

**SAE INTERNATIONAL**

# **GLOBAL MATERIAL & PROCESS SPECIFICATIONS TO SUPPORT CERTIFICATION OF AM PARTS FOR AVIATION**

EASA Additive Manufacturing Workshop  
28 September 2017

John Clatworthy, SAE International

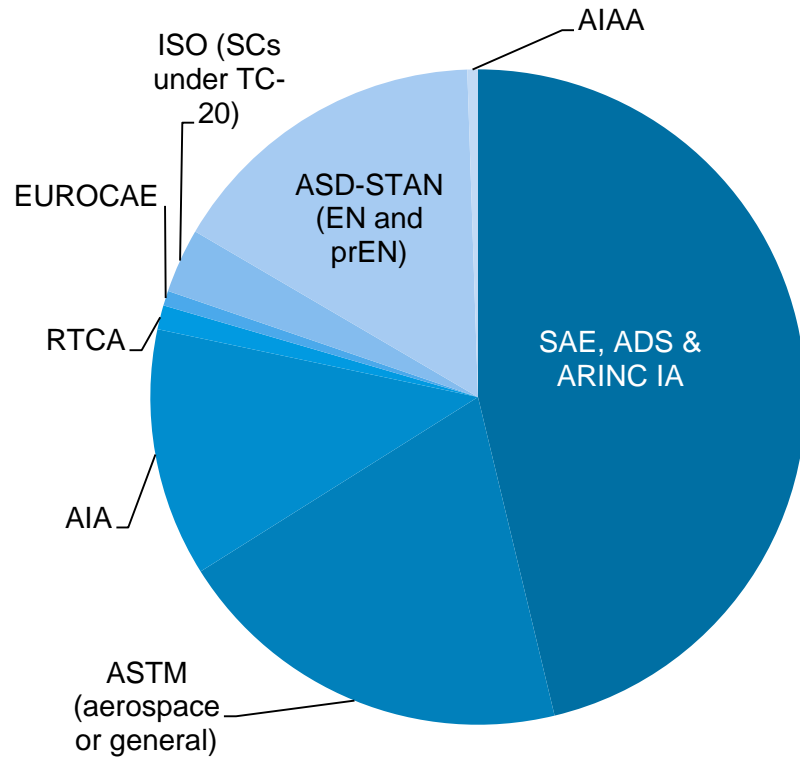


# AGENDA

- SAE Aerospace Standards Program Overview
- SAE's Role in Developing AMS Specifications to Support Aircraft Certification
- SAE Additive Manufacturing Committee Overview & New Developments

# SAE AEROSPACE STANDARDS PROGRAM OVERVIEW

# Aerospace Standards Landscape: SAE Global Leadership



**8500+**

standards

**150+**

committees, subcommittees, and task groups

**11000+**

global participants

**Civil and Military**

applications addressed



# **SAE'S ROLE IN DEVELOPING AMS SPECIFICATIONS TO SUPPORT AIRCRAFT CERTIFICATION**

# EASA/FAA Requirements

## CS/Part 25.603 Materials

- All materials used to produce structural elements whose failure would have a negative impact on safety must:
  - Be established on the basis of experience or test
  - **Conform to approved specifications that ensure having strength & other properties assumed in the design data**
  - Take into account effects of environmental conditions

## CS/Part 25.605 Fabrication Methods

- All manufacturing processes must:
  - Produce a consistently sound structure
  - If a fabrication process(e.g. gluing, spot welding, heat treating) requires close control, **the process must be performed under an approved process specification**
  - Be substantiated by a test programme

