

**Special issue on advances in rotorcraft research and technology  
49th European Rotorcraft Forum**

Pahlke, Klausdieter; Gardner, Anthony; Jones, Mike; Masarati, Pierangelo; Pavel, Marilena

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# Special issue on advances in rotorcraft research and technology: 49th European Rotorcraft Forum

Klausdieter Pahlke<sup>1</sup> · Anthony Gardner<sup>2</sup> · Mike Jones<sup>3</sup> · Pierangelo Masarati<sup>4</sup> · Marilena Pavel<sup>5</sup>

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Rotorcraft research must address the needs of society, industry, and the military in the field of rotorcraft. Increased automation, reduced pilot workload, improved performance, and quieter rotor blades are needed. These topics are covered by traditional rotorcraft disciplines. However, new challenges also arise. For instance, we must reduce CO<sub>2</sub> emissions by using hybrid or fully electric power trains and sustainable aviation fuels. Additionally, we must address new threats and operational concepts in today's military environments. Uncrewed air vehicles with a high level of automation or autonomous operations are changing the landscape of civil and military operations. Well-established and new companies are trying to address these challenges with new approaches and configurations. As with any vehicle with a thrust-to-weight ratio greater than one, a technical solution for a rotorcraft must be highly efficient, limiting the innovative designs that can be considered.

The 13 papers which were selected for this Special Issue have been identified as the best technical papers of the 49th European Rotorcraft Forum (ERF) which took place in Bückeburg, Germany, in 2023. It should be noted that the

Padfield Award winning paper by Zhang et al. on “High-fidelity aero-acoustic evaluations of a heavy-lift eVTOL in hover” is not included in this issue as it has been published previously in another journal. These papers treat key disciplines, including aerodynamics, acoustics, operations, concept design, handling qualities, and automatic path planning, and their integration for extending the flight envelope of rotorcraft.

All selected papers have been extensively edited and sometimes rewritten by the authors and peer-reviewed according to the standards of the CEAS Aeronautical Journal. The following gives a short overview of their content:

1. Sridhar et al. present a detailed study of the effect of different two-equation turbulence models on the aeromechanic behavior of a rotor in forward flight. The results indicate that differences arise when separated flows are present which underlines the need for improved simulation tools for highly loaded rotors.
2. Croke et al. analyze the results of a wind tunnel investigation into the stall of tiltrotor blades in propeller mode. The propeller was tested in a range of conditions, varying blade pitch angles, advance ratios and rotational frequencies to clearly assess the blade stall boundary.
3. Möhren et al. propose a novel procedure for the rapid and efficient estimation of dynamic loads acting on propellers in oblique inflow. The importance of this topic becomes evident when looking at the many lift and cruise configurations which are proposed today for urban mobility applications.
4. Garavello et al. summarize the engine intake design, optimization, and testing activities carried out in the frame of the Bluecopter project showing an improvement of engine efficiency with minimal-to-no impact on airframe drag.
5. Gupta et al. examine the aerodynamic performance of drone and eVTOL rotors under icing conditions using

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✉ Klausdieter Pahlke  
Klausdieter.Pahlke@dlr.de

Anthony Gardner  
Tony.Gardner@dlr.de

Mike Jones  
mjones@systemstech.com

Pierangelo Masarati  
pierangelo.masarati@polimi.it

Marilena Pavel  
M.D.Pavel@tudelft.nl

<sup>1</sup> DLR, Brunswick, Germany

<sup>2</sup> DLR, Göttingen, Germany

<sup>3</sup> Systems Technology Inc, Hawthorne, USA

<sup>4</sup> Politecnico Di Milano, Milan, Italy

<sup>5</sup> Delft University of Technology, Delft, The Netherlands

- physics-based models of different fidelity. These range from a lifting line model of the rotor with a prescribed inflow coupled with an ice accretion solver, to a 3-D unsteady Navier–Stokes analysis with a tightly coupled water droplet transport model for modeling the collection of liquid droplets over the rotor.
6. Chen et al. discuss the observations and results from wind tunnel tests and simulations of an isolated cargo container carried in a 2-point inverted-V suspension with a laterally active forward cargo hook. A controller design for the active cargo hook based on a linearized simulation model shows good load stabilization performance.
  7. Yin et al. present the activities performed in the GARTEUR Action Group RC/AG-26 to study the acoustic and aerodynamic characteristics of small rotor configurations, including the influence of rotor-rotor interactions. The acoustic and aerodynamic predictions are compared to wind tunnel test data, including performance, PIV, and acoustic directivity.
  8. Bergmann et al. introduce a serial multidisciplinary propeller optimization approach, integrating blade element momentum theory for performance assessment and Farassat's formulation 1A for noise emission prediction. The approach is combined with a genetic algorithm and applied to three different propeller design strategies.
  9. Guntzer et al. describe activities to model the noise emission of a new helicopter candidate design based on an existing noise database, corrected using a source separation technique. The resulting hemisphere database is used with a sound propagation tool to simulate various use-cases, from predicting certification noise levels to computing noise footprints based on realistic scenarios, including low noise flight procedures. The conference version of this paper won the Ian Cheeseman best paper award at the ERF.
  10. Vegh et al. introduce the collaborative effort between the U.S. Army and ONERA in comparing their concept design tool chains applied to a common set of geometries and common sizing missions. Broad agreement for the baseline mission requirements is observed for all tools. Design sensitivities show substantial differences in performance estimates versus forward flight speed.
  11. Jusko et al. report on an augmented reality (AR) system utilizing a head-mounted display to create virtual MTE (Mission Task Element) courses allowing the assessment of the handling qualities of rotorcraft for mission profiles that cannot be addressed by physical MTE ground courses. The study investigates the impact of AR visual cues on pilot handling qualities, workload ratings, and task performance.
  12. Goerzen et al. present a hierarchical planning method that was demonstrated in simulation and in autonomous flight on a Black Hawk helicopter at four different sites with different types of terrain. The addition of a mission level improves the ability of the system to keep to a desired height above ground level, while allowing the pilot or operator to better predict the route of the aircraft and time to destination.
  13. Solarski et al. provide an insight into the wide range of activities needed by Engineering and Flight Line teams to modify an existing helicopter for the needs of over water operational capabilities. Additionally, the activities needed to modify an existing helicopter to be controlled as an unmanned aerial vehicle with the use of a satellite data link are presented.

The ERF edition in 2023 in Bückeburg was the second in presence after the COVID crisis. The personal interaction and the many fruitful discussions in the breaks and in the evenings after the technical sessions are one of the key characteristics of the ERF. We were fortunate to enjoy both the beautiful city of Bückeburg and the helicopter museum at the conference site, with many unique and interesting aircraft.

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## Declarations

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