SECTOR SKILLS STRATEGY IN ADDITIVE MANUFACTURING

Co-funded by the Erasmus+ Programme of the European Union

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CU 36: Coordinating the AM Process (Pilot)

TOPIC 10: Complying with Standards

David Wimpenny

FOR SAM PILOT ATTENDEES AND TRAINERS ONLY

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Topics covered include…

- What are standards and why they are important
- Role of standards in AM
- Standards development for AM
- Standards organisations
- Examples of AM standards
- AM Standards gaps
- ASTM AM Centre of Excellence
- Sector specific standards

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What are standards ?

"Document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose"

- Full blown standards
- Best practice Guides

https://www.nena.org/page/Standards

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Why are standards important

- Help to ensure safety, durability, and market equivalence
- Provide common language to measure and evaluate performance
- Help to ensure technology works seamlessly and establish trust
- Ensure interoperability of components and systems made by different companies.

National Institute of Standards & Technology, U.S. Department of Commerce, NIST

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Role of standards in AM

- AM can dramatically change product design, manufacture and supply
- Risks of failure ..leading to loss of confidence and even life
- Standards provide framework for introduction of new manufacturing methods, materials and designs
- Will eventually lead to improved reliability of equipment, processes
- Enable critical interoperability – design data, software and data from process monitoring etc..

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Challenge of standards development for AM

- Dramatic shift from established manufacturing processes
- Rapidly developing technology
- Rush to introduce the technology
- Lack the experience to fully understand the benefits and limitations
- New approach affects so many aspects;
  - Product design
  - Material technology
  - Equipment, software, design data
  - Control of information
  - Inspection
  - Supply chains
  - Qualifications & training
  - Design and operation of facilities

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How are standards developed

1. Area requiring a new standard is put forwards as a new work item
2. Checks performed to ensure that standards don't already exist or a standard is not already in development
3. Work item approved and lead (convener) is selected
4. Standards committee is assembled
5. Meet to agree the scope of the standard
6. Draft text for standard is prepared
7. Sent for ballot
8. If changes are required these are made
9. Standard is approved
10. Standard is published
11. Future revisions may be required

THIS PROCESS CAN TAKE YEARS !

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Types of standards

- National standards – for example BSI in the UK
- International standards – for example ISO
- Sector specific standards

Sector specific standards take precedent

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Standards organisations include……

American Society for Testing and Materials (ASTM)

American Society of Mechanical Engineers (ASME)

Association for the Advancement of Medical Instrumentation (AAMI)

American Welding Society (AWS)

CEN CENELEC

Digital Imaging and Communications in Medicine

Institute for Electrical and Electronics Engineers (IEEE)

International Organisation for Standardisation (ISO)

Medical Imaging Technology Alliance (MITA)

Metal Powder Industries Federation (MPIF)

National Electrical Manufacturers Association (NEMA)

SAE International (SAE)

British Standards

The Association Connecting Electronics Industries (IPC)

American National Standards Institute (ANSI)

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ASTM F42 / ISO T261 joint committee

ASTM INTERNATIONAL

- Established in 2013
- Aim is to use the limited pool of experts to generate more standards, quickly and avoid unnecessary duplication

