ASTM/ISO Update: How Standards Can Accelerate Additive Manufacturing Adoption in Industry

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- **Visiting Research Professor**, JHU Materials Science and Engineering Department
- **Chair**, ASTM-I F42 on AM Technologies
- **Fellow**, ASTM-I
- Previously, 25 years at The National Institute of Standards and Technology (NIST)
- Entire career focused on measuring and understanding **advanced manufacturing processes, including metal-based AM**
Bio

- Munich University of Applied Sciences, Full-Professor for Manufacturing Technologies and Additive Processes (since 09/2019)
- Fraunhofer Institute for Casting, Composite and Processing Technology IGCV, Augsburg (Germany, Munich area)
  - 2018 – today: Head of Additive Manufacturing
  - 2018 – 2019: Director “Strategy and Institute Development”
  - 2014 – 2018: Head of Department “Components and Processes”
- Chairman ISO TC 261 „Additive Manufacturing“ (since 2019) after being member of TC 261 since 2012
- Independent Munich-based Management Consultant on AM (“GoAdditive”, since 2014)
- Appointed expert of DIN/VDI Steering Group for Additive Manufacturing and Appointed expert of VDI Advisory Board for “Production technology and manufacturing processes” (Germany, both since 2018)
- Editor for the Springer Technical Journal "Progress in AM” (since (2016)
Outline

1. Additive Manufacturing (AM) Market and the Need for Standards
2. ASTM AM Footprint
3. Cooperation between ISO/TC 261 and ASTM F42
4. Current ISO TC 261 and ASTM F42 Standardization Projects
5. Key Takeaways
AM Market and the Need for Standards
Market Size and Trends

• For comparison, the current $10B Global AM Market [1] is roughly the same size as Daimler’s 10B Euro in E-Mobility [2,3].

• And although it is currently a niche market, it has experienced significant growth rates [4]

• The recent growth (from $0.2B in 2009 [5] to $2.8B in 2018 [6]) in direct manufacturing of AM components (as opposed to prototyping or tooling) highlights the need for robust standards on EHS, quality, etc.

Stakeholder Representation (partial list)

**Government**
Air Force Research Lab (US), FAA (US), FBI (US), FDA (US), NASA (US), NAVAIR (US), NIST (US), US NRC (US)

**Academia**
Auburn University (US), Wichita State University (US), Cornell University (US), DeMontfort University (UK), Fraunhofer (Germany), Georgia Institute of Technology (US), Milwaukee School of Engineering (US), North Carolina University (US), Norwegian University of Science and Technology (Norway), Rochester Institute of Technology (US), Texas University at El Paso (US), University of Louisville (US), University of Maryland (US), University of Nottingham (UK), University of Texas (US), Universidad de Zaragoza (Spain), University of Ulster (UK)

**Industry**
Airbus, Arconic (US), Arcam (Sweden), Arkema (France), Autodesk (US), BAE Systems (UK), Boeing (US), EOS (Germany), Evonik Degussa (Germany), GE (US), GKN Aerospace (US), Gulfstream Aerospace (US), Honeywell (US), Lockheed (US), Materialise (Belgium), Met-L-Flo, Inc. (US), Northrop Grumman (US), Objet Geometries (Israel), Pratt & Whitney (US), Rolls Royce (US), Schlumberger (US), Siemens (Germany), Stratasys (US)

**Trade Associations**
CECIMO (EU), National Center for Manufacturing Sciences (US), Rapid Product Development Association of South Africa (RSA), Society of Manufacturing Engineers (US)
The Role of Standards

Standards are used for (among others):

• Specifying requirements
• Communicating guidance and not course of actions
• Documenting best practices
• Defining test methods and protocols
• Documenting technical data
• Classifying materials, products, systems, or services into groups
• Providing terms, definitions, etc.
• Accelerating the adoption of new technologies
How Standards Are Developed

• All standards development is based on contribution from members
  - Members are stakeholders and base their contribution on an interest in developing the standards
  - No funding or compensation provided from the SDOs
  - SDO's have all the IPR

• Consensus based!

