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RESEARCH REPORT

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SAE INTERNATIONAL®
Warrendale, Pennsylvania, USA

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Printed in USA

EPR2020008
ISSN 2640-3536
e-ISSN 2640-3544
ISBN 978-1-4686-0169-5

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About the Editors

Richard Hann is a researcher at the Norwegian University of Science and Technology (NTNU) on the topic of icing on unmanned aerial vehicles. In 2013, he graduated with excellence from the University of Stuttgart in Germany as an aerospace engineer. After working for three years in the petroleum industry as an upstream project engineer, he returned to academia in 2016 to start a PhD on icing of unmanned aircraft. He is part of the Centre for Autonomous Marine Operations and Systems (NTNU-AMOS) and the Centre for Integrated Remote Sensing and Forecasting for Arctic Operations (CIRFA). Richard has more than eight years of experience with numerical and experimental icing aerodynamics on wind turbines and aircraft. Today, he is one of the leading researchers in the emerging research field of icing on unmanned aircraft. He holds a position as lead aerodynamics engineer and shareholder at UBIQ Aerospace. Richard is also promoting the application of drone technology in the Arctic with several ongoing projects in the fields of meteorology, glaciology, and atmospheric pollution at the University Centre in Svalbard.

Tor Arne Johansen received his MSc in 1989 and PhD in 1994, both in electrical and computer engineering, from NTNU in Trondheim, Norway. From 1995 to 1997, he worked at SINTEF as a researcher before he was appointed Associated Professor at NTNU in 1997 and Professor in 2001. He has published several hundred articles in the areas of control, estimation, and optimization with applications in the marine, aerospace, automotive, biomedical, and process industries. In 2002, he co-founded the company Marine Cybernetics AS where he was Vice President until 2008. Prof Johansen received the 2006 Arch T. Colwell Merit Award from SAE International. He is currently a principal researcher with NTNU-AMOS and director of the Unmanned Aerial Vehicle Laboratory at NTNU and the SmallSat Laboratory at NTNU. He recently co-founded the spin-off companies Scout Drone Inspection, UBIQ Aerospace, and Zeabuz.

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Unsettled Topics in Unmanned Aerial Vehicle Icing

Abstract

Unmanned aerial vehicles (UAVs) are an emerging technology with a large variety of commercial and military applications. In-flight icing occurs during flight in supercooled clouds or freezing precipitation and is a potential hazard to all aircraft. In-flight icing on UAVs imposes a major limitation on the operational envelope. This report describes the unsettled topics related to UAV icing. First, typical UAV applications and the general hazards of icing are described. Second, an overview of the special technical characteristics of icing on autonomous and unmanned aircraft is given. Third, the operational challenges for flight in icing conditions are discussed. Fourth, technologies for ice protection that mitigate the icing hazard are introduced. Fifth, the tools and methods required to understand UAV icing and to develop aircraft with cold-weather capabilities are presented. Finally, an assessment of the current and future regulations regarding icing on UAVs is provided.

Icing is a key challenge that the UAV industry needs to address in order to unlock the full potential of this emerging technology. UAVs must be capable of safe and reliable operation in a wide range of weather conditions. This report outlines the most important challenges and gives short- and long-term recommendations on how to solve UAV icing issues.

NOTE: SAE EDGE™ Research Reports are intended to identify and illuminate key issues in emerging, but still unsettled, technologies of interest to the mobility industry. The goal of SAE EDGE™ Research Reports is to stimulate discussion and work in the hope of promoting and speeding resolution of identified issues. SAE EDGE™ Research Reports are not intended to resolve the challenges they identify or close any topic to further scrutiny.

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ISSN 2640-3536