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Aeronautics industry proposal for Clean Sky 3 programme

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This paper defines the initial proposals for aeronautics flagship technology programmes in R&I Framework Programme 9 "Horizon Europe" that are building on new technologies to be explored, matured and demonstrated concurrently. This will be complemented by papers that cover the underlying elements of the research eco-system for Aeronautics in more detail.

1 Aeronautics research for the clean, autonomous and electrified World

In the next European Union Research Framework, Aeronautics can make a World of difference. Europe is a leader in Aeronautics and the 565,000 scientists, mathematicians and engineers who are supported by the European Union research programmes have worked to ensure that this World is served by cleaner, quieter, safer and more reliable aircraft.

The next era of aviation is likely to see Europe's citizen demand even greater levels of air mobility and air transport with ever reducing environmental effects. Achievement of this will require continuation of the focused and high technology research that has been so successful in previous European Union Research Frameworks.

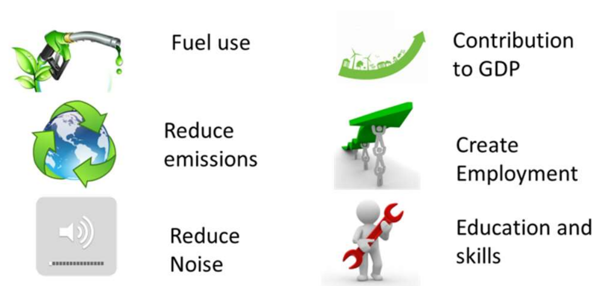
Of course, Aeronautics is part of a complex transport system that directly influences the quality of life, health and competitiveness of European Society. Links to other sectors, such as rail and road, especially through digital and manufacturing themes, will help promote competitive, mobile and resilient industries in Europe.

Aviation also impacts global society and aeronautics can help drive improvement in many of the United Nations sustainable development goals, not least climate action, responsible consumption and production and quality education for all.

Aviation and the aeronautics research programmes that support it have wide societal impacts. The aeronautics business contributes 4.1% to European GDP and 65% of this is exported. Whilst aviation only accounts for 2% of global emissions, it is growing at 4.5-6% per year and work to reduce the impact of aviation is required. Flightpath 2050 and the ACARE SRIA have dedicated targets:

- **CO_2 down by 75 %**
- **NO_x down by 90%**
- **Noise down by 65%**

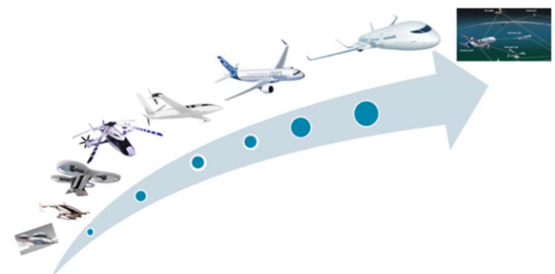
The Impact of Aeronautics research at a glance



2 Technology flagships for clean, autonomous and electrified World

Aeronautics research, underpinned by work in universities, research facilities and industrial companies across Europe, requires technology maturity through demonstration and proving in representative environments. Large scale demonstrators pull together many technology building blocks to deliver and prove a system solution. The future framework 9 aeronautics public-private partnership ("Clean Sky 3") should contain flag ships initiatives covering the entire perimeter of aviation and demonstrate the most advanced and ambitious air-transport/ mobility missions:

- Air mobility of the future and smart rotor craft
- Autonomous (or more) air vehicle demonstration
- Hybrid-electric Regional/biz jet aircraft
- Long distance (mass transport) aircraft – increased efficiency, electrification, integration
- Disruptive configurations (distributed propulsion, BLI (boundary layer ingestion), aero control)
- Qualification and digital certification



2.1 Disruptive urban air mobility and smart rotorcraft programme

New advanced Vertical Take Off and Landing (VTOL) capabilities combined with fast forward speed flight characteristics are shaping the future of aviation and of air mobility. They will offer new urban mobility for people and goods while improving the quality of urban life and contributing to the future vision of smart cities. Hybrid and electric-powered for Urban Air Mobility applications are expected to become a reality for private/public transportation. They will be key to developing new mobility concepts in synergy with SESAR, to ensure that the developed Clean Sky technologies could be introduced in the future Air Traffic Management system.

The programme will also boost the maturation of all basic functionalities of new high speed formulas of Tiltrotor and Compound Rotorcraft to fly higher, faster, further; innovative way of traveling within the Clean Sky 3 (CS3) timeframe. This will pave the way to achieve successful breakthroughs for subsequent industrialization and mission capabilities such as EMS (Emergency Medical Services), transport and para-public missions...