## CS/Part 25.613 Material Strength Properties & Material Design Values

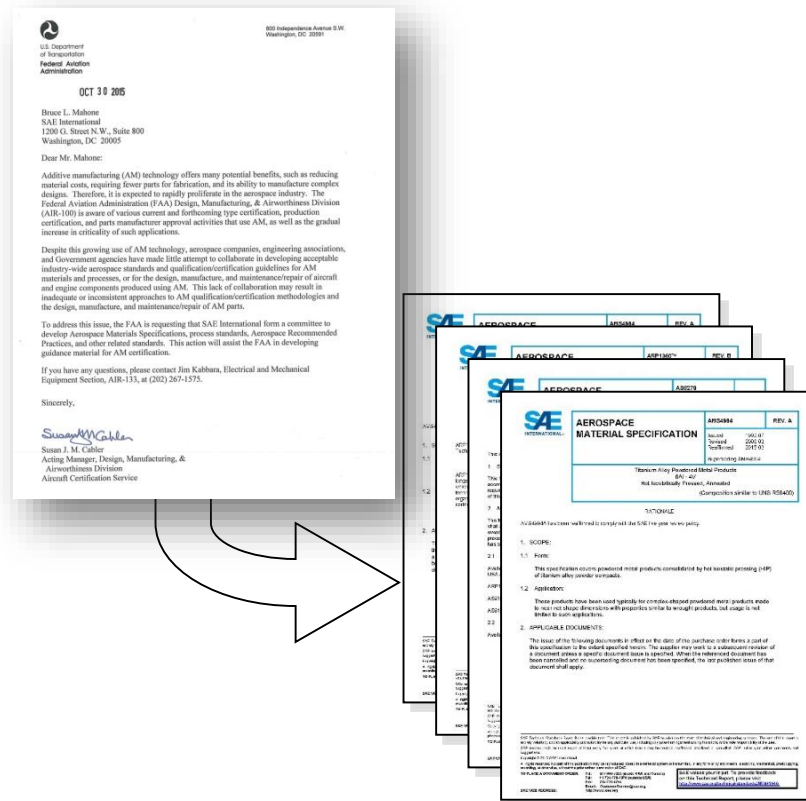
- Strength and Design values used to design structure must:
  - **Be based on testing of materials meeting approved specifications to establish design values on a statistical basis**

# FAA Task Request to SAE

Signed October 30, 2015

Requested SAE International  
'form a committee to develop  
Aerospace Materials Specifications,  
process standards, Aerospace  
Recommended Practices, and other  
related standards ...

to assist the FAA in  
developing guidance  
material for AM certification.'





# SAE AMS Key Principles Support Aircraft Certification

## AMS = Aerospace Material Specifications

- Establish appropriate requirements and controls to ensure quality and consistency of final product
- Traceable to statistically substantiated material property data
- Enable public material property database with verifiable pedigree
- Downgrading the properties or characteristics of published AMS are not permitted
- Provide foundation for regulatory acceptance and certification processes

### Minimum Tensile Properties

Section Size (In)	Tensile Strength (ksi)	Yield Strength (ksi)	Elongation (%)
Direction >>	Z	Z	Z
Up to 0.5	120	50	30

# SAE ADDITIVE MANUFACTURING COMMITTEE (AMS-AM) OVERVIEW & NEW DEVELOPMENTS

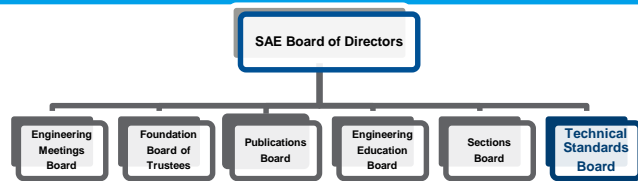
## Formed in 2015

## Currently

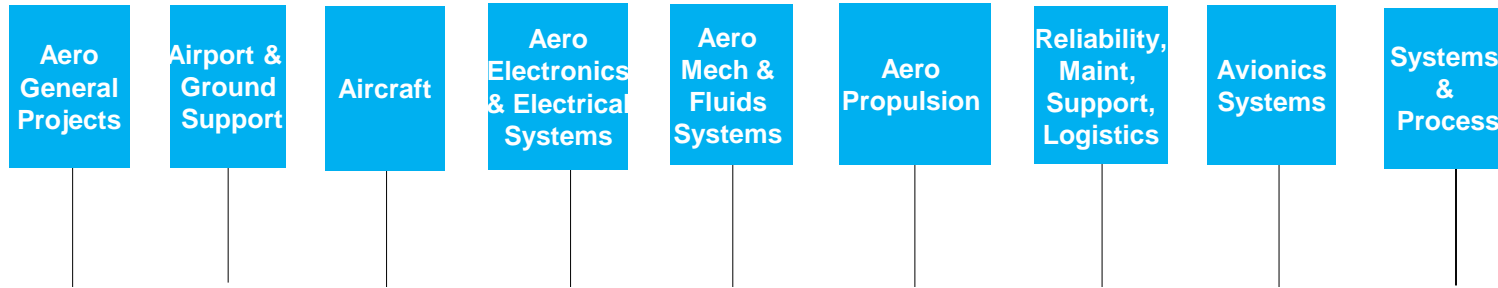
- 250+ members from 15 countries
- 6 specs and 2 guidance documents under development
- Polymer Subcommittee formed January 2017