ISO

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SAM SECTOR SKILLS STRATEGY IN ADDITIVE MANUFACTURING

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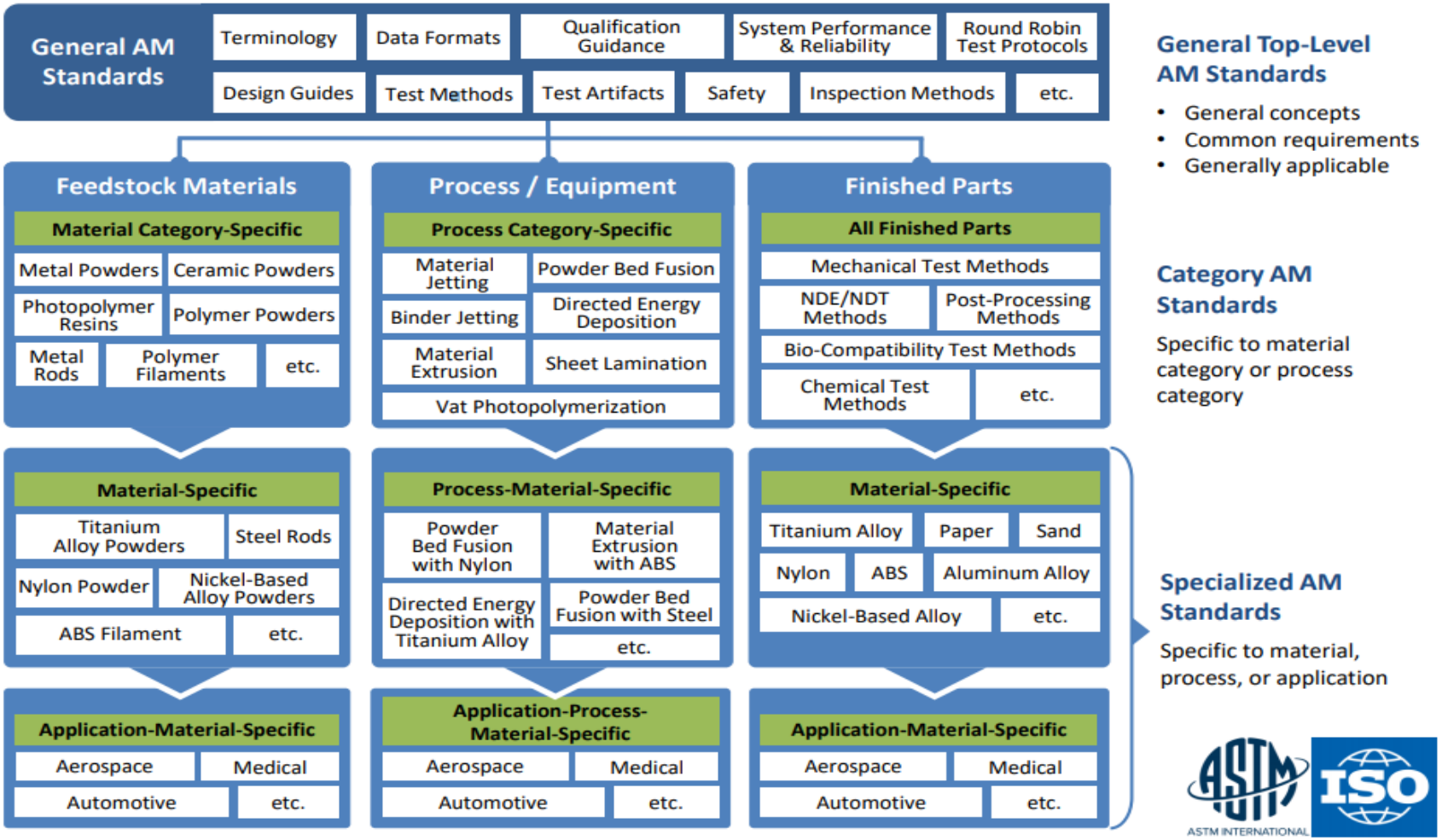
Additive Manufacturing Standards Structure



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List of AM standards developed by ASTM

ASTM INTERNATIONAL

Applications

Designation	Title
ISO / ASTM52942 - 20	Additive manufacturing — Qualification principles — Qualifying machine operators of laser metal powder bed fusion machines and equipment used in aerospace applications
ISO / ASTM52941 - 20	Ac… m…

Design

Designation
F3413 - 19
ISO / ASTM5291C
ISO / ASTM52911 19
ISO / ASTM52911 19
ISO / ASTM52915

ISO / ASTM52941 - 20

Additive manufacturing — System performance and reliability — Acceptance tests for laser metal powder-bed fusion machines for metallic materials for aerospace application

Active Standard ISO / ASTM52941 | Developed by Subcommittee: F42.07

Book of Standards Volume: 10.04

	Format	Pages	Price	
	PDF	8	$52.00	ADD TO CART
	Hardcopy (shipping and handling)	8	$52.00	ADD TO CART

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Materials and Processes

Designation	Title
F2924 - 14	Standa Powde
F3001 - 14	Standa Low In
F3049 - 14	Standa Manuf
F3055 - 14a	Standa Fusion
F3056 - 14e1	Standa Fusion
F3091 / F3091M - 14	Standa
F3184 - 16	Standa Powde
F3187 - 16	Standa

ASTM F3001 - 14

Standard Specification for Additive Manufacturing Titanium-6 Aluminum-4 Vanadium ELI (Extra Low Interstitial) with Powder Bed Fusion