• ASTM: experts nominated directly by stakeholder (Company, University, Professional organization, etc.)
  - Type of membership depend on the nature of the stakeholder's interest

• ISO & CEN experts nominated national SDO committees, which is based on stakeholder memberships
### Trusted
One set of AM standards to be used all over the world

### Similarity
Common roadmap and organizational structure for AM standards

### Don’t reinvent the wheel
Use and build upon existing standards, modified for AM when necessary

### Partnerships
Emphasis on joint standards development
Current Challenges in AM Standards Landscape

- Rapidly growing list of organizations working/planning to develop AM standards
  - Scopes of SDOs have evolved
- High risk of duplication of efforts and overlapping content
- Potential for inconsistencies (or even contradictions)
- Conflicting standards create ambiguity and confusion
- Coordination/Collaboration is critical!!
ASTM AM Footprint
**ASTM AM Footprint**

**Breadth**
- More than 20 AM relevant Committees
- 1000+ standards applicable to AM
- 2000+ technical experts

**History (F42)**
- Oldest
- Largest
- Most globally relevant

**Collaboration**
- PSDO – ISO TC261 (CEN TC438)
- MOU & Membership – America Makes
- MOU – SME
- Liaison Agreement – 3MF
- Strategic Relationships – NIST, NASA, FAA, FDA, DOD, ....
Quick Facts

- **Formed:** 2009
- **Current Membership:** 1000+ members (Over 30% outside the US)
- **Standards:** 30+ approved, 45+ in development (Jointly with ISO)
- **Meet twice a year, next meeting:** May 2021, Colorado School of Mines
- **Global Representation, including:**
  - Argentina
  - Australia
  - Austria
  - Belgium
  - Canada
  - China
  - Czech Republic
  - France
  - Germany
  - India
  - Italy
  - Japan
  - Korea
  - Mexico
  - Netherlands
  - Nigeria
  - Norway
  - Russian Federation
  - Singapore
  - South Africa
  - South Korea
  - Spain
  - Sweden
  - Switzerland
  - Taiwan
  - United Kingdom
  - United States

8 Subcommittees and Focus:

- Test Methods
- Design
- Materials & Processes
- Terminology
- Applications
- US TAG to ISO TC 261
Committee F42 Structure

Standards under the jurisdiction of F42 (https://www.astm.org/COMMIT/SUBCOMMIT/F42.htm)

Subcommittees address specific segments within the general subject area covered by the technical committee.

- **F42.01** Test Methods – J. Boyer, Pratt & Whitney
- **F42.04** Design – D. Rosen, GA Tech
- **F42.05** Materials and Processes – Frank Medina, UTEP
- **F42.06** Environment, Health, and Safety – Francoise Richard, P&W Canada
- **F42.07** Applications – Shane Collins, Additive Industries
- **F42.08** Data – Alex Kitt, EWI
- **F42.90** Executive – J. Slotwinski, JHU/APL
- **F42.90.01** Strategic Planning – K. Jurrens, NIST
- **F42.90.02** Awards – H. Hack, NGC
- **F42.90.05** Research and Innovation – M. Donovan, Jabil
- **F42.91** Terminology – Klas Boivie, Sintef
- **F42.95** US TAG to ISO TC 261 – Stacey Clark, US Army
New Sub-Committee on Applications

F42.07 Applications

Scope

- The development of standards for additive manufacturing in a variety of industry-specific applications, settings, & conditions.
- The work of this subcommittee will be coordinated with other F42 subcommittees, ASTM technical committees, and national/international organizations having mutual or related interests.
Representative Standards

Approved
2. ISO/ASTM52907 Additive manufacturing — Feedstock materials — Methods to characterize metallic powders
5. ISO/ASTM52901-16 General Principles – Requirements for Purchased AM Parts

Under Development
1. WK49229 Orientation and Location Dependence Mechanical Properties for Metal Additive Manufacturing
2. WK64190 Additive Manufacturing Design - Decision Guide
3. WK71616 Additive manufacturing -- Qualification principles -- Part 2: Requirements for industrial additive manufacturing sites
4. WK72391 Additive manufacturing -- Environment, health and safety -- Standard guideline for use of metallic materials

https://www.astm.org/COMMITTEE/F42.htm

Courtesy of GE
F42 Standards Development Process

1. Comes to ASTM via external source – Industry Driven

2. The need must be fully fleshed out:
   • What is needed & why?
   • Who will benefit?
   • How will standard be used?
   • Does anything presently exist?

3. Work item is registered (title, scope, user community, keywords, other relevant stakeholders)

4. Approval of subcommittee Chair

5. Appropriate Template chosen
Cooperation between ISO TC261 and ASTM F42
ISO/ASTM standards reflect highest degree of international consensus and are the most powerful industry standards for AM, more than 30 standards in total are already published, about 50 under development

Collaboration between ISO TC261 and ASTM F42 is unique!
(PSDO = Partner Standards Developing Organization)

About 1,000 experts are involved in ISO/ASTM collaboration
Collaboration – 2011 PSDO Agreement

• Standards are needed, but we don't need several competing standards...

