

SAE EDGE™
RESEARCH REPORT

**Unsettled Topics in
the General Aviation
Autonomy Landscape**

Anna Mracek Dietrich

Currently in preview, click to buy full version

Unsettled Topics in the General Aviation Autonomy Landscape

Anna Mracek Dietrich
AMD Consulting

EDGE DEVELOPMENT TEAM

Paul Bartlett, *Near Earth Autonomy*

Stephen Cook, PhD, *Northrop Grumman Corporation*

Carl Dietrich, PhD, *Jump Aero Incorporated*

Maxime Gariel, PhD, *Xwing*

Clint Harper, *Urban Movement Labs*

Steve Hiles, *Xwing*

Andy Lacher, *Noblis*

Jonathan Lovegren, *Jump Aero*

Craig Milliard, *Xwing*

Marilyn Pearson, *CAE*

Wes Ryan, *NASA Ames Research Center*

Mark Skoog, *NASA Armstrong Flight Research Center*

Dave Stevens, *Joby Aviation*

Brandon Suarez, *General Atomics Aeronautical Systems*

Andy Supinie, *Federal Aviation Administration*

Andy Thurling, *Thurling Aero Consulting*

Yolanka Wulff, JD, *Community Air Mobility Initiative*



About the Publisher

SAE International® is a global association of more than 128,000 engineers and related technical experts in the aerospace, automotive, and commercial-vehicle industries. Our core competencies are lifelong learning and voluntary consensus standards development. Visit sae.org

SAE EDGE™ Research Report Disclaimer

SAE EDGE™ Research Reports focus on topics that are dynamic, in which knowledge is incomplete, and which have yet to be standardized. They represent the collective wisdom of a group of experts and serve as a practical guide to the reader in understanding unsettled subject matter. They are not meant to provide a recommended practice or protocol. The experts have assembled as a community of practitioners to contribute and collectivize their thoughts and points of view. These are not the positions of the institutions or businesses with which they are affiliated, nor is one contributor's perspective advanced over others. SAE EDGE™ Research Reports are the property of SAE International and SAE alone is responsible for their content.

About This Publication

SAE EDGE™ Research Reports provide state-of-the-art and state-of-the-industry examinations of the most significant

topics in mobility engineering. Contributors to SAE EDGE™ Research Reports are experts from academia, government, industry, and research who have come together to explore and define the most critical advancements, challenges, and future direction in areas such as vehicle automatic unmanned aircraft, cybersecurity, advanced propulsion, advanced manufacturing, Internet of Things, connectivity, and quantum technology.

Related Resources

SAE EDGE™ Research Report: Unsettled Issues Regarding the Certification of Electric Aircraft by Ravi Rajamani, PhD and Anna Mracek Dietrich
<https://saemobilus.sae.org/content/EPR2-21007/>

SAE Team

Frank Menchaca, Chief Growth Officer
Michael Thompson, Director of Standards, Information, and Research Publications
Monica Noguchi, Director of Content Acquisition and Development
Beth Miller Labeler, Product Manager
William Jucinski, Managing Technical Editor

Copyright © 2022 SAE International. All rights reserved.

No part of this publication may be reproduced, stored in a retrieval system, distributed, or transmitted, in any form or by any means, without the prior written permission of SAE International. For permission and licensing requests, contact SAE Permissions, 400 Commonwealth Drive, Warrendale, PA 15096-0001 USA; e-mail: copyright@sae.org; phone: +1-724-772-4028; fax: +1-724-772-9765.

Printed in USA

Information contained in this work has been obtained by SAE International from sources believed to be reliable. However, neither SAE International nor its authors guarantee the accuracy or completeness of any information published herein and neither SAE International nor its authors shall be responsible for any errors, omissions, or damages arising out of use of this information. This work is published with the understanding that SAE International and its authors are supplying information but are not attempting to render engineering or other professional services. If such services are required, the assistance of an appropriate professional should be sought.

EPR2022004

ISSN 2640-3536

e-ISSN 2640-3544

ISBN 978-1-4682-9130-6

To purchase bulk quantities, please contact: SAE Customer Service

E-mail: CustomerService@sae.org

Phone: 877-606-7323 (inside USA and Canada)

+1-724-776-4970 (outside USA)

Fax: +1-724-776-0790

<https://www.sae.org/publications/edge-research-reports>

About the Editor



Anna is an industry-recognized leader in policy, certification, and government relations for advanced air mobility (AAM), electric vertical takeoff and landing aircraft, and autonomous aviation. Her experiences include Mars rover testing, being the founding Chief Operating Officer of Terrafugia, testifying on AAM for Congress, and speaking at TEDGlobal. She has appeared on or been published in a wide range of outlets including CNN, *Ms. Magazine*, and *Good Morning America*. Currently, she runs AMD Consulting, serves as Regulatory Lead for Xwing, and is the Co-founder and Director of Industry and Strategy at the Committee on Air Mobility Initiative. Anna also has leadership roles in ASTM International (formerly the American Society of Testing and Materials) and General Aviation Manufacturers Association committees. She received her bachelor's and master's in aerospace engineering from the Massachusetts Institute of Technology and is a private pilot.