Active Standard ASTM F3001 | Developed by Subcommittee: F42.05

Book of Standards Volume: 10.04

Format	Pages	Price	
PDF	6	$52.00	ADD TO CART
Hardcopy (shipping and handling)	6	$52.00	ADD TO CART
Standard + Redline PDF Bundle	12	$62.00	ADD TO CART

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Materials and process continued

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F3213 - 17	Standard for Additive Manufacturing – Finished Part Properties – Standard Specification for Cobalt-28 Chromium-6 Molybdenum via Powder Bed Fusion
F3301 - 18a	Standard for Additive Manufacturing – Post Processing Methods – Standard Specification for
F3302 - 18	
F3318 - 18	
F3434 - 20	
ISO / ASTM52901 - 16	
ISO / ASTM52904 - 19	
ISO / ASTM52903 - 20	
ISO / ASTM52903 - 2 - 20	Additive manufacturing — Material extrusion-based additive manufacturing of plastic materials — Part 2: Process equipment

ISO / ASTM52904 - 19

Additive Manufacturing – Process Characteristics and Performance: Practice for Metal Powder Bed Fusion Process to Meet Critical Applications

Active Standard ISO / ASTM52904 | Developed by Subcommittee: F42.05

Book of Standards Volume: 10.04

Format	Pages	Price	
PDF	11	$58.00	ADD TO CART
Hardcopy (shipping and handling)	11	$58.00	ADD TO CART

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ASTM INTERNATIONAL

Terminology

Designation	Title
ISO / ASTM52	

Test Metho

Designat
F2971 - 13
F3122 - 14
ISO / ASTM52 19
ISO / ASTM52 13(2019)
ISO / ASTM52 19

ISO / ASTM52907 - 19

Additive manufacturing — Feedstock materials — Methods to characterize metallic powders

Active Standard ISO / ASTM52907 | Developed by Subcommittee: F42.01

Book of Standards Volume: 10.04

	Format	Pages	Price	
	PDF	14	$58.00	ADD TO CART
	Hardcopy (shipping and handling)	14	$58.00	ADD TO CART

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ASTM Roadmap and committees

ASTM INTERNATIONAL

Additive Manufacturing

F42 AM Technologies

F42.07.01 Aviation

F42.07.02 Spaceflight

F42.07.03 Medical/Biological – E34

F42.07.04 Transportation/Heavy Machinery – F45, F48

F42.07.05 Maritime – F41

F42.07.06 Electronics – F01

F42.07.07 Construction – C01/C09, D35

F42.07.08 Oil/Gas – D02

F42.07.09 Consumer – F15, F08

Applications

E55 Manufacture of Pharmaceutical and Biopharmaceutical Products

F04 Medical and Surgical Materials and Devices

F07 Aerospace and Aircraft

F25 Ships and Marine Technology

F37 Light Sport Aircraft

F38 Unmanned Aircraft Systems

F44 General Aviation Aircraft

Test Methods

E07 Nondestructive Testing

E08 Fatigue and Fracture

E28 Mechanical Testing

E37 Thermal Measurements

E57 3D Imaging Systems

G01 Corrosion of Metals

Feedstock Materials

A01 Steel, Stainless Steel and Related Alloys

B09 Metal Powders and Metal Powder Products

D20 Plastics

D30 Composite Materials

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Additive manufacturing standards committee

