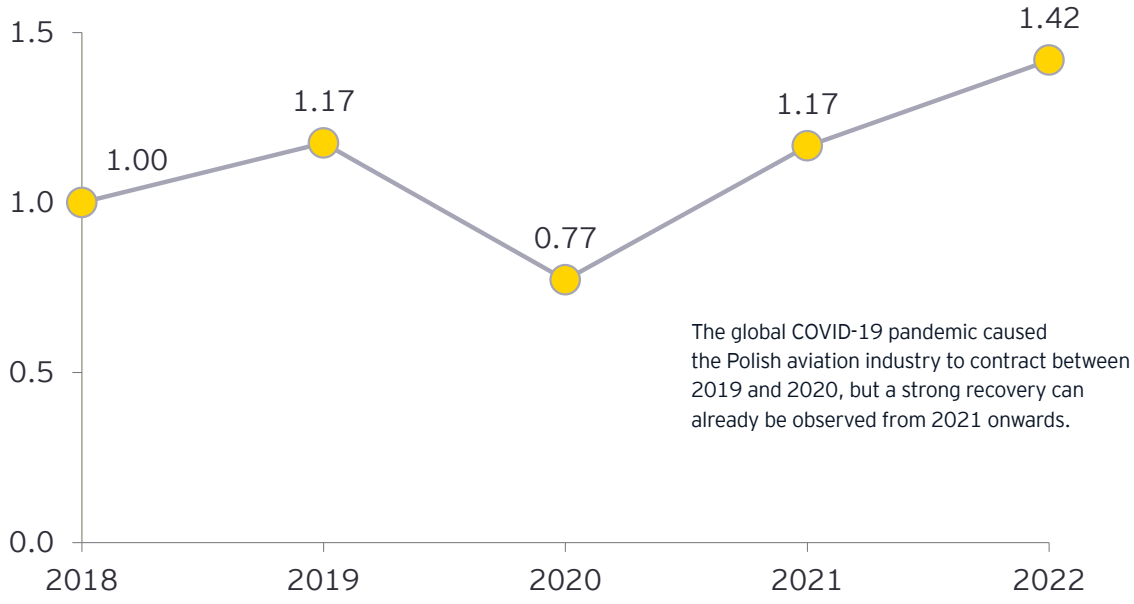
As a result, the SAMAS II project, which this time focuses on a much broader topic: integrated helicopter condition management, of which ITWL is also a part, has been ongoing since 2021. The continuation of the programme is a natural progression – in aviation, a long time horizon is crucial to gain knowledge and develop a reliable product. **The extension of the investment horizon also allows for additional revenues from commercialisation**, which is also an important source of revenue for the Institute (PLN 180 million from commercialisation of scientific results in 2017–2022).

The Polish aviation industry today and tomorrow

Despite the disruptions in the global aviation market, which have also affected Polish aviation companies, the Polish aviation industry continues to grow at a double-digit rate.

Today, Poland holds a well-established position in global supply chains thanks to three main pillars: production, research and development services as well as maintenance services, both for the civil and military aviation segments. Building on nearly 100 years of tradition, and with contemporary investment support, competence-based R&D centres and significant production and service centres of foreign companies have emerged in Poland, in fact generating the bulk of the industry's revenue. This is also confirmed by the case studies *Creation of an R&D centre for aircraft gears* (on page 104) and *Placing a competence centre in Poland thanks to a know-how base* (on page 38). However, in the context of increasing globalisation and competition, various factors are acting on the Polish aviation industry, which are already affecting its position and attractiveness on the international stage. What works today will not necessarily work tomorrow. To understand what the "tomorrow" of the Polish aviation industry might be and how to prepare for it, it is necessary to examine what is shaping and directing the market today.

Chart 7. Year-on-year growth of the Polish aviation industry, highlighting the COVID-19 pandemic in 2020 (%)

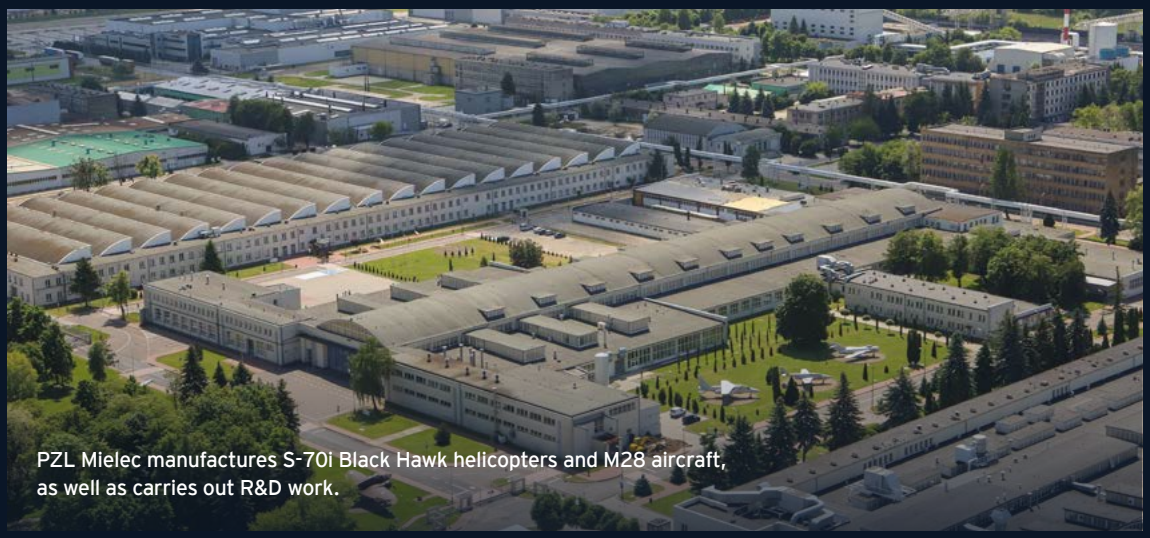


Source: EY's own elaboration based on survey data

Black Hawk helicopter production line at PZL Mielec. Since 2010, the plant has manufactured more than 100 machines of this type, steadily increasing the production.

Case study

Placing a competence centre in Poland thanks to a know-how base



PZL Mielec manufactures S-70i Black Hawk helicopters and M28 aircraft, as well as carries out R&D work.

Company name:	**Polskie Zakłady Lotnicze sp. z o.o.**
Name of completed project:	Creation of a corporate composite competence centre
Institution / programme under which funding was provided:	Own financing
Total project value / own financing / funding:	USD 2.3 million
Project period:	2018-2020

In the 16 years since the acquisition, Polskie Zakłady Lotnicze (PZL Mielec) has become Lockheed Martin's largest facility outside the US and a centre of composite competence for the entire corporation. In order to reach this position, PZL Mielec had been systematically building capacity for many years, in which a significant role was played by the subsidies offered to Polish companies in the aviation industry.

First, between 2010 and 2014, thanks to the POIG programme, a Research and Development Center was established at PZL Mielec. This was the first impetus for building R&D competences within the company. In 2013, the company took a step further by deciding to establish composite production, including both component parts and complete composite sets. A key factor in making this decision was the possibility of funding two additional composite projects under the INNOLOT 2 programme, which convinced the then-owner to locate the production activities in Poland. This is a standard operating model – the offer of support for a given investment often plays a decisive role for the owner when making a decision about the location for the selected business activity.

Previously implemented investments allowed PZL Mielec to conduct research and also implement the latest composite materials produced by autoclave and non-autoclave methods into production.

Thanks to previous experience in 2018, Lockheed Martin, i.e., the current owner of PZL Mielec, decided to open a key Composite Centre in Poland – already with its own funds. A decisive factor in locating the Centre in Poland proved to be the experience gained by the staff in previous INNOLOT 2 projects. The conduct of independent research work by PZL Mielec in the INNOLOT 2 programme proved to the entire group that R&D projects can be successfully carried out in Poland.

Thanks to the implementation of the above projects, PZL Mielec now has a solid know-how base and can benefit from it. Firstly, the company today has complete competences in the area of composites[24] and has expanded the chain of suppliers related to this area, strengthening the division's position in the Lockheed Martin global value chain. Secondly, the production of high-tech components has increased through the transfer of orders to the company. Thirdly, thanks to the implementation of the above projects, PZL Mielec created permanent jobs for qualified employees and established cooperation with Rzeszów University of Technology not only in terms of R&D work, but also at the educational level[25], to provide the company with qualified employees.

24 Beginning with analysis, design, research, testing, construction of demonstrators and prototypes and ending with series production and repairs.

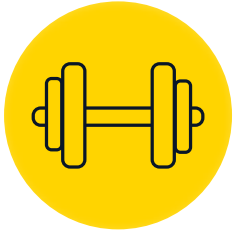
25 A post-graduate course was created and implementation doctorates were launched.

SWOT analysis of the Polish aviation industry

S

Strengths

- Educated workforce with extensive experience
- Cost advantage while maintaining quality
- Multidimensional competences of industry's companies
- Local supplier networks, including SMEs
- Strong international connections
- Established cooperation between the private sector and research-scientific entities
- Specialized research and development facilities
- Geographical concentration of the industry
- Poland's membership in the European Union and NATO
- Organization of the industry into associations and clusters



W

Weaknesses

- No major local OEM
- Lack of a coherent national strategy for the aviation industry
- Limited access to capital for aviation companies, especially SMEs
- Relatively little support in obtaining European funding
- Insufficient use of military equipment purchases to build industrial capacity

O

Opportunities

- Participation in innovative R&D projects
- Early development of the next big thing areas: low-carbon aviation, Industry 4.0, unmanned aircraft
- New foreign investment, including in research and development as well as other services
- Development of the maintenance and repair services segment through infrastructure investments in airports
- Modernisation of the Polish army
- Development according to a joint strategy of the business and government side

T

Risks

- Risk of technical obsolescence in the Polish aviation industry
- Risk of relocation of services and production outside the EU
- Reduction of staff
- Insufficient investment expenditure

S

Strengths

Foreign investors are interested in the Polish aviation industry for good reason. One of the factors that make this industry attractive in Poland is, above all, the availability of **qualified and experienced staff**. Thanks to our long-standing aviation tradition, Poland has a workforce that can perform all tasks in the aviation industry: from the development of technology, through the production of parts, modules, components and entire aircraft, to after-sales service, i.e., maintenance and overhaul. The attractiveness of the Polish workforce is also underlined by **competitive labour costs**, which are still significantly lower than in the West, while maintaining the highest quality of work. However, relatively low labour costs as a factor that differentiates Poland from other countries also have a downside. See the "Weaknesses" section for more information. This state of affairs will not continue indefinitely, of course, as labour costs in Poland will approach European levels.

In addition to their experience, employees also have directional technical and engineering training. There are trade schools training manufacturing workers, and a number of universities have dedicated aviation studies, preparing graduates for work related to the development, research or production of aerospace products, modules or structures. Employers in the aviation industry also participate in the vocational training of future employees, ensuring availability of staff. Qualifications and experience are the main factors that allow Polish companies to compete with others inside global organisations.

The knowledge of **employees reflects the multifaceted potential of Polish companies**, which has been created thanks to Poland's long experience and aviation tradition, cooperation with international partners and the development of innovative technologies. The strengths of the Polish industry lie in its diversity – competences in the development services, manufacturing and service segments – but also in its ability to work together to build local value chains. **On the one hand, the participation of small and medium-sized enterprises in sub-supplier networks** is a cornerstone of the industry in Poland. On the other hand, **close ties with international companies** positively position the Polish aviation industry to participate in the development of new technologies and enable participation in the production and service process, as illustrated by the example of *Building competence and positioning through participation in international projects* (on page 34).

When talking about the potential of the industry, it is impossible not to mention the **cooperation between aviation market participants and the research and development sector**, in which a large part of the major players in the Polish aviation industry participate[26]. For companies, an additional benefit is also **access to local scientific and production facilities**, which facilitates the implementation of R&D projects. In addition, Polish companies also have their own very modern facilities and research and development centers. Such specialized infrastructure is an essential element on the path to building their own products.

26 The cooperation is based, among other things, on internship programmes that allow students to get to know a potential future employer already during their studies, and for the companies running the internships, it represents an opportunity to recruit the best talent early on.

The strength of Polish industry is **Poland's convenient geographical location and the focus of companies on building a position in global supply chains**. At the same time, the concentration of actors in one macro-region allows for closer local business ties. Locally, the high concentration of aviation industry players in the south-eastern Poland region naturally attracts investment, as it permits efficient project implementation and a shorter supply chain. Globally, both Poland's central location in Europe and its **membership of the international organisations** of the European Union and NATO additionally provide security for investment in Poland (and, in the area of opportunities, for participation in R&D programmes within the EU and NATO). Rising tensions in Asia (traditionally a low-cost manufacturing partner), the experience of the global COVID pandemic and supply delays caused by the blockade of the Suez Canal provide in this case a reminder of the importance of self-sufficiency and resilience in the supply chain, which companies want and need to influence and maintain production continuity in times of uncertainty. Poland, as a trusted business partner and EU member, is a desirable location for investments following the trend of nearshoring, which aims to shorten the supply chain and place it in a secure location (more on this trend in Chapter 4).

At the domestic level, the Polish aviation industry has **an organisational advantage**. The Association of Polish Aviation Industry and Aviation Valley bring together an important part of the aviation industry. This ensures that the industry is integrated and the companies are ready to work together.

W

Weaknesses

The political transformation of the 1990s changed the business landscape of the aviation industry in Poland and distanced us from the prospect of building a key global aviation industry. None of the world's dominant aircraft manufacturers, such as Airbus in France, Boeing in the United States, Embraer in Brazil or Bombardier in Canada, nor any of the leading aircraft propulsion manufacturers, such as Pratt & Whitney, GE Aerospace or Rolls-Royce, have their headquarters in Poland (although significant branches of most of the above companies are located in Poland). This situation is not likely to change in the near future, as the global aircraft manufacturing market is consolidated to such an extent that the production of a new large airframe or helicopter, without a simultaneous guarantee of significant orders, would be very risky and costly[27].

The OEM's role in building the aviation industry

A large local manufacturer organically centralises and develops the market around it, builds a network of suppliers and collaborators, is a driver for innovation and has a positive impact on the economy[28].

In the countries where the OEM company is based, others have a pre-assured position in the supply chain of such an entity. They are a natural, close and already well-known partner for the local industry giant. Other countries are using other strategies to build their aviation industry, e.g., by attracting investment or knowledge and technology transfer (TOKAT) through military procurement.

27 Other obstacles include the huge barriers to entry associated with capital expenditure, the need to build a full supply chain, the lengthy testing and certification process, the need to provide the customer with after-sales service and a full range of MRO services, etc.

28 By generating jobs and taxes.

This would not be a problem if the Polish industry had a coherent direction and development strategy. **Indeed, it is not necessary to have an in-house OEM for the aviation industry to function well and grow steadily.** One of the examples can be Germany, where a thriving aviation industry has been built up through dedicated support, such as the LuFo programme offering R&D funding, which has been operating continuously since 1995 (see page 113 for more), or the consistent growth of German players in the value chain of large OEM companies. As a result, the German industry has already developed such a rich background that it is able to face the challenge of building its own products such as OEM. It should be emphasised here that Polish industry does not lack the competence to become an OEM, but the market conditions, i.e., huge barriers to entry, a very long R&D process and lack of support at the commercialisation stage, pose too great a risk to undertake this task.

Poland currently lacks a coherent national strategy for the entire aviation industry. As a result, the direction of the industry, rather than being a concerted effort by companies to build national capacity, is primarily driven by the corporate objectives of individual companies. The existing thematically similar documents to the strategy are not comprehensive[29], and with regard to the aviation industry they do not provide a clear and coherent vision of how to see it as part of economic and social policy. Maintaining the status quo consequently leads to a reduction in the importance of the industry. Only action by the government and the public sector to develop a joint strategy that takes into account the pursuit of economic and social objectives would enable the industry to grow faster in the desired segments and position Polish companies in those parts of the value chain that bring the greatest long-term benefits to the economy, the companies themselves and their employees.

A national strategy must entail dedicated and targeted support. This is another element in need of improvement. **Polish aviation industry players face limited access to capital.** The problem is, in particular, related to the possibility of subsidising SME entities that need orders from large companies or R&D partnership cooperation culminating in joint production. In European programmes that offer funding for R&D projects, on the other hand, you have to compete with stronger rivals that enjoy the support of their own government representatives already at the programme planning stage in dedicated working groups. Polish programmes and calls for proposals, on the other hand, are mostly unsuited to the long development cycles of aerospace products. This means that funds for innovation, e.g., from programmes of the National Centre for Research and Development (NCBR), are not designed with the conditions of industries such as aerospace in mind and end up being allocated to products with less innovation potential, but with a shorter time to market. **Unfortunately, product development in the aviation industry is a marathon, not a sprint**, and when developing products one needs to look at a 10- or 15-year horizon, not a 3- or 5-year horizon. Currently, there is a lack of a stable investment environment and recurring programmes, such as the German LuFo, which would allow companies to plan their activities with greater certainty for the coming years. Additionally, the lack of support for projects aimed at modernizing production facilities and research centers distances Polish companies from implementing Industry 4.0 technologies and smart manufacturing. The absence of modernization, coupled with rising labor costs, leads to a decline in international competitiveness.

29 Such a document is, e.g., the Policy for the development of civil aviation in Poland until 2030 (with an outlook until 2040).

The area of support for the aviation industry also requires improvement in the segment of military aircraft, where **every significant**[30] **purchase for the Polish Air Force provides the opportunity to negotiate the transfer of knowledge and technology (TOKAT) or offset commitments**. As defined in the Offset Act[31] offset is a mechanism through which the purchasing state secures the required independence from a foreign supplier as mandated by the State Treasury, in order to maintain or establish on the territory of the Republic of Poland the capability for transferring production, service and maintenance-repair capacities. Offset[32] can only be applied in cases of a justified essential security interest of the state. Both offset and TOKAT are mechanisms that incur additional costs within the framework of the order, so it is important that they provide the expected return.

The use of the above instruments to acquire capacity is common practice. In Norway, for example, discussions on the purchase of the F-35 included an offset offer from the supplier from the outset, similarly in the case of Finland, which already declared before the purchase of the fighter jet that the eventual contract winner must offer an offset worth at least 30% of the contract value. Let us remember that the Polish taxpayer pays for any negotiated offset commitment or TOKAT, so it is crucial to target those tools to those who will best use them to make the industry independent of the military equipment supplier (mostly in terms of service) and acquire new capabilities. Otherwise, the potential that offset (or TOKAT) offers could be wasted.

The Polish industry suffers from the limited ability to benefit from offset and TOKAT in the procurement of equipment for the Polish Air Force. This is due to several factors – primarily costs, difficult negotiations, the ability of partners selected by the government to absorb commitments and political aspects[33]. The failure to locate key offset/TOKAT services (e.g., production and overhaul of airframes and their engines) in Polish branches of multinational companies supplying the equipment is a missed opportunity. Reversing this situation can both meet the national needs of safeguarding the fundamental interest of state security and influence the investment decisions of companies regarding the further development of their Polish branches.

30 Significant in terms of value and number of aircraft purchased.

31 The offset mechanism can only be used in G2G or G2B formula purchases. Poland currently has a law on contracts concluded in connection with the implementation of contracts of fundamental importance for state security (Journal of Laws 2014, item 932), which allows offsets. The scope of the offset must be linked exclusively to the defence contract and its purpose is to establish or maintain a defence capability.

32 According to the definition in the Act of June 26, 2014, on certain agreements concluded in connection with the implementation of orders of fundamental importance for state security.

33 As in every country, some of Poland's defence equipment purchases are aimed not only at modernising or supplementing the equipment of the Polish Armed Forces, but also at strengthening relations with strategic partners.

O

Opportunities

Today, decisions are being taken that will determine the future, both in the aviation industry and elsewhere. The changes that will shape the aviation industry in the future have already begun. The biggest of them include the **introduction of low-carbon aviation, Industry 4.0 manufacturing technologies and the development of unmanned aircraft**. By aligning with these new trends now (at the level of conducting research), the Polish aviation industry has the opportunity to become permanently integrated into future supply chains and develop specializations. In the future, this will translate into a sustainable strengthening of the industry's long-term position in the country's economy and the global market. Thanks to its integration into global supply chains, the Polish aviation industry can grow even more efficiently in the coming years.

A key opportunity for the industry is to **develop through participation in R&D projects**, which Polish players are keen to take advantage of (see case study *Building competence and positioning through participation in international projects* on page 34). International aviation programmes, such as NATO's combat aircraft programme, known as the New Generation Fighter (NGF), or the Next Generation Medium Transport Aircraft (FMTC) programme, offer a real opportunity to join projects that not only seek to develop and sell the final product in series, but also provide an opportunity to build their own brand, increase exposure and establish relationships in the market. All this while developing the company's local competences, which translate into strengthening the industry as a whole.

This opportunity is not so easy to seize, however, because in large programmes it has become accepted that the final decisions are made by the countries with the largest aviation industries, to which Poland does not currently belong. In order to circumvent this difficulty, it is advisable to join programmes preferably at the earliest possible stages, which would be facilitated by strong national representation on programme boards and EU institutions entrusted with aviation R&D funding. Read more about the benefits of joining programmes early in the case study *Integrating companies through joint project implementation* (on page 48).

R&D projects are not the only path to growth linked to investment. Simultaneously an opportunity may be found in **new foreign investments**, including those going beyond R&D and relating to production and maintenance services. The high cost of entry, particularly in manufacturing services (due to the capital-intensive nature of setting up a factory), means that these tend to be investments that last for many years and create permanent jobs.

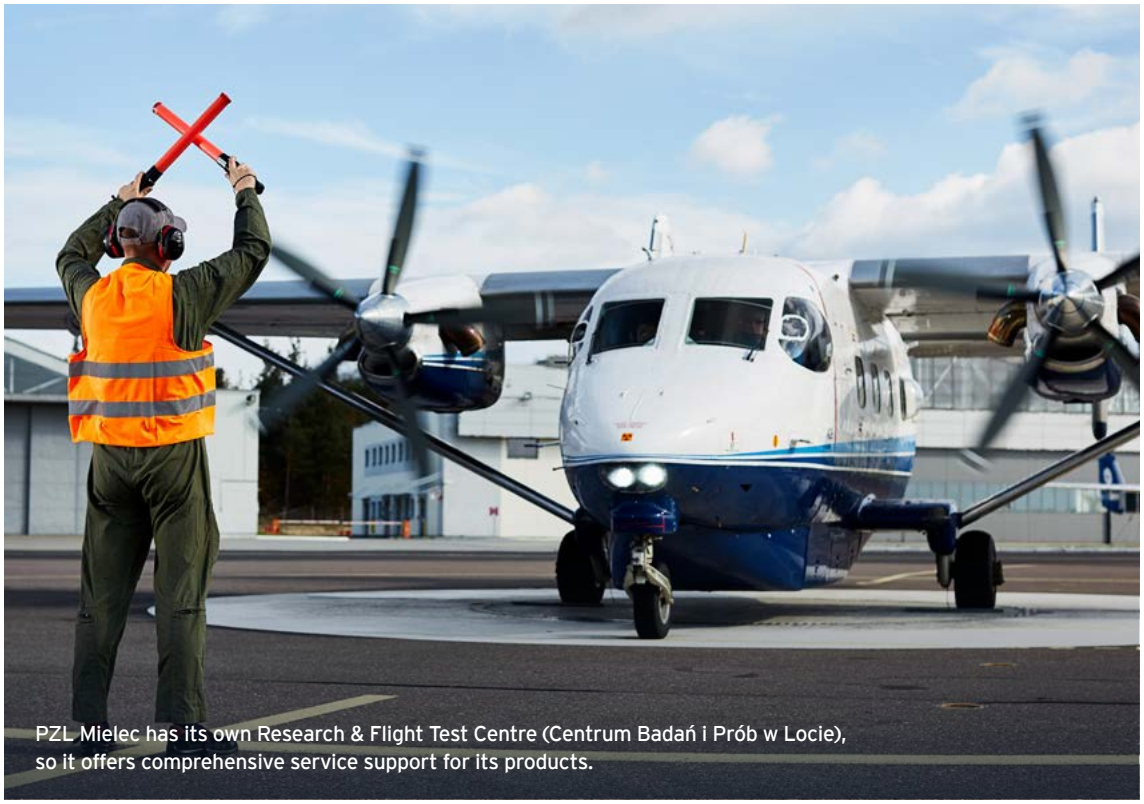
Assembly of LEAP gearboxes at Safran Transmission Systems Poland in Sędziszów Małopolski.

Another opportunity for the Polish aviation industry is to **specialise in the most important areas of development that can have the greatest impact on the future of the industry** – the next big thing. At present, the key areas of aviation industry development revolve around:

- low-carbon technologies that reduce the environmental impact of aviation products, as dictated by, among other things, European Union requirements such as Fit for 55;
- modern production technologies (Industry 4.0), using automation and digitalisation and increasing productivity;
- new unmanned aircraft for military and civilian use.

Specialisation in selected competences would make the Polish aviation industry the default partner on the international stage in potential projects in a given area, attracting investment and increasing the maturity and readiness of the industry to carry out joint Polish projects.

In parallel to positioning ourselves in areas that will be important in the future through R&D work, it is possible to **improve the conditions for the development** of maintenance and production services. For MRO services, infrastructure investment in airports constitutes a step towards increasing the value of maintenance and repair services in Poland. This coincides with good prospects for the development of communications aviation worldwide. Manufacturing services, in turn, can benefit from the strengthening of producer-supplier relationships between local companies, gradually contributing to the transformation of small companies into medium-sized ones and medium-sized ones into large ones.



