A Systems Engineering Approach to Standards Development

GLOBAL PRODUCT DATA
INTEROPERABILITY
SUMMIT 2025

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Vice-Chair of the Digital Standards Alliance

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Professional experience

- Over 20 years' experience leading software and hardware product development projects.
- Over 10 years' developing solutions that leverage artificial intelligence and machine learning.
- Dedicated to establishing best practices for authoring and use of digital standards.

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SAE INTERNATIONAL®

MISSION: *To advance mobility knowledge and solutions for the* ***benefit of humanity***

NEUTRAL FORUMS

Address society's mobility needs

RESOURCES

Engineering resources to advance mobility

EDUCATION

STEM programs and professional courses, building the workforce

COMMUNITY

Global community pulling from each other's collective wisdom

STANDARDS

Consensus-based standards that advance quality, safety and innovation

ROLES IN INDUSTRY: Professional Association, SDO, Publisher, STEM Educator, Professional Workforce Development, Knowledge & Networking Resource

SAE Community: Aerospace and Ground Vehicle

105+
Years

11,000+
Participants

44,000+
Standards

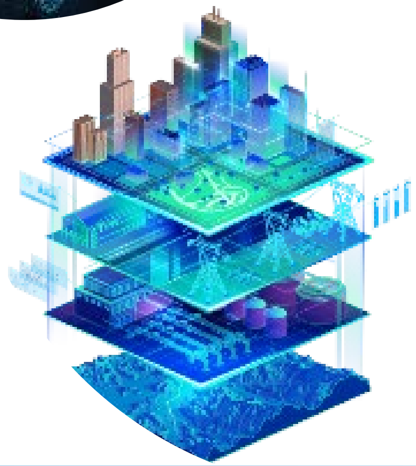
59+ Countries

570+
Technical Committees

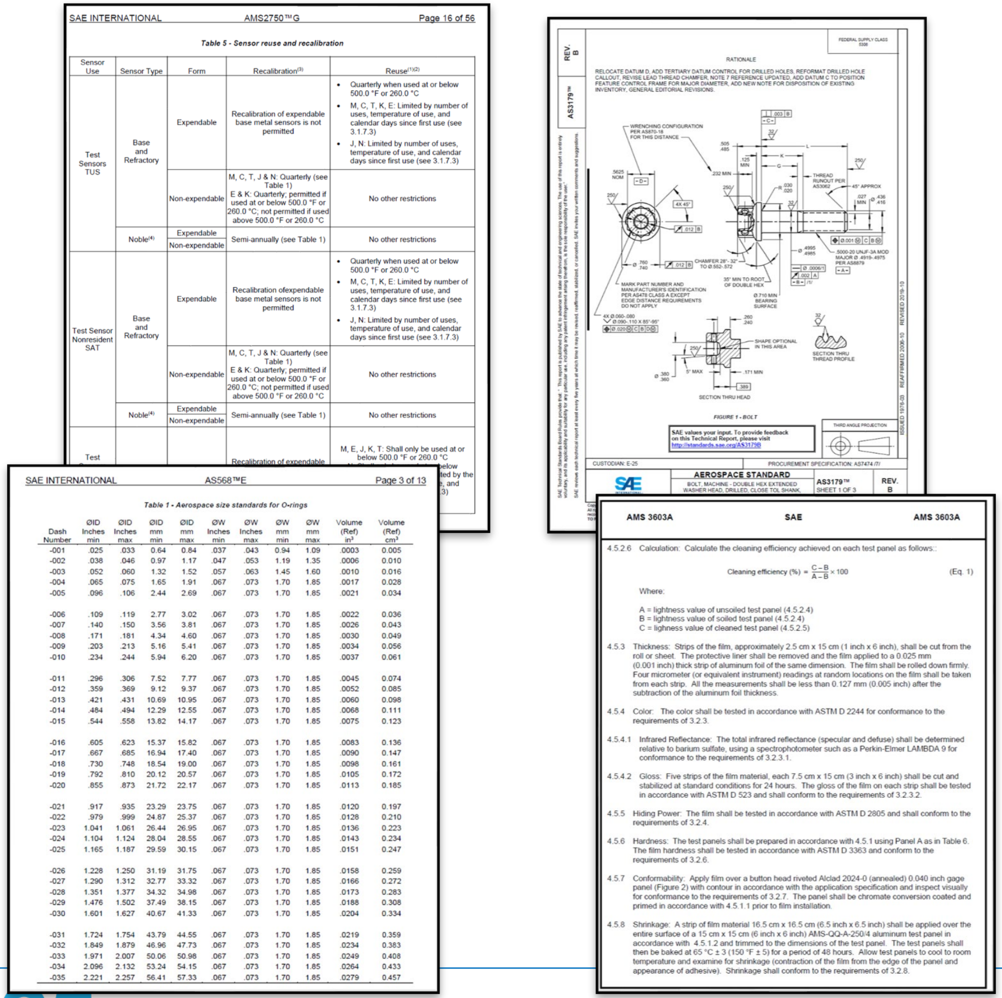
1,800+
Works in Progress

550+
Committees & steering groups

How Do We Get to a Digital Ecosystem?



When Starting Here?



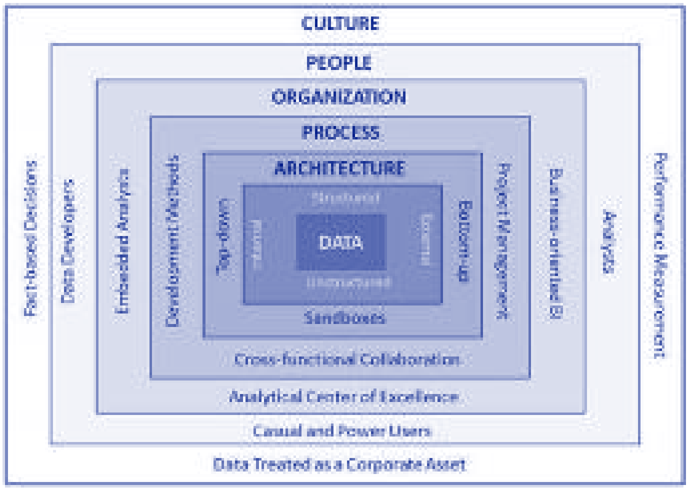
