

Global trends in aviation – new research directions

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Abstract: *For more than two decades, the aviation world is revolving around one idea: reducing the impact on the environment. Although each action taken now, each strategy, each programme make reference to the decisions taken within the United Nation Conference on Climate Change, in Paris, in 2015, aviation community has recognized the environment and the climate change as a major challenge for aeronautics and air transport since the publication of Vision 2020 (European Commission, [1]) in January 2001. This document set the agenda for the European aeronautics ambition to better serve society’s need and all the Strategic Research Agendas that followed – SRA1 (published in October 2002), SRA 2 (published in October 2004), 2008 Addendum to the SRA and the more recently Strategic Research and Innovation Agenda Vol. 1 and Vol. 2 they all are addressing the “Challenge of environment” in SRA 1 and SRA 2 or in SRIA 1 and 2 identifying one of the big five challenges to 2050 – “Protecting the environment and the energy supply”. The concern for protecting the environment is not new, the only.*

Key Words: *climate change, European Green Deal, sustainable aviation, emission free, climate neutral, zero emission aviation, sustainable aviation fuels*

1. INTRODUCTION

The vision that guided the aeronautical field, starting with 2011 when FlightPath 2050 was launched and then the Strategic Research and Innovation Agenda proposed by ACARE (strategy based on the FlightPath 2050 vision), must be renewed. Although this vision reaches the horizon of 2050, many things have changed in the past 10 years since its publication, 10 years in which research and technology have advanced, 10 years in which more and more emphasis is placed on environmental protection, especially following the 2015 United Nations Conference on Climate Change in Paris (United Nations, [1]).

The Paris Agreement is an international treaty, adopted by 196 countries of the world, including Romania, and signed on December 12, 2015, entering into force on November 4, 2016. The Paris Agreement, which aims to strengthen the global response to the threat of climate change, by limiting global warming to well below 2 degrees Celsius, the target being a maximum of 1.5 degrees Celsius, compared to the pre-industrial level, until 2050.

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The Paris Agreement is a milestone in the multilateral process of climate change because, for the first time in history, a legally binding agreement unites all nations in a common cause to make ambitious efforts to combat climate change and to adapt to its effects.

All subsequent steps on climate change, at European and global level, have as a starting point the objectives set by the Paris Agreement.

In December 2019, the European Commission launches the European Green Deal - for the European Union and for the citizens of the European Union. (European Commission, [2]).