• ISO & ASTM have signed a Partnership Standards Development Organization (PSDO) agreement:
  o Co-development of joint ASTM/ISO standards for industry
  o Fast tracking adoption of existing ASTM and ISO standards
  o Maintenance of published standards
  o Publication, copyright and commercial arrangements
Even More International...

- **ISO Technical Committee 261 (ISO/TC261)**
  - Established 2011, after an initiative from DIN, based on VDI Guidelines on "Rapid Technologies"

- **Scope:** (Next slide)

- **Membership**
  - Based on representation of different national standardization organization. Each member organization may nominate experts for different workgroups.
  - 1 vote/organization

- **25 Participating (P) countries:**
  - Germany, France, United Kingdom, Spain, Italy, Sweden, Norway, Canada, Singapore, Japan, South Korea, Belgium, Netherlands, Ireland, Israel, Portugal, Poland, Brazil, Denmark, Finland, Jordan, Switzerland, China, Russian Federation, USA

- **8 Observing (O) countries:**
  - Austria, Romania, Iran, New Zealand, Czech Republic, South Africa, Turkey, Jordan

- **Plus 26 Liaisons**
**ISO/TC 261 Scope**

**Standardization in the field of Additive Manufacturing (AM),** concerning their processes, terms and definitions, process chains (Hard- and Software), test procedures, quality parameters, supply agreements and all kinds of fundamentals.

**Typical areas of standardization include but are not limited to:** terminology and basic concepts, processes and manufacturing systems, feedstock materials and part materials, design and data modelling, test and verification methods, qualification guidelines and quality specifications, guidelines and requirements related to environment, health and safety, as well as all things specific to the use of AM technology.
ISO TC261 “Additive Manufacturing”

How does it work?

- WGs serve as “Melting pots” where all projects in a certain field are managed.
- Standards are being developed in ISO/ASTM-Joint Working Groups (JGs):
  - You write your standards in small teams of ASTM/ISO experts within JGs.
  - You maintain overview on related activities by attending WG meetings.

https://committee.iso.org/home/tc261
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ISO TC261/ASTM F42 “Additive Manufacturing”
How to get aboard? 5 steps to your standard!

1. Need for Standard
   - Check if there is already a standard available (https://www.iso.org/committee/629086.html)
   - If there is none, proceed to step 2

2. Contact ISO or ASTM
   - Get in touch with Chair of TC261 or F42 or one of our WG Convenors/Subcommittee Chairs
   - Become member of either ISO and/or ASTM

3. Get started!
   - Your project is being assigned to either an existing JG or we create a new one within less than 4 weeks!
   - Worldwide experts will be provided to support your project

4. Deliver draft
   - Write draft, preferably have first draft ready within (less than) 6 months
   - Drafts will be balloted according to ISO and ASTM rules

5. Finalize
   - Consider comments, finalize document
Joint ASTM F42/ISO TC261 Meeting weeks
(Spring Meetings in the US / Fall Meetings in Europe/Asia)

Spring Meetings 2019 @Auburn, AL, USA
(March 25th to 29th)
Current ISO TC261/ASTM F42 Standardization projects
AM-Standards in every day life
Highlights along the AM Process Chain

Pre-Process
- Use Design standards, cf. ISO/ASTM 52911-1, -2, -3

In-Process
- Check Machine capability by using test artefacts; cf. ISO/ASTM FDIS 52902
- Powder, cf. ISO/ASTM FDIS 52907 and get in touch with JG71 (Alexander Elsen)

Post-Process
- NDT; cf. ISO/ASTM CD TR 52906
- Non-destructive testing (NDT) of additive manufactured products
- Working with Extrusion?, cf. ISO/ASTM CD 52903-3

- Interested in Certification?
  Get in touch with ISO/ASTM JG72 (Karl D’Ambrosio) and JG75 (Gregor Reischle) → 3 Standards currently under Development covering IQ/OQ/PQ, certification of AM facilities
- No own machines? “Buy Scenario”
  Check ISO/ASTM 52901:2017 for Requirements for purchased AM parts
- Challenged by EHS-topics?
  Get involved with ISO WG 6 and in particular JG69 (for metals) and JG68 (for extrusion)

Picture: Langefeld
Roland Berger VDI
Strategiekongress 2017
IQ/OQ/PQ: Installation, Qualification, Operational, Qualification and Performance Qualification

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Key Takeaways
Key Takeaways

• This is an **exciting time for industrial uses of AM, and AM standards play and will play a critical role** in the development and adoption of AM.

• The **ASTM/ISO collaboration** leverages international AM technical expertise, and is resulting in a unified set of high-quality AM standards accepted and used around the world, for the benefit of industry.