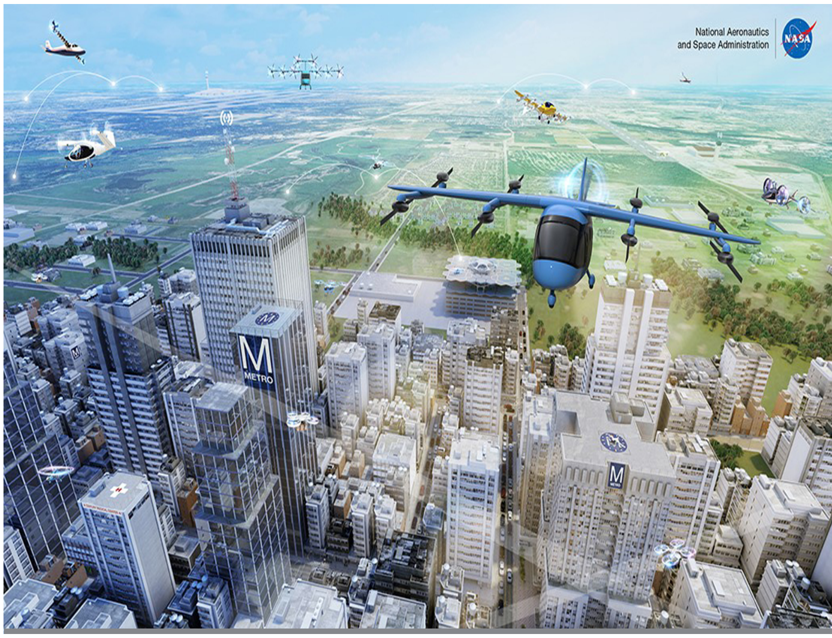


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Aerospace

Active Turbulence Suppression System for Electric Vertical Take-Off and Landing (eVTOL) vehicles

Suppression of Dutch-Roll Oscillations for Air Taxis Using Existing Propellers

Electric Vertical Take-Off and Landing (eVTOL) aircraft, conceptualized to be used as air taxis for transporting cargo or passengers, are generally lighter in weight than jet-fueled aircraft, and fly at lower altitudes than commercial aircraft. These differences render them more susceptible to turbulence, leading to the possibility of instabilities such as Dutch-roll oscillations. In traditional fixed-wing aircraft, active mechanisms used to suppress oscillations include control surfaces such as flaps, ailerons, tabs, and rudders, but eVTOL aircraft do not have the control surfaces necessary for suppressing Dutch-roll oscillations. NASA Ames has developed a novel approach for actively controlling Dutch-roll oscillations of an eVTOL aircraft by using existing outboard propellers to dampen oscillations. This novel technology avoids the need to add hardware or change the design of eVTOL vehicles to address the negative effects of turbulence.

BENEFITS

- Enables a safe and comfortable passenger experience: solves gust-induced oscillation instabilities for eVTOL aircraft, which experience challenges due to their relatively light weight
- Compatible with most eVTOL designs with multiple propellers
- Does not require additional hardware: eVTOL manufacturers benefit from ability to keep aircraft weight low, enabling longer battery life and thus vehicle range
- Low cost to implement: design costs can be significantly reduced with high fidelity modeling of flows by using the Navier Stokes equations and reducing amount of wind tunnel test cases

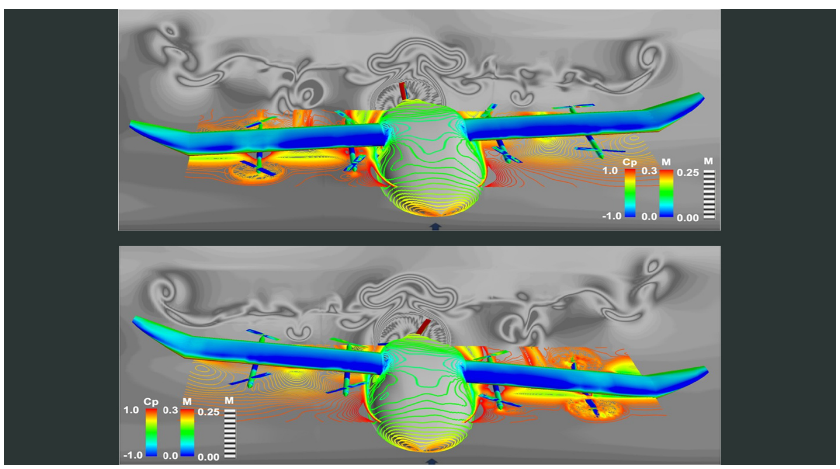
APPLICATIONS

The technology has several potential applications:

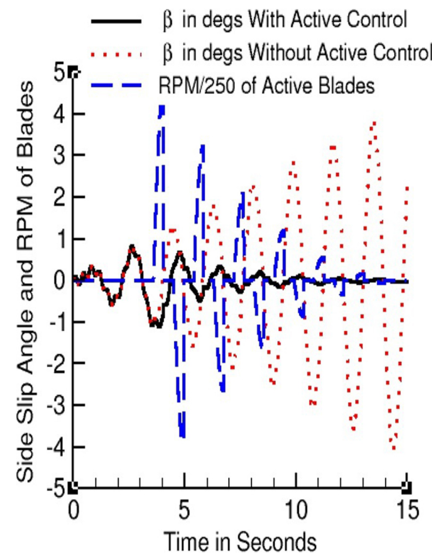
- electric Vertical Take-Off and Landing (eVTOL) industry
- Air- Taxis industry
- Aerospace industry
- eVTOL manufacturers

THE TECHNOLOGY

The Active Turbulence Suppression (ATS) system for electric Vertical Take-Off and Landing (eVTOL) vehicles employ existing lifting propellers to dampen instabilities during flight, such as Dutch-roll oscillations and other gust-induced oscillations. When a roll angle of an eVTOL aircraft has deviated or is about to deviate from a current stable aircraft state to an undesirable, unstable, and oscillating aircraft state, the ATS system queries a turbulence suppression database that stores a set of propeller speed profiles for mitigation a deviation of a given roll angle for a particular aircraft with specified propellers. Using this data, the eVTOL flight controller adjusts the speed of the propellers for a certain duration of time, according to the propeller speed profiles for mitigating the deviation. In models of aircraft with adjustable propeller angles, the database includes blade angle profiles for mitigating the effects of turbulent conditions. Timing and rate of propeller activation can be pre-computed using higher order computational modeling performed with NASA's super computing resources. Because the data is pre-computed, the use of the ATS system onboard does not require significant computing resources to implement on eVTOL vehicles. The technology, a mechanism by which existing eVTOL propellers are leveraged to suppress gust-induced oscillations enables a safe and comfortable passenger experience at low-cost and without added hardware.



TOP: Snapshot surface pressure coefficient (Cp), in plane and field Mach numbers when right wing out-board propellers are activated
Bottom: Snapshot surface pressure coefficient (Cp) in plane and field Mach numbers when left wing out-board propellers are activated



Responses of side slip angle Beta with and without active cont along with RPM

PUBLICATIONS

Patent Pending

https://www.sciencedirect.com/science/article/pii/S1270963821006684

https://arc.aiaa.org/doi/10.2514/1.J060055

https://www.nas.nasa.gov/SC21/research/project1.html#demo-2

https://arc.aiaa.org/doi/10.2514/3.10179

More Information

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ARC-18707-1, TOP2-308