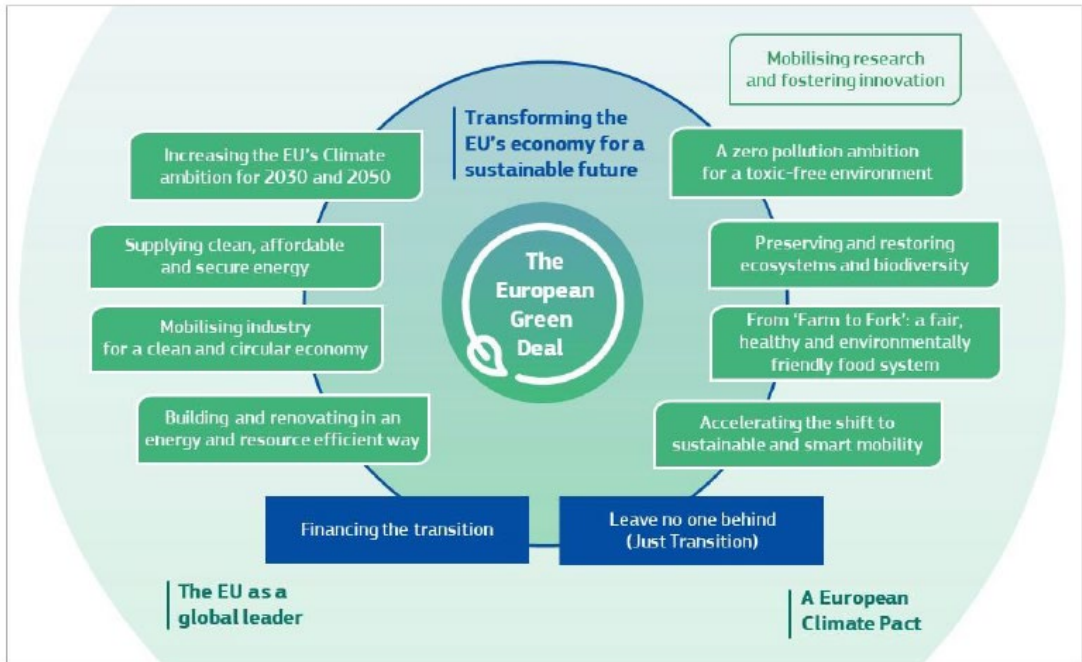


Fig. 1 European Green Deal (European Commission, [2])

The climate change that has intensified in recent decades, bringing with it environmental degradation, represents a real threat to Europe and the world. In order to find solutions to combat this increasing threat, Europe must develop and pursue a new growth strategy that transforms the economy of the European Union and its Member States into a modern, competitive and resource-efficient economy.

The President of the European Commission, Ursula Von Der Leyen, in her presentation on the European Green Deal, said that this pact represents the new strategy for Europe's growth and that we must act now. The European Commission has prepared three concrete actions, which will serve as a solid basis for the European Green Deal:

- Europe will become the first climate-neutral continent by 2050, which will translate into real benefits for Europe's citizens: zero pollution; affordable energy sources; integrated and smart transport; high quality food;
- economic growth will be decoupled from the use of resources;
- no person and no place will be left behind.

Investments will amount to one trillion Euros, giving investors' confidence to make long-term decisions in projects related to the environment and climate change, projects that will bring many jobs, a cleaner environment and a better quality of life in general.

2. INDUSTRY'S ANSWER TO EUROPEAN GREEN DEAL

The European Green Deal sets out the European Union's roadmap for achieving a sustainable economy. This will be possible by working together at European level and turning climate change and environmental challenges into opportunities.

The European aviation industry has adhered to the goals mentioned in the European Green Deal and is working together to support the goal of Europe becoming the first climate-neutral continent by 2050. Representatives of the world's largest aviation industry companies signed a Declaration for the Sustainability of Aviation, at the International Airshow in Le Bourget, near Paris - taking it shortly before the European Commission, but addressing the same topic of climate change (GlobalNewswire, [3]).

The signatories of this declaration are representatives of the 7 major aircraft manufacturers worldwide: AIRBUS, BOEING, DASSAULT AVIATION, GE Aviation, Rolls Royce, SAFRAN and United Technologies. They are committed to working together for the sustainability of aviation, in three major technological directions:

1. Continue to develop innovative technologies for aircraft and engines, with a view to continuously improving fuel efficiency and reduced CO₂ emissions. Over the past 40 years, aircraft and engine technology has reduced CO₂ emissions by an annual average of over one percent per passenger mile. This has been possible due to significant investments in materials research and development, aerodynamic efficiency, digital design and manufacturing methods, improvements in turbomechanics as well as the optimization of aircraft systems.

For many years, industry and research organizations, or international organizations, the entire aviation community has voluntarily committed to meeting a set of aggressive goals to improve the aircraft's environmental performance. The targets set by the Advisory Council for Aeronautical Research in Europe (ACARE) require a 75% reduction in CO₂, a 90% reduction in NO_x and a 65% reduction in noise by 2050, compared to 2000 levels (Advisory Council for Aviation Research and Innovation in Europe, [4]). To help achieve these aggressive goals, the global agreements concluded by ICAO require that a standard of fuel performance be part of the certification process applied to each aircraft. The aerospace industry remains committed to improving existing aircraft and engine designs in order to continue the path of improving efficiency as much as possible.