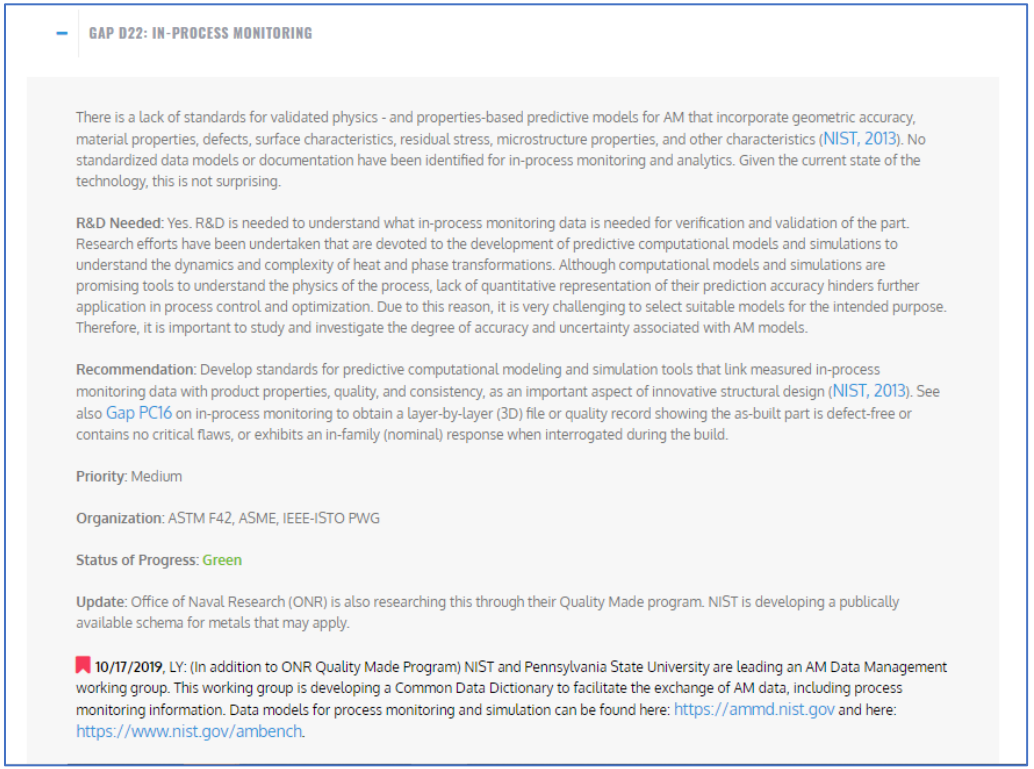
https://www.ansi.org/portal/amsc/AMSC-Gaps-Design

America Makes

ANSI American National Standards Institute

List of **gaps** in current standards provision covering;

- Design
- Precursor materials
- Process control
- Post-processing
- Finished material properties
- Non destructive evaluation
- Maintenance and repair
- Qualification & certification



GAP D22: IN-PROCESS MONITORING

There is a lack of standards for validated physics - and properties-based predictive models for AM that incorporate geometric accuracy, material properties, defects, surface characteristics, residual stress, microstructure properties, and other characteristics (NIST, 2013). No standardized data models or documentation have been identified for in-process monitoring and analytics. Given the current state of the technology, this is not surprising.

R&D Needed: Yes. R&D is needed to understand what in-process monitoring data is needed for verification and validation of the part. Research efforts have been undertaken that are devoted to the development of predictive computational models and simulations to understand the dynamics and complexity of heat and phase transformations. Although computational models and simulations are promising tools to understand the physics of the process, lack of quantitative representation of their prediction accuracy hinders further application in process control and optimization. Due to this reason, it is very challenging to select suitable models for the intended purpose. Therefore, it is important to study and investigate the degree of accuracy and uncertainty associated with AM models.

Recommendation: Develop standards for predictive computational modeling and simulation tools that link measured in-process monitoring data with product properties, quality, and consistency, as an important aspect of innovative structural design (NIST, 2013). See also Gap PC16 on in-process monitoring to obtain a layer-by-layer (3D) file or quality record showing the as-built part is defect-free or contains no critical flaws, or exhibits an in-family (nominal) response when interrogated during the build.

Priority: Medium

Organization: ASTM F42, ASME, IEEE-ISTO PWG

Status of Progress: Green

Update: Office of Naval Research (ONR) is also researching this through their Quality Made program. NIST is developing a publically available schema for metals that may apply.

10/17/2019, LY: (In addition to ONR Quality Made Program) NIST and Pennsylvania State University are leading an AM Data Management working group. This working group is developing a Common Data Dictionary to facilitate the exchange of AM data, including process monitoring information. Data models for process monitoring and simulation can be found here: https://ammd.nist.gov and here: https://www.nist.gov/ambench.

