From Standards to Systems: Insights on Digital Transformation and MBSE Integration

International Council on Systems Engineering
A better world through a systems approach

Leslie McKay
Director of Digital Standards Development
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

Our Community
Aerospace and Ground Vehicle

11,000+
Participants

105+
Years

44,000+
Standards

59+ Countries

570+
Technical Committees

550+
Committees & steering groups

1,800+
Works in Progress

Everyone is Talking About Digital Engineering
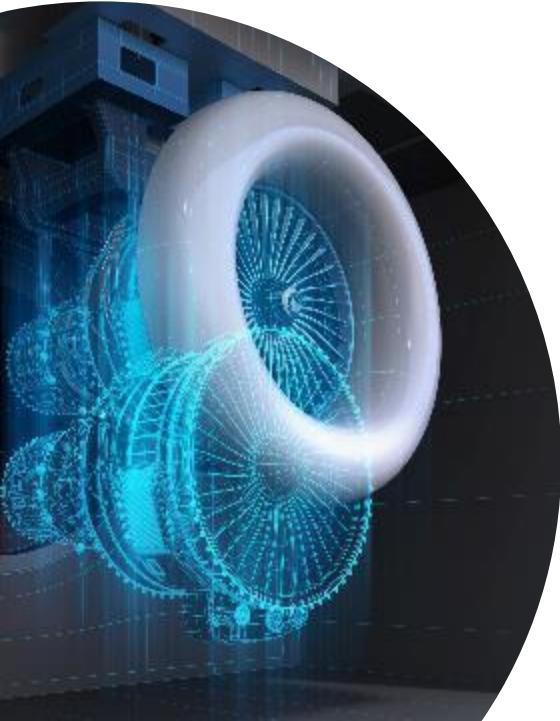
But How Do We Get There When We're Starting Here?
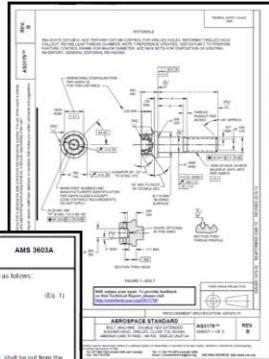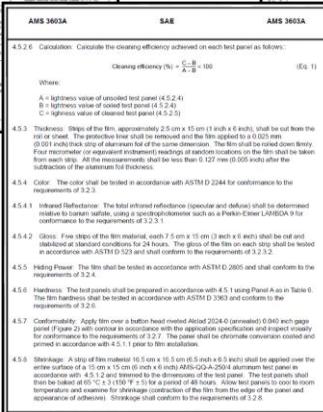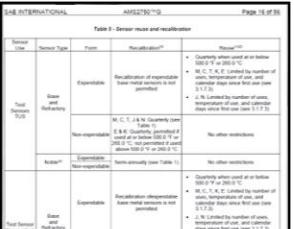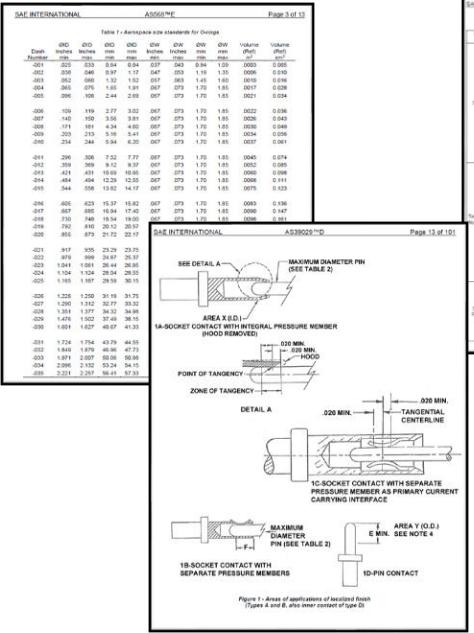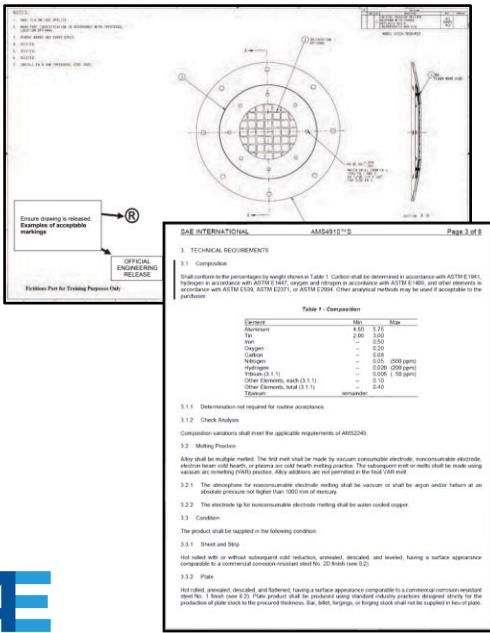
So, We Asked…

Strawman: Do You Think Standards Should be Provided as MBSE models?