2. Supporting the marketing of **sustainable alternative fuel - SAF**. About 185,000 commercial flights have already shown that today's planes are ready to use them. Aviation will continue to rely on fossil fuels as the main source of energy for medium and long-haul aircraft for the foreseeable future. Even according to the most optimistic forecasts for electric flight, regional commercial aircraft will remain in operation in the global aircraft fuel fleet for decades to come. Therefore, the development of sustainable aviation fuels (SAF) that use recycled carbon, rather than fossil-based carbon and meet sustainability standards, is a key component of a sustainable future. There are already five approved ways to produce sustainable aviation fuels, and the commercial scale production of one of these ways is already in place. Accelerating production growth on all five of these commercially viable levels, while developing additional ways to lower costs, is the key to success. This activity is already under development in research centers and industry companies. There is a need for increased government support for technology development, investment in production facilities and incentives for fuel production worldwide. This new aviation fuel must be sustainable, scalable and compatible with existing fuels. The aviation industry will work closely with fuel

manufacturers, operators, airports, environmental organizations and government agencies to bring these fuels into widespread aviation use well before 2050.

3. The development of new propulsion and air “**third generation of aviation**”.

Aviation is at the dawn of the third major era, based on the foundation laid by Aurel Vlaicu and Traian Vuia, but also by the Wright brothers and the innovators of the 1950s, who brought the jet plane. The developments of new architectures, the advancements in thermodynamic engine efficiency, development of electric and hybrid-electric propulsion, digitization, artificial intelligence, materials and production will enable the third aviation era. Larger aircraft will begin to benefit from new models, which will further improve efficiency by managing aircraft drag and distributing propulsion in new ways. The new materials will allow the appearance of lighter aircraft, improving efficiency. Aviation is entering the most interesting era since the beginning of the Jet Plane era, aviation is entering the “third era of aviation”, which promises a positive impact on people's lives all around the world.

3. RESEARCH SUPPORT TO EUROPEAN GREEN DEAL

In response to this “Declaration for the Sustainability of Aviation” formulated by large industry globally and in line with the European Green Deal (already launched in December 2019), research institutes in Europe and over the world (KARI in south Korea, CAE in China, TsAGI in Russia) responded with a statement in support of the industry's proposed objectives, through the declaration ZEMA - Zero Emissions Aviation - signed in Berlin on November 24, 2020, on the occasion of the Berlin Aviation Summit, by 13 research institutions in the world, including INCAS - National Research and Development Institute “Elie Carafoli” from Romania (**Zero Emission Aviation group**, [5]).

The research organizations, signatories of this ZEMA declaration, gathered under the title of ZEMA group, make the following statement: “As researchers, we aim for an aviation system which is free of negative impacts. We will do our utmost to protect our planet and communicate this to the public in order to achieve not only acceptance but strong support for aviation. For future generations of aviation products, the overall goal is to achieve the least possible impact of aviation. That means close to zero emission aviation for the entire product life cycle. In the long run, a single parameter target, such as being CO₂ neutral, is insufficient and misleading. We must view the transformation as a holistic challenge”.

In this statement, research institutes propose to address the following topics:

- Design of aircraft and engines in order to **improve efficiency** and reduce emissions from combustion processes as well as noise. The evolutionary technologies available today allow rapid development and implementation.
- **Sustainable aviation fuels** will play an important role - because the combustion of any type of fuel is an emissions-producing combustion process, so the development of an alternative energy source for propulsion is essential.
- **Optimized routing for minimal climate impact** will be a key element. Using appropriate tools and data, the trajectories will be defined according to time and location, also defining the requirements that the aircraft must meet in order to be able to fly efficiently on these trajectories.
- **Urban air mobility and electric flight** are new elements in the field of aviation and will provide access to innovative technologies and open new dimensions of sustainable mobility.
- The focus will be on the **entire life cycle of the vehicle**, from design and manufacture to operation and maintenance. The objective of the ZEMA Group is to achieve a minimum impact

throughout the product life cycle.

Research in Europe, through EREA - Association of European Research Establishments in Aeronautics also appeals to European authorities, especially the European Commission through the Commissioner for Innovation, Research, Culture, Education and Youth, Mariya Gabriel, but also the Commissioner for Transport, Adina Valean (EREA, [6]).