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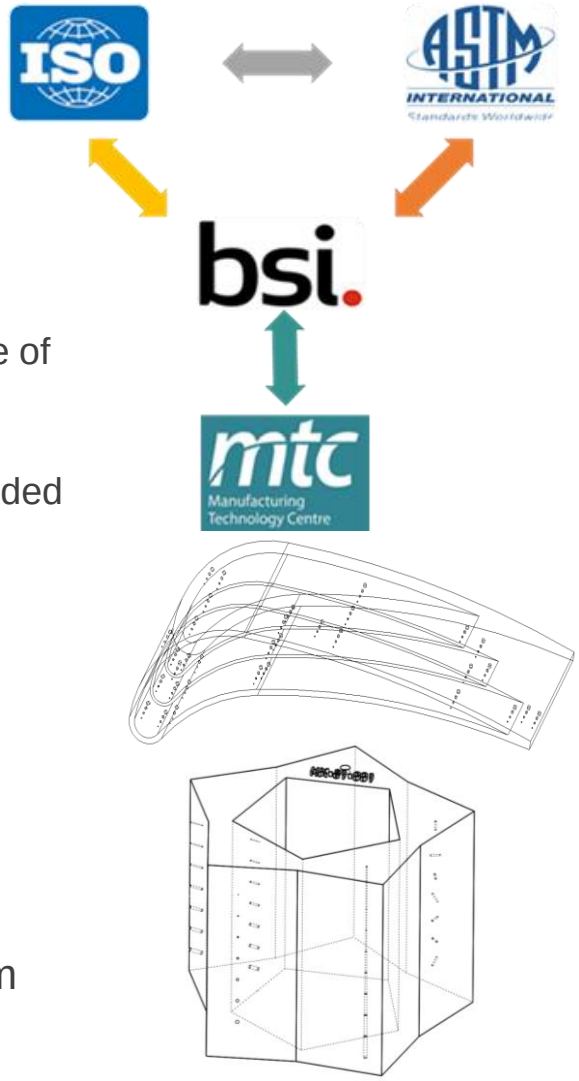
Inspection for AM Standards

- No comprehensive inspection standards for AM
- ISO/TC 261– ASTM F42 NDT For AM Parts (JG59)
  - Draft is under review, covering different sectors, lead by Ben Dutton ,MTC
  - Best practice guide based on existing standards capable of covering some of the AM defect types.
  - For AM only defects, not covered by current standards, it presents NDT methods verified potential to detect defects through star artefacts with seeded defects.
  - It then describes and provides an example for an à la carte framework to follow for a specific AM part geometry.
- ASTM E07 Non-Destructive Testing (WK47031)
  - Draft is under review focused on aerospace sector, effort lead by NASA.
  - Considers the selection and application of established and emerging NDT procedures for AM metal parts throughout their life cycle.
- Standards groups linked, also interact through common consortium members.



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ASTM AM CoE

CENTER of EXCELLENCE
RESEARCH TO STANDARDS
Additive Manufacturing

Center Goals:

1. Accelerate standardisation and close standards gaps in AM
2. House and facilitate R&D in its partners laboratories
3. Create strong global partnerships among AM developers, users and stakeholders
4. Support education, training, proficiency testing, and certification programs
5. Host professional events, workshops, and symposia featuring subject matter experts and practitioners

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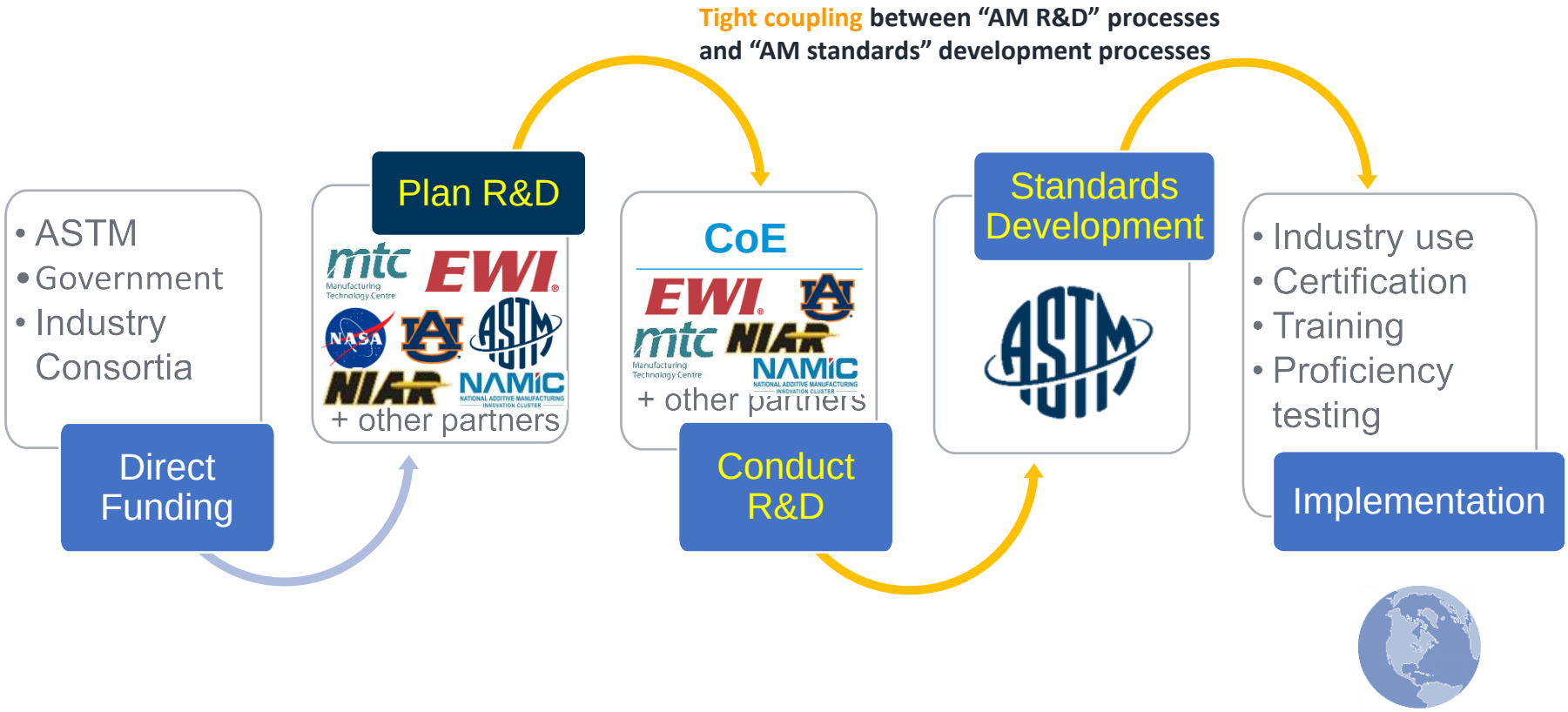
Research and Development (R&D) Progress: How it works