VTOL flight operations shall become as safe as commercial aircraft services. Efficient and effective noise emissions control is required for public acceptance of existing VTOL and emerging Urban Air Mobility.

This will change the business model of air transportation, like on-demand flight, stronger integration with other ground transportation means and adoption of Urban Air Mobility (UAM) concepts.

2.2 Autonomous air vehicle demonstration

The autonomous demonstration will accelerate the implementation of solutions to cope with the foreseen increase of air traffic and to strengthen the competitiveness of the sector.

The maturation of the enabling technologies for aircraft Reduced Crew Operations (RCO) envisions the possibility of operating in safer conditions, encompassing the transition to Single Pilot Operations (SPO) and ultimately the elimination of on-board pilot (Zero Pilot Operation, ZPO) towards a fully autonomous aircraft.

The implementation of such disruptive approach, always guided by safety and security considerations, would encompass a stepped approach, evolutionary through a progressive delegation of tasks to people on the ground, in the aircraft, or in another aircraft. In order to achieve such a goal, the implementation of a secured and reliable high throughput connectivity is an enabling factor but other technology streams need to be matured, affecting the aircraft systems architecture:

- Optimization Functions through Connectivity
- Disruptive new Digital-Native Avionics with distributed architecture

- Automation - Single-Pilot Operations, ultimately Zero Pilot Operations towards a world of Drones

The envisaged socio-economic benefits include the reduction of direct operating cost for the airliners and an increase of the safety, through the reduction of the human induced errors in the flight management, as well as an increased level of security.

A dedicated and specific effort will be necessary to address the evolution of the regulations essential to move from the two pilots cockpit to a single pilot or even a fully automatic cockpit operation. The effective implementation, provided that the proposed solutions are economically and technically viable, will change the whole air transportation system.

2.3 Hybrid-electric regional/biz jet aircraft

The Hybrid Electric Aircraft Flag ship will boost the advance in aeronautic technology and an early adoption of innovations in the regional segment to materialize substantial environmental and socio-economic benefits.

It is focused on providing significant and innovative performance improvements beyond what is achievable with today's technologies. The programme is maturing, adapting and integrating the most advanced technologies with the aim of reducing development and production cycles, to strengthen competitiveness and to achieve substantial reduction of noise and emissions, while enabling a more affordable and effective mobility services.

The goal is to accelerate the maturation of enabling technologies for future products application encompassing more versatile and Hybrid-Electric Regional aircraft.

Technology lines that serve Europe's strategy of regional aircraft leadership, smarter products, more connected, more services and multiple missions include configuration, propulsion and systems areas and implementation shall be closely related to new disruptive configuration, Qualification and digital certification Flagship for several substantial mutual benefits and interactions.

- ➢ Pursue the acceleration of innovation and introduction of entirely new regional and multi-missions vehicle products and services that will bring significantly environmental and socio-economic benefits as soon as they are technically and economically viable.

2.4 Long distance (mass transport) aircraft– increased efficiency, electrification, integration

The next programme will need to boost the aeronautic technology advance and an early adoption of innovations in the high-volume market segment to materialize substantial environmental and socio-economic benefits.

The Clean Sky 3 - Next Large Passenger Aircraft Research programme is focused on providing between 20 and 30% improvements beyond what is currently achievable with today's technologies. The programme is maturing, adapting and integrating the most advanced engine, wing, fuselage, cabin and cockpit technologies for derivative aircraft. It aims reducing development and production cycles, to strengthen the competitiveness and harvest the already accessible environmental and socio-economic benefits.

As air traffic will more than double in the coming twenty years, the European industry expects a need for nearly 35,000 new aircraft worth some US$5.3 trillion. The economic impact is expected to be equivalent to the economic value that comes from the current large passenger aircraft business and is vital element for Europe's overall economic impact and trade balance.

The programme will deliver the highest immediate potential to reduce energy consumption and emission such as CO_2, NO_X and noise, required to mitigate the growth driven environmental impacts. Its overall objective is to enable sustainable growth of societal air mobility, which is today's most efficient mode of high-speed, long-distance travel at low cost.

The project is a vital requirement for maintaining the technological leadership and sovereignty which is the root of Europe's aircraft industry in a market segment which supports thousands of highly skilled jobs in Europe.

- ➢ Seeking an early introduction of substantial technological and operational improvements that can bring significant benefits to market as soon as they are technically and economically viable.