PZL Mielec has its own Research & Flight Test Centre (Centrum Badań i Prób w Locie), so it offers comprehensive service support for its products.

Case study

Integrating companies through joint project implementation

Prepared for flight tests, the PZL M28 aircraft with a new nacelle, which is a demonstrator of the manufacturing technology in the SAT-AM project coordinated by the Łukasiewicz Research Network – Institute of Aviation.

Name of entity:	**Łukasiewicz Research Network – Institute of Aviation**
Name of completed project:	SAT-AM: Cheaper production of small aircraft
Institution / programme under which funding was provided:	European Commission / EU Horizon 2020 – Clean Sky 2
Total project value / own financing / funding:	EUR 9.0 million / EUR 3.0 million / EUR 6.0 million
Project period:	2017–2021

The Łukasiewicz Research Network – Institute of Aviation (ILOT) was one of the supporting members[34] of the EU's Clean Sky 2 programme, which aimed to develop cleaner air transport technologies and build a strong and globally competitive aviation industry and supply chain in Europe. As part of one of the Clean Sky 2 activities, the Institute carried out an international SAT-AM project to develop technological solutions to reduce the labour intensity and cost of manufacturing small transport aircraft.

ILOT's task was to provide engineering support and coordination to the consortium partners, i.e. ,six other Polish partners (PZL Mielec and five SME companies: Eurotech, Szel-Tech, P.W. Metrol, Ultratech, Zakłady Lotnicze Margański & Mysłowski) and the Italian research institute Centro Italiano Ricerche Aerospaziali. In addition, the Institute's role was to design, test and demonstrate technological solutions. The main demonstrator was the nacelle and front fuselage section of the PZL M28 aircraft.

34 A supporting member is an entity that participates in programme planning.

In addition to the development of green technology solutions for air transport, the implementation of the Programme has brought two main benefits:

Developing and increasing the competitiveness of Polish companies, primarily through the implementation of new production solutions, the rebuilding of machinery, increasing employment and production space.

In addition, half of the consortium members later obtained additional funding for the development and implementation of the developed technologies from regional funds, reinforcing the positive effects of the Programme.

Establishing and strengthening cooperation between companies – the project proved that companies in the Polish aviation industry are able to establish effective cooperation and, on the basis of this cooperation, efficiently implement a multilateral project.

The joint participation in SAT-AM has resulted in the networking of the industry, i.e., the creation of new business relationships between companies, which is particularly important for small and medium-sized enterprises.

The element that paved the way for Polish entities to take advantage of the opportunities offered by the Clean Sky 2 programme was adequate Polish representation in investment decision-making circles, i.e., ILOT's position as a supporting member. In the next edition of Clean Sky 2 (already under the name Clean Aviation), the Institute of Aviation has secured an even better position – it is already a founding member of the Programme.

Most of the aeronautical structures developed by the Polish aviation industry after the war were tested in the tunnels of the Łukasiewicz Research Network Aerodynamic Research Laboratory – Institute of Aviation. The figure presents the T-3 low speed tunnel drive fan after modernisation.

Polish engineers provide ongoing support for the operation of the GE Aerospace CF34 engine, which has been produced in more than 7.5 thousand units and has a total flight time of more than 200 million hours.

In the military segment of the aviation industry, modernisation programmes, such as the Polish Armed Forces' Technical Modernisation Plan, have significant potential to strengthen and expand it. It is defence procurement that represents the best opportunity to acquire capabilities that may otherwise never emerge organically in the industry.

The way to make these opportunities a reality: to fit in with global trends, build R&D capacity, develop companies in line with their specialisation and increase the capacity of companies in the military segment, is to plan for development by establishing an aviation Industry Contract and including a development plan that meets current opportunities and challenges.

The Industry Contract is an agreement between the government and representatives of the aviation industry that commits them to take the actions and provide the resources necessary to achieve the objectives set by both parties. Poland currently lacks such a tailor-made Contract that serves the economy, industry and society and supports the development of domestic companies in a sustainable and systematic way.

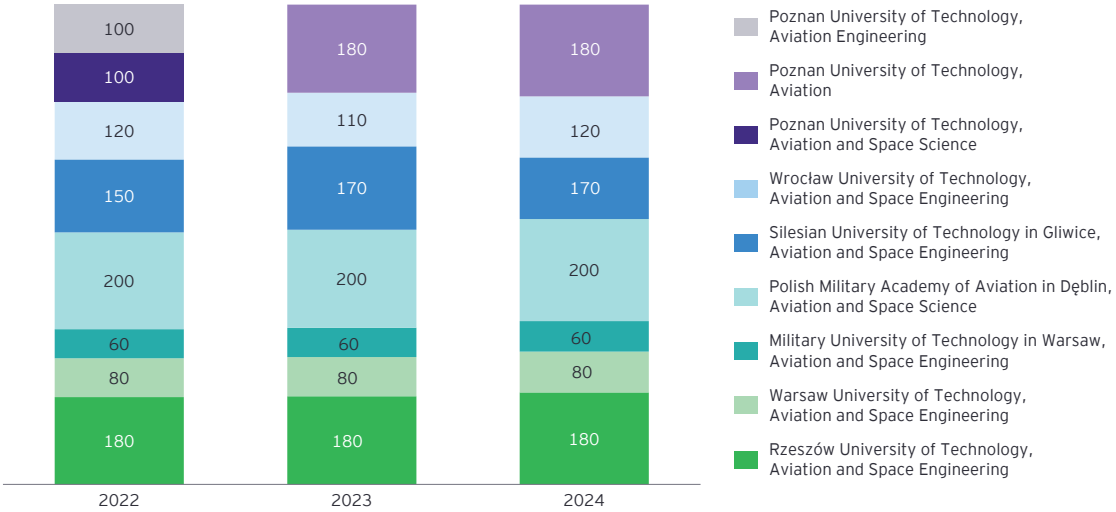
Risks

Insufficient investment in the Polish aviation industry carries the risk that current competitive advantages will disappear: the machinery parks and R&D centres of Polish companies will no longer be associated with the latest technologies, and unmodernised (decapitalised) assets will not be able to provide services that are competitive in terms of price and quality. A reduction in the attractiveness of the industry's employers, if coupled with inadequate salary increases, could result in a brain drain – an exodus of qualified staff from Poland. In this scenario, the lack of investment in maintaining the competitiveness of Polish industry may lead to the relocation of services and production outside Poland and to disinvestment.

The same is true in the area of human resources, which are currently the strength of the Polish industry, but, with the number of graduates and academic staff in aviation studies currently in decline, it is difficult to say how long this state of affairs will last. The continued growth of the industry requires a continuous supply of educated employees, so the declining interest in aviation-related degrees is a direct threat to the availability of human resources. It should be borne in mind that aviation students also do well in other industries, which contributes to their exodus from the aviation industry.

Maintaining the attractiveness of the industry's employers, as well as the education process itself, therefore becomes a priority. It is also necessary to make the learning process much more flexible than before and to adapt it quickly to changing needs, especially when it comes to completely new competences in the aviation industry, necessary for the development of innovative products and processes.

Chart 8. List of seat limits for aviation study programmes



Source: EY's own elaboration based on data from universities

In order to educate engineering staff for the aviation industry, providing highly qualified teaching staff at universities is essential. Creating the conditions to retain the brightest graduates at universities will be key to meeting industry-generated demand for skilled workers and can be a significant barrier to industry growth. The problem of generational replacement of scientific staff also affects research institutes that provide facilities for industry. This may affect the scope of R&D activities undertaken, which will consequently reduce the competitiveness of the Polish aviation industry.

Currently, the Polish industry is attractive mainly due to the availability of educated and cost-effective personnel, guaranteeing the desired quality of products and services, a developed supplier base, and Poland's strategically secure location. In the future, however, **Poland's cost advantage will diminish** due to rising wages, so the Polish industry must prepare to secure its place in global supply chains in other ways. The answer to this challenge can therefore lie precisely **in modernising and expanding know-how through projects, or in specialising in a selected area or areas and consistently implementing a strategy** that will lead the industry to its desired position in the global aviation industry.

Poland will not be able to achieve the desired position in the global industry if the **disparity between the level of investment** in the aviation industry in Poland and the consistent and long-term support for domestic enterprises provided, for example, in Germany, France or the United Kingdom, continues to grow. More on this topic can be found in Chapter 6.

The global aviation industry also faces other challenges: additional taxation on aviation fuel in the EU, the increasing competitiveness of alternative short-haul carriers (e.g., rail) and the currently insufficient availability of SAF and green hydrogen in light of the industry's environmental commitments. In addition, geopolitical instability in different parts of the world can have an impact on the industry that is difficult to predict. However, it is fairly safe to conclude that these problems are universal and do not affect Poland more than other countries.

Importance of the aviation industry

The conditions outlined above for the development of the Polish aviation industry, and the factors that will certainly affect its future, should change in a positive way to move the industry up a level – to become a natural partner for global aerospace players and a globally important aerospace technology research centre.

As it stands, the aviation industry already generates benefits for the Polish economy – through direct and indirect job creation, contributions to gross domestic product and fiscal effects from taxes. However, **profitable and forward-looking industries** such as aviation should be **developed and supported** not only for the sake of simple economic calculation, but also – or especially – **because of their innovation potential. It is innovation that determines which products and services will dominate the market in the future.**

Aviation product development process

Years 1-3:
Preliminary research

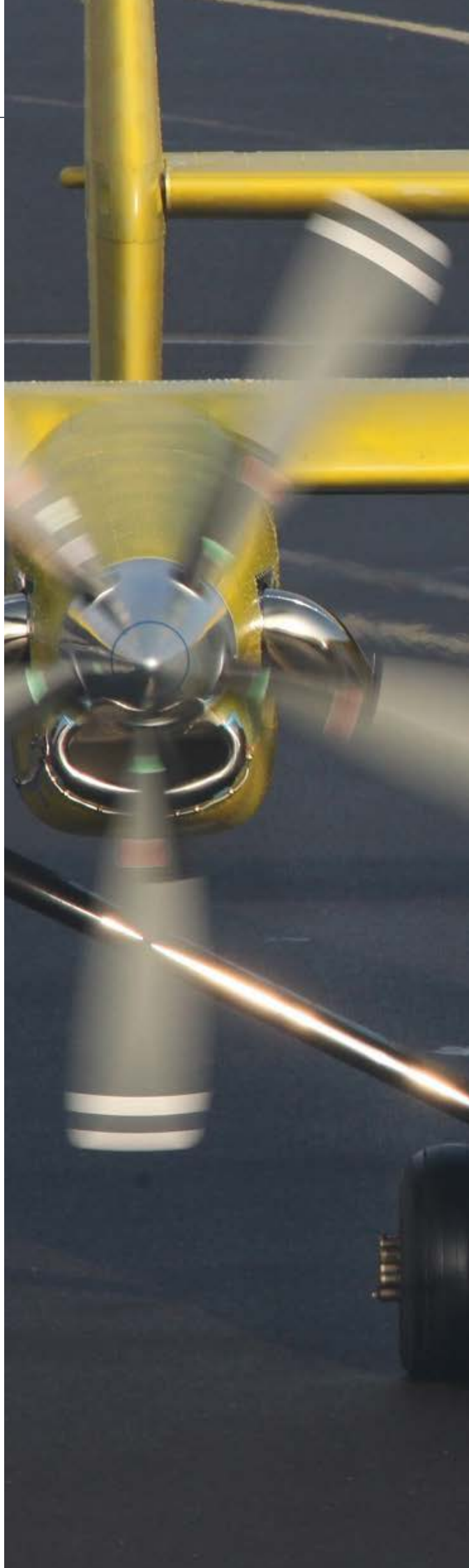
Years 4-6:
Testing of technology demonstrators

Years 7-10:
Development of a commercial product

The process of innovation is **marked by risk**, as there is no guarantee that the funds dedicated to R&D will indeed pay off in the form of a marketable product. However, innovative products are desirable due to their additional functionalities, greater efficiency, easier handling or other attractive benefits for customers.

From a manufacturer's or service provider's perspective, the development of innovative products and services is beneficial because it strengthens the company's position and increases its chances of commercial success and profit growth. **From the perspective of the economy**, the advantage of developing innovations lies in the revenue potential associated with increased sales by companies as taxpayers, the creation of jobs for skilled workers and the building of the national industry's image as innovative, making it an attractive location for investments (particularly in R&D centers).

In general terms, innovations lead to the development of the entire industry, and any growth in the aviation industry triggers a domino effect, multiplying not only strictly economic gains but also benefits in other sectors of the economy and contributing to social development. Chapter 3 outlines the benefits of building a strong aviation industry.



PZL M28 aircraft – a flying technology demonstrator in the European More Affordable Small Aircraft Manufacturing (SAT-AM) project after a completed test flight. Flights tests are an important element in the aircraft research and development process.

3

Analysis of the economic and social importance of the aviation industry

A modern Service Centre for C-295 aircraft has been built in Warsaw.

Impact of the Polish aviation industry on the economic environment

No industry operates in a vacuum. The economy consists of countless interactions between companies that impact each other. The impact of the selected sector on the economic environment also extends to other directly unrelated industries. This means a positive impact of the selected industry on the economic development of the entire country through new job creation, investments and business cooperation requiring domestic partners involvement.

The Polish aviation industry undoubtedly belongs to the sectors of strategic importance. To investigate the impact, a quantitative analysis was conducted, the purpose of which was to examine the influence of the aviation industry on the economic environment.

This study evaluates the benefits of the aviation industry in Poland, including benefits that go beyond the direct effects of the companies' operations.

Methodology

The EY Spectrum model, which is a combination of an input-output model and advanced spatial econometrics tools, was used to study the impact of aviation industry operations on the Polish economy. In addition to the direct effects of the aviation industry, the model allows for the inclusion of so-called demand effects generated within the supply chain of aviation companies, which can be divided into two categories:

1

Indirect effects, that result from demand generated in the supply chain. In order to carry out its activities, the aviation industry cooperates with other entities, acquiring, among other things, materials and components, energy, engineering services, etc. These entities produce part of their output to meet the demand reported by the aviation industry. They also have their own suppliers who cooperate with additional companies, which means that the demand reported by the aviation industry is "spilling over" into the economy.

2

Induced effects, that result from demand generated by aviation employees and workers in the rest of the supply chain to the extent that their salaries result from purchases by the aviation industry. Employees receive compensation for their work, which is spent on the consumption of goods and services as well as savings. The part of the salary that is spent on consumption generates an additional demand boost in the economy.

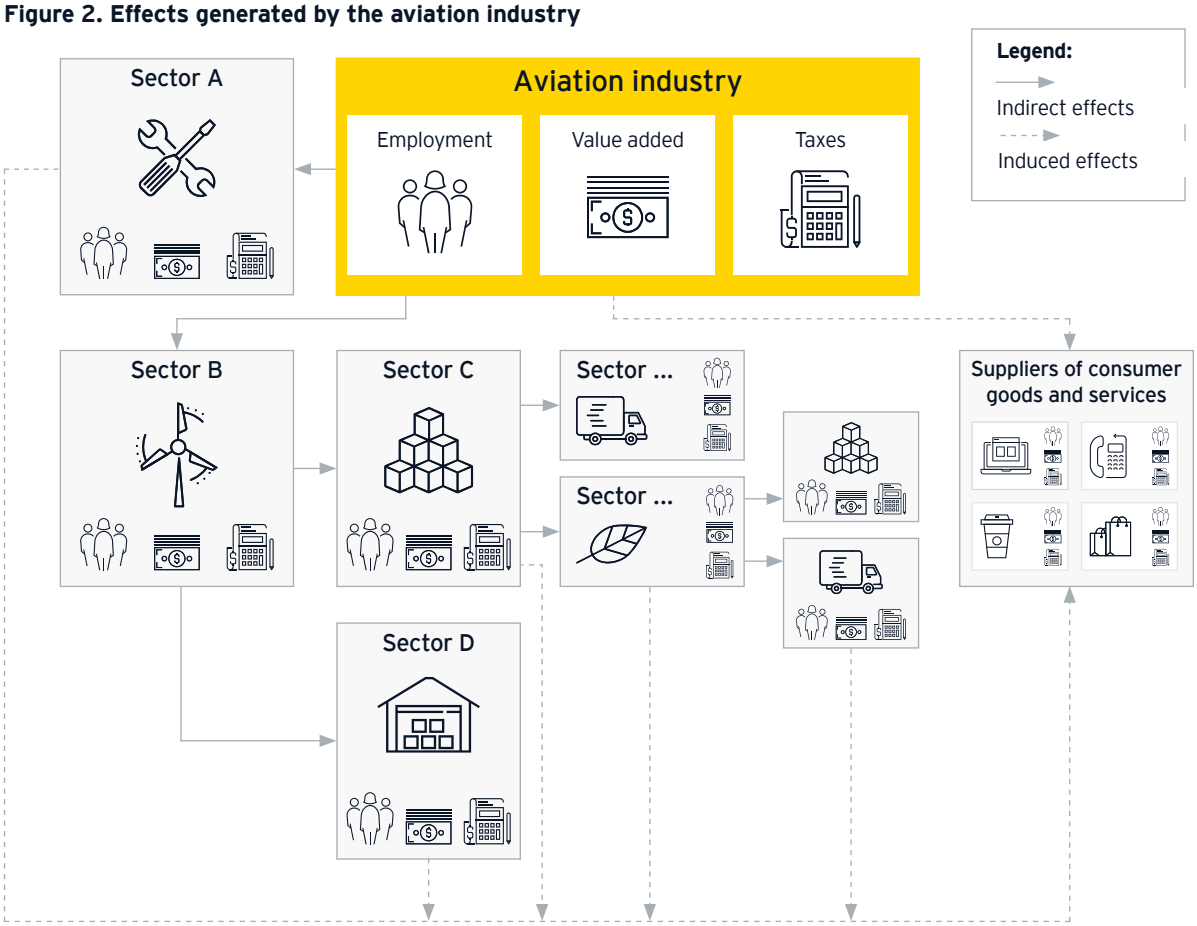
The analysis carried out considered the impact of the aviation industry in direct, indirect and induced effects on the following economic indicators:

- gross value added, approximation of the contribution to Poland's total gross domestic product;
- employment, i.e., the number of people working on average per year in connection with the activities of the aviation industry;
- revenues of the public finance sector resulting from income taxes, VAT, excise taxes and social security contributions.

The analysis uses the latest CSO input-output tables from 2015 (published in 2019).[35] By using an innovative approach, the EY Economic Analysis Team was able to approximate the structure of the newer tables for 2018, based on statistics from other sources. The tables contain data for 77 economic sectors, distinguished on the basis of the Polish Classification of Goods and Services (PKWiU 2008). This made it possible to establish structural relationships between the sectors.

35 CSO, Balance of Input-Output in Current Base Prices in 2015, Warsaw 2019. The edition published in 2024 shows the data for 2020 in which the structure of the economy has temporarily changed due to COVID-19 lockdowns.

Figure 2. Effects generated by the aviation industry



Source: internal EY Study

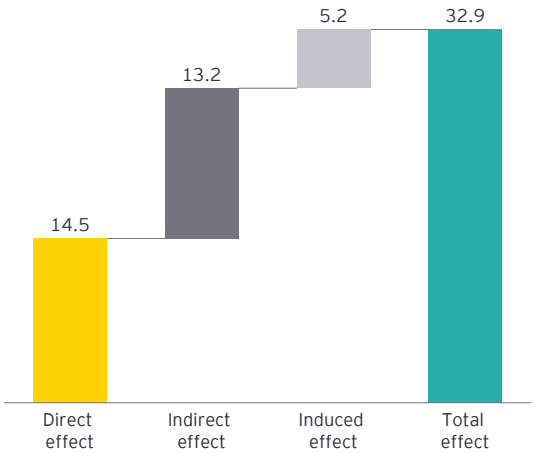
In 2022, **the value** of revenues of the aviation industry in Poland amounted to **PLN 14.5 billion**. From an economic perspective, however, a more important role is played by **gross value added** (abbreviated as value added), which can be defined as **the surplus of a company's revenues over its expenditures** on goods and services necessary for day-to-day operations. The sum of the value added of all actors in the economy provides a good measure of the output produced in a country. It is worth adding that the commonly used measure of gross domestic production (GDP) in economics is equal to the sum of the value added of all resident entities (hence the reference to domestic production), further adjusted for taxes and product subsidies (most notably VAT).

In contrast to value added when calculating revenue (so-called output), the value of products produced at the earlier stages of the supply chain is not deducted. This means that when adding up the revenues (output) generated through indirect and/or induced effects as the number of stages in the supply chain increases, the value of (semi) products created in earlier stages of the chain is multiplied many times over.

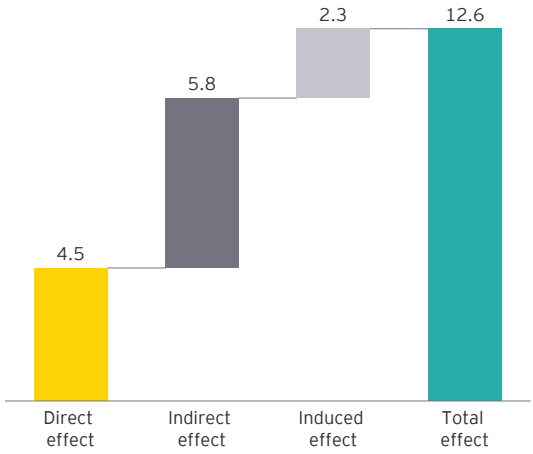
Gross value added

Chart 9. Economic effects generated by the aviation industry on gross value added in 2022

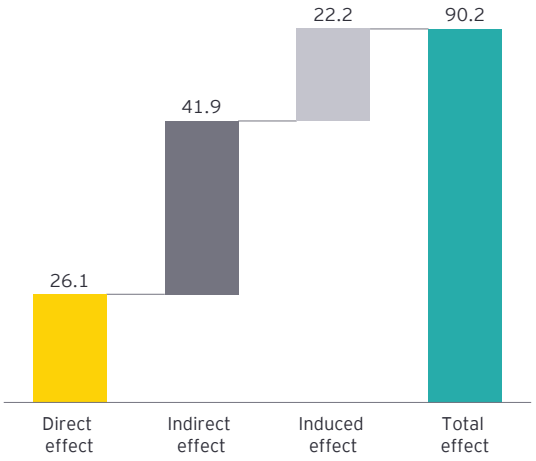
Global output
(current basic prices, PLN billion)



Gross value added
(current basic prices, PLN billion)



Average annual employment
(thousands of people)



Revenue of the public finance sector
(current prices, PLN billion)

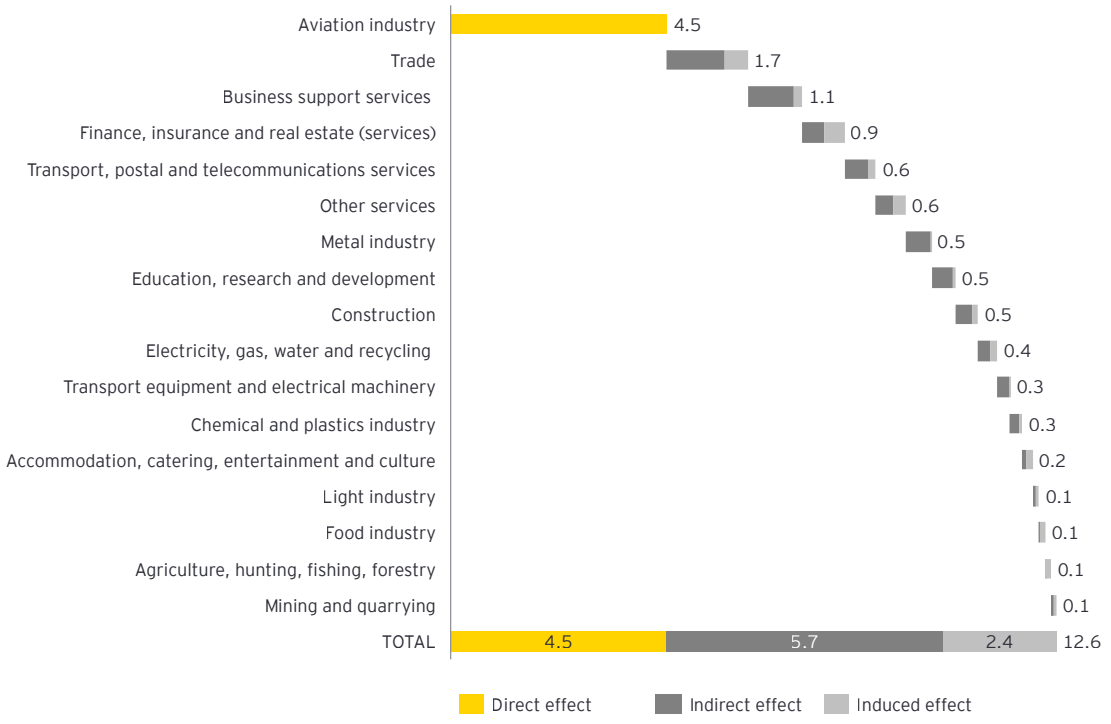
Source: EY own elaboration based on survey data and EY Spectrum tool, Central Statistical Office

PZL-130 Orlik training aircraft designed and manufactured by PZL Warszawa Okęcie (now Airbus Poland S.A.).