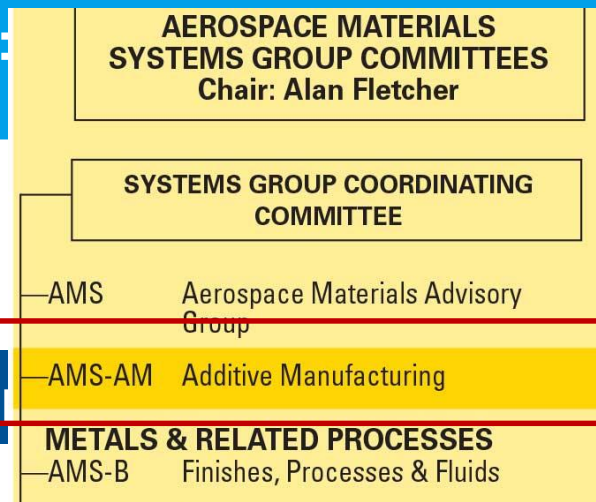
# SAE Organizational Structure



## Systems Groups



## Technical Standards Committees



AEROSPACE MATERIALS SYSTEMS GROUP COMMITTEES Chair: Alan Fletcher	
SYSTEMS GROUP COORDINATING COMMITTEE	
AMS	Aerospace Materials Advisory Group
AMS-AM	Additive Manufacturing
<b>METALS &amp; RELATED PROCESSES</b>	
AMS-B	Finishes, Processes & Fluids
AMS-D	Nonferrous Alloys
AMS-E	Carbon & Low Alloy Steels & Specialty Steels & Alloys
AMS-F	Corrosion & Heat Resistant Alloys
AMS-G	Titanium, Beryllium & Refractory Materials
AMEC	Aerospace Metals Engineering
AMEC-SE	Surface Enhancement
<b>NON-METALS &amp; RELATED PROCESSES</b>	
AMS-CE	Elastomers
AMS-P	Polymeric Materials
AMS-P-17	Polymer Matrix Composites
AMS-CACRC	ATA/IATA/SAE Commercial Aircraft Composite Repair Committee
	Repair Materials TG Repair Techniques TG Inspection TG Design TG Training TG Analytical Repair Techniques TG
AMS-G-8	Organic Coatings Corrosion & General Test Methods TG Surface Preparation & Cleaning TG Appearance & Durability TG
AMS-G-9	Aerospace Sealing New Sealant Specification Rqmts TG Sealant Removal Techniques TG Surface Preparation for Sealing & Finishing TG Fuel Cell TG
AMS-J	Aircraft Maint Chemicals & Materials
AMS-M	Aerospace Greases
<b>NON-DESTRUCTIVE EVALUATION</b>	
AMS-K	Non-destructive Methods & Processes Magnetic Particle & Penetrant Methods TF

