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Onera's study of the air transport market in 2050 lays the groundwork for a long-term analysis

Will mass air travel still exist in 40 years? What breakthrough technologies are in the pipeline? Will aviation offer an alternative to private cars? Where should we focus our research investments? Onera, the leading aerospace research organization in France, formed a multidisciplinary task force to study the technological and organizational decisions needed to ensure a viable air transport system in 2050. The resulting study, entitled "Research paths for a viable air transport industry in 2050", lays the groundwork for a long-term analysis and also identifies the priority research objectives.

Long-term planning: a natural extension of Onera's missions

As a pivotal player in long-term planning for the aerospace industry, Onera called on a dozen of its specialists from complementary areas of expertise to write this study (taking about 30 days over a period of six months). The multidisciplinary task force was able to draw on the broad scope of research at Onera, which covers all disciplines in aeronautics and space.

The task force explored all avenues of this subject, based on in-depth investigations and sometimes heated discussions between experts. They took stock of the state of the art in air transport, revisited old ideas and developed new ones, explored innovative paths in light of new knowledge, and identified the technological hurdles we face and the breakthrough or even disruptive technologies needed to advance. The main conclusions of their work are summarized in the Onera study, "Research paths for a viable air transport industry in 2050".

"The success of Onera's research depends on making the right initial decisions, sometimes decades before the actual implementation," emphasizes Thierry Michal, General Technical Director at Onera. "Being able to identify the most promising paths for research is an absolute prerequisite if we want to stay ahead of the curve and maintain our role as a leading player in international aerospace research. That's why long-term design and planning is an integral part of our mission. This aspect takes shape quite naturally, either within each department that has the specific areas of expertise needed to explore its discipline, imagine and shape the future; or through multidisciplinary working groups like that formed for this study."

Four different scenarios for the air transport system in 2050

The future of any leading-edge sector largely depends on decisions made decades earlier in research centers and laboratories. In key technology areas such as energy, materials, design, onboard systems, infrastructure and environmental protection, making correct and timely decisions is crucial.

Working in partnership with EREA (the association of European Research Establishments in Aeronautics), Onera wanted to study these different areas in greater detail, based on the four scenarios defined by the Consave[1] study. Each of these scenarios is defined in relation to the three major factors characterizing today's air transport environment: the safety imperative; limited energy resources; and the growing need to reduce environmental impact.

> Scenario 1 – Unlimited Skies: explosive growth, deregulated markets
The airspace is crowded, with a broad range of vehicles and an increasingly diverse range of applications (leisure, surveillance, military transport) and players (airlines, control systems, ground infrastructure).

Challenges to be met in this scenario include the design of new vehicles, revamping the air traffic management system, and developing intermodal transport solutions.

Scenario 2 – Regulatory Push & Pull: regulations to benefit a comprehensive environmental protection approach
Demand for transport services (air, land, sea) is just as strong, and the providers are as numerous and diverse. But at the same time, there is an emerging awareness of the need to regulate the supply, in order to enhance our conservation of energy resources and reduce our environmental footprint.

Against the backdrop of a regulated sky, new vehicles, infrastructures and procedures (green flight paths, approach phases, etc.) will emerge, all more environmentally-friendly, with limits on emissions and noise.

> **Scenario 3 – Down to Earth: a world that functions with virtually no fossil fuels and generates no emissions**
There is strong general demand to limit the consumption of energy resources, for both environmental and economic reasons. As a result, airspace is reserved for priority missions, and mobility is limited to travel in the public interest.

In this scenario, players in the air transport system will be motivated to develop specialized vehicles for security or surveillance related missions, based on green technologies, and in particular making wide use of automation. Land transportation also continues to develop, and alternatives to conventional travel emerge, such as virtual communications. Furthermore, any non-priority flights must use zero-pollution aircraft.

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1 Consave : Study run by the consortium DLH, DLR, NLR, QinetiQ, IIASA, MVA, Airbus on behalf of the European Union

Scenario 4 – Fractured World: a juxtaposition of independent worlds, developing at very different paces
A juxtaposition of the three previous scenarios, this one represents a world divided into several blocs, each following its own scenario, depending on its needs and characteristics.

The development of the air transport system will necessarily demand a distinctive offering for each bloc. Aircraft are designed locally, and each bloc will choose its own shapes and technologies. International flights between blocs are decreasing, but regional flights within a bloc are on the rise. Due to tensions between blocs, we could also see more conflicts or terrorist activities – which means the demand for security is stronger than ever.

Four priority research objectives, for a viable air transport industry in 2050

No matter which scenario ultimately prevails, Onera has already identified the common research objectives where investments should be focused, concerning aircraft, traffic management and flight control, airport infrastructures and design, evaluation and testing tools.