The COVID-19 crisis has hit the global aviation security hard, but even then, research can take advantage of innovations that will revolutionize aviation and transportation. Fully autonomous aircraft, revolutionary configurations and a new climate-neutral propulsion mechanism are just some of the areas where significant changes can be expected in the coming decades. The question is not whether, but how quickly we can make this transition. This is more of a political question than a technological one, so the involvement and support of the authorities is mandatory. The European Commission can create the right framework for this transition to climate-neutral aviation to become a reality, through several means:

1. EREA calls on the two European Commissioners to renew Europe's vision for Aviation. Since the publication of the FlightPath 2050 vision in 2011, the world of aviation has changed dramatically, as a result of extensive digitization and in the last year as a result of the crisis caused by COVID-19. Given these changes, it is time for the European Commission to ask European aviation stakeholders to develop an updated vision and roadmap on how Europe will become the first climate-neutral continent in 2050, so as the President of the European Commission herself stated at the launch of the European Green Deal, while maintaining Europe's competitiveness and the highest levels of aviation safety and security. The scientific and research community is ready to actively participate in the development of this new updated vision of European aeronautics.

2. Strengthen public funding to accelerate the transition to climate-neutral aviation It is clear that the European economic recovery is extremely important. All measures that contribute to this goal should be carefully considered, including the consolidation of public R&D budgets, which are needed more than ever for successful technological transitions for both the EU economy and society. There is much research to support the claim that public investment in research and development not only stimulates significant private research and development, but also adds substantial value to the economy. Where most countries are cutting spending, only a few have increased public research and development spending since the 2008 crisis. The data suggest that this has helped them emerge stronger and more competitive. We should learn from this example both the European Parliament and the EU leaders to reconsider the EU budget and the recovery proposal and make it ambitious and appropriate to the purpose, especially since the current circumstances have made this necessary and justified. There is no doubt that the first priority of the EU budget should be to find a remedy or vaccine for COVID-19 (which happened in July 2020, when this letter of European research was sent to the European authorities), but At the same time, investment is needed to aim for rapid economic recovery in order to remain at the forefront of research and innovation, supporting the development of innovative technologies. This recovery is an opportunity to accelerate the transition to a sustainable and competitive aviation sector, and an adequate and ambitious budget is essential in this regard.

3. Create the appropriate legal framework to accelerate the transition to climate-neutral aviation European research and innovation is the key to supporting recovery and transition. Current and previous Framework Programs for Research and Innovation have supported the creation of European research and development ecosystems, integrating industry, SMEs,

research organizations and academia to work together to find solutions to the global challenges of large-scale projects that each nation could not achieve on its own. The future Horizon Europe Framework Program, including its partnerships, should continue to support these fruitful, trans-European and cross-sectoral collaborations, with appropriate budgets and conditions for participation. This applies in particular to public-private partnerships, where this strategic and long-term cooperation between industry, SMEs, research organizations and academia is essential. It is absolutely essential that such partnerships are inclusive and attractive to all stakeholders and that there are no barriers to participation. For every technological breakthrough, research and technology infrastructures are essential to demonstrate an idea, test and validate technology and simulate its effectiveness. For this reason, the European Union, together with the Member States, has a long history of investing in state-of-the-art research infrastructure. However, in order to bring technologies beyond the laboratory environment, applied test facilities or Technology Infrastructures (IT) must be fully recognized. Such facilities are indispensable in the innovation process; without them, research cannot be capitalized on products and services. Large technological infrastructures are expensive to build, use and maintain and can rarely be commercially exploited. EREA institutes manage many of these infrastructures and thereby guarantee technology transfer, helping the industry to move from Technology Readiness Level (TRL) 2 to 6 and beyond. (NASA, [7]). On the TRL scale, introduced by NASA in 1990 and used in aeronautics worldwide, research institutes can go as far as TRL 6, where the systems or prototypes are demonstrated in a relevant environment, this being done in these research and technology infrastructures.