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Sector Specific Standards

- Aerospace
- Space
- Medical
- Marine
- Defence

Sector specific standards may refer to generic standards but they take <u>precedence over them</u>

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Aerospace Specific International standards

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The four aerospace additive manufacturing technical standards are:

- AMS7000: Laser-Powder Bed Fusion (L-PBF) Produced Parts, Nickel Alloy, Corrosion and Heat-Resistant, 62Ni - 21.5Cr - 9.0Mo - 3.65Nb Stress Relieved, Hot Isostatic Pressed and Solution Annealed
- AMS7001: Nickel Alloy, Corrosion and Heat-Resistant, Powder for Additive Manufacturing, 62Ni - 21.5Cr - 9.0Mo - 3.65Nb
- AMS7002: Process Requirements for Production of Metal Powder Feedstock for Use in Additive Manufacturing of Aerospace Parts
- AMS7003: Laser Powder Bed Fusion Process

ASTM is developing four aerospace specific standards cover feedstock materials (**WK67454**), finished part properties (**WK67461**), system performance and reliability (**WK67484**), and qualification principles (**WK67485**)

ISO/ASTM 52941:2020
Additive manufacturing — System performance and reliability — Acceptance tests for laser metal powder-bed fusion machines for metallic materials for aerospace application

ISO/ASTM 52942:2020
Additive manufacturing — Qualification principles — Qualifying machine operators of laser metal powder bed fusion machines and equipment used in aerospace applications

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Space Specific International standards

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ECSS Standards

The European Cooperation for Space Standardization (ECSS) is an initiative established to develop a coherent, single set of user-friendly standards for use in all European space activities.

ECSL

European Centre for Space Law (ECSL) The ECSL was founded in 1989 on the initiative of the European Space Agency. Its objectives are the improvement in space law research, education and practice in Europe.

CCSDS Recommendations

The Consultative Committee for Space Data Systems (CCSDS) is an international voluntary consensus organization of space agencies and industrial associates interested in mutually developing standard data handling techniques to support space research, including space science and applications.

ISO Standards

The International Standards Organization Standards (ISO) catalogue.

IEEE Standards

The Institute of Electrical and Electronics Engineers (IEEE) standards.

ESCIES System

The European Space Components Information Exchange System (ESCIES) is a repository for EEE parts information hosted by ESA, on behalf of the Space Components Steering Board, as part of the European Space Components Coordination.

EPPL Listing

The European Preferred Parts List (EPPL) is a list of preferred and suitable components to be used by European manufacturers of spacecraft hardware and associated equipment.

ESA is collaborating with NASA on standards

https://www.esa.int/About_Us/Business_with_ESA/Space_Related_Standards2

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www.skills4am.eu

Questions ?
& Thank you

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