> **Aircraft: new conceptual and technological options**

For the aircraft themselves, Onera is considering new types of propulsion, new layouts, new materials and new control modes. The multitude of technologies involved demands a multidisciplinary, multicriteria approach to make sure that all of these phenomena are integrated and modeled.

Whether propelled by distributed, hybrid, electric or nuclear systems, tomorrow's aircraft will reduce their energy budget and noise. Some systems could also meet the daunting objective of zero CO_2 emissions.

Onera is also examining several new layouts, reviewing their respective advantages to incorporate new technologies that enhance energy efficiency and environmental performance. For example, the "flying wing": in addition to its clear aerodynamic advantages, this type of aircraft design also offers an intrinsically low structural weight, and would be able to integrate its propulsion system inside the airframe.

The advanced materials needed for these aircraft (e.g., composites, shape memory alloys, etc.) would have to be studied in more depth to evaluate their ability for noise absorption, robustness and aging tolerance. These materials may prove to offer very astonishing capabilities.

> **Traffic management and flight control: towards traffic control and aircraft automation**

The use of automation, whether in air traffic control or on the aircraft themselves, will depend on whether we can meet several major challenges, in particular high-speed calculation, and clearly proving the safety and security of this type of system, since it would represent a major cultural upheaval for passengers. The transition period

between the current system and an automated future will also require particular attention.

From the standpoint of procedures, the use of “green flight paths” based on the 4D contract could offer a host of advantages. These contracts are established based on the aircraft’s performance, weather forecasts and traffic demand. Each aircraft will have to comply with its 4D contract, or renegotiate it if it can’t meet the terms, for instance due to unexpected weather conditions.

Automated air traffic management could lead to energy savings, less noise and pollution, greater safety, smoother traffic, heightened predictability and optimized management of contingencies.

The automation of most tasks, including communications between the aircraft and air traffic control (ATC), navigation, management of contingencies and flight control, could also reduce the accident rate.

> **Airport infrastructures: optimized logistics**

Research on airport infrastructures will focus on overall design and optimization of logistics. The use of powerful simulation programs is indispensable if we are to effectively evaluate all possible solutions.

Initial goals include airports that are emissions-neutral, especially for CO_2, plus reduced noise and impact on air quality. To achieve these goals, the notion of sustainable development must be incorporated in every part of the infrastructure’s life cycle, from design to recycling. In terms of actual operation, local energy production should be considered, whether from wind or geothermal power stations, or from remote stations.

Other paths worth exploring include redesigned terminals and runways, revamped boarding procedures and new takeoff aids (such as catapults) and green taxiing (automated/electric tractors). This will all enhance ground traffic and boarding gate management, while also facilitating intermodal transport.

> **Design, evaluation and testing tools and methods: indispensable!**

The development of design, evaluation and testing tools and methods for the three aforementioned research objectives is indispensable.

Design methods are of course needed for aircraft development, while evaluation tools help reduce noise and improve performance, and validation tools and methods will play a major role in the development of new air traffic management approaches.

Research must concentrate on models anchored in the laws of physics, rather than simply capitalizing on historical data.

Within this context, several major challenges must be met: integrating the innovative solutions developed, which are brand-new, multidisciplinary design optimization,

consolidating these tools within interoperable platforms, and testing the security offered by these systems.

“This study is a perfect example of our ability to spotlight the areas of research where investments should be targeted to pave the way for tomorrow’s air transport system,” concluded Thierry Michal, Onera’s General Technical Director. “Through its publication, we are laying the groundwork for a long-term analysis. Our work has already been shared with our colleagues at EREA, and will shortly be submitted to the main decision-makers in France and Europe.”

“At the same time, we are currently conducting and federating a number of research programs,” he added. “I would especially like to mention PPlane, a personal aircraft in which complete automation replaces traditional piloting, as well as SWAFEA, a European study on the feasibility and impact of alternative fuels. More recently, we were involved in Europe’s 4Dco-Gc studies on the automation of air traffic, IESTA, a platform to evaluate air traffic systems, and of course a number of projects on minidrones, focusing on their design, autonomy and integration in airspace. All of these efforts will help shape a different world, one in which aviation will maintain a key position.”

Onera

Onera is the leading aerospace and defense research organization in France. A public establishment created in 1946, it reports to the French Ministry of Defense. Onera has over 2,000 employees at eight major facilities, including 1,500 scientists, engineers and technicians. Building on its multidisciplinary expertise and a world-class fleet of test facilities, Onera works for both government and industry, spanning major corporations and small businesses. Onera deploys an innovative partnership-based approach to research, with five times more contract business per researcher than the average in France. In 2008, Onera had revenues of 202 million euros. Onera is a recognized source of innovative solutions, technical expertise and long-term design vision, paving the way for tomorrow’s programs. Onera has contributed to some of today’s most successful aerospace and defense programs, including the Ariane 5 launcher, Airbus jetliners, Eurocopter helicopters, the Rafale fighter and the Falcon 7X business jet.7X.

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