## Scope:

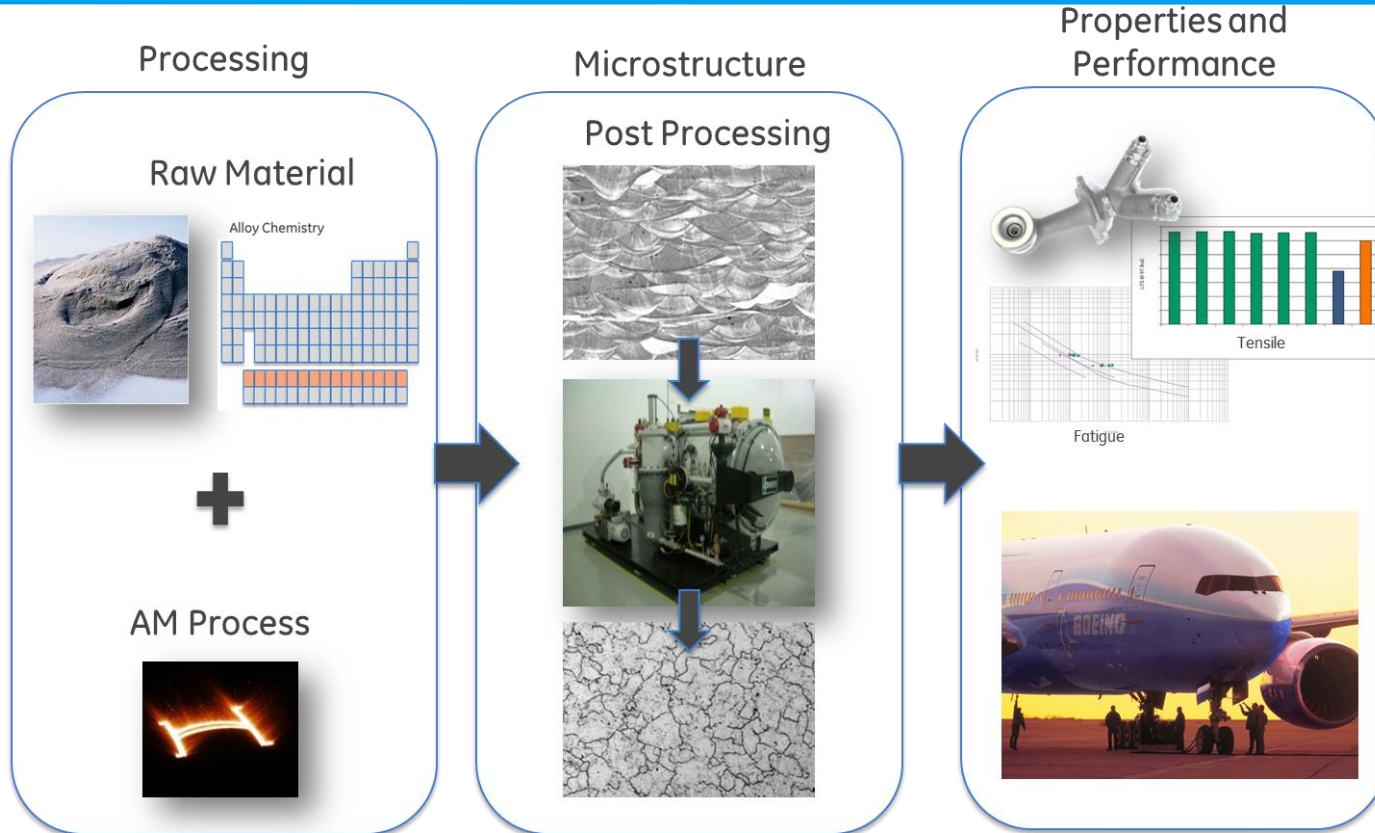
**...to develop and maintain aerospace material and process specifications ...for additive manufacturing, including precursor material, additive processes, system requirements and post-build materials, pre-processing and post-processing, non-destructive testing and quality assurance.**

**...the committee will collaborate with other standards development organizations such as MMPDS, ASTM Committee F42 on Additive Manufacturing, AWS D20, Nadcap Welding Task Group, America Makes, CMH-17, and regulatory authorities such as FAA, EASA, US DoD, and NASA.**