VOC from Systems Engineers

	Benefits					Interoperable Formats								Use Cases/Purpose							Authoring Recommendations				Other	
	Traceability	Faster Product Development	Efficiency Gains	Reusability	Better Standards	ReqIF	Extend NISO-STS	SysML	UAF, UML, OPL, or Other Simpler Modeling Languages	MathML	Tool Agnostic (JSON, HTML)	QIF	PDF as Authoritative Source	Processes/Support Compliance	Support Certification	Performance Standards	Data Exchange Interfaces	Trade Space Analysis	Partner Expert Modelers with Authors	Component Libraries	Modularization of Standard Content	Use Authoring Framework	Graphics/Table Challenges	Validation	Ontology	Policy/Business Challenges
Government						X		X					X											X	X	
Aero OEM	X	X	X	X	X	X	X		X	X	X		X	X								X	X	X	X	
Aero OEM								X	X					X	X							X				
Digital Consultant		X	X	X	X			X											X			X				
Digital Consultant	X			X		X		X			X											X				
Digital Consultant	X				X	X		X					X	X						X	X	X			X	
CV OEM	X				X		X		X		X	X	X	X										X	X	X
Aero OEM					X						X	X		X			X			X	X				X	
Government	X	X	X	X	X			X	X	X				X		X	X			X	X	X				
Academia	X		X	X	X					X	X			X	X		X	X		X					X	X
Aero OEM								X	X															X		
Academia					X				X					X												
	50%	25%	33%	42%	67%	33%	17%	58%	50%	25%	42%	17%	33%	67%	17%	8%	25%	8%	8%	33%	25%	50%	8%	33%	50%	17%

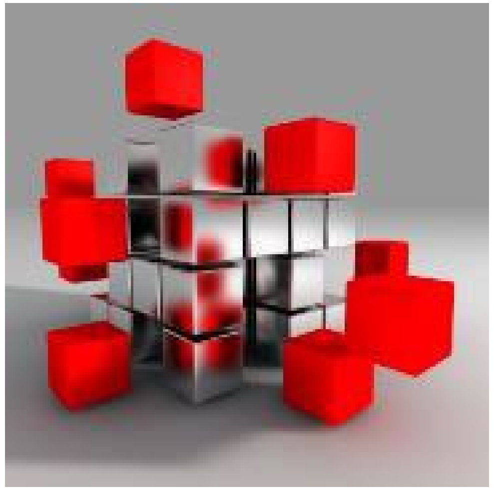
Need **authoring framework** for standards

Problems Today:	Inconsistency In Standards	Interoperability Lacking	Standards are not Automation-Ready	Ambiguity in Standards

How Should Standards Organizations Address This?



