

**Unsettled Topics on
the Benefit of Additive
Manufacturing for
Production at the Point
of Use in the Mobility
Industry**

Kevin T. Slattery, DSc

Unsettled Topics on the Benefit of Additive Manufacturing for Production at the Point of Use in the Mobility Industry

Kevin T. Slattery, DSc
at Barnes Global Advisors

EDGE DEVELOPMENT TEAM

Bruce McLean, *AM industry Consultant*
Jeffrey Gadder, *U.S. Army*
Nick Wale, *RPM Innovations, Inc.*

Jamie Cleland, *Upshot Ventures*
Fernando Ferreira Fernandez,
F3 Consulting





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 life-long 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 automation, unmanned aircraft, cybersecurity, advanced propulsion, advanced manufacturing, Internet of Things, and connectivity.

Related Resources

SAEMOBILUS® Advanced Manufacturing Knowledge Hub
<https://saemobilus.sae.org/advanced-manufacturing/>

SAE EDGE™ Research Report: Unsettled Topics on Surface Finishing of Metallic Powder Bed Fusion Parts in the Mobility Industry by Kevin T. Slattery, DSc
<https://saemobilus.sae.org/content/EPR2021001/>

SAE EDGE™ Research Report: Unsettled Topics on Nondestructive Testing of Additively Manufactured Parts in the Mobility Industry by Kevin T. Slattery, DSc
<https://saemobilus.sae.org/content/EPR2020017/>

SAE EDGE™ Research Report: Unsettled Topics on the Feasibility and Desirability of Using Additive Manufacturing in the Mobility Industry by Kevin T. Slattery, DSc
<https://saemobilus.sae.org/content/EPR2020009/>

SAE Team

Frank Menchaca, Chief Growth Officer
Michael Thompson, Director of Standards, Information, and Research Publications
Monica Nogueira, Director of Content Acquisition and Development
Beth Ellen Dibeler, Product Manager
William Kucinski, Managing Technical Editor

Copyright © 2021 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.

EPR2021006

ISSN 2640-3536

e-ISSN 2640-3544

ISBN 978-1-4686-0293-7

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



Andy Kunkel—Triad Production Group

Kevin T. Slattery, DSc— Kevin is a Principal ADDvisor® at The Barnes Global Advisors (formerly The Barnes Group Advisors). His primary expertise is in Metallic Additive and Metals Manufacturing, focusing on test program development and process and product verification, qualification, and certification. He has supported over 25 clients on five continents throughout the entire additive manufacturing value chain—from raw material to finished components. He was a 2020 Ambassador for America Makes and was part of the Materials Challenge Silver Medal team in the United States (US) Air Force Rapid Sustainment Office Advanced Manufacturing Olympics.

Kevin was previously the Chief Scientist for Additive Manufacturing at Boeing Research and Technology (BR&T). He was responsible for developing and integrating the technology roadmaps and development plans for metallics additive manufacturing for the entire company, along with building and leading a multiskilled team to execute and deliver the technology throughout the enterprise. Prior to that, he was Chief Scientist for Metals, Ceramics, and Mechanical Systems at BR&T, with the responsibility for portfolio development and coordination, while executing the additive manufacturing portion.

He served as Division Chief Engineer for the US Navy and US Air Force fighter aircraft and US Army rotorcraft in Boeing's Military Sustainment organization. From 1997 to 2012, he was on the BR&T Metals Team as a researcher and senior manager, where he primarily developed advanced low-cost titanium

processing technologies supporting all Boeing products. He was the technical and programmatic lead in implementing the first aerospace metal-additive manufactured structural aircraft components for both spares and production, with five other first-in-the-industry technology implementations.

He began his career at McDonnell Douglas (now Boeing) as a non-destructive testing engineer, where he developed inspection technologies for metallic and composite components, along with integrating the impact of discontinuities with the acceptance criteria for carbon/epoxy composites.