In 2022, the aviation industry in Poland directly generated PLN 4.5 billion in gross value added, i.e., the value of goods created as a result of the production process (or R&D process, or maintenance services). Additionally, in 2022, as part of indirect and induced effects, Poland's aviation industry generated PLN 8.1 billion in gross value added (see Chart 9). The total impact on value added in Poland consists of approximately 35.7% of direct effects of the aviation industry's operational activities, 45.7% of indirect effects and the remaining 18.6% of induced effects. Those entities that record the highest share of value added in final product have the greatest impact on the generation of national GDP.

The highest effects of the aviation industry in Poland for value added were recorded in the sectors (see Chart 10): (1) trade, (2) business support services, (3) finance, insurance and real estate services and (4) transport, postal and telecommunication services. This means that it is these sectors that benefit most from collaboration and the provision of services and products to the aviation industry.

Chart 10. Economic effects generated by the aviation industry on gross value added (PLN billion)



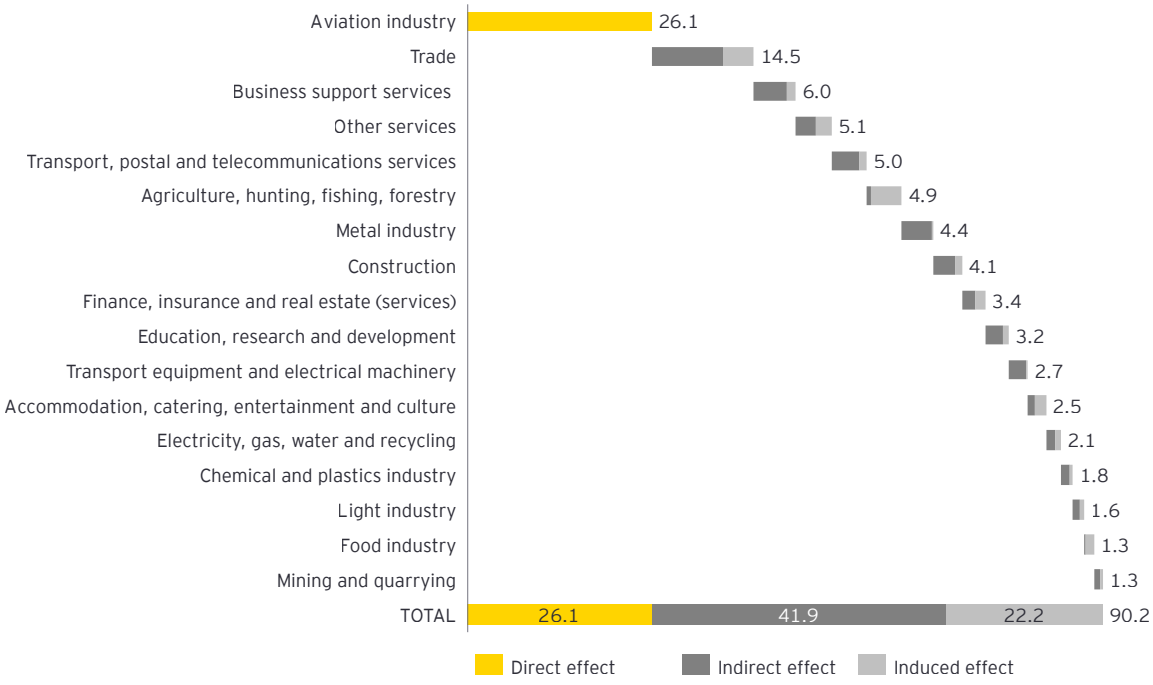
Source: EY own elaboration based on survey data and EY Spectrum tool, Central Statistical Office

Employment

By contrast, in the case of the labour market, in 2022, **26,070 people** worked directly in the aviation industry in Poland[36], and an additional **64,082 jobs** were supported through indirect and induced effects (see Chart 11). One of the reasons for this was the demand for the services of these companies, generated by customers in the aviation industry. The total number of jobs supported by the activities of the aviation industry in Poland in 2022 consisted of 28.9% created directly by companies in the industry, whereas 46.5% were supported through indirect effects and 24.6% through induced effects.

The highest employment effects of the aviation industry were recorded in the following sectors: (1) trade, (2) other services, (3) business support services, (4) transport, postal and telecommunication services, and (5) metal industries.

Chart 11. Economic effects generated by the aviation industry on the labour market (thousands of people)



Source: EY own elaboration based on survey data and EY Spectrum tool, Central Statistical Office

36 In an earlier section of the report, we reported employment at 32,000. It should be noted that this is a value for 2024, while the necessary data for the economic analysis was collected for 2022 (more recent data is not yet available). In addition, the results presented do not include some of the smallest entities for which it was not possible to collect the necessary data to estimate economic effects (no financial statements available). Therefore, the results presented can be regarded as conservative estimates of economic effects.

Revenue of the public finance sector

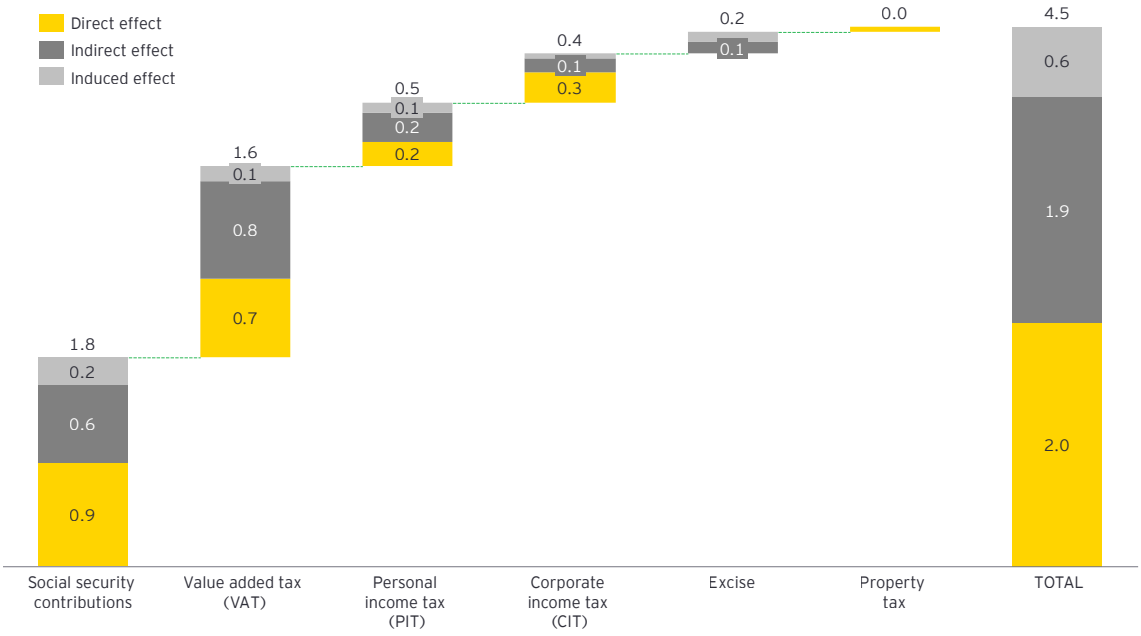
In addition, the aviation industry contributed **PLN 4.5 billion** in direct, indirect and induced effects to the generation of general government revenue in 2022 (see Chart 12). The main source of revenue for the public finance sector generated by the aviation industry in Poland was social security contributions, which reached **PLN 1.8 billion** (38.7% of the total effect), with the second most important category being value added tax (VAT), which reached **PLN 1.6 billion** (35.5% of the total effect).

Out of the total amount of **PLN 4.5 billion**, the state budget received PLN 2.4 billion (52.4%) and the social security sub-sector PLN 1.8 billion (38.7%). The revenues of local government units amounted to PLN 271 million (6.0%) for municipalities ("gminas"), PLN 61 million (1.3%) for districts ("poviats") and PLN 69 million (1.5%) for provinces ("voivodeships"), respectively. These are amounts that have directly supported the financing of budget expenditures at the national and local level at the place of the companies' location (place of registered office).

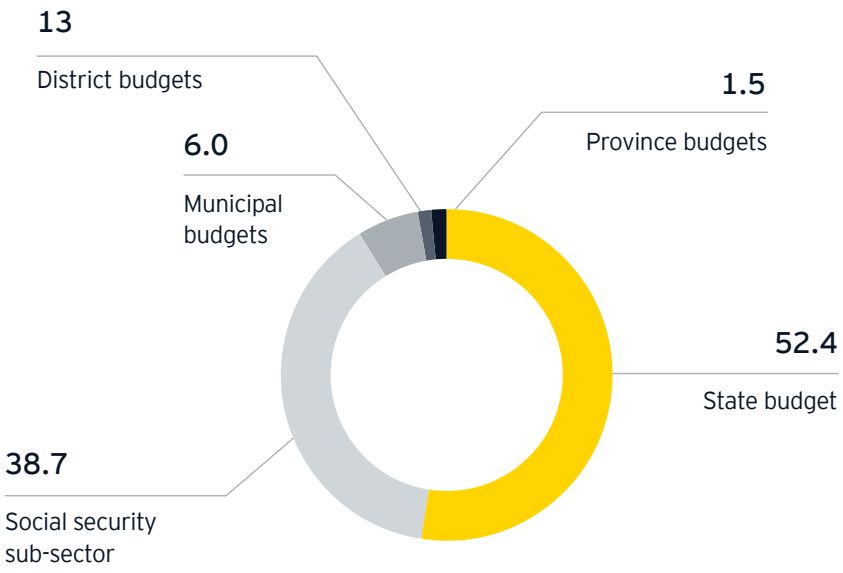
The Airbus Poland plant in Warsaw produces electrical harnesses for military and passenger aircraft manufactured by Airbus.

Chart 12. Economic effects generated by the aviation industry on government revenues

a) by type of effect and category of tax (PLN billion)



b) by type of effect and category of tax (%)



Source: EY's own elaboration based on survey data and EY Spectrum tool

Aviation industry benefits for Poland

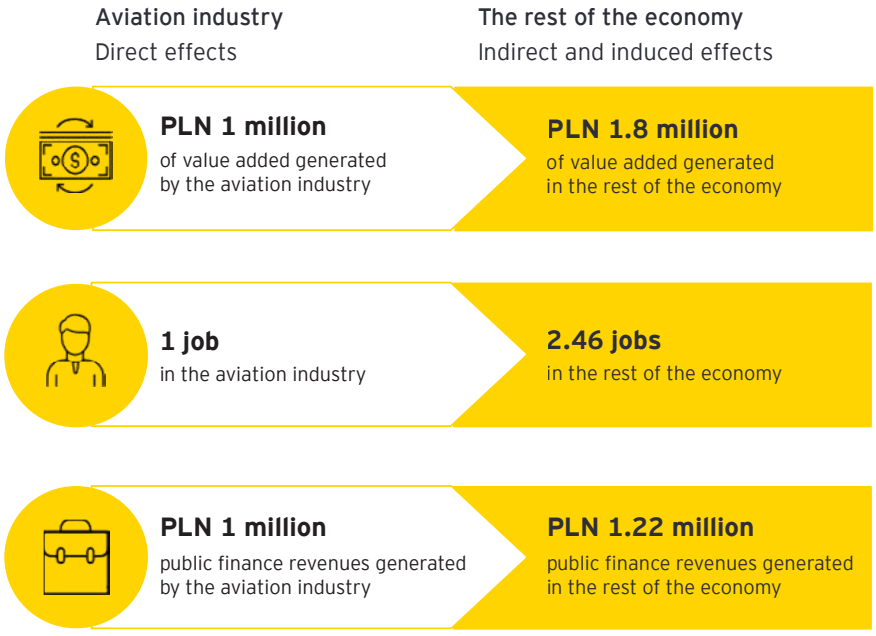
Based on the magnitude of the effects of the aviation industry on the Polish economy, it can be concluded that (see Figure 3):

Every PLN 1 million of value added generated directly by the aviation industry **in 2022** led to the generation of PLN 1.8 million of value added in indirect and induced effects in the rest of the economy.

Every job supported directly by the aviation industry **in 2022** led to the creation of approximately 2.5 jobs in indirect and induced effects in the rest of the economy.

Every PLN 1 million of government revenue generated directly by the aviation industry **in 2022** led to the generation of PLN 1.22 million of government revenue in indirect and induced effects in the rest of the economy.

Figure 3. Economic effect multipliers for the aviation industry



Source: EY's own elaboration based on survey data and EY Spectrum tool

The above ratios of value added, employment and government revenue generated through indirect and induced effects to directly generated effects are called multipliers. The aviation industry is characterised by relatively high multipliers compared to manufacturing, with average multipliers of 1.26 for gross value added, 1.40 for employment and 1.04 for the public finance sector. Multipliers can be even higher if the aviation industry supports local supply chains, thereby strengthening cooperation within the industry.

Advanced technologies developed, among others, by Polish engineers in the CFM LEAP engine family have made it possible to achieve improved propulsion efficiency and a 15% reduction in fuel consumption. The key components of this engine family are manufactured and serviced in Poland.

4

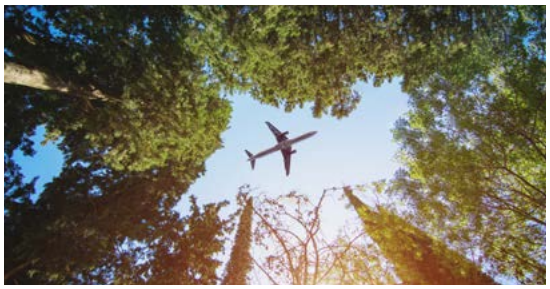
Trends in the aviation industry

Pratt & Whitney and Hamilton Sundstrandt campus in Rzeszów.

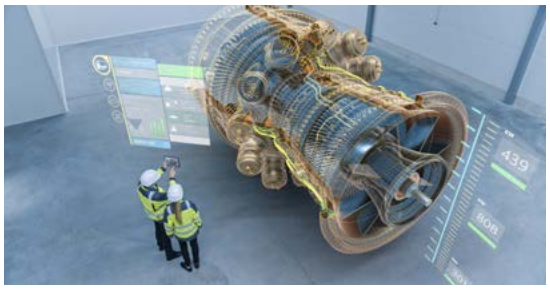
Trends in aviation

The aviation industry continues to grow intensively. This is driven by three main factors. The first two affect volume: increasing demand for air transport in the civil segment and growing political uncertainty driving purchases in the military segment. The third factor strongly shaping the industry's growth is technological progress. It is thanks to technological advancements that the industry develops, creating increasingly advanced aircraft that utilize increasingly innovative IT solutions and new materials.

While the aforementioned factors influence the growth of the industry, trends give direction and determine the transformation of companies to meet new challenges and opportunities. In this context, three main trends stand out that are currently shaping the aviation industry:



Environmental trends, responding not only to the growing environmental awareness and sustainability drive in the aviation sector, but also to cost pressures in a competitive industry.



Technological trends driven by scientific advances, taking into account the development of new aircraft architectures and propulsion, alternative fuels and energy sources, the development of new materials and repair and manufacturing technologies, aircraft autonomy and the use of AI.

Trends related to the transformation of management processes and the organisation of production, both at the level of individual companies and the industry as a whole. Foremost among these are nearshoring/reshoring and the digitalisation and automation of production.

Environmental trends

Low-emission aviation

In the face of the EU's ambitious climate targets[37] the aviation sector has committed to actively working to reduce its environmental impact. This is not without justification – June 2023[38] was globally the warmest June on record in terms of measurements, and global surface air temperatures have already exceeded pre-industrial levels by more than 1.5 degrees Celsius. This alarming trend points to an urgent need for action, which in the aviation industry in particular means reducing the use of traditional fuel. The plan to achieve climate neutrality is divided into two phases: low-carbon (by 2035) and zero-carbon (by 2050).

This includes, among other things, the development of:

- more efficient engine technologies;
- the search for alternative propulsion;
- low-carbon energy sources;
- more energy-efficient aircraft configurations.

It should be noted that the reduction in fuel consumption not only has an environmental aspect, but also a cost aspect: more efficient engines/propulsion translates into better flight characteristics of the aircraft, thus increasing the efficiency of its use.

One of the developments in aviation is the **electrification of aircraft fleets** on short-haul (regional) routes, in which the largest market players are already participating, including Rolls-Royce with a demonstrator of the ACCEL electric aircraft. There is also ongoing work on **batteries** that can store electricity in hybrid or electric aircraft, among other improvements in the energy density of storage systems. Examples of **hybrid engine** demonstrators, i.e., the combination of conventional internal combustion engines with electric machines, include Pratt & Whitney Canada's Hybrid Electric Propulsion and the Electrified Aircraft Propulsion Flight Demonstration Project run in collaboration between GE Aerospace, Boeing and NASA.

In addition, work is underway to **improve the efficiency of aircraft propulsion systems** (including the development of engine modules with significantly improved operational performance) and to develop **new, unconventional aircraft architectures and propulsions**, examples of which include CFM RISE[39] or Pratt & Whitney's WET Engine.

Polish companies are also part of this trend – see more in the case study *Commercial success in a fuel reduction technology project* on page 22 and in the case study *Industrial networking through an innovative high-pressure turbine cooling technology development* on page 72.

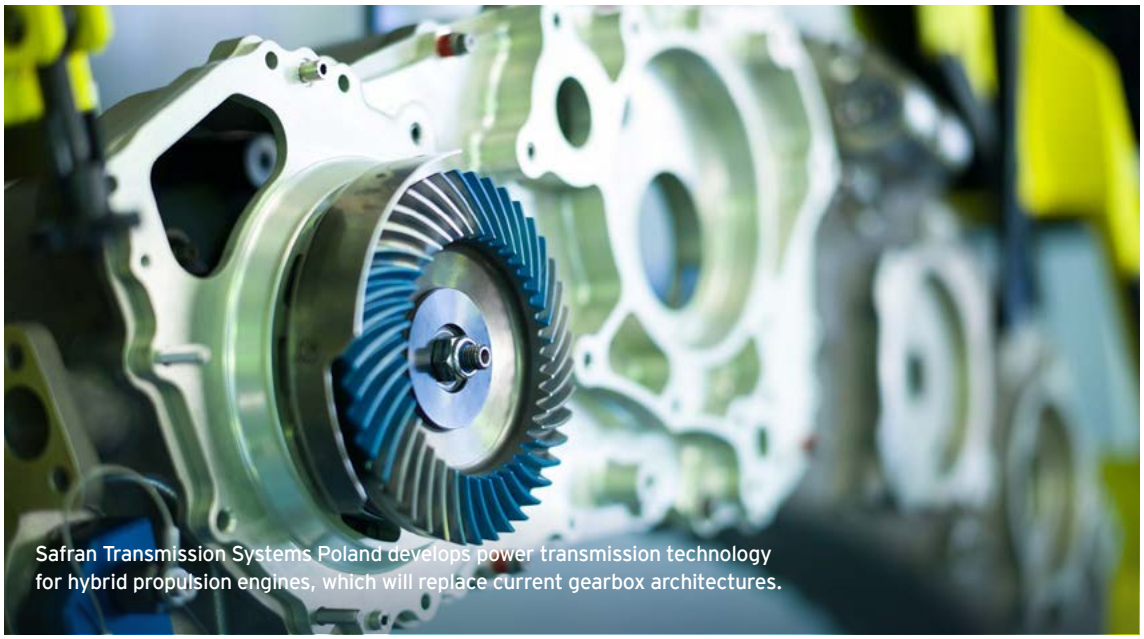
37 Such as climate neutrality by 2050, and the global Paris Agreement of 2015, which aims to limit global warming to below 2 degrees Celsius.

38 According to information from the EU's Copernicus programme.

39 50/50 joint venture between GE Aerospace and Safran Aircraft Engines.

Another area that is attracting attention is **hydrogen**. Hydrogen, as an energy source, is attractive because of its relatively low greenhouse gas emissions[40]. Examples of efforts towards its use include the Airbus ZEROe project – a concept for a hydrogen-powered hybrid aircraft that could enter service as early as 2035 – or the HYDEA project coordinated by GE Avio SRL under the Clean Aviation programme, focusing on ways to store, distribute and burn hydrogen. With widespread deployment, it is estimated that hydrogen has the potential to reduce aviation CO_2 emissions by up to 50%[41]. Hydrogen can be burned in modified gas turbine engines or converted into electricity to supplement the operation of the gas turbine. This is done via fuel cells that power various on-board systems in addition to aircraft propulsion, further contributing to the energy efficiency of aircraft.

However, it is worth noting that hydrogen is not the only path to sustainable aviation. **Other sustainable aviation fuels**, such as biofuels and synthetic fuels, are also constantly being researched and developed. Currently, aviation fuel demand is dominated by aviation kerosene[42], while sustainable aviation fuels (SAF) account for less than 0.1% of all aviation fuels consumed[43], but EU targets state that by 2025 2% of fuel refuelled at European airports is to come from sustainable sources. By 2050, the European Union will require this proportion to rise to as much as 70%, so it is safe to say that the role of alternative sources will only increase in the aviation fuel mix.



Safran Transmission Systems Poland develops power transmission technology for hybrid propulsion engines, which will replace current gearbox architectures.

40 Eissele, J., et al. (2023), *Hydrogen-Powered Aviation–Design of a Hybrid-Electric Regional Aircraft for Entry into Service in 2040*, "Aerospace", 10(3), 277, DOI: 10.3390/aerospace10030277, https://dx.doi.org/10.3390/aerospace10030277 (access: 10 February 2024).

41 Airbus (2023), *Hydrogen in low-carbon aviation*, https://www.airbus.com/en/innovation/low-carbon-aviation/hydrogen (access: 10 February 2024).

42 According to the International Energy Agency.

43 International Energy Agency (2023), *Aviation*, https://www.iea.org/energy-system/transport/aviation (accessed: 10 February 2024).

Case study

Industrial networking through an innovative high-pressure turbine cooling technology development

Significant number of the key components of the Catalyst™ engine, entirely designed in Europe, will be manufactured in Poland.

Company name:	**GE Aerospace Poland Sp. z o.o.**
Name of completed project:	Development of cooling technology for hot section components in rotating machines with particular reference to high-pressure turbine blades and vanes
Institution / programme under which funding was provided:	Ministry of Development Funds and Regional Policy / National Centre for Research and Development / Smart Growth Operational Programme 2014-2020
Total project value / own financing / funding:	PLN 55.3 million / PLN 27.3 million / PLN 28.0 million
Project period:	2016-2019

Since 2008 GE Aerospace Poland has successfully applied for and implemented R&D projects with EU funding.

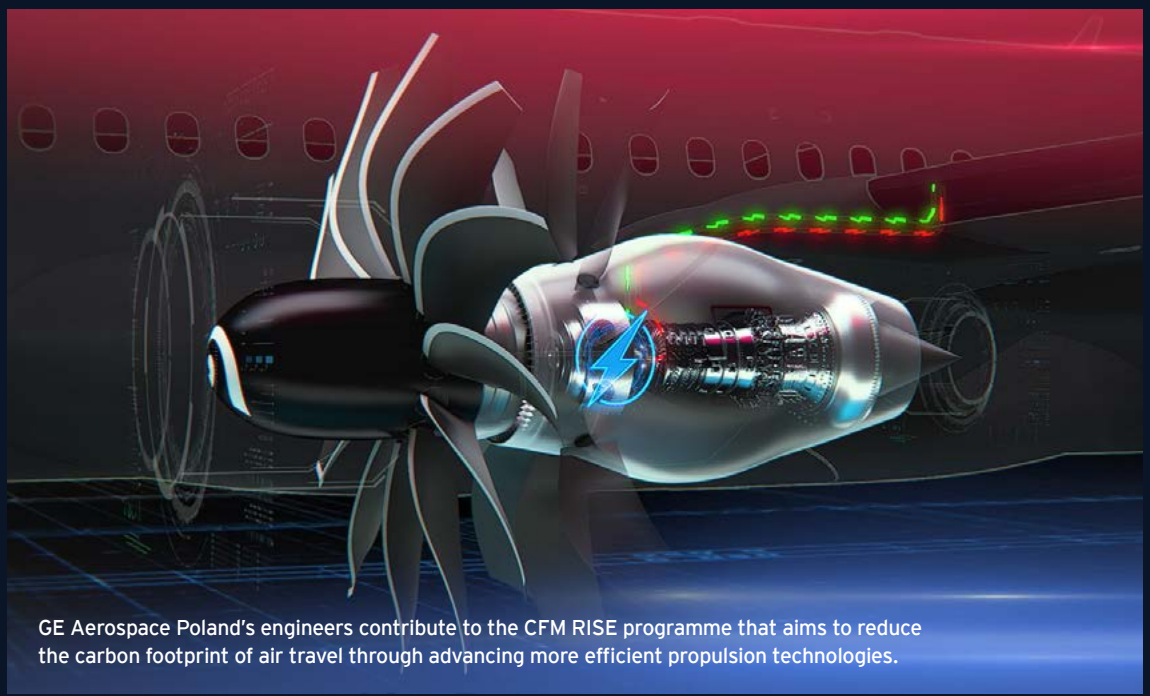
As part of the Innovative Economy Operational Programme, a high-tech computing centre and an R&D centre for new emission reduction and combustion optimisation technologies were created. As a next step, under the Smart Growth Operational Programme, the company undertook an R&D project to develop an innovative technology for cooling, sealing and control of radial and axial clearances of the dedicated hot section of a modern high-pressure turbine.

Completed in June 2023, the project is a global product innovation that will increase engine efficiency and reduce fuel consumption by up to 20%, a step towards meeting climate neutrality targets with ever-increasing air traffic. The benefit of the developed technology is also an increase in the time between engine repairs and maintenance, which translates into lower maintenance cost. The uniqueness of the developed result is enhanced by the fact that it is the first technology of its kind developed in Poland and also the only one outside the USA. The new technology will find wide application in aircraft engines, particularly in the business and general aviation (BGA) segment.