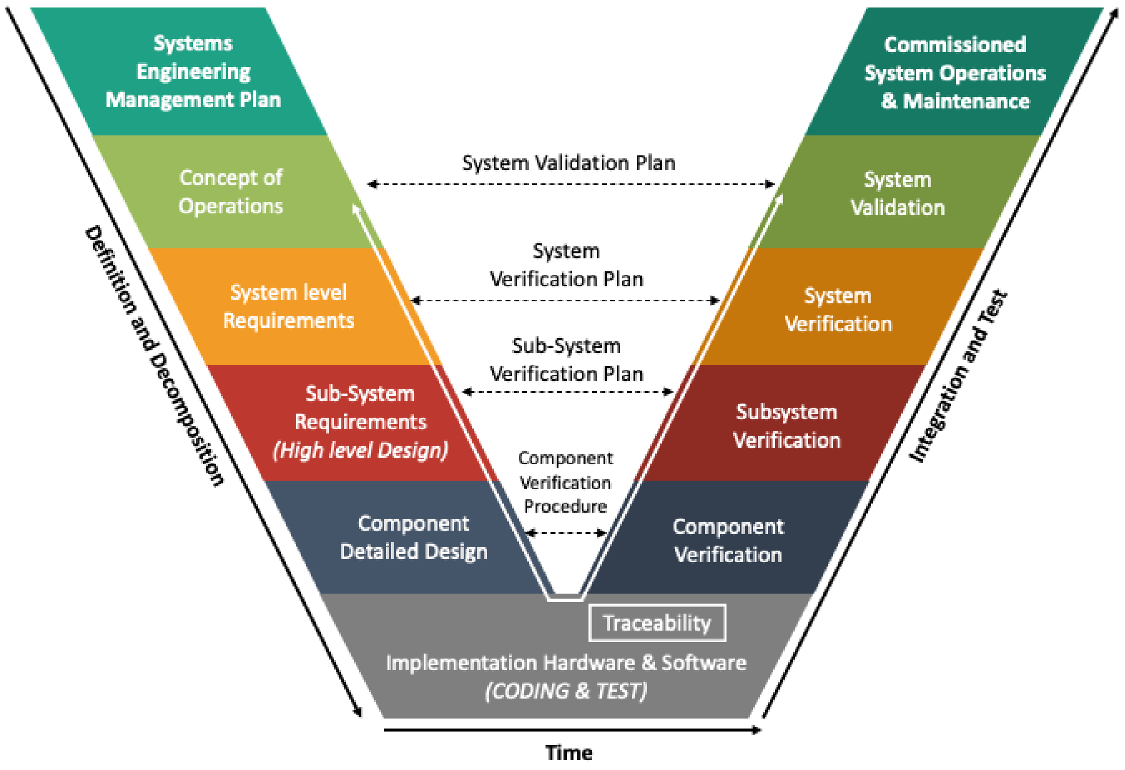
Implement an Authoring Framework



Modularize Standards Documents

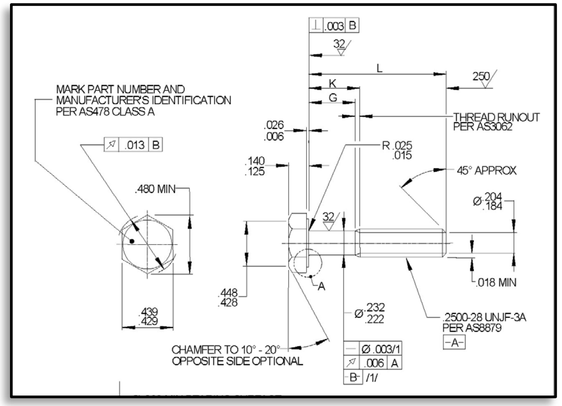
Implement a Framework

Approach, Methodology, Etc.



Editorial and Structure Recommendations are a Start

Drawings and Variables



Content

3.3.2 Average Grain Size

Shall be no larger than 20 microns (20 µm), determined in accordance with ASTM E112, using the intercept method at 500X magnification.

3.4 Quality

The product, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from imperfections detrimental to usage of the product.