Dr. Slattery holds Bachelor of Science and Master of Science degrees in Metallurgical Engineering from the University of Missouri-Rolla (now Missouri S&T) and a Doctor of Science in Material Science and Engineering from Washington University in St. Louis. He currently holds 36 US patents, with another 15 applications pending; along with 36 significant publications and conference presentations.

contents

About the Editor

Unsettled Topics on the Benefit of Additive Manufacturing for Production at the Point of Use in the Mobility Industry . . . 3

Introduction	4
<i>State of the Industry</i>	4
<i>Unsettled Domains in AM Production at the Point of Use</i>	4

Benefits of AM for Production at the Point of Use	4
<i>Reduced Inventory</i>	5
<i>Speed of Delivery</i>	6
<i>Local Customization</i>	6
<i>Supply Chain Simplification</i>	8
<i>Recommendations</i>	10

Challenges to AM for Production at the Point of Use	11
<i>Selection of Materials and Processes</i>	12
<i>Feedstock Safety, Cleanliness, and Shelf Life</i>	12
Powers	13
Polymer Liquids	13
Wire and Foil	13

<i>Post-processing, Inspection, and Part Acceptance</i>	15
<i>Obtaining Approval by the Engineering Authority</i>	15
<i>Equipment and Operator Utilization</i>	16
<i>Recommendations</i>	16

Alternatives	17
<i>AM Versus Conventional Manufacturing at the Point of Use</i>	17
<i>AM Versus Centralized Air and Air Shipment</i>	18
<i>Recommendations</i>	19

Summary	19
<i>Determining if AM Production at the Point of Use Is Appropriate</i>	19
<i>Conclusion</i>	19
<i>SAE EDGE™ Research Reports</i>	20
<i>Next Steps for AM Production at the Point of Use</i>	20
<i>Recommendations</i>	21
<i>Definitions</i>	21
<i>Acknowledgments</i>	21
<i>Contact Information</i>	21



Unsettled Topics on the Benefit of Additive Manufacturing for Production at the Point of Use in the Mobility Industry

Abstract

An oft-cited benefit of additive manufacturing (AM), or “3D-printing” technology is the ability to produce parts at the point of use by downloading a digital file and making the part at a local printer. This has the potential to greatly compress supply chains, lead times, inventory, and design iterations for custom parts. As a result of this possibility, both manufacturing and logistics companies are investigating and investing in AM capacity for production at the point of use. It can be imagined, however, that the feasibility and benefits of point-of-use manufacture are a function of size, materials, build time, manufacturing complexity, cost, and competing technologies. Because of this, there are instances where the viability of point-of-use manufacturing ranges from the perfect solution to the worst possible choice.

As the fourth installment in an ongoing series on AM, this report discusses the benefits, challenges, trade-offs, and other determining factors regarding AM at the point of use.

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

Notes on terminology:

- **Product**: What the customer purchases from the manufacturer
- **Assembly**: Putting together multiple AM and non-AM parts to make the product
- **Product OEM (Original Equipment Manufacturer)**: Organization that makes the product (automobile, airplane, launch vehicle, etc.) that is sold to the customer
- **Tier-1**: Supplier of integrated assemblies or subsystems to a product OEM
- **Tier-2**: Supplier of subassemblies or nonintegrated subsystems to a Tier-1
- **Part OEM**: Organization that makes a part that goes into a larger product (either directly or via a Tier-1 or Tier-2 supplier)
- **Product team**: The integrated team for a product or a substantial subpart of a product
- **Using organization**: An organization that uses a product and is concerned with keeping the product operational

KEVIN T. SLATTERY, DSc
The Barnes Global Advisors

EDGE Development Team

Bruce McLean, *AM Industry Consultant*
Jeffrey Gaddes, *U.S. Army*
Nick Wald, *RPM Innovations, Inc.*
Jamie Cleland, *Upshot Ventures*
Fernando Ferreira Fernandez, *F3 Consulting*

ISSN 2640-3536