In the course of the R&D work, the company's engineering team met the challenge of conducting research in an engine environment where the temperature reaches 1,400 degrees Celsius and the rotor speed is 45,000 revolutions per minute. It has also gained a unique competence in the design of cooled engine hot section components, which gives the company a competitive advantage in the industry and contributes to the perception of the aviation industry as innovative and attractive to new generations of engineers in Poland.

Simultaneously, the project would not have been possible without the establishment of effective cooperation with the scientific sector and a number of subcontractors, both Polish and foreign. The cooperation network built within the project will be further developed during the implementation phase of the project results, when Polish companies, including SMEs, will be part of the supply chain for the production of new engines using the hot section component cooling technology developed within the project. Already at the stage of preparing the project results for implementation, Polish entities involved in the manufacturing and processing of advanced aircraft engine parts were effectively integrated into the supply chain. The share of these almost 20 players in the production of key engine parts reaches nearly 40%.

The success of this R&D project proves that investing in Polish technical thought, a world-class research workforce educated at Polish universities, and a developed ecosystem of collaborating entities allows effective competition in the global market while simultaneously contributing to increasing innovativeness of the Polish economy.



GE Aerospace Poland's engineers contribute to the CFM RISE programme that aims to reduce the carbon footprint of air travel through advancing more efficient propulsion technologies.

Technological trends

New material technologies

Innovations in materials, such as composites and new metal alloys, offer opportunities to progress and create **more efficient and durable products**, leading to tangible benefits for the aviation industry that is expensive to maintain and committed to the highest safety standards.

In 2022, the global composites market was valued at USD 112 billion and is expected to grow 8% per year until 2027[44]. This growth is being driven by increasing demand from the wind power, aerospace and defence, and automotive and transport sectors. **Carbon fibre-based composites** are increasingly used in the aviation industry for their light weight and strength[45]. Aircraft made from these composites can be much lighter than their metal counterparts, resulting in great fuel savings. For example, the Boeing 787 Dreamliner, which is largely made of carbon fibre composites, uses 20% less fuel than similar aircraft made of aluminium[46]. Polish companies are also playing a role in the global market for new composite materials. More in the case study *Placing a competence centre in Poland thanks to a know-how base* (on page 38).

Another example is the F-35 Lightning II combat aircraft, which uses advanced materials and construction techniques to achieve undetectability to radar, including specialised coatings that absorb radar waves. The F-35 fighter jet is designed to minimise wave reflection. In addition, 35% of the aircraft's weight was made of composite materials, which had a positive impact on reducing the detectability of the fighter jet's flight. The combination of modern design and materials with limited/low radar detectability results in an effective radar reflectivity surface (RCS) of this aircraft that is comparable to the size of a golf ball[47]. This is a clear testament to the effectiveness of the technologies employed in minimising radar detection through the use of new material technologies.

44 Markets and Markets. *Aerospace composites market forecast*, 2023.
45 https://www.sciencedirect.com/topics/engineering/boeing-787-dreamliner (access: 10 February 2024).
46 https://www.thoughtco.com/boeings-787-dreamliner-820385 (access: 10 February 2024).
47 https://militaryembedded.com/radar-ew/signal-processing/radar-cross-section-the-measure-of-stealth (access: 10 February 2024).

Centrum Doskonałości Aerostruktur (Aerostructure Centre of Excellence) at PZL-Świdnik develops competences in advanced aerospace composite structure technologies.

New metal alloys, such as aluminium-lithium alloys, also play an important role in the aviation industry. They are strong, lightweight and corrosion-resistant, making them the ideal material for selected aircraft modules. In addition, the development of new material technologies can bring safety benefits, including in the area of resistance to structural and mechanical damage.

The development of new material technologies will create opportunities for the aviation industry. The industry, in search of efficiency and safety improvements, will have to adapt to the implementation of new materials, in addition to introducing innovative design and production methods.

Automation and Autonomization of Aircraft

Unmanned Aerial Vehicles (UAVs) are becoming an increasingly important segment of the aviation industry. These are flying objects that do not have a pilot on board and can be controlled remotely, fly autonomously based on pre-programming or use a combination of both[48], primarily without endangering the crew/operator.

The growing demand for safety and efficiency in the missions carried out is driving the development of this technology. The most advanced unmanned aircraft can already carry out **complex and risky tasks with minimal human intervention**. As with unmanned land vehicles and maritime vehicles[49] unmanned aircraft will gradually take over some of the tasks or, in the case of the military, the responsibilities of manned vehicles, especially in terms of transport and monitoring.

Applications for unmanned systems span a wide range of industries – from civilian operations such as agriculture, construction and infrastructure inspection to government and military applications such as search and rescue, border patrol and reconnaissance missions and military combat missions.

The largest segment of the Unmanned Aerial Vehicles market is for civilian use, i.e., for commercial and private use. Civilian UAVs are mainly used for aerial filming and photography. Depending on the method of image capture, the data so acquired is used in entertainment and the arts, for thermal imaging inspections of buildings, crop inspection or inspection of power grids. In Poland, the civilian market segment is mainly dominated by SMEs designing and manufacturing UAV for agriculture and transport. Read more about SME involvement in UAV development in the case study *Developing SME cooperation in innovative technologies for aviation* on page 84. Civilian unmanned aircraft can also be used in combat missions, as demonstrated by the war in Ukraine, where modified devices performed surveillance, reconnaissance and combat functions on the frontline.

Loyal wingman – use of unmanned vessels to work with manned vehicles

The concept of the loyal wingman – an unmanned aircraft that acts as a support to manned aircraft – is another important technological trend in aviation directly linked to UAV. Loyal wingman type of unmanned aircraft can perform a variety of tasks, such as reconnaissance, attack and even acting as communication relays in cooperation with manned aircraft, but without endangering the crew and with less risk of equipment loss. An example of a loyal wingman product is an unmanned aerial system called the MQ-28 Ghost Bat manufactured by Boeing Australia. There is no doubt that in the future, loyal wingman will be of strategic value to military operations.

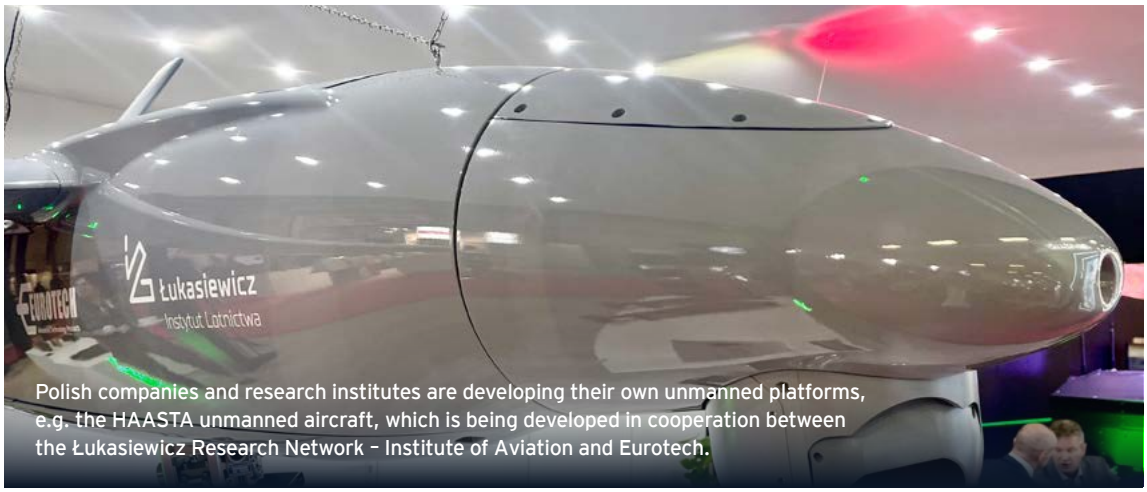
48 Unmanned Aerial System' (UAS), on the other hand, is a term that encompasses not only the UAV, but also all the software, hardware, payload, pilot and communication systems necessary to operate the vehicle, including ground control stations and data links. For the purposes of this report, the terms 'unmanned aircraft' and 'unmanned aviation system' will be used interchangeably.

49 Both surface and underwater.

Civilian UAVs are also used in logistics. It is estimated that interest in this use will continue to grow. The most extensive use of UAVs in the industry is expected to be in the so-called **'last mile delivery'**, the final stage of online order delivery, widely recognised as the most problematic and difficult to optimise. In addition, solutions using unmanned aircraft are proving to be beneficial in terms of sustainability[50]. Amazon announced Prime Air, a service offering delivery of goods by drone, back in 2013. The service was piloted in 2022 and customers in Lockeford, California, and College Station, Texas, can now use the service as part of a pilot programme. Walmart, the largest supermarket chain in the US, has done likewise, partnering with DroneUp to offer UAV-based delivery to around 4 million US households[51].

The second largest segment of UAV includes devices for military purposes. Due to the multiplicity of applications in this category, it is here that the largest range of classes of UAVs used can be observed – from those the size of an insect, such as the Black Hornet Nano, used by the Commando Special Forces Group, to the 4-tonne RQ-4 Global Hawk, which performs more than 24-hour surveillance missions in the Black Sea region during Ukraine's ongoing war. Polish companies are developing unmanned aircraft for reconnaissance and surveillance, as well as to combat ground targets. These activities are carried out, for example, as part of the Wizjer or Orlik modernisation programmes. In parallel, the loitering munitions segment (so-called kamikaze drones) and the jet and propeller-based aerial target imitators used for training by Anti-aircraft warfare are being intensively developed.

In the defence industry in particular, the use of unmanned aircraft can be expected to be very high. The war in Ukraine and other conflicts that have taken place in recent years in Europe[52], demonstrate the widespread use of unmanned aircraft and its high effectiveness against the enemy. Emergence of automated and unmanned systems is a trend in the armed forces that the defence industry is following.



Polish companies and research institutes are developing their own unmanned platforms, e.g. the HAASTA unmanned aircraft, which is being developed in cooperation between the Łukasiewicz Research Network – Institute of Aviation and Eurotech.

50 https://unmanned.life/environmentally-friendly-drone-technology/ (access: 10 February 2024).
51 https://unmanned.life/environmentally-friendly-drone-technology/ (access: 10 February 2024).
52 Conflict between Armenia and Azerbaijan in Nagorno-Karabakh.

Air taxis

The latest significant segment of UAVs (Unmanned Aerial Vehicles) being developed worldwide includes large systems designed for the transportation of goods and people in large urban areas (including so-called air taxis, Air Taxi). Current knowledge allows for the construction of a multirotor with the appropriate lift capacity to fulfill this function. The development of this segment is focused on the decarbonization aspect, meaning the use of exclusively electric propulsion systems, which translates into the need to increase the mass efficiency of batteries.

One of the pioneers in this field is Airbus, owner of the CityAirbus project, a multi-rotor electric vertical landing aircraft (VTOL type) capable of carrying up to four passengers over a distance of up to 100 km. CityAirbus is currently in the testing phase. Work on air taxis is also being carried out in Poland, mainly within research centres and SMEs, but these concepts do not have sufficient financial support. Although some regulatory aspects, such as the lack of access to civilian space for UAVs weighing more than 25 kg, impose restrictions on the development of this technology, the European Union is preparing to allow UAVs with a take-off mass of up to 3,000 kg to fly in 2030. Consequently, now is the time to direct funds towards the development of VTOL technology, enabling it to take its desired position in the market.

Supersonic flight

Supersonic flight, which was once the domain only of military fighter jets and the legendary Concorde, is now getting closer to becoming a reality for commercial transport. New technologies and materials make it possible to build aircraft capable of flying safely and efficiently at supersonic speeds, while ensuring that demanding noise emission standards are met.

One example includes Boom Supersonic, a company working on the Overture aircraft, which is expected to be able to carry passengers at more than twice the speed of sound. This would mean that a flight from New York to London could take as little as 3.5 hours. Overture is scheduled to enter commercial service in 2029[53].

United Airlines and American Airlines have committed to purchase Overture aircraft from Boom Supersonic, highlighting interest in the supersonic commercial jet[54].

Another example is the collaboration between Lockheed Martin, GE Aerospace and NASA to develop the X-59 QueSST supersonic aircraft under NASA's Quiet SuperSonic Technology programme. The project is to verify the feasibility of reducing the sonic boom generated in flights at a minimum speed of Mach 1, which is the primary reason for the restrictions on commercial supersonic flights. For the observer on the ground, the X-59's flight at a cruising speed of Mach 1.5 is supposed to be no different in noise from the flight of classic passenger jets.

53 https://mlodytechnik.pl/eksperymenty-i-zadania-szkolne/wynalazczosc/30965-samoloty-naddzwiekowe-wyzwania-zwiazane-latajacym-konstrukcjami-naddzwiekowymi (access: 10 February 2024).

54 https://boomsupersonic.com/press-release/american-airlines-announces-agreement-to-purchase-boom-supersonic-overture-aircraft-places-deposit-on-20-overtures (access: 10 February 2024).

Use of UAVs during the war in Ukraine

FlyEye reconnaissance unmanned aircraft in flight.

Since the start of the Russian invasion on 24 February 2022, Ukraine has been using a variety of unmanned aircraft to fight the enemy. Among the most spectacular at the start of the war were undoubtedly the Turkish-made Bayraktar TB-2 systems[55] which are reconnaissance and combat systems that have gained international recognition for their effective neutralisation of Russian heavy vehicles, including armoured vehicles.

Relatively small strike drones, so-called kamikaze drones, with ranges of up to 1,000 km and equipped with warheads weighing up to 50 kg, are playing an increasingly important role in the war in Ukraine. Large shipments of Shahed drones have been launched by the Iranians, with Russia announcing production of 6,000 per year[56].Ukraine is responding by producing Ukr-Jet drones[57], which have already repeatedly attacked Moscow.

Unmanned aircraft can destroy equipment worth up to USD 500,000, while some are only worth about USD 1,000. Currently, UAVs are an important part of the Ukrainian army's operations, as evidenced by the fact that between November 2022 and May 2023. Ukraine has trained 10,000 UAV operators and another 10,000 are undergoing training[58].

The Ukrainian army uses a variety of UAVs for reconnaissance operations, ranging from aircraft with a 15-metre wingspan, to medium-sized UAVs such as the fully-produced FlyEye and miniature Black Hornets, not much bigger than sparrows.

55 MALE-class unmanned reconnaissance and combat aircraft (Medium Altitude Long Endurance).

56 https://www.businessinsider.com/russia-making-own-versions-iranian-attack-drones-2023-8?IR=T (access: 10 February 2024).

57 https://ukrjet.ua/eng (access: 10 February 2024).

58 https://abcnews.go.com/US/inside-ukraines-efforts-bring-army-drones-war-russia/story?id=103152130.

As a result of the war in Ukraine, the demand for UAVs is steadily increasing, as the Ukrainian side is estimated to be losing around 10,000 UAVs per month[59] (these are mainly small civilian drones, but by comparison the French army has 3,000 military UAVs in all models combined[60]). Demand generates supply, and thanks to this, Ukraine is becoming a serious manufacturer of UAVs – a year ago there were 7 UAV manufacturers there, today there are more than 80[61]. Large military purchases in Ukraine and highly qualified specialists in the aviation industry are attracting investment and building the industry.

In addition to strictly military UAV, the Ukrainian military uses civilian UAV for military operations. The adoption of commercial UAV technology has changed the way surveillance, reconnaissance and assault missions are conducted.

During the war, for example, a formalized 'Drone Army' initiative is developing[62], which aims to place a minimum of 200 drones flying along the extensive front line for uninterrupted transmission of the fighting. Civilian UAVs are also used for other unconventional warfare, such as delivering or dropping small munitions and defusing minefields, as was the case in the southern Kherson region. The psychological warfare aspect also comes into play. Although the explosives dropped by the UAVs do not necessarily cause significant damage, the constant possibility of such an attack creates a lasting sense of fear and even panic among the enemy.

The extensive use of drones in Ukraine demonstrates both the versatility of UAVs in a variety of combat scenarios and the value of adopting commercial technology for military applications.

The FlyEye system can be used for battlefield surveillance, artillery guidance, signal retransmission, border patrol or critical infrastructure monitoring.

59 We are referring to both military and civilian UAVs, https://ecfr.eu/article/drones-in-ukraine-and-beyond-everything-you-need-to-know/ (access: 10 February 2024).

60 https://www.lemonde.fr/en/international/article/2023/06/18/russia-and-ukraine-take-drone-warfare-to-unprecedented-scale_6033281_4.html (access: 10 February 2024).

61 https://abcnews.go.com/US/inside-ukraines-efforts-bring-army-drones-war-russia/story?id=103152130 (access: 10 February 2024).

62 https://abcnews.go.com/US/inside-ukraines-efforts-bring-army-drones-war-russia/story?id=103152130.

Trends in the transformation of management processes and production organisation

Nearshoring/reshoring

In the past, many companies focused on outsourcing production to countries with low labour costs, as this solution offered increased profits. Time has shown that this business model can lead to over-dependence on one or a few suppliers and a reduction in the quality of production, and over-reliance on it has meant that disruptions in supply chains have posed a major threat to the business, including the risk of losing core competences to suppliers or partners.

Faced with the COVID-19 pandemic and other disruptions in international supply chains, such as the blockade of the Suez Canal, companies are once again reviewing their strategies for organising production. Increasingly, it is being relocated to safe, close locations, a phenomenon known as **nearshoring** (where production is moved from countries with low labour costs to countries that may have higher costs but are geographically closer) or **reshoring** (which involves moving production back to the country where the company is based).

Both strategies aim to **shorten supply chains** and increase control over production processes. They can also allow for greater flexibility and enable companies to respond more quickly to changes in the market and, most importantly, ensure their **self-sufficiency**. Nearshoring and reshoring are not without their challenges, however, and therefore any decision to relocate a business must be preceded by a thorough analysis and take into account both the company's short- and long-term goals. Despite the aforementioned challenges, this trend is likely to continue to grow as a response to current and future opportunities for turbulence in global supply chains.

Automation and digitalisation

In the manufacturing area, the most important trend is the **automation and digitisation of production processes**. Thanks to technological advances, companies are able to increase the efficiency of their operations, which translates into lower costs and a greater technological advantage over their competitors. Solutions from the area of **Industry 4.0**, which is associated with the broadly understood digitisation and robotisation of production processes, are used precisely to increase production efficiency, and technologies such as AI, Big Data, the Internet of Things or Digital Product Definition contribute to the creation of 'smart' factories, where machines, systems and products communicate with each other in real time, enabling the optimisation of the entire value chain.

In the context of aviation, these trends are particularly relevant. By implementing automation and **digitalisation** solutions, aviation companies are able to reduce production times, improve process accuracy and increase

employee safety in particular. The robots can work in tight spaces and hard-to-reach areas, further improving the efficiency of production and repairs. In quality control, on the other hand, the use of robots reduces potential human error and allows early identification of any problems that may arise, increasing the repeatability of production and ensuring that the final product does not differ from the expected one.

The aviation industry is also seeing increasing use of Industry 4.0 technologies. For example, some end tools in robotics are connected to the **Internet of Things** (IoT), which makes it possible to collect real-time data and plan the optimisation of industrial processes. In addition, IoT-connected scanners can identify the material of a part so that robots can later use this information to select the right screw size and apply the correct torque for the material.

The new trends in manufacturing include 3D model-based **digital product definition**. Digital product definition means that instead of traditional construction documentation, it is the 3D model that becomes the main source of information about a product, such as an engine component, and it is on this that engineering work is based. In this way, throughout the entire product life cycle (from the offer stage, technology development, manufacturing process, parts control, logistics, to repair and remanufacturing of aerospace components), everyone involved in the process has access to a digital, always up-to-date configuration and the latest requirements for the aviation product. The use of digital product definition streamlines the aircraft and aircraft engine maintenance process: it reduces the time and cost of the work in the various stages and reduces the possibility of human error. Digital product definition is beginning to dominate the latest aircraft design and propulsion solutions.

Embedding product information in a 3D model naturally links to 3D printing. 3D printing is a significant advance in the automation of aerospace manufacturing, enabling the simplification of manufacturing processes and the optimisation of structure production, resulting in weight reduction. 3D printing is becoming a standard part of the aerospace product value chain and, in some cases, even the basis of it – aviation company Relativity Space, for example, produces rockets almost exclusively using 3D printing. In the process, the printer uses artificial intelligence and machine learning to control and optimise the printing process, enabling the production of complex rocket component geometries. 3D printing is also increasingly being used in repairs.

Another important area is the use of artificial intelligence in the production process, for example to automate quality control. This is not its only application – the aviation AI technology market is expected to exceed USD 12 billion by 2031 with an average annual growth rate of 37% between 2023 and 2031[63]. Artificial intelligence will also bring significant benefits in the areas of **robotics and security**. Robots will increasingly replace humans in tasks such as grinding, drilling, painting, coating and assembly, increasing crew safety and workflow.

63 https://www.transparencymarketresearch.com/ai-in-aviation-market.html (access: 10 February 2024).

Case study

Developing SME cooperation in innovative technologies for aviation

HAASTA unmanned aircraft using HybriDrive.

Company name:	**EUROTECH Sp. z o.o.** Cooperating entities: WALDREX, CEREL, Rzeszow University of Technology
Name of completed project:	Hybrid propulsion unit technologies for light or unmanned aircraft (HybriDrive)
Institution / programme under which funding was provided:	NCBiR / INNOLOT I
Total project value / own financing / funding:	PLN 12.5 million / PLN 5.1 million / PLN 7.4 million
Project period:	2013-2017

In 2013, as part of the INNOLOT programme, Eurotech launched the ambitious HybriDrive project. It concerned the development of hybrid engine technology for an unmanned aircraft with the ability to scale up to Ultra Light – an aircraft designed for amateur flying.

Eurotech – as a medium-sized company – was able to take on the role of consortium leader thanks to **its advanced R&D infrastructure and well-established project management skills and experience gained from working on other R&D initiatives** (e.g., SAT-AM) or projects carried out in collaboration with foreign entities. Combining the strengths of all the partners, however, was a real value in the project, as it was working in a consortium that allowed the partners to support each other and complement the group's expertise.

At the conceptual design stage, the Rzeszów University of Technology stood out and was responsible for most of the initial work. Further stages were implemented by the partners with the leadership of Eurotech. **With its own R&D department, this is where the development work for the HybriDrive project took place.** The R&D part of the project involved, among other things, research and optimisation of the subassemblies of the combustion-electric hybrid, as well as the technical design of the propulsion, control and coupling system, which allows the drives to be disconnected during flight. This was followed by a demonstrator and propulsion tests on dedicated test benches and in flight on an unmanned platform.

Although the aim of the project was to achieve Technology Readiness Level 6, Eurotech went one step further.

Using its own resources, it continued to work extensively on the technology, which ultimately resulted in the prototype and later commercialisation of a globally unique hybrid propulsion system for the HAASTA UAV.

The example of the HybriDrive project shows that **financial support opens the door for SMEs to carry out important and advanced work**. Small and medium-sized enterprises, despite their small size, already have state-of-the-art technological facilities and experience gained from working with others. Projects like HybriDrive allow this background and knowledge to be put into practice.

The digitisation of processes and products allows for the collection and processing of data from various sources, such as IoT sensors, production data, logistics data or information on the current state of the process/product in operation. Artificial intelligence offers the possibility to process collected databases and the resulting information can be used, among other things, for process or product optimisation, decision-making processes, centralised product reliability management or the creation of intelligent solutions in the area of product quality control.

The implementation of **digital twin** technology will be important for the future of the aviation industry. A digital twin is a virtual model that replicates a physical object, process or system (physical twin). As the virtually indistinguishable digital equivalent of the physical twin, it serves for practical applications such as simulation, integration, testing, monitoring, maintenance and repair. It is assumed that, in the future, the digital twin will be the basis for managing the entire product life cycle (from the design process to research, construction, operation and disposal or recycling) of the physical twin it represents.

One of the key elements in the process of releasing aviation products to the market is their **certification**. It is the process of proving that a product meets the safety requirements set out in normative acts. Its implementation requires the undertaking of often lengthy and costly studies. The search for methodologies to both shorten this process and reduce the costs involved is ongoing. One of these is the use of digital simulation methods. It is assumed that, using a digital twin and digital simulations, it will be possible to obtain the reliable data necessary to carry out the process enabling product certification.

Conclusions

The direction of change has already been set by trends, and the race for market space is on. Now is the time for the Polish industry to invest in taking the best possible position in the industry in the long term. This should be a two-pronged action: on the one hand, **safeguarding the competitiveness of** current production and service resources and, on the other hand, **building the capacity of industry in the technologies of the future**. The indicated activities must be preceded by the identification of the main directions of development of the Polish aviation industry. These directions should be included in the **Research Agenda** which is an integral part of the aviation **Industry Contract**.

The aviation industry is facing a complete transformation on both the product and operational sides. The process of change is unavoidable, as the industry is highly competitive and transformation enables a better position in the market through more innovative products, lower operating costs or more efficient customer service, e.g., in the MRO segment.

Strengthening the industry brings tangible benefits in economic, national security and social terms, so, **traditionally, key development initiatives are supported by public funding**. The remainder is covered by the beneficiary's own resources, which involves strategic decisions on which research programmes and in which country to invest the funds.

The next chapter takes a closer look at the support opportunities available to Polish aviation companies.

The W-3PL Głuszec combat support helicopter is a development version of the Sokół helicopter designed and manufactured at PZL-Świdnik.