3.4.1 Density

Shall be at least 99.0% of theoretical density, determined by the water displacement method. The accuracy of density determination shall be to the second decimal, or better.

3.4.1.1 The theoretical density shall be calculated using Equation 1:

$$\text{Theoretical Density (gm/cm}^3\text{)} = \frac{100}{\dfrac{100 - \%\text{Be0}}{1.8477\ \text{gm/cm}^3} + \dfrac{\%\text{Be0}}{3.009\ \text{gm/cm}^3}} \qquad \text{(Eq. 1)}$$

3.4.1.2 Thermally Induced Porosity (TIP) Resistance

3.4.1.2.1 Sample product shall be subjected to a TIP test consisting of a heat treatment in inert atmosphere or under vacuum at 1450 °F (788 °C) for 1 hour.

Document Structure

Nickel Alloy, Brazing Filler Metal
73Ni - 0.75C - 4.5Si - 14Cr - 3.1B - 4.5Fe
1790 °F (977 °C) Solidus to 1970 °F (1077 °C) Liquidus
(Composition similar to UNS N99600)

RATIONALE

AMS4775K incorporates industry standard requirements of AWS A5.8, revises Title, Burn-off of Binder (3.3.1.1, 3.3.2.2) Powder mesh designations (3.5.1.1), Sampling and Testing (4.3.2.1), and Reports (4.4), prohibits unauthorized exceptions (3.6), and is a Five-Year Review and update of this specification.

1. SCOPE

1.1 Form

This specification covers a nickel alloy in the form of wire, rod, strip, foil, and powder and a viscous mixture (paste) of the powder in a suitable binder.

1.2 Application

This filler metal has been used typically for joining corrosion and heat-resistant steels and alloys requiring corrosion and oxidation resistant joints with good strength at elevated temperatures, but usage is not limited to such applications. Also may be used as a corrosion and oxidation resistant hard coating.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

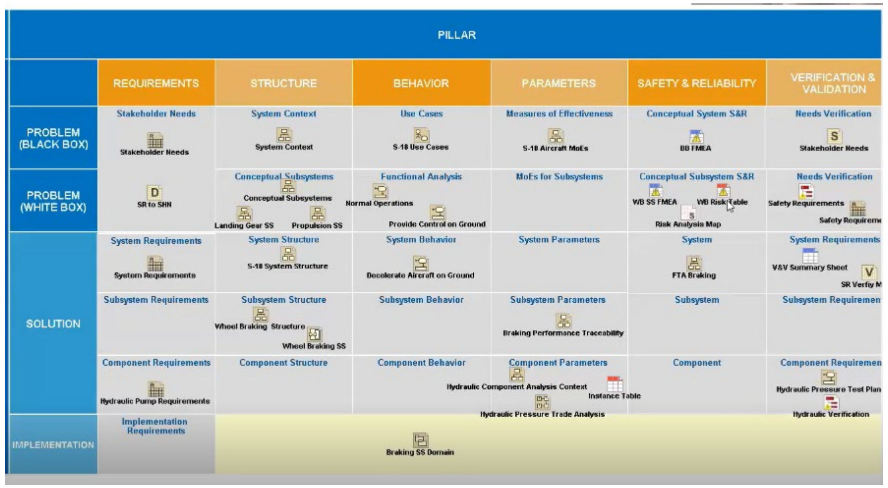
Table Structure

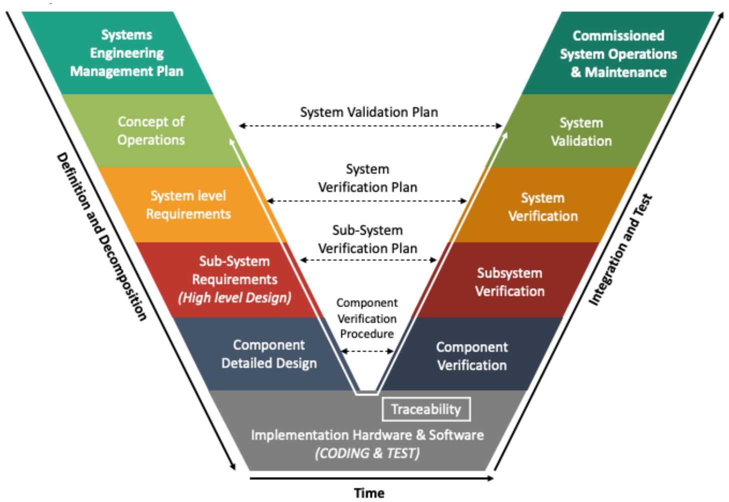
Table 2 - Hardness and minimum tensile properties