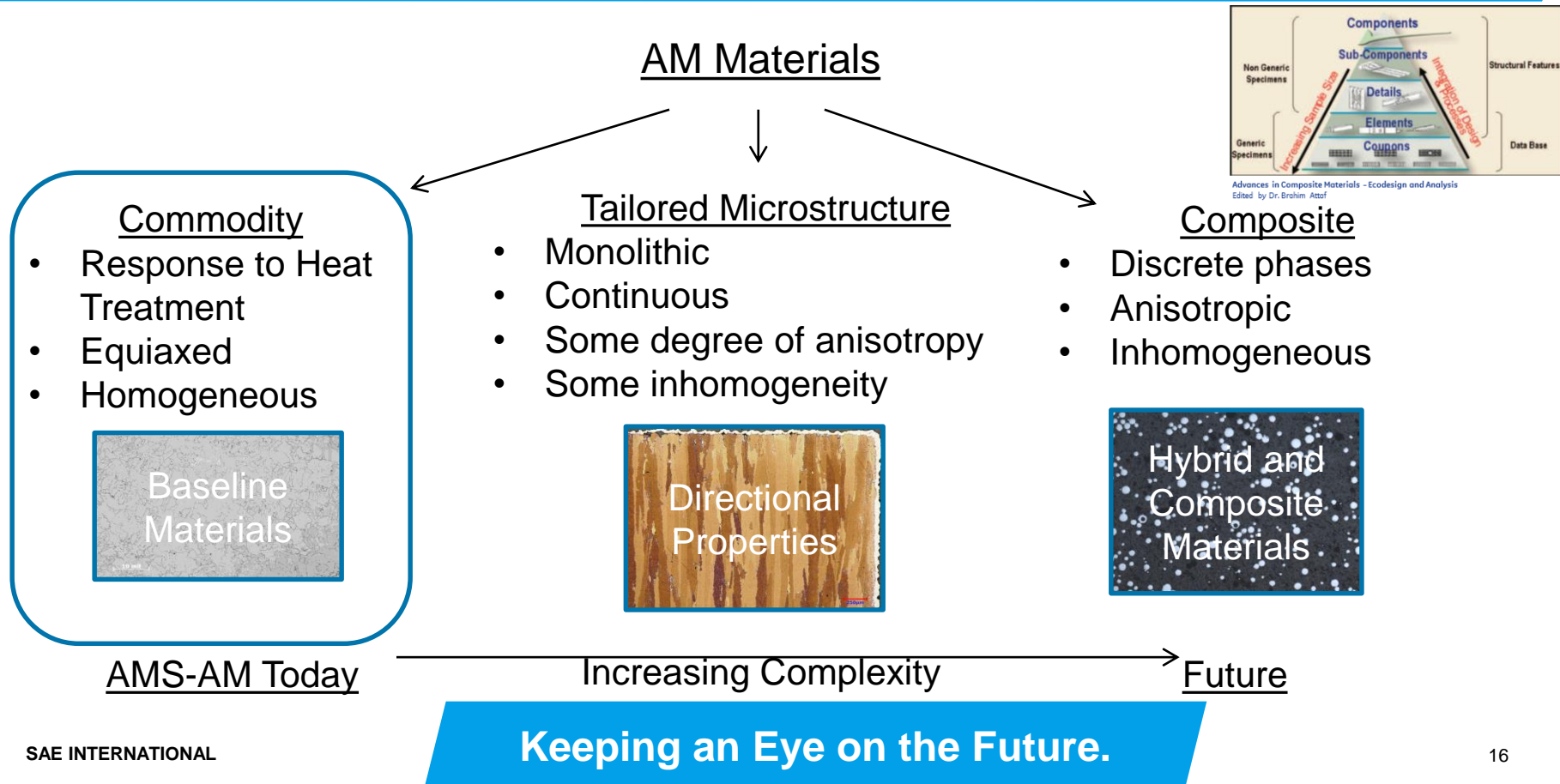
# SAE AMS-AM Committee Charter Objectives

- ...**develop Aerospace Material Specifications (AMS)** for the procurement of additive precursor and manufactured materials ... When applicable, ensure the material specification is tied to the appropriate shared material property database.
- Further the adaptation of industry sponsored material specifications through coordination with **MMPDS, ASTM, AWS, Nadcap, other AMS committees** and associated organizations.
- Coordinate requirements for publishing data in shared material property databases with **MMPDS** Emerging Technology Working Group for new metallic materials and **CMH-17** for new composite materials.
- Establish a system to ensure material specifications are **controlled and traceable**.