5

Support for the development of companies in Poland

At the PZL-Świdnik Aerostructure Centre of Excellence, advanced competence is being developed in the manufacture of helicopter fuselage structures and assembly.

The development of the Polish aviation industry is currently based on two main pillars: projects implemented in companies on the basis of overarching corporate strategies[64] and projects implemented under national or EU programmes. This combination enables the stable growth of the industry, the acquisition of new competences and the expansion of companies' activities. However, this is not enough impetus to escape the mid-growth trap, an area where companies are growing at nominal values but not increasing their global market share.

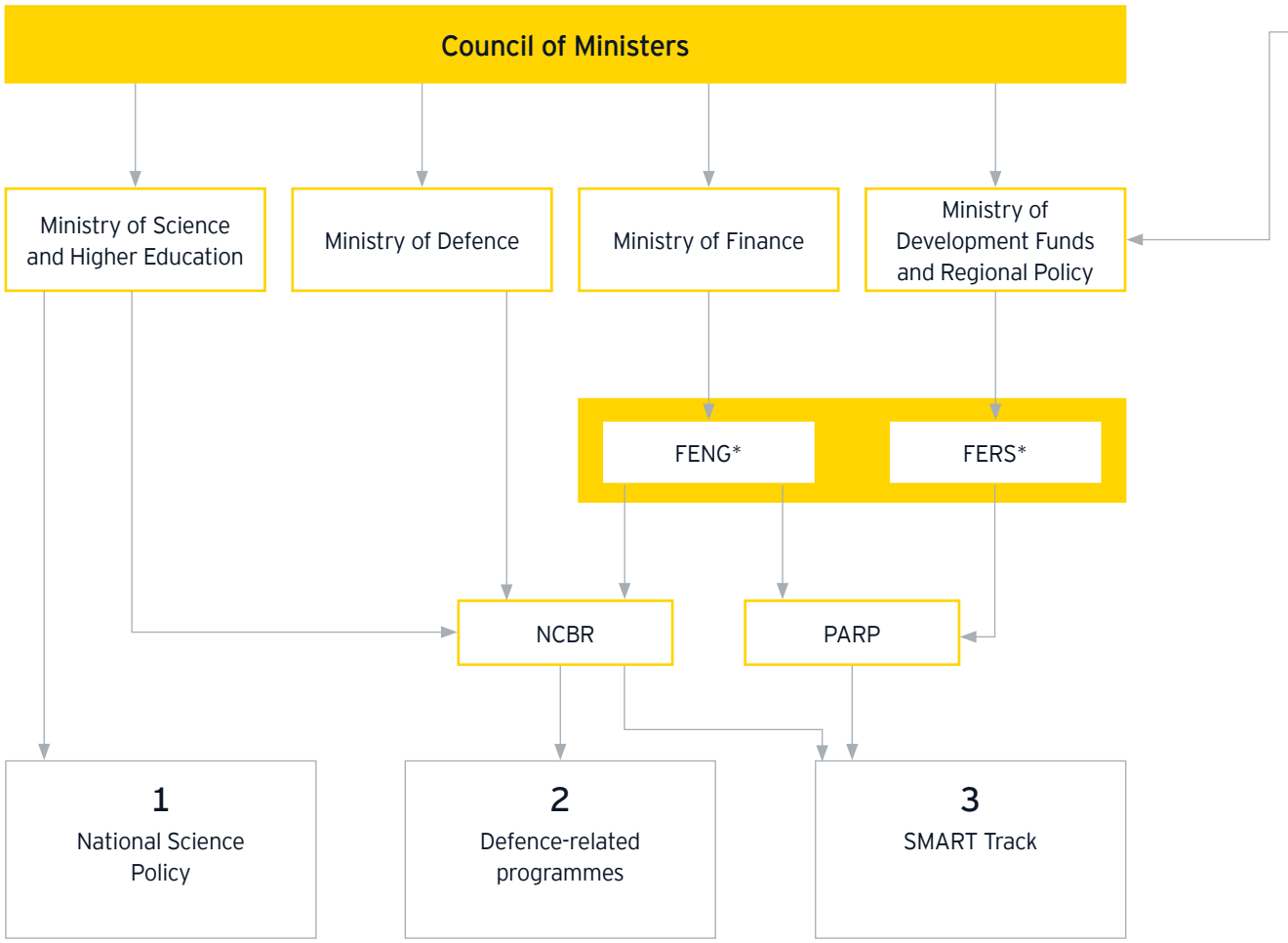
Improving the industry's competences and entering new product areas is facilitated by financial support in the form of funding, particularly for R&D and infrastructure projects. This is extremely important for an industry such as aerospace because of the large infrastructure costs, the long research and prototyping process and the need to pay educated and experienced staff.

This chapter presents the development opportunities facing the Polish aviation industry primarily in the context of currently active national and EU programmes.

64 In the case of entities whose ultimate owner is established abroad.

Fund allocation rules

Figure 4. Simplified list of funding for EU and national aviation programmes



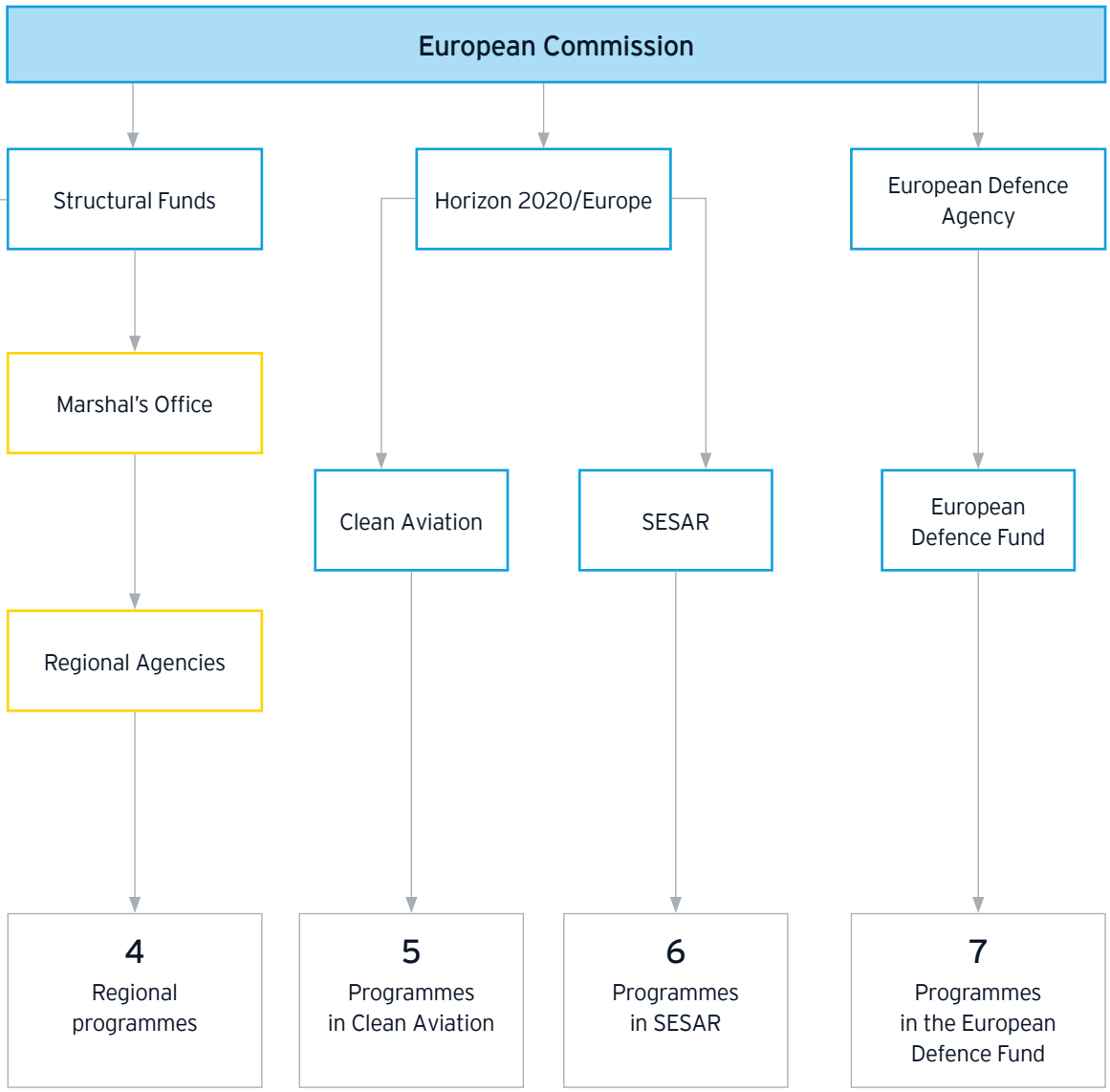
Legend:

Programmes

EU institutions/ organisations

National institutions/ organisations

* EU programme, which is implemented at national level. Funding for this programme comes partly from European funds and partly from the national budget.


European Commission
Structural Funds
Horizon 2020/Europe
European Defence Agency
Marshal's Office
Clean Aviation
SESAR
European Defence Fund
Regional Agencies
4
Regional programmes
5
Programmes in Clean Aviation
6
Programmes in SESAR
7
Programmes in the European Defence Fund

In Poland, funding for research programmes mostly comes from two sources: European Union and the national budget of the Republic of Poland. Accordingly, four types of programmes are distinguished:

A

Nationally funded programmes
for the development of science (1) and security and defence activities (2) and other funding.

B

European-funded national programmes
(3) benefiting from blended funding, in particular the European Funds for Smart Economy (FENG) programme 2021-2027 (successor to the Smart Growth Operational Programme – POIR).

C

European-funded regional programmes
with funds divided into regional programmes (4), outlined by the Marshall Offices.

D

Programmes directly funded by European Union agencies (5, 6 and 7).

Funds from the European Union (B and C) are allocated to member states within the framework of a budget that is approved by the European Commission, the Council of the European Union, and the European Parliament. Subsequently, member states, in collaboration with the European Commission, define high-level goals and priorities for the allocation of these funds. Once the plan is approved, the funds are transferred to the member states. It is important to note that these funds are integrated with the long-term strategies of the European Union, such as the European Green Deal and the European Industrial Strategy.

The distribution of allocated funds is carried out directly by the ministries that are the custodians of these funds (Managing Authorities), which can select intermediary institutions acting as agencies (Intermediate Bodies and Implementing Authorities), which select intermediary institutions acting as agencies. At the national level, the key agencies in this system are the National Centre for Research and Development (NCBR) and PARP[65].

The Stator line at Safran Transmission Systems Poland is part of the Engine Components Division at the Sędziszów Małopolski plant.

65 The Polish Agency for Enterprise Development has funds from the FENG fund for SMEs and funds from the FERS fund.

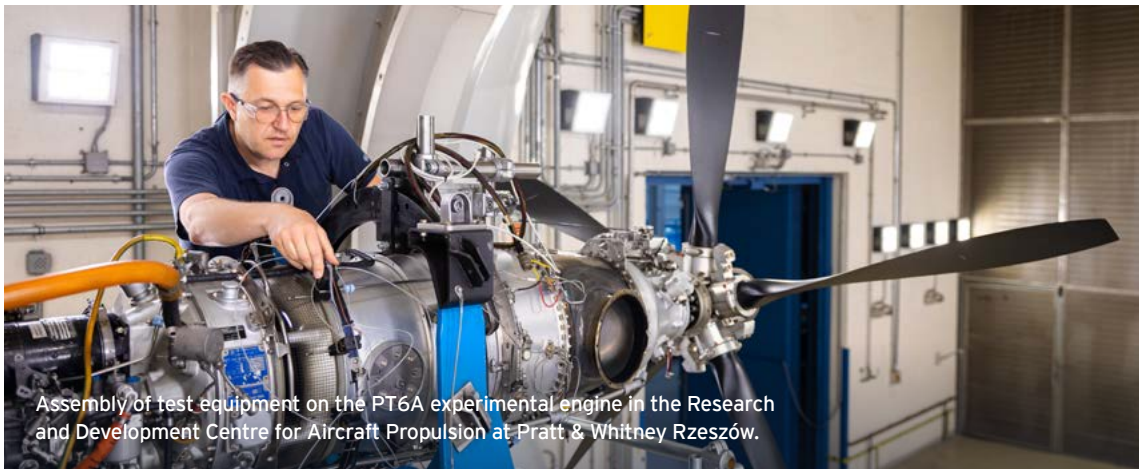
A Programmes 100% nationally funded (1 and 2)

Only a small portion of R&D programmes is funded exclusively from national sources.

The aviation industry has the opportunity to participate in programmes dedicated strictly to the national objectives of the Ministry of Defence[66]. Some R&D projects in the area of defence are carried out on behalf of the Ministry of Defence through the Armaments Agency (formerly the Armaments Inspectorate). In addition, the National Centre for Research and Development carries out projects for national defence and security – currently 76 projects[67]. However, it should be remembered that aviation and flying systems are only a small part of the country's defence system, and the aforementioned programmes are intended to respond to the entire defence needs of Poland. Thus (and rightly so) defence-related **programmes** (2) are not dedicated solely to the aviation industry. To date, 19 calls for proposals have been held in NCBR's defence programmes, with a total budget of over PLN 4.1 billion[68].

In addition to this, programmes are implemented whose scope follows the directions previously indicated in the National Research Programme, replaced in 2022. **National Science Policy** (1) which is intended to respond to strategic technical, scientific or social challenges set by the Ministry of Science and Higher Education.

Programmes implemented with national funds by NCBR include strategic programmes. The 32-member Council of the National Centre for Research and Development, composed of representatives of the scientific, socio-economic and financial communities and the state administration, is responsible for their preparation[69]. The draft strategic programme prepared is then approved by the minister responsible for science. It is the Minister of Science and Higher Education who has the final say on the allocation of national science funding.



Assembly of test equipment on the PT6A experimental engine in the Research and Development Centre for Aircraft Propulsion at Pratt & Whitney Rzeszów.

66 In accordance with the provisions of Decision No. 40/MON of the Minister of Defence of 22 March 2022, the planning document for material and financial planning in the field of scientific research in the Ministry of Defence is the Scientific Research and Technology Development Plan.

67 https://www.sejm.gov.pl/sejm9.nsf/InterpelacjaTresc.xsp?key=CUPHTX&view=S (access: 10 February 2024).

68 https://www.gov.pl/web/ncbr/programy-i-projekty---obronnosc-bezpieczenstwo (access: 10 February 2024).

69 It is intended that the composition of the Council (comprising scientific experts, representatives of the financial and socio-economic community and representatives of ministries) will ensure that research programmes are scientifically and business sound, in line with government and EU strategy.

B EU-funded national programmes (3)

Over the past several years, NCBR has launched several mechanisms for the distribution of R&D funds that can be used by aviation-related entities. Most of them were horizontal, i.e., their thematic scope was not dedicated to specific research areas or economic sectors.

The first major potential source of funding for the Polish aviation industry was the **Programme for Applied Research (PBS)** established in 2012. The programme supported the academic and business sectors for applied research in various scientific fields (programme strand A) and industries (programme strand B). The programme was aimed at funding research projects of an applied nature, i.e., the most promising in the area of future application.

The programme had three calls for proposals with a total allocation of PLN 1.2 billion. Its last edition was held in 2014.

Another programme, **INNOTECH**, which has already been completed, supported the implementation of innovative projects in various scientific fields and industries (programme path In-Tech), with a particular focus on the area of advanced technologies (programme path Hi-Tech).

INNOTECH was intended to encourage investment in R&D and strengthen cooperation between science and business. Five calls for proposals were held under the programme, with a budget of PLN 130 million for the In-Tech path and PLN 40 million for the Hi-Tech path. The level of funding depended on the type, size and nature of the development or research project and the applicant. The project duration was three years for In-Tech and two years for Hi-Tech projects, with maximum funding of PLN 10 million and PLN 5 million.

Table 1. Maximum funding offered by the INNOTECH programme (%)

	Research work	Development work
Scientific entities	100	100
Micro and small companies	80	60
Medium-sized companies	75	50
Large companies	65	40
Implementation projects		
In-Tech track	90 (maximum PLN 10 million)	
Hi-Tech track	50 (maximum PLN 5 million)	

Source: EY's own elaboration based on NCBR data

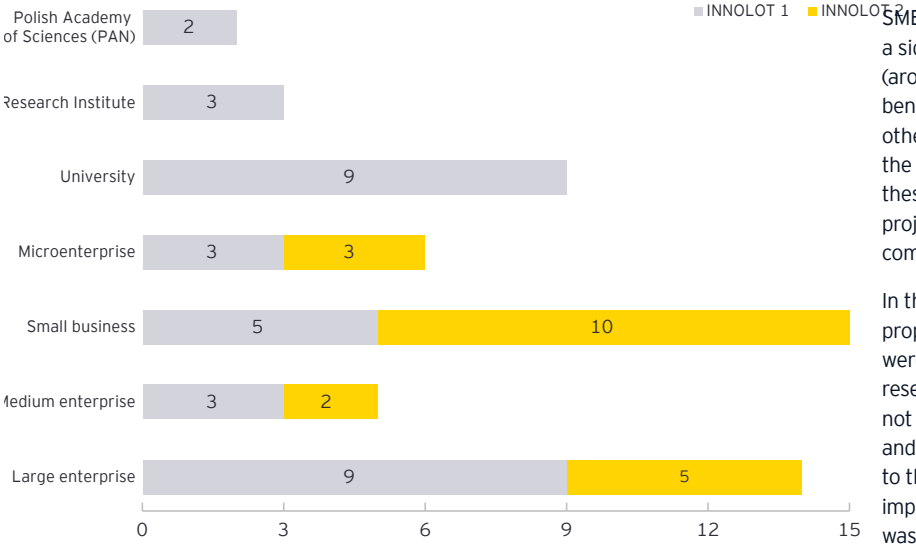
It should be noted that, due to its general nature, the INNOTECH programme was not tailored to the needs of the aviation industry. The main constraint hindering the participation of aviation players was the short time horizons allocated to projects, which hindered the submission of proposals for R&D work, which in the aviation industry generally lasts an average of 8-10 years. Furthermore, it is worth noting that the INNOTECH programme highlighted 93 areas in the Hi-Tech category, **and only one of these was related to the aviation industry, while as many as seven were related to the automotive industry**.

Directly targeting the aviation industry was **the INNOLOT**, or Innovative Aviation, **programme**, established in 2012 on the basis of an agreement between the National Centre for Research and Development and the Polish Aviation Technology Platform, which brings together the majority of companies operating in the aviation industry in Poland. The programme was jointly managed by NCBR with representatives of the aviation industry[70]. It was intended that 40% of the funds provided for R&D would come from public funding and the remaining 60% from the beneficiaries.

Two calls for proposals were held under the programme to award funds for research and development in the aviation industry. Financially supported projects could include:

- industrial research aimed at acquiring new knowledge and skills and subsequently developing new products, processes and services or making significant improvements to existing ones;
- development work involving the acquiring, combining, shaping and using existing knowledge and skills to create new, altered or improved products, processes and services.

Chart 13. Structure of beneficiaries in the calls for proposals of the INNOLOT programme (PLN million)



SMEs accounted for a significant proportion (around 48%) of INNOLOT's beneficiaries. This was, among other things, the result of the obligation to include these companies also in projects carried out by large companies.

In the second call for proposals, research units were not direct beneficiaries, research units were not direct beneficiaries and their participation to the extent necessary for the implementation of the project was included as a subcontract.

Source: Association of Polish Aviation Industry

70 Steering Committee consisting of four experts designated by NCBR and three representatives of the aviation industry.

In the first call for proposals, the total budget for project co-financing was PLN 174 million (out of the PLN 180 million allocated in the call for proposals), and scientific and industrial consortia could also apply.

In the second call for proposals, concluded in 2015, funding amounted to PLN 160 million (out of the PLN 400 million allocated in the call[71]) and only companies could be direct beneficiaries[72]). The lower uptake in the second call was due to a change in the funding conditions of the programme, linked to higher expectations regarding the level of development of the final project product. While under the first INNOLOT call for proposals the project had to end at the demonstrator level (TRL 6), the next call for proposals required implementation (TRL 9). As a result, large players in the aviation industry with innovative products at an early stage of development had no chance of being awarded funding in this call.

NCBR's summary of the effects of the INNOLOT programme[73] indicates that the activities undertaken in the INNOLOT programme have contributed to:

- increased investment in R&D, as some of the companies involved began to invest more in research after the programme;
- strengthening of cooperation between business and research entities, as most of the programme's beneficiaries have maintained R&D contact after the funding ended;
- training of human resources for the aviation industry due to the participation of universities, which then involved students and doctoral students in the research work.

Thus, INNOLOT, despite the incomplete uptake of funds, has fulfilled its purpose – it has provided an impetus for the industry to invest in R&D and has enabled cooperation between industrial and scientific players. The project succeeded in creating an environment in which the Polish aviation industry would increase its competitiveness by investing in innovation and strengthening relationships. However, the above opinion did not convince NCBR to continue the programme.

The SMART Track (3) (and previously the Fast Track implemented under the POIR) is currently virtually the only open nationwide fund distribution mechanism available to large companies and consortia (by NCBR) and small and medium-sized enterprises (by PARP) as part of the implementation of the FENG.

The SMART Track supports activities aimed in particular at strengthening R&D capacity, implementing research-based innovation and increasing the competitiveness of companies[74]. All projects implemented under the SMART Track must fit into at least one National Intelligent Specialisation and the minimum funding level is PLN 1 million. The SMART Track's predecessor, the Fast Track, has been used by, among other things, Wytwórnia Sprzętu Komunikacyjnego "PZL-Świdnik" with a project to optimise the design and improve the parameters of the Sokół helicopter's carrier rotor blade. Read more about this in the case study *Infrastructure investment as an impetus for further development* on page 98.

71 This was the result of a change in the source of funding.

72 Any research and development work not carried out directly by the beneficiaries was done by commercially procuring it from research units or universities.

73 In the report of 2017, Summary of system projects implemented by NCBR under Measure 1.5 POIG.

74 Other areas that can attract funding under the SMART Track are the implementation of green and digital transformation of enterprises, internationalisation of products, protection of industrial property and enhancement of employee competencies.

C EU-funded regional programmes (4)

The European Union co-finances programmes in areas of key importance to the development of the region. These areas are defined in the individual regional programmes and established in the course of negotiations directly between the provincial authorities and the European Commission. According to the available programme documentation, the aviation industry will be able to apply for funding in Subcarpathia, Silesia and Mazovia. Horizontal programmes targeting specific industries can also be launched with EU funds.

D European programmes (5, 6 and 7)

Topics related to the support of R&D activities in the aviation industry have long been present in European Union programmes. The main objectives and development directions, as well as the paths to achieving them, have been developed by specialists in dedicated documents[75]. In order to achieve this, the European Commission, in consultation with the aviation industry, has set up dedicated institutional joint undertaking – organisations jointly funded by the Commission and the aviation industry to coordinate and manage the implementation of the strategy prepared.

At EU level, R&D support is doing slightly better than in Poland. The Union recognises the special, **i.e., above all long-term, nature of aviation research**, which is why the aforementioned partnerships have created dedicated tools to support the European aviation industry.

The first of these was the **Clean Sky** project, **which ran from 2008 to 2016**. It had a budget of EUR 1.6 billion, of which 50% of the budget was funded by the European Commission and the other 50% came from aviation stakeholders. In the next framework programme, the work undertaken was continued in the **Clean Sky 2** partnership, running from 2014 to 2022.

Its budget increased to EUR 4 billion, of which the European Commission provided EUR 1.755 billion and the private sector the remainder. The next round of aviation R&D funding is currently underway – the **Clean Aviation** partnership **(5) with a horizon of 2022-2027 and a budget of EUR 4.1 billion**.

75 European Aeronautics, *A Vision For 2020, Flightpath 2050 and the Strategic Research and Innovation Agenda.*

Case study

Infrastructure investment as an impetus for further development

Assembly of the AW 139 helicopter cabin at the Aerostructure Centre of Excellence in PZL-Świdnik.

TOPR helicopter

Company name:	**Wytwórnia Sprzętu Komunikacyjnego "PZL-Świdnik" S.A.**
Name of completed project:	Optimisation and improvement of the Sokół helicopter carrier rotor blade design using new composite materials and new manufacturing technology
Institution / programme under which funding was provided:	Fast Track / Smart Growth Operational Programme
Total project value / own financing / funding:	PLN 28 million / PLN 12 million / PLN 16 million
Project period:	2019-2023

The development of PZL Świdnik is closely linked to the opportunities offered by Polish and European funds. One of the big boosts related to the R&D area was a PLN 98 million project to modernise and expand the R&D infrastructure, thanks to which the Advanced Technology Laboratory, the Advanced Technology Department, the Design Department and the Ground Test and Measurement Laboratory were established or thoroughly modernised in 2015. The project was co-financed by European funds and aimed at enabling world-class R&D in Poland and increasing the company's participation in the European Research Area. As a result, the company is researching innovative material technologies and moulding methods for composite aerostructures, which are currently among the most advanced in their field.

Thanks to the fact that PZL Świdnik today has a modern infrastructure, it is possible to carry out advanced R&D projects, both civilian and for defence. Such projects include the design of a new carrier rotor blade for the Sokół helicopter, featuring a modern hybrid carrier structure, manufactured from modern materials and using advanced technology. These materials are prepregs – fabrics consisting of resin-reinforced fibres, moulded under high pressure.

