VoltAir | Efficient Airframe Technologies

The performance of a fully electric aircraft depends on the battery system's storage capacity and weight – which will be heavier than an equivalent amount of kerosene fuel. An essential requirement for the VoltAir concept is to have a light and low-drag airframe. Advanced carbon fibre composite materials are used, and an unconventional configuration with an optimum fuselage thickness-to-length ratio is selected to minimize aerodynamic drag while providing a maximum useful internal volume. The fuselage's generous volume is used for a better integration of the landing gear, significantly improving the aerodynamic properties of the wing-to-fuselage junction.

The VoltAir concept benefits from a new freedom in aircraft design that results from the electric propulsion system. Unlike the fuels that are burned in a combustion engine, the electric energy storage system does not change its mass during the flight. It is therefore possible to locate the batteries away from the aircraft's centre of gravity, balancing the propulsion unit's weight at the rear of the fuselage. **The absence of wing-mounted engines and landing gear results in an aerodynamically-clean wing,** which benefits from the undisturbed airflow – with an anticipated 60% of its surface enjoying the low drag of laminar flow. Conformal antennas and smooth surfaces of the composite wings and fuselage add to the VoltAir concept's low-drag design.

VoltAir's rear-mounted shrouded propulsion system configuration enables the propellers to ingest the wake from the fuselage, thereby reenergizing this low energy boundary layer to obtain maximum propulsive efficiency.

VoltAir | Enhanced Passenger Comfort

In addition to the propulsion system's benefits, the VoltAir concept will offer a pleasant flight experience to its future passengers. The shaping of the fuselage for improved aerodynamics in terms of its width-to-length ratio will also result in very low noise levels from airflow along the fuselage skin. The already very quiet electric motors are located downstream at the rear of the fuselage, far away from the cabin. In addition, VoltAir's wide cabin cross-section will give the passengers the feeling of spaciousness as in a wide-body aircraft.

VoltAir | EADS INNOVATION WORKS

In addition to environmental targets, "Flightpath 2050 – Europe's Vision for Aviation" addresses customer orientation and market needs as well as industrial competitiveness and the need to maintain adequate skills and a research infrastructure base in Europe. It also emphasizes that technological leadership will continue to be a major competitive differentiator and that break-through technologies will be required to secure future competitive advantages. The VoltAir project supports the Flightpath 2050 goals in these respects.

EADS INNOVATION WORKS is the corporate network of research centres of EADS. A highly skilled workforce of more than 700 is operating the laboratories that guarantee EADS' technical innovation potential with a focus on the long-term. The structure of the network and the teams within EADS INNOVATION WORKS are organised in seven global and transnational Technical Capability Centres:

- Composites Technologies
- Metallic Technologies and Surface Engineering
- Structures Engineering, Production & Aeromechanics
- Engineering, Physics, IT, Security Services & Simulation
- Sensors, Electronics and Systems Integration
- Energy & Propulsion
- Innovative Concepts and Scenarios

VoltAir is one of the concepts related to airborne platforms for the next generation of EADS products which are being researched by "The Future of Flying" department within the "Innovative Concepts & Scenarios" Technical Capability Centre. In addition to advanced concepts, the team applies its skills in the areas of advanced design and visualization, human-centred architecture as well as services, maintenance and logistics.

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VoltAir

All-electric Transport Concept Platform

EADS

VoltAir |

All-electric propulsion system concepts for future air vehicle applications are being developed by EADS INNOVATION WORKS, the corporate research and technology network of EADS. This activity is part of the EADS group's research to support the aviation industry's ambitious environmental protection goals as spelled out in the European Commission's roadmap report, called "Flightpath 2050 – Europe's Vision for Aviation." This report sets the targets of reducing aircraft CO_2 emissions by 75%, along with reductions of Nitrous Oxides (NOx) by 90% and noise levels by 65%, compared to levels of the year 2000.

One of EADS INNOVATION WORKS' all-electric propulsion definition studies is the VoltAir technology concept platform, which **supports the vision of a zero-emission air vehicle** that could become a reality 25 years from now. VoltAir is one of the projects grouped under EADS INNOVATION WORKS' eCO_2avia activities, which also include such efforts as demonstrating the feasibility of algae biofuel use for aviation.

VoltAir's electric energy storage system (essentially two next-generation batteries) will power highly efficient superconducting electric motors that drive two co-axial, counter-rotating shrouded propellers mounted at the rear of the fuselage.

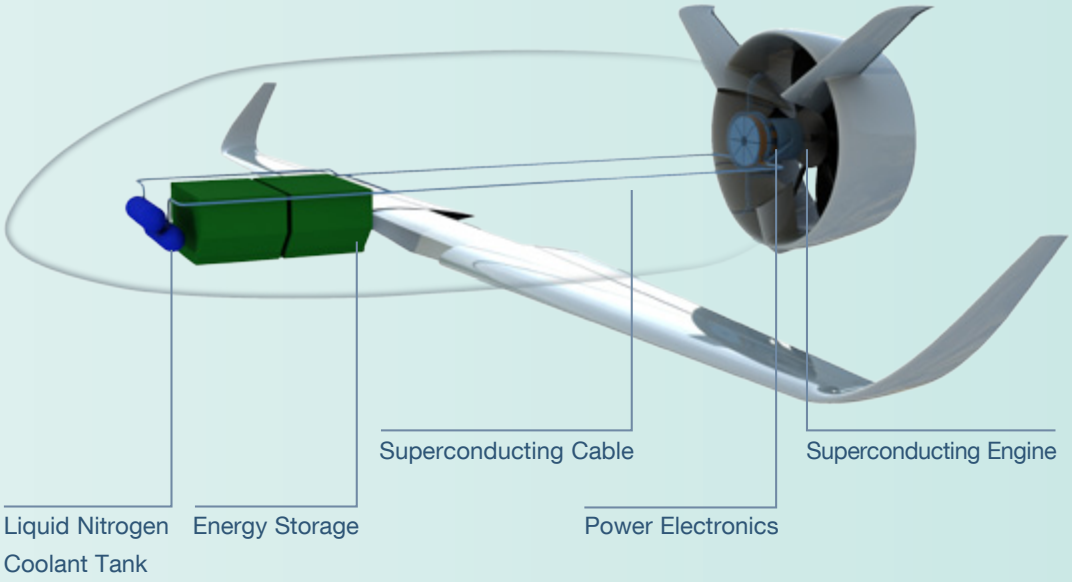
A radical approach to airframe design results in excellent aerodynamics and low weight, thereby requiring a minimum amount of energy for propulsion. Combined with the promising developments expected in electric propulsion technologies, the VoltAir concept could pave the way towards ultra-quiet and emission-free flight.