Condition	Tensile Strength ksi (MPa)	Yield Strength at 0.2% Offset ksi (MPa)	Elongation in 4D %	Reduction of Area %	Hardness (1) HB	Hardness (1) HRC	Temperature/ Time °F (°C)/Hours
H900	190 (1310)	170 (1172)	10	40 (2)	388-444	40-47	900 (482)/1 (3)
H925	170 (1172)	155 (1069)	10	44 (2)	375-429	38-45	925 (496)/4 (4)
H1025	155 (1069)	145 (1000)	12	45	331-401	34-42	1025 (552)/4 (4)
H1075	145 (1000)	125 (862)	13	45	311-375	31-38	1075 (579)/4 (4)
H1100	140 (965)	115 (793)	14	45	302-363	30-37	1100 (593)/4 (4)
H1150	135 (931)	105 (724)	16	50	277-352	28-37	1150 (621)/4 (4)
Solution Heat Treated					363 (5)	39 (5)	1900 (1038) (6)

NOTES:
1. Hardness shall not be the basis for rejection if tensile properties are acceptable, determined on specimens taken from the same sample as that with nonconforming hardness or from another sample with similar nonconforming hardness.
2. For sizes over 3 inches (76 mm), 35% for H900 condition and 38% for H925 condition.
3. Temperature tolerance ±10 °F (±6 °C); time tolerance ±0.1 hour (±5 minutes); cool in air.
4. Temperature tolerance ±10 °F (±6 °C); time tolerance ±0.3 hour (±15 minutes); cool in air.
5. Maximum; alternate for wire: 175 ksi (1207 MPa) or equivalent hardness (see 8.3).
6. Temperature tolerance ±25 °F (±14 °C); time commensurate with thickness, heating equipment, and procedure used, and cooling as required to below 90 °F (32 °C).

Systems Engineering Framework → Better Standards





An Example

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AEROSPACE MATERIAL SPECIFICATION

AMS2610™	
Issued	2003-09
Reaffirmed	2023-05

Pressure Testing, Gaseous Media
Pressure as Specified

RATIONALE

AMS2610 has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE:

This specification provides requirements and procedures for gas-pressure leak testing of parts.

2. APPLICABLE DOCUMENTS:

There are no referenced publications specified herein.

3. TECHNICAL REQUIREMENTS:

3.1 Equipment:

3.1.1 Fixtures: Test fixtures and apparatus shall be designed and constructed to seal off only the ports and passages required to pressurize the part, and to permit 100% evaluation of all areas of the part where leakage could occur. The design shall not induce any stress on the part other than that provided by the test media. If pressure testing cannot be accomplished without inducing additional stresses, the design, including fitting types, shall be approved by the purchaser.

3.1.2 Gaskets: Gasket material shall be used with plugs or blanking plates to prevent damage to finished surfaces. Flanges or fittings designed for use with specific O-rings or gaskets shall use those seals for test. Formed-in-place gaskets that could mask dimensions or surface flaws shall not be used except on unmachined castings when sealing.

3.1.3 Bleeder Ports: Valved bleeder ports shall be provided to release entrapped gas.

3.1.4 Gauges: Pressure gauges and flow meters shall have sufficient dial divisions or readability to permit monitoring within plus or minus 5% of specified pressure and shall have been calibrated, within one year of use, using either primary standards or standards traceable to the National Institute of Standards and Technology (NIST).

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

For more information on this standard, visit
https://www.sae.org/standards/content/AMS2610/

A Framework Makes the Implicit More Explicit

Stakeholders

- Designers
- Planners
- Testers
- Others

Context

- Why
- When
- Relationships to Other Standards and Processes

Use Cases

- Who Plans
- Who Preps
- Who Performs
- Who Validates
- Who Evaluates

Measures

- Acceptance Criteria

A Framework Makes the Implicit More Explicit

Requirements

- Planning and Prep
- Procedure
- Results Analysis
- Reporting
- Equipment Calibration