# Additive Manufacturing Process Basics

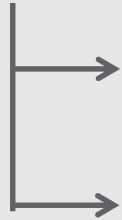


# Increasing Degree of Complexity...





**Material Specification** (i.e. finished product material requirements)



**Process Specification**

**Feedstock Material Specification**

**Feedstock Process Specification**

- **Hierarchical**
- **Parent spec for AM produced material**
- **Child specs for AM build process & metallic feedstock**

## **SAE AM Material Specifications**

- Describe metallic powder manufacturing, composition, size distribution and quality, AM build process controls and resulting AM material requirements for use in typical aerospace applications

## **SAE AM Process Specifications for AM Material Fabrication and Metallic Powder Production**

- Establish necessary controls and metrics to ensure quality and consistency in material produced by AM processes
- Fixed process enables establishment of lot acceptance values, specification minimums and ultimately, design allowables

## **SAE AM Build Process Specification Key Requirements**

- Address generic laser powder bed process
  - Specific machine settings, adjustments, monitoring and control are defined in proprietary process control documentation (PCD)
- Utilize statistical process controls (SPC) to monitor process or material element condition and demonstrate process stability
- Validate and substantiate AM material produced through chemical, metallurgical and mechanical testing protocols to demonstrate acceptance, equivalency and repeatability to parent specification

# SAE AMS-AM Committee – Current Metallic Activity

## Continued Growth...

### **3 specifications submitted for third ballot:**

- **Material – AMS7001 LPBF 625 Powder**
- **Process – AMS7002 Powder Manufacturing**
- **Process – AMS7003 LPBF Process**

### **2 sets of guidelines balloted:**

- **Data Submission for Specification Minimums**
- **Terminology for Additive Manufacturing (supplement to ISO/ASTM 52900 with aerospace specific terminology)**

## Continued Growth...

### **2 specifications submitted for second ballot:**

- **Material – AMS7000 LPBF 625 Finished Product (includes specification minimum data)**
- **Material – AMS7004 PTAW Ti-6-4**

### **1 specification under development:**

- **Process – AMS7005 High Deposition Rate AM Process**

## Polymer Subcommittee established January 2017

### Developing framework for polymeric material & process specifications

- **Initial target commercialized materials**
  - PEI Copolymer (9085)
  - Enhanced Flow PEI (1010)
- **Coordinate with America Makes/NIAR project**
- **AMS7100 Fused Deposition Modeling (FDM) Additive Manufacturing Process**
- **AMS7101 Fused Deposition Modeling (FDM) Material Characterization Method**



# AMS-AM Summary

- **Addresses the needs of the aerospace community for consensus industry standards**
- **Initiated for metals but expanding to other material systems and other AM-specific technology**
- **Utilizes a specification hierarchy of material and processing specifications that work together to establish the necessary controls to ensure quality and consistency in AM-produced products**

# Upcoming SAE AMS-AM Meetings

## Monthly Virtual Meetings (Metals & Polymers)

When: October 16 – 19, 2017

Sponsor: LAI International

Where: Chandler, AZ, USA

Who: Open registration



When: April 23 – 26, 2018

Sponsor: Norsk Titanium AS

Where: Hønefoss, Norway

Who: Open registration



Register online at [www.sae.org](http://www.sae.org).

# QUESTIONS?

Dave Abbott  
GE Aviation  
SAE Chair  
m +1 513.284.9677  
[Dave.abbott@ge.com](mailto:Dave.abbott@ge.com)

Laura Feix  
Aerospace Standards Engineer  
SAE International  
m +1 724.799.9198  
[Laura.feix@sae.org](mailto:Laura.feix@sae.org)

John Clatworthy  
Aerospace Standards Engineer  
SAE International  
o +44 1189331437  
m +44 7798 826443  
[John.clatworthy@sae.org](mailto:John.clatworthy@sae.org)

Rhonda Joseph  
Aerospace Standards Specialist  
SAE International  
o +1.724.772.7176  
m +1.724.591.6364  
[Rhonda.joseph@sae.org](mailto:Rhonda.joseph@sae.org)



# AMS-AM Committee Expansion