VoltAir | Next-Generation Energy Storage

High-density batteries have achieved impressive advances in their capabilities during the last decade, boosted by the large demand in automotive applications and the proliferating use of hybrid and fully-electric cars. However, today's battery performance is still far from what is theoretically possible. New materials with promising capabilities are currently being investigated for a new generation of batteries. Some of them are based on lithium-air and lithium-sulfur combinations. Scientists expect these batteries to exceed energy densities of 1,000 Wh/kg (Watt hours per kilogram) within the next two decades, which would result in a more than doubling of today's performance.

Lithium-air batteries are the most promising solution for the VoltAir concept's energy storage requirements. They have a higher energy density than lithium-ion batteries because of the lighter cathode, along with the fact that oxygen is freely available in the environment and does not need to be stored in the battery. Lithium-air batteries currently are under development, and are not yet commercially available. The VoltAir concept is based on the assumption that the required level of energy density can be achieved within the targeted 25-year timeframe envisioned for the aircraft's development and service entry.

VoltAir's batteries are integrated in replaceable, containerized units in the lower fuselage hold -- enabling an easy replacement of depleted batteries at the airport in a process similar to the loading and unloading of cargo or luggage containers. Performing the batteries' recharging and maintenance process on the ground reduces the system's weight and complexity onboard the aircraft, and allows for fairly conventional airport operations. Turnaround times are not affected, since "repowering" can be considered to be at least as fast as conventional refuelling.

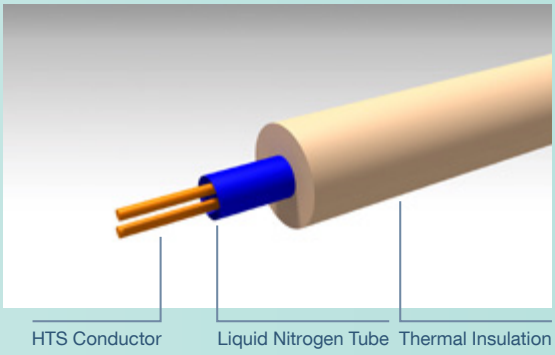


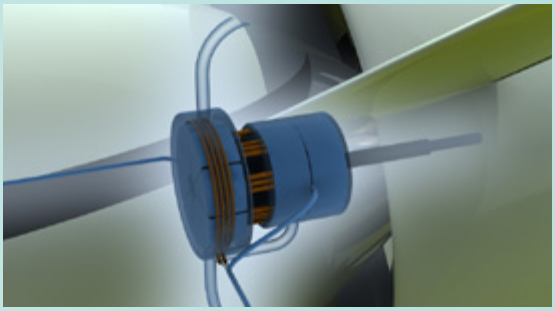
VoltAir | Ultra-High-Density Electric Engines

Conventional electric motors are known to be very efficient but generally do not offer the power densities (energy output per unit weight/kiloWatt per kilogram) required for large-scale airborne applications. The discovery of high-temperature superconducting (HTS) materials provides the key solution to this problem. (For additional details, see the superconductivity box, below). HTS materials are the basis for high density superconducting motors that are becoming available today, and which are expected to exceed the power-to-weight ratio of gas turbine (turboshaft) engines as their development progresses. **The necessary cooling to reach superconducting temperature can be realized with low-cost – and environmentally-friendly – liquid nitrogen.**

In the VoltAir concept, HTS motors are expected to reach power densities of 7-8 kW/kg with almost no electrical losses. This compares to 7 kW/kg for today's turboshaft engines. Higher values for HTS motors would be possible if the operating temperature would be cooled down to around 30K, but this would require a more complex and costly cooling system using hydrogen or helium.

As the motors deliver their full power to the propellers, **passengers onboard the VoltAir aircraft will appreciate the engines' extremely low noise level. In flight, this fully-electric propulsion system does not emit any carbon dioxide or nitrous oxide "greenhouse gases."** Only small amounts of harmless nitrogen are vented overboard after being used to cool the superconducting electric leads and motors.





By applying superconductivity, the VoltAir technology concept platform will benefit from higher-power motors and wiring that weighs less.

Superconducting Wires and Motors

Superconductivity is an electrical resistance close to zero, which occurs in certain materials when they are cooled below a characteristic "critical" temperature. An electric current flowing in a loop of superconducting wire can persist practically indefinitely with no power source. In 1986, it was discovered that some materials have critical temperatures above 90 K (–183 °C). These are the so-called high-temperature superconductors (HTS).

In superconducting motors that employ HTS windings in place of conventional copper coils in their rotors, electrical resistance and current loss are reduced to nearly zero, so the motor can achieve higher power and torque with thinner wires. This results in an increased power density and leads to a smaller size and weight.