EASA
European Union Aviation Safety Agency

VRS (Helicopter Vortex Ring State Experimental Research)

Contractor

ONERA

Consortium Members

DGA-EV

Contract period

02/11/2022 - 01/11/2024

Budget

379 762 €

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Main objectives:

The current Certification Specifications for helicopter certification lack requirements for applicants to determine flight conditions where the helicopter's Vortex Ring State occurs and to include pertinent information in the Rotorcraft Flight Manual. While Vortex Ring State (VRS) is included in training regulations, the recovery maneuvers taught to pilots are often conventional. This research aims to enhance understanding of VRS across various helicopterstypes, exploring analytical, simulation, and flight test methods. Additionally, it assesses alternative recovery maneuvers, like the one proposed by Capt. Vuichard. These insights will inform the need for potential revisions in certification specifications, pilot training regulations, and associated guidance, contributing significantly to the Agency's decision-making process.

The experimental research aims for the following outcomes:

- Experimentally determine the onset conditions of Vortex Ring State (VRS) for a minimum of two diverse helicopter types, validating theoretical methods predicting vortex ring boundaries.
- Experimentally assess the efficacy of the Vuichard recovery technique compared to the conventional one across at least two distinct helicopter types.

The research program entails experimental flight tests on two helicopters of different weight and rotor size. These aircraft will be equipped with sensors for real-time measurement of flight and system parameters relevant to the research goals. Parameters will be monitored in real-time onboard or, preferably, transmitted to a ground control station. Additionally, parameters will be recorded for subsequent post-flight data analysis.

Impacts & benefits

- Current helicopter certification lacks requirements for determining the flight conditions in which VRS occurs.
- Training regulations focus on traditional recovery maneuvers, limiting awareness of alternative methods like Vuichard's.
- The research aims to enhance VRS understanding, evaluate recovery techniques, and inform potential changes in certification and training regulations.

This project has been funded from the European Union's Horizon Europe research and innovation programme.

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Further reading

The Vortex Ring State (VRS) in helicopters arises during near-vertical or vertical descent when the upward air velocity equals the downward induced main rotor flow rate. This results in the recirculation of downward flow into the rotor, forming a toroidal vortex ring. Despite the engine supplying power, rotor efficiency is lost, leading to high vibration, uncommanded pitch and roll oscillation, and limited control power, often with a descent rate of up to 6,000 fpm.

While several studies have investigated the phenomenon, there is limited understanding of the specific flight conditions (mass, air density, rotor rpm, airspeed, rate of descent, etc.) under which VRS may develop for each helicopter type. Traditional recovery methods involve increasing airspeed, but this comes with drawbacks, including pitch down and altitude loss, particularly if VRS develops at low altitudes close to the ground.

Recently, Capt. Claude Vuichard proposed a novel recovery technique. This approach recommends increasing the collective to maximum available power while simultaneously applying pedal input and opposite lateral cyclic to achieve a 10^{o} to 20^{o} bank angle, aiming for lateral movement away from the vortex. Claimed to be more effective with limited altitude loss compared to traditional methods, the proposed technique necessitates verification across diverse helicopter models, considering variations in dimensions, rotor types, and different VRS development conditions. This validation is crucial for advancing our understanding of VRS and enhancing helicopter safety practices.

The current Certification Specifications for helicopter certification lack a mandate for determining specific conditions in which the VRS occurs and for incorporating pertinent information in the Rotorcraft Flight Manual. Despite the inclusion of VRS in current training regulations (AMC2 to Part-FCL.210) for the private pilot license for helicopters (PPL-H), student pilots are primarily taught traditional recovery maneuvers. The research's dual outcome aims to enhance comprehension of the VRS phenomenon across diverse helicopters, including analytical and simulation prediction methods, and flight test procedures for its identification. Simultaneously, it will gauge the effectiveness of alternative recovery techniques, like the one proposed by Capt. Vuichard. This multifaceted outcome is pivotal for the Agency's evaluation of potential revisions to certification specifications, pilot training regulations, and associated guidance materials.

This project is part of the portfolio of EASA managed research projects funded under the European Research Programmes. Projects under this portfolio address research needs of civil aviation authorities and are geared to generate mid-term benefits after the successful completion of the project to enhance safety, security and sustainability.

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