The new blades will significantly improve the parameters of the Sokół helicopter (e.g., flight parameters such as speed, flight range, maximum take-off weight), as well as significantly prolonging the service life of the blades themselves on helicopters used in the civilian area and by the Polish Armed Forces. Once the project is completed, it is anticipated that the new lifting rotor blades will allow the modernisation of not only helicopters used in Poland, but also platforms of foreign users (e.g., from the Czech Republic, the Philippines or Algeria). Thus, the result of the project will increase the competitiveness of the Sokół helicopter itself and improve its position in the market.

Thanks to the initial 2015 investment, PZL Świdnik has acquired a base for advanced research that leads to real benefits: new competences, the development of technologies that meet customer requirements and an increasingly higher position in the owner's value chain. As a result, PZL Świdnik is now not only one of the three most important research centres in the Leonardo Helicopters group worldwide, where activities such as full-scale fatigue tests of the fuselage of the new tiltrotor AW609 rotorcraft are carried out, but also the Aerostructure Centre of Excellence for the entire group. However, the benefits of this project are not limited to PZL Świdnik or the owner, as the laboratories are made available to other entities, which encourages the expansion of R&D activities by SMEs.

The Polish single-engine light helicopter PZL SW-4 designed and manufactured at PZL-Świdnik is also the platform for the RUAS SW-4 Solo unmanned helicopter.

European work focused on aviation development is based on long-standing research agendas and from the outset has considered it very important to reduce emissions (CO_2 and NO_x) and noise and to improve the competitiveness of European industry. However, it is becoming apparent that the evolutionary approach to emissions reductions to date will not ensure that the EU's ambitious climate neutrality targets will be met[76]. Achieving them will require the development of breakthrough, even revolutionary technologies. Accordingly, the Clean Aviation research agenda currently underway is to develop three core areas of new technology:

- hybrid electric regional aircraft;
- ultra-efficient short- and long-range aircraft;
- hydrogen-powered aircraft.

The thematic areas of the Clean Sky and Clean Aviation calls for proposals were selected by submitting proposals from those willing to participate – which is why it is so important to participate from the earliest stages, even before the projects are formally established. Active involvement in the ongoing work may be crucial to building a long-term position in the aerospace sector, which also applies to the Polish aviation industry. In addition to involvement in the work carried out by the Clean Aviation partnership[77] consideration should be given to strengthening the participation of representatives of the Polish aviation industry in working groups and associations that influence the strategic directions and operational activities of the programme as a whole, and European aviation policy.

It is worth highlighting the fact that the basis for the successive Clean Sky or Clean Aviation programmes is a multi-annual strategy covering several financial design periods. This ensures that actions taken in subsequent funding periods are continuous and predictable. This allows for the rational development and materialisation of innovations on the way to implementation and, at the same time, makes it safe to plan participation in future editions of the programme.

The Clean Aviation Programme is not the only action of the European Commission in the field of aviation[78]. Other projects include the **SESAR (6)** JU (Join Undertaking) programme, implemented, like Clean Aviation, on the basis of an institutional partnership. While Clean Aviation is focused on the development of technology and design solutions related to aircraft production, the subsequent SESAR JU programmes focus on airport operations, network operations, air traffic services and support technologies. Work carried out under the programme **SESAR JU 3 (2021-2027)**, the current edition of the partnership, focuses on preparing aviation infrastructure for future growth, taking into account aspects such as safety, efficiency and minimising environmental impact. Innovative technologies and solutions can be the tools to achieve them, i.e., primarily automation and optimisation of traffic management, cyber security and virtualisation of infrastructure and air traffic.

76 One of the European pillars of climate policy is the European Green Deal, a policy document that aims to achieve a reduction in greenhouse gas emissions to zero by 2050.

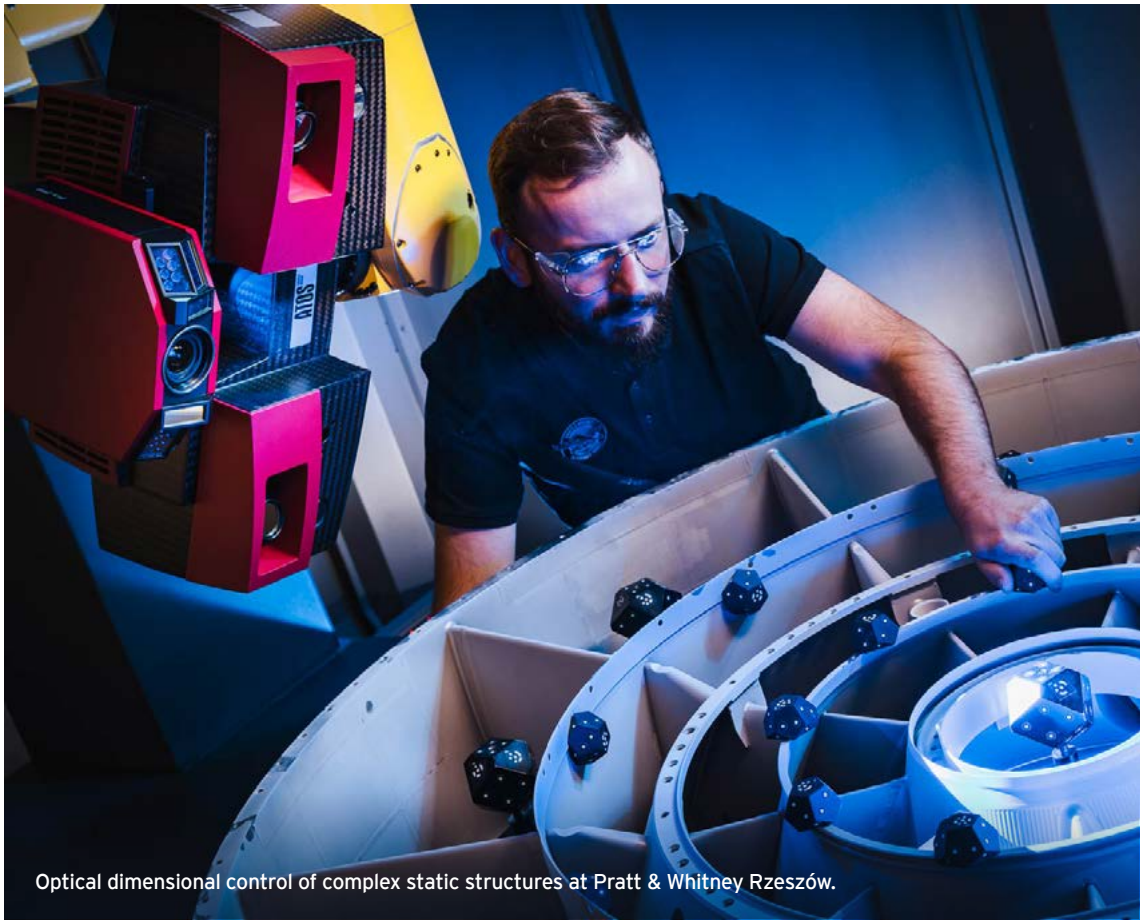
77 Łukasiewicz Research Network – Institute of Aviation is one of the programme members of Clean Aviation.

78 In addition, the European Union is working on the Single European Sky.

Another funding mechanism creating a potential source of support for the aviation industry is the European Defence Fund (7) – the European Defence Fund (EDF). This fund is part of the European Security and Defence Policy and the money from this source is used to finance R&D projects in military equipment and defence technology.

The aim of the EDF is to finance research and development projects that make it possible to strengthen the competitiveness and innovation of the European technology industry, but not strictly in the aerospace field, rather in the broader area of security and defence. The total budget of the programme for 2021-2027 is EUR 7.95 billion, of which EUR 2.65 billion is for research and EUR 5.30 billion for development.

EDF calls for proposals are open to industrial-scientific consortia consisting of at least three entities from three different Member States or associated countries. The programme currently favours the participation of small and medium-sized enterprises. In this programme, as in other EU programmes, engagement is already at an early stage and government support (in this case: the Ministry of Defence) would increase the likelihood of Polish participation. It is important to remember the role of the Ministry of Defence as a consultant in the application process for EDF funds, without which industry cannot participate in projects.



Optical dimensional control of complex static structures at Pratt & Whitney Rzeszów.

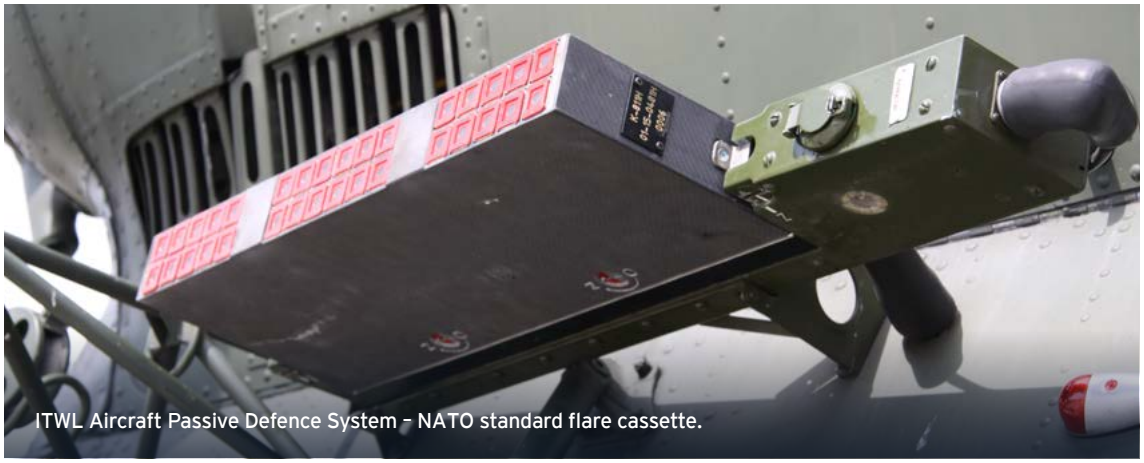
Key findings from the support of R&D projects in Poland

The aviation industry is characterized by strong consolidation at the global level. The place where new production, research or service facilities will be located largely depends on the availability of support available in specific locations around the world.

Subsidised projects carried out by Polish aviation companies contribute to the development of the industry in Poland and build the position of local companies in global value chains, as evidenced, for example, in the case study *Creation of an R&D centre for aircraft gears* (on page 104). This applies not only to the revenue aspect, but also to networking, i.e., cooperation between industry players. This is a particularly important aspect for SMEs, as it is the larger companies that draw the smaller ones into their value chains – not the other way around. Funding also increases the chance of success, which is never guaranteed with R&D.

It is important that support mechanisms have an effective impact on the Polish aviation industry and, as a result, create lasting value for the Polish economy. However, it is worth emphasising that the support available to Polish aviation companies is not free of the following challenges.

LBĆ – Air Training Exercise (ITWL).



ITWL Aircraft Passive Defence System – NATO standard flare cassette.

1 Lack of consistency in funding and short investment horizon of programmes

Generating new and potentially disruptive solutions (e.g., electrification or hydrogenisation of aviation) requires many attempts, which do not always result in commercial success. The long development and market introduction cycles of new technologies very often extend beyond the periods for which support instruments are prepared. Typically long-term EU budgets (seven years) do not allow the results of breakthroughs to be commercialised during a single programming period, which is why programmes such as Clean Aviation have their continuation in subsequent multi-annual budgets[79]. It is worth emphasising that these activities are based on long-term strategies jointly developed by the European Commission and public sector representatives[80]. In the current structure of funds available to Polish companies for research and development, it is rather the European programmes that offer the possibility of long-term funding, while national programmes have too short an investment horizon or place too much emphasis on a short timeframe for the implementation of project results. A characteristic feature of national support programmes is the lack of action based on clear directions for technology development defined by research strategies prepared through dialogue between government and industry.

2 Insufficient support for breakthrough research projects with low TRL Technology Readiness Levels

Securing adequate funding from the early stages of technology development is quite a challenge for the Polish aviation industry. Currently, the only funds available to develop innovative projects at the early stages of research (low TRLs) are national funds at the disposal of the Minister of Science and Higher Education. If the Polish aviation industry is to produce its own innovative solutions, support is needed right from the idea generation and concept formulation stage. This challenge cannot be circumvented in any other way.

79 With an emphasis on demonstrating solutions during the programme period, with commercialisation anticipated at a later date.

80 European Aeronautics, A Vision For 2020, Flightpath 2050, or Strategic Research and Innovation Agenda – Clean Aviation.

Case study

Creation of an R&D centre for aircraft gears

Safran Transmission Systems Poland plant in Sędziszów Małopolski.

Safran Transmission Systems Poland

Company name:	**Safran Transmission Systems Poland Sp. z o.o.**
Name of completed project:	Creation of an R&D centre for aircraft gears
Institution / programme under which funding was provided:	Ministry of Funds and Regional Policy / POIR 2014-2020 (OJ 2.1)
Total project value / own financing / funding:	PLN 33 261 660 / PLN 19 740 660 / PLN 13 521 000
Project period:	2019-2023

Safran Transmission Systems Poland (STSP) has been building competence in gearbox development since 2008, when the project for the new BR725 family engine for Rolls-Royce began. In 2009, the Technology Department was established and Polish engineers from STSP became involved in the development of new gearbox manufacturing technologies together with the design office in France.

In 2013, an initiative to establish its own R&D Centre in the area of structures in Sędziszów Małopolski first appeared, but the corporation needed final confirmation of the engineering skills in the company before making a decision. The impetus was the positive outcome of the Advanced Manufacturing Techniques for Aircraft Gear – INNOGEAR project in the INNOLOT programme. The project's success was only possible thanks to the high level of skills demonstrated by STSP's employees in Poland and served as proof to the entire Safran Group that the Sędziszów Małopolski-based company was ready to establish its own Research and Development Department and initiate R&D activities.

The establishment of the in-house R&D centre was made possible thanks to funding from the Ministry of Funds and Regional Policy. The implementation of the project was delayed by the COVID-19 pandemic, but the start of the Centre's operations was already in 2021. The centre currently employs 27 people and the planned staffing level will be at least 40 R&D staff focused on modern propulsion technologies. It is currently divided into four teams: Production Support, Analysis, Design and Development. By locating the R&D department in Poland, it is possible to build up comprehensive local competence in engine technology more efficiently.

The good experience at STSP led another Safran Group company – aircraft engine company Safran Aircraft Engines – to decide to open another Research and Development Centre in Rzeszów, which took place in May 2023, and plans to eventually employ more than 250 R&D staff in the development of modern aircraft engines. The opening of a second R&D centre by global company Safran in Poland underlines the confidence in Polish engineers and the attractiveness of Poland as a destination for R&D activities.

Aircraft gears assembled at the Safran Transmission Systems Poland plant are designed for the Boeing 737 and Airbus A320 aircraft.

3 Insufficient quantity and value of dedicated tools for the aviation industry

With the exception of the INNOLOT programme, which was an attempt at a systemic, dedicated approach to subsidising R&D in the Polish aviation industry, the aforementioned programmes were aimed at all industries, and thus their rules did not take into account the needs of the aviation industry. In addition, financing institutions, through their evaluation criteria, focus on a quick return on investment, which is not always possible in the aviation industry, where development cycles are very long. The requirement to meet such expectations puts the industry at a loss, as with other innovative industries such as pharmaceuticals, automotive or space. Another challenge is the amount of funding available, which, for example in the case of the INNOTECH programme, could not exceed PLN 10 million, effectively excluding large R&D projects, the value of which often exceeds this amount several times over. Tools for the aviation industry must take into account the fact that high-potential technologies require very costly development (although they carry significant revenue potential). However, it is apparent that some programmes are slowly adapting to the high-capital nature of the aviation industry – the SMART Pathway, for example, raises the support limits to EUR 25 million and EUR 35 million.

The establishment of a modern Service Centre in Warsaw is a key element in strengthening the competences of the Polish industry.

4 Formula for launching EU programmes and partnerships

The largest Community-critical EU programmes are co-programmed by the European Commission and public sector representatives. The largest European companies in the industry, represented by sectoral associations, is decisive (the associations seek to support the industry locally rather than through the optics of global corporate networks of locally based companies). The largest share of funding therefore goes to the countries that represent their interests most effectively.

In order to increase the effectiveness of activities allowing for an increase in the participation and position of Polish aviation industry entities in European programmes, it is necessary to coordinate activities at several levels. On the one hand, it is necessary to increase the activity of Polish actors in associations and working groups at a Union level, and thus to participate in the shaping of programmes and their implementation. On the other hand, the strengthening of lobbying activities on the part of representatives of government agencies to increase the participation of Polish entities in European programmes.

6

Systemic support for the aviation industry

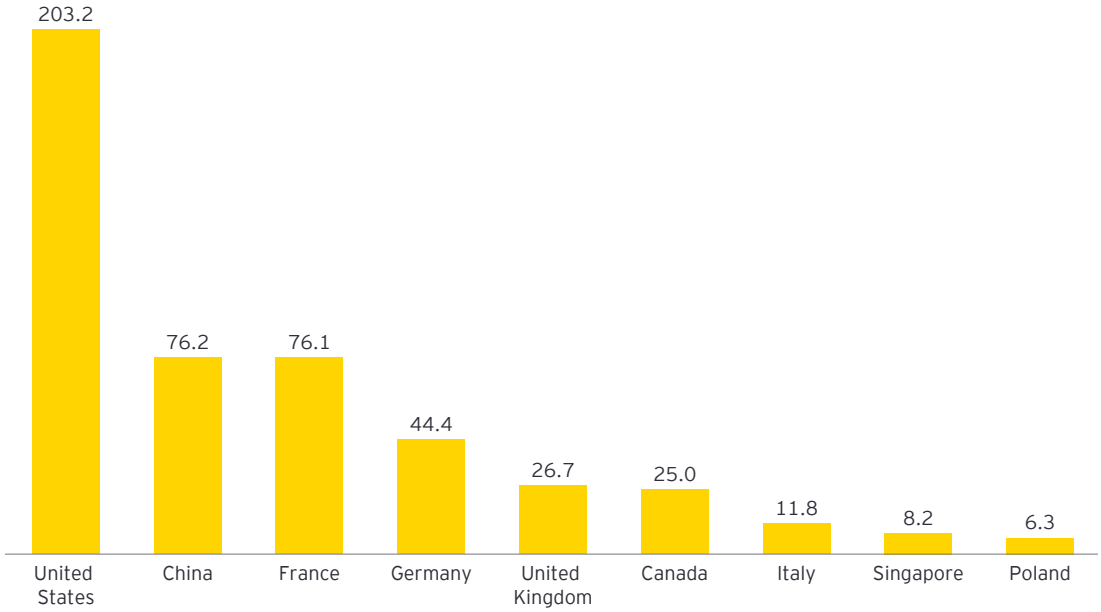
The Safran Transmission Systems Poland plant,
where aircraft gears are manufactured, employs more than 750 people.

The potential of the aviation industry and its key role has been recognised by many other European countries over the past two decades. Our European neighbours[81] have long been active in strengthening their international market position in the aviation industry. These activities are based on multidimensional support in terms of strategy, funding R&D projects, setting up projects for the industry and providing the foundations for future development in the form of human resources.

In terms of actively shaping and supporting industry development, the approach and mechanisms developed in the UK, France or Germany are of particular note.

Together, these best practices demonstrate the wide range of forms of industry support that can be offered by government.

Chart 14. World's largest aviation industries in 2022 (gross production in EUR billion)



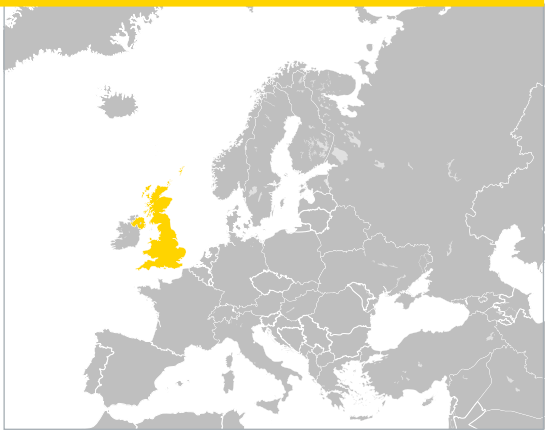
Source: Statista database

81 For example, France, Spain, Italy, Germany, Austria, the UK, Sweden, the Netherlands or Finland.

United Kingdom

The aviation industry plays an important role in the UK – a country with the world's fourth largest aviation revenue. The country is home to companies such as BAE Systems and Rolls-Royce, which are among the leading manufacturers of advanced aviation systems and jet engines. British companies are also influential in the development of aerospace technology, including unmanned aerial vehicles and other innovative solutions. The UK has gained and managed to maintain this position thanks, among other things, to government initiatives that focus on supporting the industry mainly by forming meaningful connections and collaborations between government, industry players and academic, research and education bodies.

Cooperation has been structured through the introduction of a joint development strategy for the sector. The Department for Business and Trade, the Department for Transport and the Department for Business, Energy and Industrial Strategy have together produced the Aerospace Sector Deal – a document outlining a growth strategy for aviation in the UK for 2018-2027. The main aim of the strategy is to maintain the competitiveness of the UK aviation industry, as well as to continue its sustainability and decarbonisation.



The key elements of the Aerospace Sector Deal include:

- **Stimulating innovation** – through joint government and industry investment, the government has secured GBP 125m for the Future Flight programme under the Industrial Strategy Fund. This programme is to fund the development of new projects ranging from aircraft, prototypes and demonstrators to aeronautical ground infrastructure.
- **SME-led R&D funding** – a decision was made to involve SMEs in R&D projects by making it easier for them to obtain funding.
- **Improving energy efficiency** – increasing the competitiveness of SMEs in terms of energy use by implementing the SME Energy Efficiency Scheme, which will facilitate retrofits and make funds available for new energy infrastructure for SMEs.
- **Education** – strengthening cooperation between the aviation industry and educational institutions to ensure a large pool of future human resources for the aerospace sector and increasing women's participation in the industry.

Industry Contracts such as the Aerospace Sector Deal are an ideal tool to develop the industry, as they allow for a single common direction for all players, allowing them to capitalise on industry strengths and deliver projects with maximum benefit to the economy and society. The existence of a long-term (i.e., approximately 8-10 years) strategy is beneficial from a long-term planning perspective, as it allows resources to be prepared and brings a sense of stability to the business.

A number of projects are underway as part of the current strategy, including:

Wing of Tomorrow

An Airbus project to develop new technologies and manufacturing processes to enable the construction of a next-generation composite wing and thereby help the company to lead the narrow-body market.

UltraFan

A Rolls-Royce project to develop a new low-emission yet more efficient engine.

AIRTECH

A project by a consortium comprising Williams Advanced Engineering, JPA Design and SWS Certifications, aiming to develop a lightweight seat for commercial flights, thereby reducing the weight of aircraft and thereby reducing emissions.

Aerospace Electric Propulsion Equipment, Controls & Machines

Safran Electric & Power UK project to develop electrical power systems with the intention of improving energy consumption in future aircraft.

In parallel to the implementation of the strategy and ambitious aviation projects, cooperation between educational bodies and industry players is taking place. These activities are supported by the Aerospace Research Consortium (ARC), which was established thanks to the Aerospace Institute of Technology, acts as a facilitator of cooperation between companies and research institutions and offers a platform for domestic and foreign entities to access national research centres linked to the industry. This is not the only initiative supporting workforce development in the UK – the Apprenticeship Institute is working with industry to develop the future educational standards needed by the aviation industry. This action aims to ensure that there is a well-qualified workforce ready to work in the industry and enable its further development. Additionally, despite leaving the European Union, from 1 January 2024 the UK will be able to participate in Horizon Europe on an equal footing with other EU member states, along with access to funding. This is made possible by the trade and cooperation agreement between the European Union and the UK.

Germany

Good positioning in the supply chain undoubtedly has the positive impact on the industry – this is the motto of the German aviation industry. German entities specialise in the production of aerospace components such as engines and structures. The industry as a whole is one of the largest in the world in terms of revenue. And this is in spite of the absence of a German market giant such as Airbus (France) or Boeing (USA), but 'only' thanks to the presence of the above companies in the supply chains. German industry is also supported by the ME purchasing policy, which ensures that German companies are included in the production process of the equipment purchased. The purchase of 35 F-35A fighter jets by the Bundeswehr is no different, with the negotiated establishment of a fuselage factory in Germany[82] for this aircraft, initially for its own use and later for export. Already in its initial phase, the investment will provide 450 jobs.

Across Poland's western border, the potential of the aviation industry was recognised shortly after the country's reunification and its development has been continuously supported since 1995. Germany has an aviation industry-wide strategy, similar to the Aerospace Sector Deal in the UK, known as the Luftfahrtstrategie der Bundesregierung (Federal Government Aviation Strategy). The document describes the current state of the German aviation industry, assesses its capabilities and potential, and focuses on methods the government can use to stimulate the industry's development, especially in the field of research and development. The strategy identifies two main objectives for the German aviation sector:

- creating an air transport system that meets high standards of efficiency, safety, sustainability and competitiveness as an integral part of the global transport system;
- establishing a framework for a competitive German aviation industry, enabling it to maintain and further develop its position in international competition through advanced technologies and innovative products.

The strategy also emphasises Germany's importance in the global market as a key partner for OEMs and seeks to strengthen cooperation with them, while expanding and enhancing the competence of German companies. There is also a strong emphasis on the goals set out in the European Flightpath 2050 strategy. The development of the aviation industry is overseen by the Bundesministerium für Wirtschaft und Energie (German Ministry of Economics and Technology). The ministry's main objectives for the development of the aviation industry are to increase competitiveness, reduce emissions and noise pollution.