Structures

- Fixtures
- Gauges
- Gaskets
- Data

Behaviors

- Interactions between Personas and Equipment and Media and Process Steps

Functional Analysis

- Apply Equations and Evaluations to Structures and Behaviors

Benefits of Using a Framework

- Better analysis
- More complete standards
- Less ambiguity
- Easier application

Hope is Not a Plan

SDOs Must Determine Framework Appropriate to their Standards

Existing Stabilized Standards

- Need
- Relevance
- Priority

Existing Standards on Revision Cycle

- Leverage Existing Cycle
- Consider Need, Relevance, Priority
- Minimize Volunteer Time

New Standards

- Relevance
- Minimize Volunteer Time

Modularize Standards

Processes in Standards

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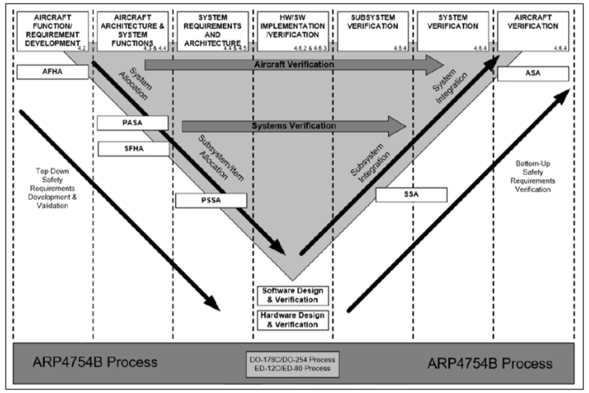
Manufacturing

Operational

Testing

Organizational



Modularity

3.4.1.3 Bending

Product 0.275 inch (6.98 mm) and under in nominal thickness shall be tested in accordance with ASTM E290 using a sample prepared nominally 0.75 inch (19.0 mm) in width with its axis of bending parallel to the direction of rolling and shall withstand without cracking when bending at room temperature through the angle and bend diameter shown in Table 3. In case of dispute, the results of tests using the guided bend test of ASTM E290 shall govern.

Table 3 - Bending requirements

Nominal Thickness Inch	Nominal Thickness Millimeters	Type of Bend	Angle Deg. Min	Bend Factor
Up to 0.1874, incl	Up to 4.760, incl	Free Bend	180	1
Over 0.1874 to 0.275, incl	Over 4.760 to 6.98, incl	Free Bend	180	3

This test is included in over 50 materials standards!

Prerequisites

Process

Outcomes

How can we create reusable modules for this test to be leverage across standards and committees?

Digital Modules Can Map Directly to Automated Modules

PDF

Work Instructions

Automation

Sample Size
Test Config
Acc Criteria

Bending Test

Digital Bending Test

Standards Provide Data Parameters

Bending Test Defined Once

Automation Deployed in Multiple Applications

Benefits of Modularity

- More Consistency
- Reusability
- Less work for standards authors
- Fewer assets to manage

Modularity is Not Considered in Current Committee Structures

SDOs

- Identification
- Storage and Access
- Reference
- Stabilized, Revised, New Standards
- Support Staff and Tools

Standards Authors

- Education
- Existing Standards
- New Standards

Aerospace Materials Systems Group

AMS ADV	Aerospace Materials Advisory Group
Additive Manufacturing	
AMS AM	Additive Manufacturing
AMS AM-M	Additive Manufacturing Metals
AMS AM-P	Additive Manufacturing Non-Metallic
AMS AM-R	Additive Manufacturing Repair
Metals & Related Processes	
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
ASEC	Aerospace Surface Enhancement
Non-Metals & Related Processes	
AMS CE	Elastomers
AMS P	Polymeric Materials
AMS P-17	Polymer Matrix Composites
AMS CACRC	ATA/IATA/SAE Commercial Aircraft Composite Repair
AMS G-8	Organic Coatings
AMS G-9	Aerospace Sealing
AMS J	Aircraft Maint Chemicals & Materials
AMS M	Aerospace Greases
Non-Destructive Evaluation	
AMS K	Non-destructive Methods & Processes Magnetic Particle & Penetrant Methods TF

Digital Bending Test

Standards Must Work in Digital Ecosystems

Problem	Mitigated By
Inconsistencies in Standards	✓ Applying Framework ✓ Modularity
Standards are not Automation-Ready	✓ Modularity
Interoperability Lacking	✓ Applying Framework ✓ Modularity
Ambiguity in Standards	✓ Applying Framework

Questions

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