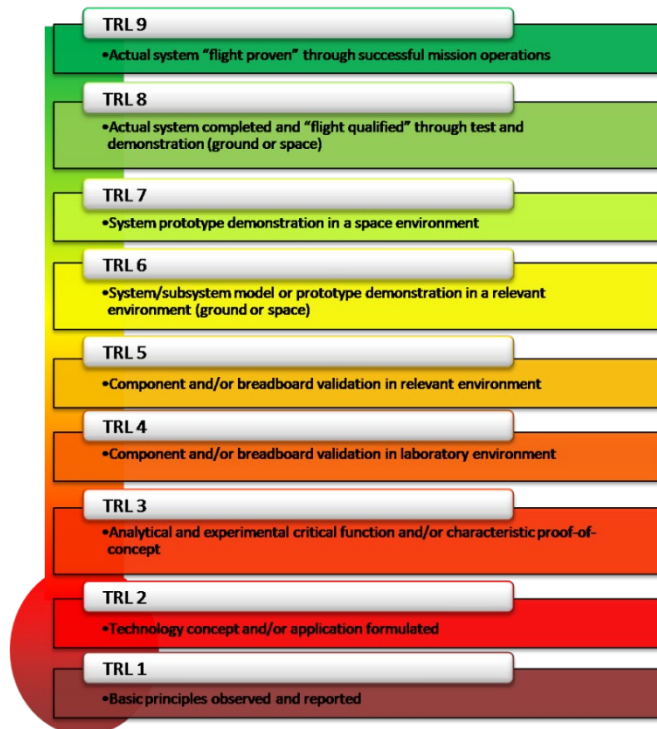


Fig. 2 NASA TRL Scale (NASA, [7])

A recent study by a European project (RINGO, [8]) on the needs, gaps and overlap of research infrastructures in Europe found that more than 24 facilities and capabilities are currently

lacking in aviation alone, and these issues need to be addressed and resolved as soon as possible. The same study mentions that in order to remain competitive, it is estimated that approximately EUR 400 million in additional funding is needed to build and modernize research and technology infrastructures. Investing in new technologies is useless if we cannot test, validate and certify them.

4. Cooperation of all actors in the field of aeronautics at European level: authorities, academia, research, small and large industry. European aeronautical research united under the EREA logo strongly believes that close cooperation is needed, including between research centers members of EREA, as EREA is representing more than the sum of its parts. That is why EREA has taken the initiative for the Joint Future Sky Program. In this context, the 15 EREA members jointly define an approach to key issues such as aviation safety, energy, noise, UAM, security and circularity. Although the Joint Future Sky Program is initiated by EREA, it is open to anyone wishing to join. The broad and inclusive approach of Future Sky has produced major flagship projects under the Horizon 2020 program, such as Future Sky Safety, (Future Sky Safety, [9]), ANIMA - Aviation Noise Impact Management through novel Approaches (ANIMA, [10]) and IMOTHEP - Investigation and Maturation of Technologies for Hybrid Electric Propulsion (IMOTHEP, [11]), having a significant impact on aviation safety, perception and management of aviation noise and hybrid-electric propulsion, respectively. What is unique about the Future Sky approach is the pooling of institutional research and innovation programs, which makes these EU projects go beyond their EU funding. In order to achieve the ambitious goal of the European Green Deal, for Europe to become the first climate-neutral continent, cooperation between all partners in the aviation value and innovation chain is vital. Only close public-private cooperation in each phase will produce the desired result.

4. CONCLUSIONS

Although the global aviation industry is responsible for only 2% of all human produced carbon dioxide (CO₂) emissions and aviation is responsible for 12% of CO₂ emissions produced by all means of transportation, compared to 74% produced by road transportation (ATAG, [12]), the public perception is a bit altered, considering that much of the emissions are produced by aviation industry and by flying itself. In 2018, in Sweden, this altered perception has even started a social movement called “flight shame” – an anti-flying movement, with only purpose of reducing the environment impact of aviation. But to reduce the environmental CO₂ print of aviation, it is not enough that few citizens cut back on their flights. European and world wide policymakers, governments and authorities all over the world have to take action. The Paris Agreement signed by 196 nations was the first step on the path of making a sustainable world for all its inhabitants, by limiting the environmental impact of humankind. Transportation and in particular aviation is responsible for a small part, but the whole ecosystem is working towards this common goal of making Europe the first emission free continent by 2050.

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