82 https://defence24.pl/przemysl/niemcy-rusza-budowa-fabryki-dla-f-35 (access: 10 February 2024).

Support for the industry focuses on subsidising R&D projects whose themes revolve around industry objectives. A leading initiative of the ministry is the Luftfahrtforschungsprogram (LuFo), the Federal Aeronautical Research Programme, which has been continuously providing direction and funding for R&D projects to the private sector for almost 30 years. During this time, the LuFo was relaunched five times, starting with LuFo I and ending with LuFo VI, which is still in operation today.

The programme offers different levels of funding depending on the size and type of applicant – large companies and SMEs can expect to cover up to 50% and 65% of eligible costs respectively, while research institutions and universities can expect to cover up to 100% of eligible costs.

Research and technology projects are funded under the following lines within LuFo:

Green Flight

This line is designed for green aviation initiatives and university research projects. The programme is dedicated to a range of subject areas, from air transport to commercial flying.

Small and medium-sized enterprises

SMEs can apply to programmes that fund even niche R&D projects, in the case of a consortium of SMEs with an academic institution, the SME is to lead the consortium.

Technology

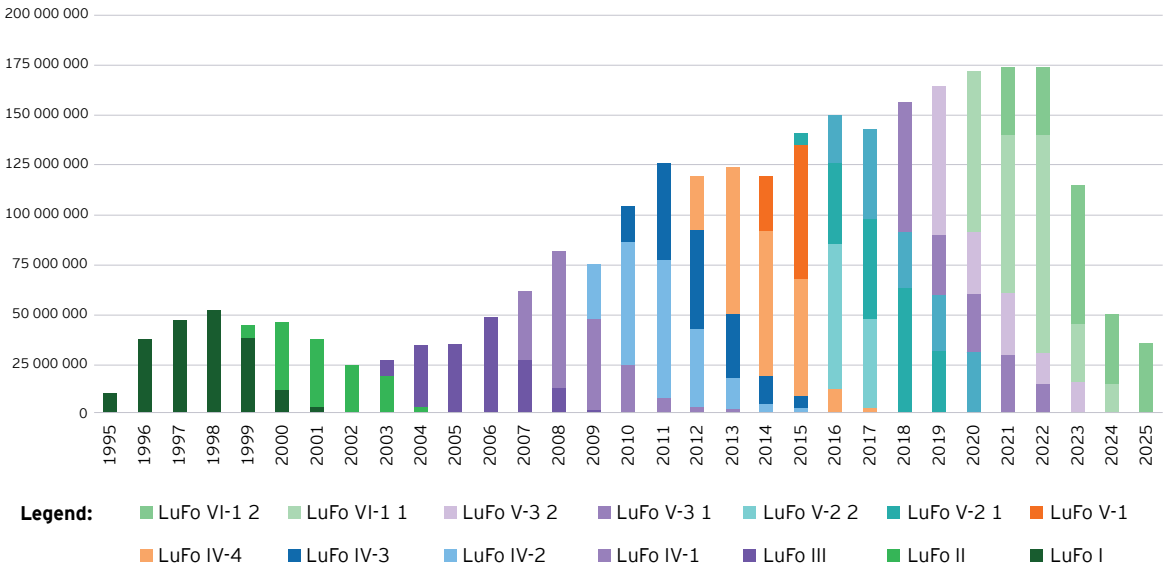
Funds from this line can be used for many environmentally and passenger-friendly projects. Quiet and efficient engines, innovative aircraft structures or flight physics are just some examples of the topics covered in this line.

Demonstration

The projects that belong to this line are based on creating a prototype of a given technology and testing its usefulness in practice. This applies to the implementation of both prototypes in existing systems and supporting subsystems.

In order to respond to the rising costs of R&D projects in the aviation industry, the budget allocated to the programmes is gradually increasing, but the most important aspect by far is its continuity, allowing players in the industry to invest in innovation without fear of having their source of funding cut off. The effectiveness of the LuFo is confirmed by the fact that, during its operation, the total revenue of the German aviation industry quadrupled between 1995 and 2022 (EUR 7.9 billion in 1995, EUR 39 billion in 2022). This growth has been possible despite the fact that no German OEM company is a global powerhouse.

Chart 15. Budget for LuFo and LuFo programmes (EUR)



Source: LuFo Programme's website

The second support programme for German aviation companies is the Luftfahrzeugausrüsterprogram, the Aerospace Equipment Manufacturers' Programme. This programme is designed for projects with TRL levels 7-9. Financial assistance under this programme is based on the provision of loans to companies in the aviation industry – 37.5% of the loans are unconditionally repayable and interest is charged at market rates, the remaining 62.5% are interest-bearing but conditionally repayable.

The funds raised from the programme are to be used to develop innovative technologies for aircraft, engines and MRO services to contribute to an efficient and environmentally friendly air transport system for the future. The total budget of the programme for the period 2009-2023 is EUR 1.2 billion.

Instead of building its own OEM company, Germany relied on a strong presence in Airbus' supply chains, and this allowed it to become the company's main partner worldwide.

France

France is a key player in the global aviation industry thanks to the activities of Airbus, Safran, Dassault Aviation and Latecoere – global leaders in aviation and aerospace. France aims to build a world-leading aviation industry and maintain its current competitive advantages. To this end, in 2013 the French Ministry of the Economy published a strategy for the aviation industry called the New French Industry. The document sets the objectives and direction of French industry as a whole and is based on the development of new innovative technologies and the creation of the industry of the future, the strengthening of European and international cooperation, and the functioning of companies in the modern French economy.

Within these strategies, seven core thematic areas have been identified on which the French industry should focus:

- digital technology, virtualisation and the Internet of Things;
- human factors in production facilities, robotics and augmented reality;
- incremental manufacturing (3D printing);
- monitoring and controlling production;
- composites, new materials and assembly;
- product automation and robotics;
- energy efficiency.

All of the aforementioned thematic areas are based on innovative technologies, modern materials or production technologies, which shows that the Ministry of Economy wants the industry to focus on innovation and competitiveness when it comes to technological development.

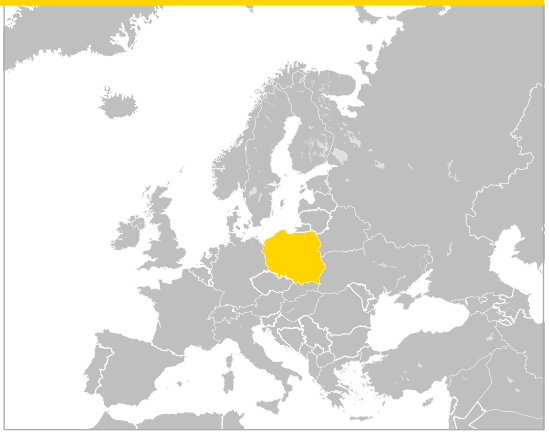
In 2015, another document entitled The New Face of French Industry was issued, based on the New French Industry, but this time it was a development strategy issued by the French government. The document clarifies the findings of its predecessor and, **in terms of aviation, focuses on electric and modern aircraft and high-lift aircraft**. It also stresses that the industry should focus on the development of innovative prototypes such as the E-Fan, an all-electric two-seat trainer aircraft, the A30X, successor to the A320, the Falcon 5X, successor to the Falcon 2000, and the X4 (now H160) and X6 helicopters, successors to the Dauphin and Super Puma. Work on a significant proportion of these has already been successfully completed, and government support has been an important factor in the process.

The aviation industry in France has access to a range of funding sources and new programmes are announced regularly. In 2020, in the wake of the COVID-19 pandemic, the French government announced an aid package for companies in the aviation industry, totalling EUR 15 billion. Out of this amount, 500 million was to go towards the development of a climate-neutral aircraft by 2035 and another 500 million to support SMEs in the industry. The support for the industry did not stop there – a EUR 8.5 billion allocation for the development of the green aircraft was announced in June 2023, with funds to be distributed by 2027.

Poland

The Polish aviation industry is developing thanks to its own investments and national and EU programmes. However, the industry cannot be said to be following a clearly defined national strategy.

The tool closest to Poland's industrial strategy was the Polish Industrial Policy (PPP) of June 2021, which identified 15 key industries and proposed development opportunities for each of them. Poland's Industrial Policy has analysed the Polish aviation industry and defined both its needs and the tools that the state can use to meet them. Key PPP recommendations concerned financial support and tax breaks for R&D projects, as well as the need to develop industry-specific education and dual education, i.e., based on cooperation between schools and businesses. **The policy also included the use of Industry Contracts tools** to develop coherent development strategies for the entire industry.



Despite its merits, however, the PPP has never been fully implemented and is therefore not a formally binding document. Currently, an alternative strategy at the central level is the Productivity Strategy 2030 of July 2022, which mentions the importance of the aviation industry and the industry contract mechanism, but does not set out any specific measures to comprehensively plan the development of the aviation industry to the economy.

Conclusions for Poland

European countries are showing a significant commitment to the development of the aviation industry by offering multifaceted support to the local industry. While the examples of France, Germany and the UK cited above are not exhaustive of all aviation-related programmes and initiatives in the above countries, they provide a glimpse of the **government's proactive approach** to supporting industry development. The examples presented also provide a sound basis for the development of a Polish model for supporting industrial development, adapted to local needs and market conditions.

A joint industry development strategy, supported by the Industry Contract, is one of the key aspects of successful cooperation between government and industry, as **it is based on dialogue, jointly set goals and directions for future development, taking into account the country's strategic objectives and the industry's real capabilities**. The UK Aerospace Sector Deal is an example of an Industry Contract that sets the industry not only the goals, but also the path, and provides the means to achieve them. Such transparency and the assurance of long-term cooperation from the government create excellent conditions for further development of the chosen industry.

Many countries are focusing on **aviation development, relying on technological innovations** that are born out of an integrated approach to research and development, providing support at early stages of Technology Readiness Levels (TRLs). Such initiatives include, among other things, funding research and development projects and building relationships between the industry and education and research bodies. The best example of a consistent approach to R&D capacity building is the LuFo programme, which has provided continuous funding for aerospace research projects since 1995 and has made a significant contribution to the development of the industry within Germany. An example that illustrates the transition from R&D to product commercialisation through the development of specific technologies and competences is the D328eco aircraft project, which involves the modification of a regional Dornier 328 turboprop aircraft into a flying test bed for zero-emission hydrogen-electric propulsion, funded by the German government. With this approach, Germany is approaching the point at which it will enter the market with its own product.

In France, the aviation industry is seen as one of the most important branches of the economy, thus the French government generously and continuously invests in its development. This allows industry players to enjoy not only the national strategy and associated funding programmes, but also additional development opportunities under programmes promoted by the government, such as Falcon 5X.

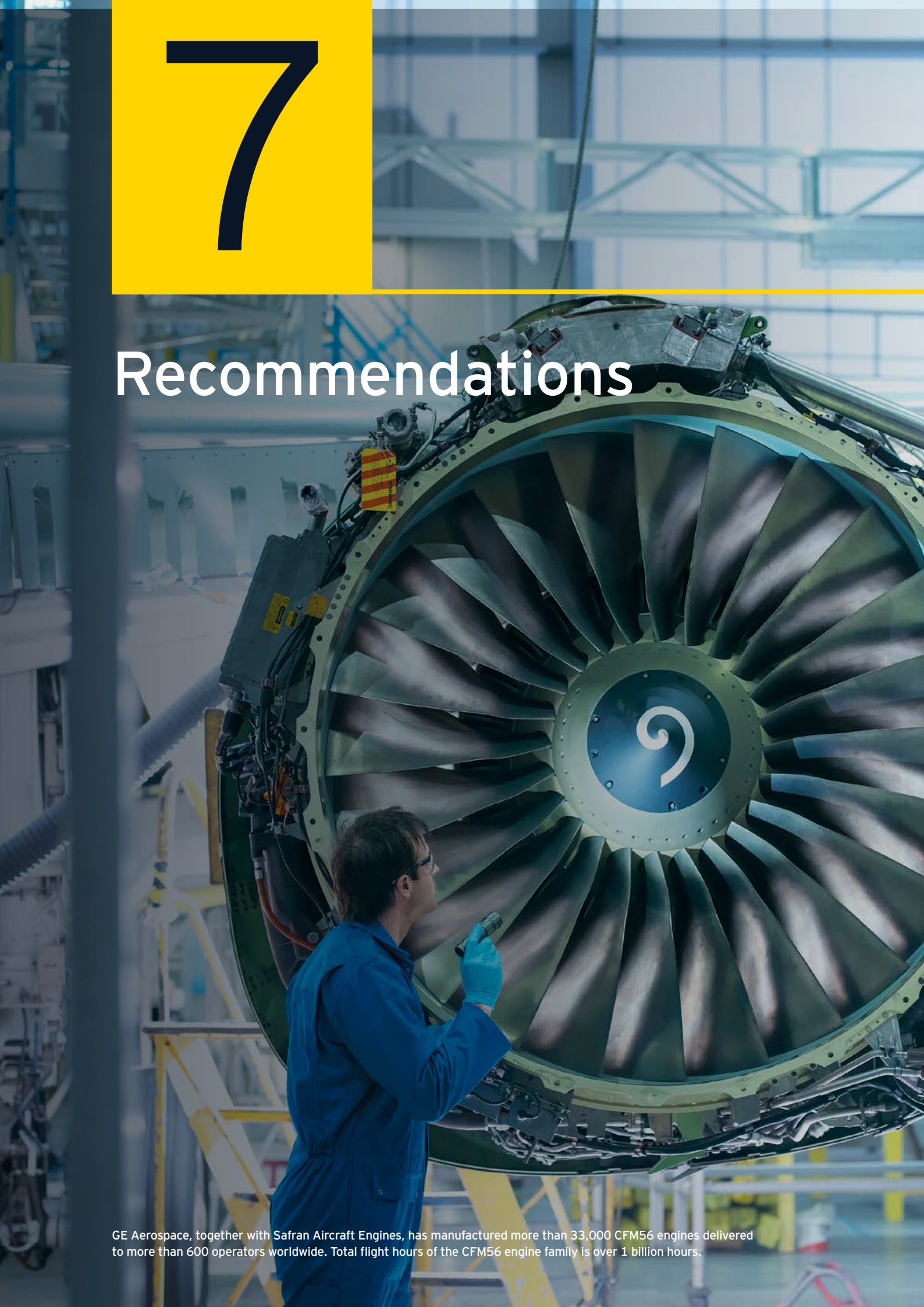
The aforementioned tools and initiatives contribute to the growth of the industry, but **the availability of a properly trained workforce** is still necessary for full success. Human resources are the backbone of the industry's development, and due to the lengthy R&D processes, the demands and rigour of safety, endurance and other tests, the need for experts – with both university and technical education – is greater than in other similar industries. To secure the workforce for the future, collaborations between private, public and educational bodies have been established in the UK. This is an advantageous solution, as the cooperation results not only in closer relations between the units, but also in the possibility of early recruitment and the development of specialised courses of study and scientific staff at universities, which together respond directly to the needs of companies from within industry.

It should be emphasised that each local market has unique needs, so it is crucial to **tailor support initiatives to the strategy and specific characteristics of the region**. Best practices from neighbouring countries are thus only a guide in the **creation of one's own aviation development strategy**, which should be based primarily on currently existing national competences and strategic objectives.

ITWL – Recording the initial state of the composite structure of the M-346 aircraft by thermography.

7

Recommendations



GE Aerospace, together with Safran Aircraft Engines, has manufactured more than 33,000 CFM56 engines delivered to more than 600 operators worldwide. Total flight hours of the CFM56 engine family is over 1 billion hours.

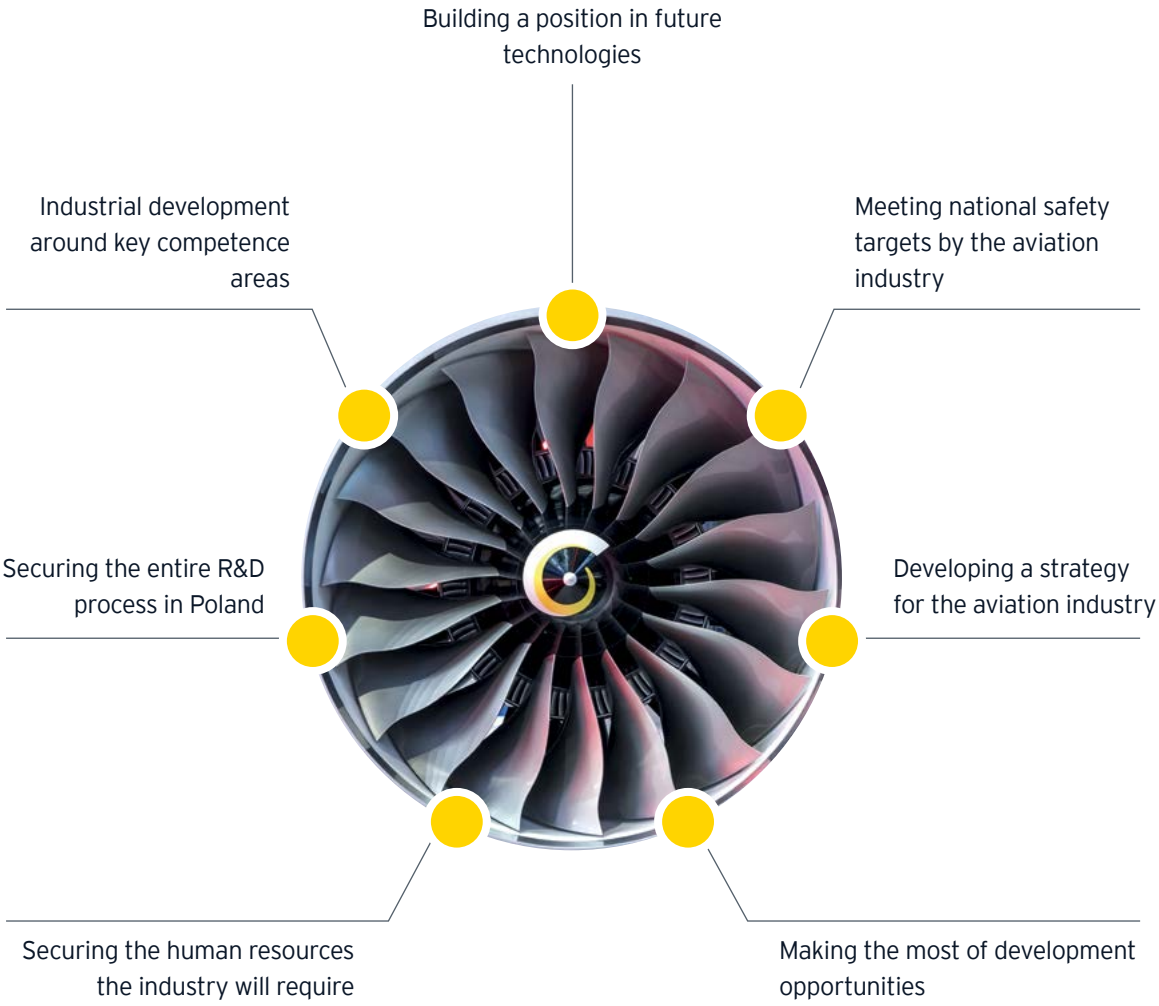
Polish aviation operators are no longer just suppliers of parts or centres of cheap labour, but create globally innovative and specialised research and development centres. They are a trusted service partner and a state-of-the-art production centre. However, there is a lack of concrete vision and targeted support for the industry, especially given the current challenges facing the aviation industry. Steps should be taken today to prepare it for the future. Otherwise, industry opportunities may remain untapped and threats may materialise, preventing the industry from realising its full potential.

The Polish aviation industry has the competence to advance in global value chains and the potential to join the biggest players in Europe – it just needs to be enabled to do so.

Recommendations

The conditions for development will not emerge on their own – they must be actively created and shaped. In view of the new challenges, above all the fourth industrial revolution and the technological changes in propulsion systems, it is necessary to follow a plan that safeguards the industry's long-term interests and supports its progress toward a desired position.

As part of this report, we present seven key recommendations for the Polish aviation industry to take it to the next level:



Recommendation 1

Industrial development around key competence areas

Poland already has certain specialisations in the area of the aviation industry including propulsion technologies (at both the R&D and production stages), materials technologies (component development and production) and maintenance and modernisation services (for both whole aircraft and engines).

In order for the industry to grow at an above-average rate, it is necessary to choose a path that makes this possible. It would therefore be beneficial for Polish industry **to specialise, i.e., to build up knowledge and expertise** in a few non-coincidentally selected areas. A number of benefits can be achieved through specialisation:

- a definitive shift from building a market advantage based on price to a position as a default, competent partner;
- building the image of Poland as a competence centre in selected areas;
- attracting business and entering more deeply into the companies' value chains, including their most desirable elements;
- building end-to-end competence and making the industry independent in selected areas;
- increased competitiveness through the adaptation of state-of-the-art technologies, in particular production infrastructure.

Specialisation allows for increasingly higher positions in the value chain (the last, highest position being OEM). In contrast to the proposals for specialisation in the Polish aviation industry, there are calls for the construction of our own national aircraft, which will have the potential for commercial success in Europe or worldwide. This is potentially possible, but firstly, hugely expensive (very high entry threshold, especially related to the organisation of production, sales and product service) and secondly, unnecessary (there are alternative and more efficient development paths). The specialisation approach, **by comparison, offers the advantage of developing expertise in areas that, collectively, encompass the entirety—or nearly the entirety—of an aircraft's components**. It is a more sustainable path and one that does not require a significant amount of investment at once.

It does, **however**, require **consistency in achieving the objectives set**.

At the same time, with all the benefits of specialisation, it is important to remember to **maintain – or develop – the competitiveness of existing resources**. Continuous investment in existing infrastructure is essential to ensure it remains modern and efficient. For more on the importance and benefits of modern infrastructure, see the case study *Infrastructure investment as an impetus for further development* on page 98.

The M28 05 multirole short take-off and landing aircraft is manufactured at Polskie Zakłady Lotnicze in Mielec, one of the largest OEMs in Poland.

Recommendation 2

Building a position in future technologies

Technological changes that will completely transform aviation have already begun. **The technological leap will occur with or without Poland's involvement.** The extent to which we benefit from it depends on when we join research into new technologies and innovative, modern production. Due to the higher risk, **establishing a position in new business segments is much easier in the early (low TRL) than in the later stages of development**. Technologies with great potential that are already approaching implementation are protected by their owners, so it makes sense to bet on building a position in future technologies from the early stages of their development.

To profit from the coming wave of innovation, you have to become part of it or help direct it. The key tools that make this possible are R&D programmes in promising areas, both nationally and internationally – but free from the challenges mentioned in Chapter 5. The implementation of ambitious projects can additionally contribute to industrial networking through the creation of new linkages and partnerships (as illustrated by the case study *Industrial networking through an innovative high-pressure turbine cooling technology development* on page 72).

Recommendation 3

Meeting national safety targets by the aviation industry

The aviation industry is one of the areas of the economy of strategic importance, primarily due to its **function in building national security. Linking the industry development programme to national autonomy objectives** in the security area would allow for **an increased ability to conduct military operations independently** and safeguard the state's interest where possible.

The procurement policy of the Ministry of Defence is closely linked to the achievement of the goals of the domestic aviation industry. It should be noted that Poland is not the manufacturer or owner of the intellectual property rights to the vast majority of aircraft in the Polish Air Force's inventory. Consequently, **developing independent capabilities, in particular key service and maintenance capabilities for military operations, depends on international agreements** made when acquiring aircrafts, as illustrated, among other things, in the case study *The role of military equipment procurement in building industry capabilities* (on page 128). This means that certain capacities can only be acquired at the time of purchasing a particular type of aircraft when the buyer holds a strong negotiating position. After that, the chance of getting them decreases. An important aspect is the presence of a number of ME manufacturers on the Polish market. This presence can be used in ongoing negotiations, involving their competence to continuously improve the level of service safety and combat readiness of the equipment being acquired.

On the one hand, the current perception of offsets and knowledge and technology transfer (TOKAT) as a cost may originate from unfortunate past experiences (not necessarily from the aviation domain). On the other hand, these mechanisms can play a critical role in meeting national security objectives—objectives that have never been more crucial than during times of war across Poland's eastern border.

Selecting a competent partner and the right capabilities to acquire through offset/TOKAT has the potential to stimulate the economy and further strengthen Polish industry.

In this connection, it is worth examining **the more frequent inclusion of offset mechanisms and TOKAT in the policy of ME acquisition**. This would lead to a strengthening of the aviation industry – first and foremost the direct beneficiaries of TOKAT or offset commitments, but also the business partners building their value chain. The key here is to select the beneficiary that will bring the greatest benefit to the economy as a whole, regardless of its ownership structure and origin of capital.

An investment in the future such as Offset or TOKAT would not only create new jobs, but would also contribute to **building the foundations of strategic autonomy** in key areas. Later on, experience shows that the acquired competences could naturally expand, increasing the positive impact on the economy and the role of the entity in question (the offset beneficiary company or TOKAT) in global value chains. A significant part of the Polish aviation industry is active in the military aviation sector, so it is possible to further expand its role in this market segment. The acquisition of military aviation equipment may be the only opportunity to expand some capabilities in this segment.

Recommendation 4

Securing the entire R&D process in Poland

Polish industry must operate under conditions that enable the entire product development process to be carried out within the country. Innovations that have a chance of gaining a good market position in the world need the right business environment, i.e., at least a stable support system and mechanisms to facilitate investments (e.g., access to human resources, necessary technological facilities and a fair system for assessing project performance).