SAE's desire to offer standards in digital format was presented
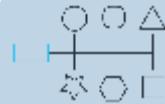
Various initiatives around model-based systems engineering, many of which are driven by government organizations, were discussed in relation to how standards must evolve to support these initiatives

Respondents were recruited from a variety of organizations, including government, industry, consulting, and academic organizations

Interviews were conducted by Leslie McKay, Director of Digital Standards Development for SAE, and Simon Powell, Senior Program Manager for SAE ITC

VOC Matrix

67% Cite Better
Better Standards

50% Cite Better
Traceability

VOC Matrix

Some kind of modeling language was most wanted— if it's the right fit

Data accessibility is more important that model type

VOC Matrix

	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		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							X				
Digital Consultant		X	X	X	X			X											X			X				
Digital Consultant	X			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	
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%	

> **Process standards** or standards that support **compliance** are most wanted use cases

VOC Matrix

|	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	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	
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				
Academia	X		X	X	X				X	X				X	X		X	X		X					X	X
Aero OEM								X	X															X		
Academia					X			X						X												
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Need **authoring framework** for standards

VOC Matrix

	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
	Benefits					**Interoperable Formats**								**Use Cases/Purpose**							**Authoring Recommendations**				**Other**	
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	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%

Ontology is critical

Turning VOC into Action

If the Model Fits, You Must…Model
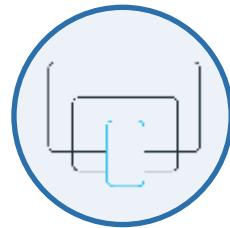
Models are Purpose-Built, but Data is Reusable

It's All About Context, and It's Got to Be Accurate
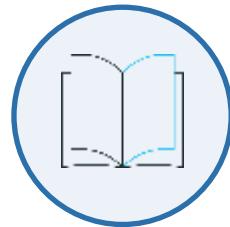
Apply Software Engineering Concepts to Standards

If the Model Fits…

Models ≠ SySML

What SAE Heard

Pros
- ✓ Fit for Purpose
- ✓ Depends on Content

Cons
- ✕ Complex
- ✕ Too much variability

Alternatives:
- Simpler types of models
- Access to requirements

SAE's Action Plan

Map Standard Types → Formats

Model Type	Standards	Purpose
ReqIF	Requirements and relationships	Tracking and traceability
SySML	System Descriptions or Constraints	Simulation and traceability
	Terms and Definitions	Consistent terms used for reference
	Defined Interfaces for Data Exchange	Simulation and design support
	Performance Requirements	Simulation and traceability
UML/UAF or OPL	Process Standards	Communicate process steps, actors, and information flow
QIF	Quality-Centric Standards	Design, metrology, and manufacturing data
MathML	Math-Based Standards	Consistent implementation of math functions
Various Model Types	Standards to Support Compliance/Certification	Provide process architecture Activity diagram with different states and info flow between states
	Digital Component Libraries	Library of reusable digital objects
	Standards to Support Trade Space Analysis	Make standards data executable for analysis

Field Test → Production

MS Word → Digital Model

Data is Reusable

Data Reuse

What SAE Heard

- Don't focus too much on any one digital format
- Think modular

SAE's Action Plan

Break Up Standards

- Extract modules for reusability

Modules → Use Cases

- MFR automation
- Operational efficiencies

Deliver Solutions

- Automation scripts
- Simulations

Context and Accuracy are Key

Requirements identification is not enough

Authoritative Source

- OEMs want digital standards from SDOs

Context and Relationships

- Relationships critical
- Context is key

Validation

- Standards SMEs → Digital Expertise

SAE's Action Plan

Validate and Ballot

Partner with Tech Experts

Applying Software Engineering to Standards Development

A Different Approach to Writing Standards

What SAE Heard

3.3 Solution Heat Treatment

The product shall be solution heat treated at a temperature not to exceed 1975 °F (1079 °C), holding at heat for a time commensurate with thickness and the heating equipment and procedure used, and cooling at a rate equivalent to an air cool or faster. Pyrometry shall be in accordance with AMS2750.

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

3.3.1 Continuous Heat Treating

When continuous heat treating is used, process parameters (i.e., furnace temperature set points, heat input, travel rate, etc.) for continuous heat treating lines shall be established by the material producer and validated by testing of product to the requirements of 3.4.

3.4 Properties

The product shall conform to the following requirements; tensile and hardness testing shall be performed in accordance with ASTM A370:

3.4.1 As Solution Heat Treated

3.4.1.1 Tensile Properties

Shall be as shown in Table 2:

Table 2A - Tensile properties, inch/pound units

Nominal Thickness Inch	Tensile Strength ksi, Max	Yield Strength at 0.2% Offset ksi, Max	Elongation in 2 Inches or 4D %, Min
0.005 to 0.010, incl	150	65.0	20
Over 0.010	150	55.0	20

Table 2B - Tensile properties, SI units

Nominal Thickness Millimeter	Tensile Strength MPa, Max	Yield Strength at 0.2% Offset MPa, Max	Elongation in 50.8 mm or 4D %, Min
0.13 to 0.25, incl	1034	448	20
Over 0.25	1034	379	20

Modular Approach to Standards

SAE's Action Plan

Drive Analytical Approaches to Standards Authoring
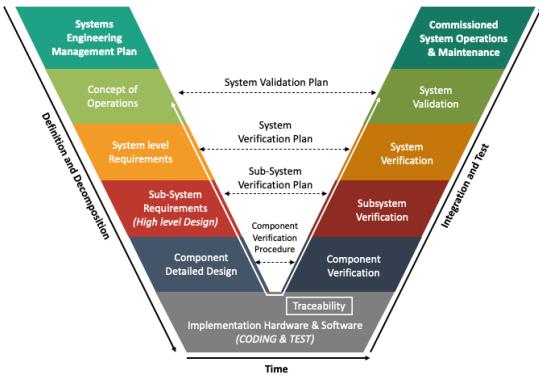
Call to Action for SDOs and Standards Authors

Publish, Publish, Publish and Test, Test, Test

Standards Authors:
- Write digital-ready content
- Write standards as digital assets (SMART from the Start)
- Think modular (DRY)
- Use analytical approach to standards authoring

SDOs:
- Collaborate
- Map standards to model types
- Conduct pilots and field test
- Attend digital engineering events

Leslie McKay

Director, Digital Standards Development

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.

- Vice-Chair of the Digital Standards Alliance

Contact

leslie.mckay@sae.org
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