Currently in preview, click buy full version

contents

About the Editor

Unsettled Topics in the General Aviation

Autonomy Landscape 3

Introduction 4

History 4

Automatic versus Autonomous 5

De-conflating Automation and Other New

Technologies within Advanced Air Mobility 6

Current Regulatory Landscape 6

Technology Commercialization Paths 7

Key Perspectives 7

Industry: Systems Developers 7

Industry: Aircraft Manufacturers 8

Industry: Operators 9

Industry: Pilots 10

Regulators 10

Civil Aviation Authorities 10

State/Local Decision-makers 10

National Aeronautics and Space

Administration 11

Standards Development Efforts 11

ASTM International 12

RTCA 12

SAE International 12

American National Standards Institute 12

International Civil Aviation Organization 13

The Traveling Public 13

Simplified Vehicle Operations 13

Optionally Piloted Aircraft 14

Unmanned Aircraft Systems 14

Remotely Piloted Aircraft 15

Self-piloted Aircraft 16

Occupied Unmanned Aircraft 16

General Considerations for Autonomous

General Aviation Aircraft 16

Minimum Acceptable Level of Safety 16

Reversionary Modes and the Role of the Human 17

Certification Approaches 17

Performance-based System Requirements 18

Standards for Autonomy 19

Terminology 19

Definition and Role of Pilot in Command 20

Airspace Integration for Autonomous

General Aviation Aircraft 20

Detect and Avoid 20

Command and Control Link 22

Air Traffic Management and Airspace

Integration 22

Autonomous/Digital Flight Rules 23

En-N Operations 23

New Training for Autonomous General

Aviation Aircraft 23

Training and Licensing Issues for Simplified

Vehicle Operations Aircraft 24

Training and Licensing Issues for Optionally

Piloted Aircraft 24

Training and Licensing Issues for Unmanned

Aircraft 25

Challenges and Opportunities 25

Summary 25

SAE EDGE™ Research Reports 26

Next Steps for Autonomy in the General

Aviation Landscape 26

Recommendations 26

Definitions 26

Acknowledgments 27

References 27

Contact Information 30



Unsettled Topics in the General Aviation Autonomy Landscape

Abstract

The extent of automation and autonomy used in general aviation (GA) has been steadily increasing for decades, with the pace of development accelerating recently. This has huge potential benefits for safety given that it is estimated that 75% of the accidents in personal and on-demand GA are due to pilot error. However, an approach to certifying autonomous systems that relies on emergency modes limits their potential to improve safety. Placing a human pilot in a situation where they are suddenly tasked with flying an airplane in a failed condition, often without sufficient situational awareness, is overly demanding.

This consideration, coupled with advancing technology that may not align with a deterministic certification paradigm, creates an opportunity for new approaches to certifying autonomous and highly automated aircraft systems. The new paths must account for the multifaceted aviation approach to risk management which has interlocking requirements for airworthiness and operations (including training and airspace integration). They occur across a variety of different operational paradigms with varying roles for the human and the systems in question. If implemented properly, autonomy can take GA safety to the next level while simultaneously increasing the number and variety of aircraft and transportation options they provide.

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. These reports are not intended to resolve the challenges they identify or close any topic to further scrutiny.

ANNA MRACEK DIETRICH
AMD Consulting

Edge Development Team

Paul Bartlett, *Near Earth Autonomy*
Stephen Cook, PhD, *Northrop Grumman Corporation*
Carl Dietrich, PhD, *Jump Aero Incorporated*
Maxime Gariel, PhD, *Xwing*
Clint Harper, *Urban Movement Labs*
Steve Hiles, *Xwing*
Andy Lacher, *Noblis*
Jonathan Lovegren, *Wisk Aero*
Craig Milliard, *Xwing*
Marilyn Pearson, *CAE*
Wes Ryan, *NASA Ames Research Center*
Mark Skoog, *NASA Armstrong Flight Research Center*
Dave Stevens, *Joby Aviation*
Brandon Suarez, *General Atomics Aeronautical Systems*
Andy Supinie, *Federal Aviation Administration*
Andy Thurling, *Thurling Aero Consulting*
Yolanka Wulff, JD, *Community Air Mobility Initiative*