At the Environmental Test Laboratory of the Łukasiewicz Research Network – Institute of Aviation, thanks to the thermal-vacuum chamber (TVAC), among other things, it is possible to carry out tests on aircraft on-board system components under near-real conditions.

Case study

The role of military equipment procurement in building industry capabilities

PZL-130 Orlik training aircraft.

Company name:	**Airbus Poland S.A.**
Name of completed project:	Establishment of a service centre for C-295M aircraft in Poland
Institution / programme under which funding was provided:	Financing under the offset agreement
Total project value / own financing / funding:	Confidential information (contract value of USD 211.5 million)
Project period:	2001-2011

In 2001, the Ministry of Defence decided to purchase eight C-295M transport aircraft. At the same time, a G2B offset agreement was concluded, under which EADS-CASA purchased 77% of the shares of PZL Warszawa Okęcie (from 2018 Airbus Poland S.A.). PZL Warszawa Okęcie was appointed to provide independent maintenance of the C-295M fleet in Poland, which currently numbers 16 aircraft. The implementation of the offset agreement, i.e., PZL Warszawa Okęcie reaching full capacity, was planned and executed by 2011.

The signing of the offset agreement has led to a strengthening of the competences of Polish industry. Prior to the opening of a dedicated service centre for the C-295M aircraft in Warsaw in 2011, Polish engineers and mechanics acquired the knowledge and expertise necessary to service this type of aircraft at the Spanish Airbus plant responsible for the production and maintenance of the C-295. Thanks to this, Airbus Poland's key customer, the Polish Air Force, which has the largest fleet of C-295s in Europe, received a guarantee that the service of the acquired aircraft would be provided at the highest level. This is also confirmed by Airbus Poland's certification, including the AS9110 certificate awarded for meeting the highest quality standards in the aviation industry.

The Warsaw service centre provides a full range of maintenance services for the C-295M aircraft and the domestically produced PZL-130 Orlik aircraft, and is constantly expanding its competence in terms of its ability to carry out modernisation work on these aircraft. As a result, the company's Design Office was awarded MDOA certification, confirming its ability to design, make structural changes and develop repairs with configuration control.

Airbus Poland primarily services aircraft owned by a Polish user, but the Warsaw MRO centre is also used by foreign customers. Interest in the service centre's offerings has led to an increase in the number of aircraft maintenance bays – from the original two bays for heavy maintenance there are now five permanently in operation, with space for an additional two aircraft held in reserve. Simultaneously, Airbus Poland has developed the Aviation Production Division and the Electrical Harness Production Division, which supply structures and aircraft harnesses for the entire Airbus Group.

Competence building is not the only benefit of concluding an offset agreement. A very important aspect is securing the ability to self-service and maintain C-295M military aircraft in Poland without the involvement of third countries. This is a fundamental aspect that strengthens national security, particularly due to the nature of the tasks that transport aircraft are responsible for, namely logistics.

The signing of the offset agreement made it possible to start production of C-295 aircraft flight structures.

The aim of research is not just to acquire knowledge, but **to later commercialise that knowledge**, providing real revenue. However, the two areas of work are closely interlinked, so both low and high TRL levels require holistic support for research providers. The recommendation for Polish industry, therefore, is to **create the conditions in which a product or technology has the opportunity to complete its full development path in Poland**. Expected benefits include:

- increasing the chance of a Polish product that will be widely implemented worldwide;
- enabling companies to operate under stable financing conditions (similar to the conditions created by the LuFo programme mentioned on page 113);
- reducing the risk of an opportunity related to the development of an innovative product not being realised;
- reducing the risk of a product's potential being wasted due to a lack of support at the final stage of development.

Recommendation 5

Securing the human resources the industry will require

Already today, there is a noticeable **shortage of skilled employees** – both in white-collar jobs related to research and development, production design, etc., and in technological and specialised jobs related to production and service. **There is a lack of a systemic approach to training the human resources** that will be needed in the future

Securing human resources is another recommendation, without which the industry will not be able to grow. Higher education and directional secondary schools (vocational and technical schools) must be linked to the needs of the industry in a systemic way – the planned growth of the Polish aviation industry must be followed (or preceded) by an increase in educated, work-ready human resources. In addition to ensuring an increase in the number of aviation graduates, it is crucial to develop an appropriate educational structure and curriculum that follows the latest trends and challenges and provides the opportunity to produce the 'engineer of the future'. Also, a key role in this aspect is played by the development of academic staff through close cooperation with industry during joint research. It is important to remember that it is not machines or infrastructure that do the real work, but people – and they too need support and a development strategy.

Recommendation 6

Making the most of development opportunities

At the national level, making the most of development opportunities is all about **supporting technology and product development at every stage (increasingly higher TRLs) of the path to market (commercialisation) and building competences in key areas of the future**. Technological change is inevitable, so in order to prepare for it, it is necessary to create a research agenda that will best position the Polish aviation industry in the global market in the long term. This is especially true for low-carbon aviation solutions, which will gradually replace the traditional one.

At the international level, for Polish industry to **actively participate in the development of breakthrough products and technologies, the support of the Polish government is necessary already at the planning stage of these projects**. The Polish aviation industry has many competitive advantages, which should be promoted and emphasised at all working group meetings at the EU level. Strong national representation in programmes such as the Clean Aviation Partnership has the potential to support the position of Polish companies and contribute to their inclusion in programmes at an early stage of development.

Qualified staff are the foundation for the development of Safran's facilities in Poland.

Recommendation 7

Developing a strategy for the aviation industry

The creation of **a long-term industrial strategy** would help give direction to the development of the industry and specifically address key areas of competence. This would allow the **market** to be **consciously shaped** by introducing mechanisms for cooperation between actors, securing funding in key areas: new projects, human resources and maintaining competitiveness. Without a strategy, the Polish aviation industry will not pursue common goals, whether national or industrial, in a coordinated manner.

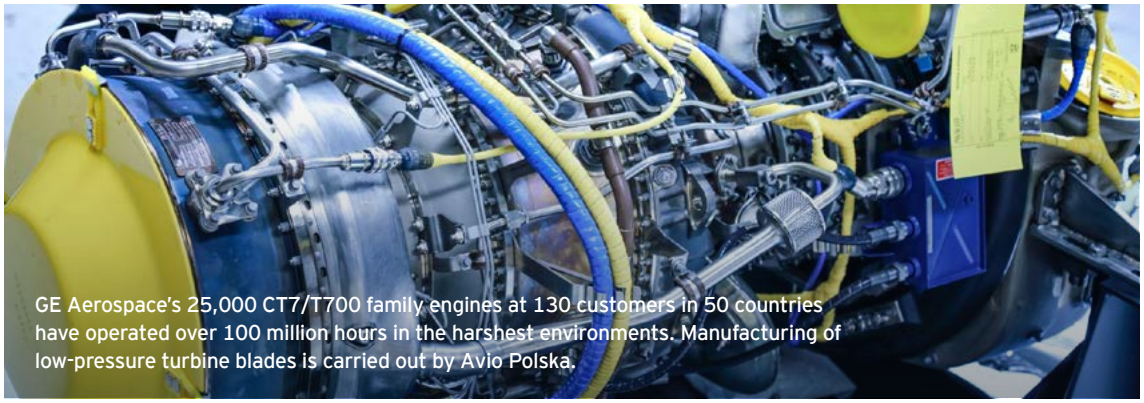
The Industry Contract, an agreement resulting from the dialogue between the government administration and industry representatives, may prove to be an instrument to help systematise the strategy of action and plan support mechanisms for the industry. The government side plays a key role here, as the predictability of support mechanisms and open dialogue with ministries is key to the implementation of an effective industrial policy.

The task of agreeing on a bespoke Contract covering the aviation industry development strategy that will serve the economy, industry and society can be entrusted to industry bodies or industry associations that represent a common interest and bring together key companies in the industry.

This solution would enable the strategy to be built by competent professionals with many years of experience, who have extensive industry knowledge and insight into real industry opportunities.

The strategy must be followed by appropriately matched support. Projects that fit into the aviation strategy require a bespoke approach, taking into account the long maturation time of technology in this industry and the risks associated with low TRL projects. Therefore, **alternative mechanisms should be considered to allow for longer-term and higher-risk projects**. It is important to remember that the ultimate goal of R&D projects is to develop one's own technology with the prospect of implementation and commercialisation of the product, so funding should promote the implementation of projects at any level of TRL readiness.

Simplifying the terms and conditions of funding and incorporating criteria to establish or enhance cooperation between actors are two more areas where changes would have a positive impact on the industry. An important aspect is the openness of intermediary institutions to work with industry in developing research plans and removing barriers to project implementation.



GE Aerospace's 25,000 CT7/T700 family engines at 130 customers in 50 countries have operated over 100 million hours in the harshest environments. Manufacturing of low-pressure turbine blades is carried out by Avio Polska.

Final conclusions

The above recommendations refer to **the desired state of the Polish industry, in which the industry becomes a centre of competence in the most promising areas** based on both the strengths of the industry and national targets for the aviation industry, with a simultaneous emphasis on the R&D process and securing the human resources necessary for the development of the industry.

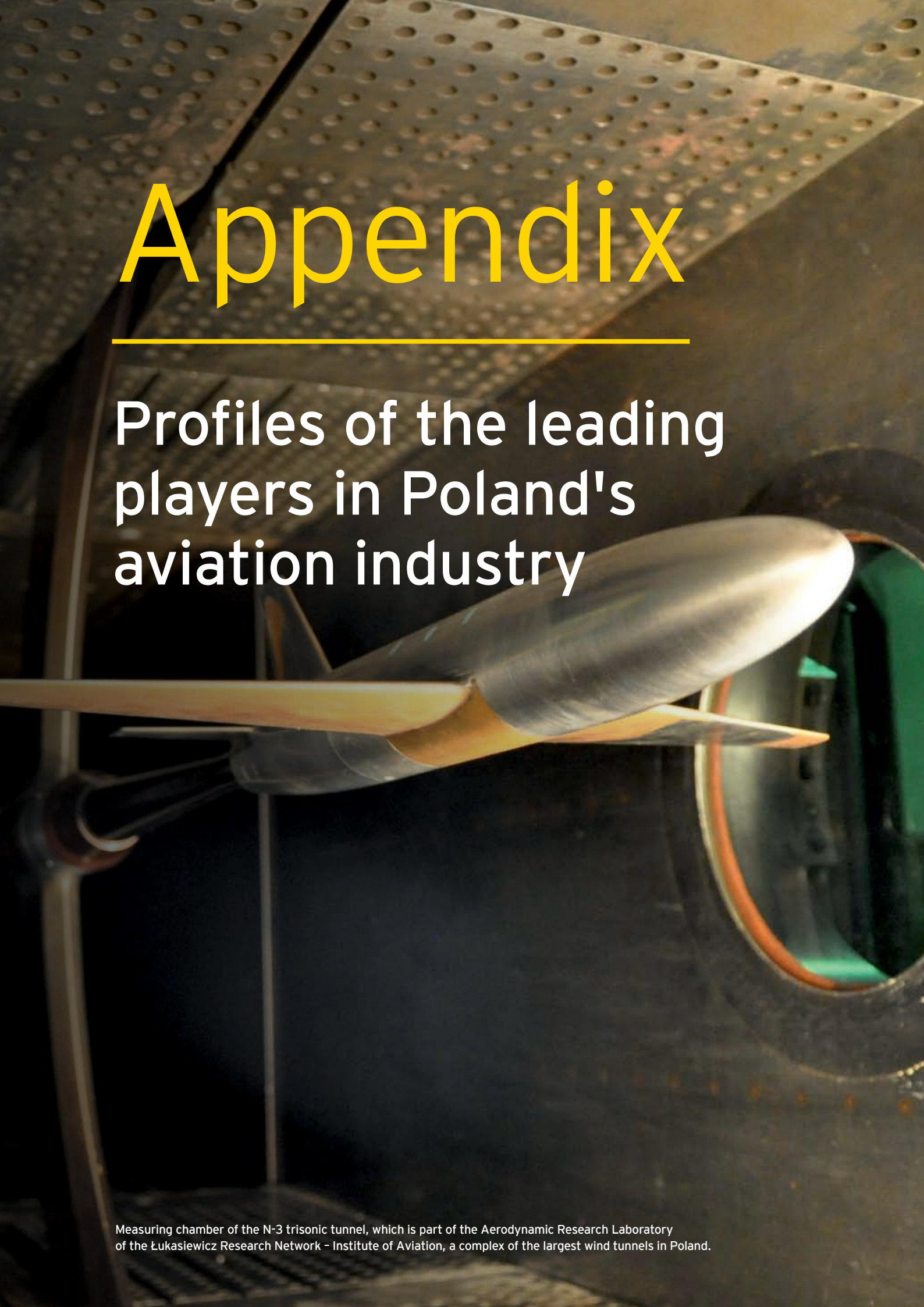
Polish industry possesses knowledge, technology, personnel and infrastructure, which together create enormous potential. What needs to be improved are the conditions for further growth so that it is ambitious and long-lasting. The measures proposed above comprise just some of the mechanisms that can lay the groundwork for increasing the competitiveness and visibility of the Polish aviation industry in Europe, riding the wave of innovation and achieving national industrial goals.

The Polish aviation industry is ready for the next step – to propose a tailor-made Industry Contract, including a strategy for the development of the industry that will serve the economy, industry and society. It is today that the opportunity for a better tomorrow must be seized.

Polish Air Force C-295 aircraft.

Appendix

Profiles of the leading players in Poland's aviation industry



Measuring chamber of the N-3 trisonic tunnel, which is part of the Aerodynamic Research Laboratory of the Łukasiewicz Research Network – Institute of Aviation, a complex of the largest wind tunnels in Poland.

Airbus Poland[83]

Primarily a manufacturer of aircraft structures and electrical harnesses for Airbus military and civil aircraft. In addition, the company is involved in the servicing and modernisation of the C-295M and PZL-130 Orlik aircraft for the Polish Air Force. The facility is distinguished by its AS9110 certification, demonstrating the highest quality of service. As an organisation, MDOA has the capability to design, make structural changes and develop all aircraft repairs with configuration control.

Avio Polska[84]

(trade name: Avio Aero)

Specialises in the design and development of aircraft engine components and modules, particularly low-pressure turbines and accessory and power gearboxes. The Bielsko-Biała plant manufactures guide vanes and rotor blades for low-pressure turbines for civil and military aircraft engines, including. GE90, GEnX, GE9X, CT7, PW308, CATALYST and LEAP. The company holds certifications such as AS9100 and NADCAP.

Boeing Poland[85]

Present in three Polish cities and carries out a broad portfolio of activities: in Warsaw, where the defence sales and engineering offices are located; in Gdańsk, where aviation navigation, software engineering and management solutions are provided; in Rzeszów, where the engineering office and aeronautical parts distribution centre are located. It is a partner of the Polish aviation industry, maintaining relationships with local communities, industry, airlines, the government and the Polish Armed Forces.

Consolidated Precision Products Poland[86]

(trade name: CPP Poland)

Has two precision foundries in Rzeszów, which supply parts for the world's largest aircraft engine manufacturers using state-of-the-art casting technologies: monocrystalline and directional solidification castings as well as grain-axis castings. The Rzeszów-based company holds certifications such as AS9100, NADCAP: HT, NDT and MTL.

Einsal East[87]

Has a business focused on the distribution of metal products for the aviation industry, such as flat bars, rods, plates and special profiles. In addition to this, the company is also able to fulfil individual orders tailored to specific customer requirements. The quality of Einsal East products is confirmed by ISO 9001 and AS 9120B certification.

GE Aerospace Poland[88]

Supports the entire lifecycle of aeroengines and products – from early-stage research, design and testing to late-stage maintenance and services. GEAP's scope of work includes commercial, military and aeroderivative engine programmes. GE Aerospace Poland holds a 75% stake in a Joint-Venture with Lufthansa Technik – an XEOS company in Środa Śląska, which is a state-of-the-art commercial engines maintenance facility (i.e. LEAP). Certifications held by the company include AS 9100 and ISO901.

83 Owned by Airbus SE.
84 Owned by GE S.R.L.
85 Owned by Boeing Netherlands B.V.
86 Owned by Consolidated Precision Products Luxembourg 2 S.A.R.L.
87 Owned by Walzwerke Einsal GMBH.
88 Owned by GE Aviation Netherlands B.V.

Goodrich Aerospace Poland[89]

Specialises in the production of advanced components and landing gear for civil aircraft, such as: Boeing 737, A320, A340, A350 and A380. The plant also produces military aircraft components, including F-16, F-18, F-35 or T7-A.

Hamilton Sundstrand Poland[90]

(trade name: Pratt & Whitney AeroPower Rzeszów)

A Centre of Excellence for the design and manufacture of auxiliary APUs for global aircraft manufacturers such as: Airbus, Airbus Military, Boeing, Embraer or COMAC, as well as an APU maintenance provider for airlines from around the world, such as: UNITED, Air France, ANA, JAL. Pratt & Whitney AeroPower Rzeszów also has a customer service department and an APU engine programme management department and is one of the few stations in Europe servicing the Fan Drive Gear System for Pratt & Whitney main engines.

Air Force Institute of Technology (ITWL)

The research institute supervised by the Minister of Defence. ITWL's work translates into scientific and research support for the operation of military aviation technology. The institute is also involved in the design, development of modern manufacturing technologies for military equipment, creation of prototype structures, including composite aerospace components and assemblies, and their implementation into production. Among other things, it is certified to ISO 9001:2015, AQAP 2210:2022 and is itself a certification body. The institute includes the engineering plastics manufacturer Nylonbor.

Linetech[91]

Focuses on the provision of MRO services. The unit in Katowice can handle up to four aircraft simultaneously. The plants can carry out the heaviest maintenance work, such as keel beam replacement, avionics modifications and the most complex technical checks on aircraft such as the A320 and B737. The company is certified under PL.145.072.

Lot Aircraft Maintenance Services[92]

Offers maintenance services for both narrow- and wide-body aircraft, such as the Boeing 737 CL/NG/MAX, 767 and 787, as well as Embraer regional aircraft, of which it is an authorised service centre. As part of its services, it serves numerous global operators, including PLL LOT. The company has its own training centre and project organisation, as well as extensive workshop facilities. The company operates under the approvals of numerous supervisors, such as EASA, FAA, CAA UK, among others.

Ls Technics[93]

The certified MRO organisation with 30 years of experience in medium-haul and regional aircraft maintenance, including Airbus A320, Boeing B737 and Embraer 170/190 family aircraft. It holds EASA Part-145 and Part-147 certificates. It carries out repairs, maintenance, inspections, tests, replacements and modifications to aircraft. It operates at eight airports in Poland: Katowice, Gdańsk, Warsaw, Kraków, Wrocław, Bydgoszcz, Poznań and Olsztyn.

89 Owned by Goodrich Limited.
90 Owned by RTX Corporation.
91 Owned by Avia Prime A.S.
92 Belongs to Polska Grupa Lotnicza S.A.
93 Belongs to Polska Grupa Lotnicza S.A.

MB Aerospace Rzeszów[94]

A manufacturer of engine housing equipment and support structures. It also has the capacity to produce key rotating components. The quality of the products created is confirmed by AS9100 and ISO 9001 certification.

MTU Aero Engines Polska[95]

Manufactures subassemblies for aircraft engines, such as blades and steering gear, seals, disks for Airbus A220/A320/A380 aircraft, and for LM6000 series gas turbines. The Tajęcin plant also manages external parts and accessories for V2500 engines. In addition to manufacturing, the company is also involved in the repair of aircraft engine parts and engineering and technology work. The company holds the necessary EASA approvals for the design, manufacture and servicing of aircraft engine components.

Polskie Zakłady Lotnicze[96]

(trade name: PZL Mielec)

Lockheed Martin's largest manufacturing facility outside the US. In addition to aircraft production, the company also provides after-sales services and conducts R&D work. The company's best-known products include the S-70i Black Hawk helicopter, the PZL M28 05 and PZL M28B Bryza aircraft, structures for Black Hawk helicopters and for the F-16 Block 70/72 programme. The company also holds numerous certificates, including: AQAP 2110/2310, AS 9100D, PART 21J, PART 21G, PART 145 and PART CAMO.

Pratt & Whitney Kalisz[97]

Focuses on three main areas of production: complex gears, compressor steering gears and main engine shafts, used in the PT6 or PW600, among others. The plant is also involved in a programme to produce gearbox components for the new PW1000 engine, which powers Airbus A320 NEO aircraft, among other things. The company is AS9100D certified.

Pratt & Whitney Rzeszów[98]

A manufacturer of aircraft engines for passenger and military aircraft and helicopters. In particular, the plant manufactures hulls, gearboxes and seals for the PT6A, PW200/600/1000 and APS2000/3000/5000 engines, as well as numerous static structures. The company's R&D centre is distinguished by its EASA-approved construction office status (DOA, POA and MOA certifications), as well as other certifications such as AS9100D and PART 145.

Pratt & Whitney Tubes[99]

A major supplier of the most modern and advanced tubular assemblies to the Pratt & Whitney Group. Production includes, among other things, components for the new generation of engines (NGPF), mainly used on Airbus passenger aircraft. The company is AS9100 D and ISO 9001:2015 certified.

94 Owned by MB Aerospace Holdings I Limited.
95 Owned by MTU Aero Engines.
96 Owned by Lockheed Martin Helicopter Company LTD.
97 Owned by RTX Corporation.
98 Owned by RTX Corporation.
99 European Union Aviation Safety Agency.

Recaro Aircraft Seating Polska[100]

Specialises in the production and development of new seats for aircraft cabins, focusing on reducing their weight while providing the greatest comfort. The company's qualifications in the area of operations are confirmed by the EN 9100:2018 certificate, which enables the company to develop, manufacture, distribute and service the seats.

Safran Transmission Systems Poland[101]

Specialises in the manufacture and servicing of complete gearboxes for aircraft such as the Boeing 737 and Airbus A320. Safran's facilities are also active in R&D work. In 2021, the company opened its own R&D centre and is currently working on three flagship projects: Electric Taxiing, Flying Whales and Hybrid Electric Aircraft. It also holds numerous certificates, including EASA Part 145/21-G.

Łukasiewicz Research Network – Institute of Aviation (ILOT)

Research unit providing R&D services in the area of aerospace technology, with a particular focus on experimental and computational research in aerodynamics, the design of metallic and composite aerostructures and the design and testing of avionics equipment. The institute is certified in accordance with European aviation law by three organisations: design (ADOA) and production and maintenance (for C and B2 approvals). In addition, the institute is AQAP 2110-2016 and NADCAP certified. It is the owner of Mieleckie Zakłady Lotnicze, which offers, among other things, MRO services.

Unison Engine Components Poland[102]

Has a plant in Dzierżoniów, which manufactures a wide range of precision-machined structural components for aircraft engines, including high-pressure turbine segments, combustion chamber and diffuser rings, bushings, housings, tubes and pipes. Among other things, the company holds AS 9100, ISO14001 and NDCAP special process approvals.

UTC Aerospace Systems Wrocław[103]

(trade name: Collins Aerospace Wrocław)

Plant focusing on the production of fuel and control systems for aircraft engines and hydraulic products for flight control in aircraft and helicopters. The engineering centre located in Wrocław is the global competence centre for Collins Aerospace.

WB Electronics S.A.

Its activities focus on the development, manufacture and supply of military electronics, software, vehicle integration services for military communications systems, as well as integrated command and communications systems and complete unmanned aerial systems. Amongst other things, the company holds the following certificates: ISO 9001:2015, AQAP 2110:2016 and AQAP 2210:2015.

100 Belongs to Recaro Airctaft Seating Internetional GMBH.
101 Owned by Safran.
102 Owned by GE Aviation Systems Group Limited.
103 Owned by RTX Corporation.

Wojskowe Zakłady Lotnicze Nr 1[104]

(trade name: WZL1)

A provider of aviation domain solutions for the Polish Armed Forces with an 80-year history. The company has specialised in helicopter maintenance and overhaul for nearly 60 years. It provides its services both to the Air Force of the Polish Armed Forces and to domestic and foreign business partners. The key activities of WZL1 are major repairs, overhauls, maintenance and upgrades of helicopters, engines and maintenance of military and civil aircraft. The plant is a Helicopter Operations Support Centre (Service Centre for Helicopters of the Polish Armed Forces), including AW101 for the Navy.

Wojskowe Zakłady Lotnicze Nr 2[105]

Focus their activities on servicing and upgrading airframes. The company has its own modern machinery. It is also investing in the development of unmanned technologies such as the Short Range Tactical UAV Category and the DragonFly LMS. The plant's technical capabilities are confirmed by certificates PL.145.015 and 2-REG.145.162. WZL-2, together with GE Avio S.R.L., owns the "Polonia Aero" Aircraft Propulsion Research Laboratory.

Wytwórnia Sprzętu Komunikacyjnego "PZL-Świdnik" S.A.[106]

(trade name: PZL Świdnik)

Manufactures helicopters with a full range of competences in their design, certification and upgrade, certified to meet AS 9100 and AQAP 2110 standards and EU aviation regulations Part 21J, Part 21G, Part 145, Part-M/CAMO, Part 147. The company's portfolio consists of helicopters of its own design: W-3 Sokół and SW-4, and the new AW149 helicopters from the Leonardo family. The company is active in aerostructure manufacturing and research, being the main location for the Aerostructure Centre of Excellence in the Leonardo Helicopters Division. It is also involved in the development of unmanned technology and in other R&D programmes.

104 Owned by Polska Grupa Zbrojeniowa S.A.
105 Owned by Polska Grupa Zbrojeniowa S.A.
106 Owned by Leonardo Helicopters.

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