2.5 Disruptive configurations (distributed propulsion, Boundary Layer Ingestion, aero control)

The new disruptive configurations programmes are exploring the vast potential that emerges when combining and exploiting the full range of new and fast evolving technologies for aviation. The enlarged design space is expected to allow for entirely new vehicles and configurations that need to be demonstrated with regard to their viability.

It explores and holistically applies the very latest and new emerging technologies e.g. new propulsion architecture (open rotor engine technology, electric-hybrid and distributed propulsion, BLI, …), connectivity and autonomous flight, new materials, 3-D printing and artificial intelligence:

- Safe, most-efficient, full autonomous flight for individual freight or passenger transport.
- Clean, silent and sustainable air vehicle offsetting the nuisance of overall traffic growth.
- Seamless integrated air transport reducing the time of regional and national door to door connections by 50%.
- Demonstrate the viability of long distance flights with more comfort and 50% more passengers while consuming 25% less energy.

2.6 Qualification and digital certification

Certification is a time and cost intensive process required to ensure the quality, safety and security of all aeronautical vehicles. Shorter innovation cycles, thanks to digitalization, are needed to optimize the certification process and thus reduce time to market.

An upstream interaction directly with EASA on a regulatory prospective framework must be planned and resourced to define new processes and standards for aircraft, including embedded systems and software. This collaborative approach will prepare the introduction of disruptive or differentiating technologies or innovations that could increase Europe's competitive edge.

In the past, the formal certification process started downstream of the technology developments. A major step change in the conduct of R&T activities will be undertaken to work upstream with EASA. Technology developments and the setup of a new regulatory framework for the certification of the products that will integrate these new technologies will run in parallel.

A smarter, more efficient mix of sub-scale test, ground test, virtual simulation and flight test will bring faster product innovation cycles within reach. The use of automated analysis and design tools, requirements fulfilment, data exchange, modelling and simulation, will have to be further developed. More integrated multi-scale and multi-physics models (icing, ditching, birdstrike, lightning...) will significantly reduce the qualification steps and optimize the test rigs to strictly as necessary. The introduction of virtualisation technologies and cyber-physical systems will enable simulations that will be as reliable as physical tests to become a principal means of demonstrating compliance. It also takes into account the special characteristics of advanced AI systems. New approaches to progress towards certified autonomy are required for operative automated assistance functions, including trust in adaptive and nondeterministic components, and complex engineered networks. There is also a need for a better optimisation of aviation test infrastructure and related assets, including synergies with other transport modes, to push towards a smarter certification process.

This initiative, with the continuous involvement of EASA, strives to be federative and transversal, involving all stakeholders of the aviation community.

3 Links to the integrated transport system and other key sectors

Digital, Cybersecurity, Artificial Intelligence, smart design, advanced materials, manufacturing and service support are at the heart of aeronautic competitiveness. The integrated, connected transport system will deliver enhanced system capability linking other modes of transport with aviation – integrating the larger transport network. Aeronautics requires an advanced manufacturing capability that supports the circular economy for competitiveness and sustainability.

- Digitalisation with required cybersecurity (cross-sector links);
- Streamlined, model-based certification;
- Industry 4.0 (cross-sector links), advanced manufacturing;
- Reuse, recycling, circular economy;
- Fuel cells, batteries, electronics.

4 Partnership and collaboration

Partnership and collaboration are at the centre of research in Europe and the framework programmes enable and nourish this eco-system. The collective endeavours of the key research entities; Universities, Research Agencies and Industry have been proven to deliver, and the Public-Private-Partnership facilitates direct engagement of key governmental entities. Future research programmes should grow, develop and nurture these partnerships.

5 Financial commitment

The aeronautics programme described in the preceding sections is visionary and will test the boundaries of existing technologies and put Europe at the centre of the next era of aviation.

The research partners including those representing the major aeronautics sectors in Europe have already recommitted to the key goals and aims of Flightpath 2050 but in order to achieve the pace and timescales that are required, partnership and support from key European government agencies remains essential. The extremely ambitious programme that is being proposed in EU Framework 9 would require a significant public-private investment.

At European aeronautics conferences, senior European industry representatives have communicated strong support for the key messages in the LAB-FAB-APP report issued by Pascal Lamy, namely to double the research budget for aeronautics.

The scale and complexity of the challenge, along with the clear benefits to European society warrant a bold and comprehensive programme.

[Signature on file], Jan Pie, ASD Secretary General, 15 June 2018