EASA / FAA
Industry – Regulator AM Event

Working Group 3

Developing a 5 Year Plan to Allow EASA / FAA acceptance – Machine Monitoring

Wichita, 17th -19th September 2024

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INTRODUCTION & SCOPE

Scope: Additively manufactured parts for use in aerospace applications to include e.g. airframe, system, propulsion, interiors.

Who is this for? This group consists of AM equipment suppliers, AM software suppliers, regulators and end users.

Aim:

- To present and discuss the progress on the ARP7068
- To discuss the ISPM development in Industry: ISPM desired outcomes and challenges.
- To define next steps in the 5-year plan.

Linked to WG2: F&DT and NDI Considerations for Metal AM.

7h

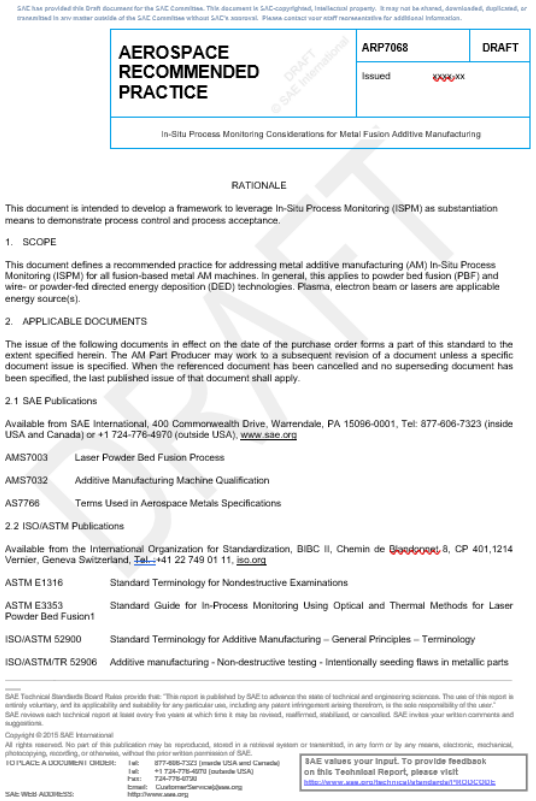
of intense, but fruitful discussions

EASA/FAA AM EVENT – WG3

WG3 BREAKOUT SESSION DAY 1

1. **To present and discuss the progress on the ARP7068**
   - Core group working since last October on it.
   - OBJECTIVE: Review it with WG3, and send to ballot by the end of the year

ARP7068 is complementary to ARP7065 (ISPM Taxonomy)



AEROSPACE RECOMMENDED PRACTICE

ARP7068 | DRAFT

Issued xxxx-xx

In-Situ Process Monitoring Considerations for Metal Fusion Additive Manufacturing

RATIONALE

This document is intended to develop a framework to leverage In-Situ Process Monitoring (ISPM) as substantiation means to demonstrate process control and process acceptance.

1. SCOPE

This document defines a recommended practice for addressing metal additive manufacturing (AM) In-Situ Process Monitoring (ISPM) for all fusion-based metal AM machines. In general, this applies to powder bed fusion (PBF) and wire- or powder-fed directed energy deposition (DED) technologies. Plasma, electron beam or lasers are applicable energy source(s).

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this standard to the extent specified herein. The AM Part Producer 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.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org

AMS7003 Laser Powder Bed Fusion Process

AMS7032 Additive Manufacturing Machine Qualification

AS7766 Terms Used in Aerospace Metals Specifications

2.2 ISO/ASTM Publications

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ASTM E1316 Standard Terminology for Nondestructive Examinations

ASTM E3353 Standard Guide for In-Process Monitoring Using Optical and Thermal Methods for Laser Powder Bed Fusion1

ISO/ASTM 52900 Standard Terminology for Additive Manufacturing – General Principles – Terminology

ISO/ASTM/TR 52906 Additive manufacturing - Non-destructive testing - Intentionally seeding flaws in metallic parts

ARP7068: ISPM Considerations for Metal Fusion AM

RATIONALE: Develop a framework to leverage ISPM as substantiation means to demonstrate process control and process acceptance.

SCOPE: PBF and DED technologies

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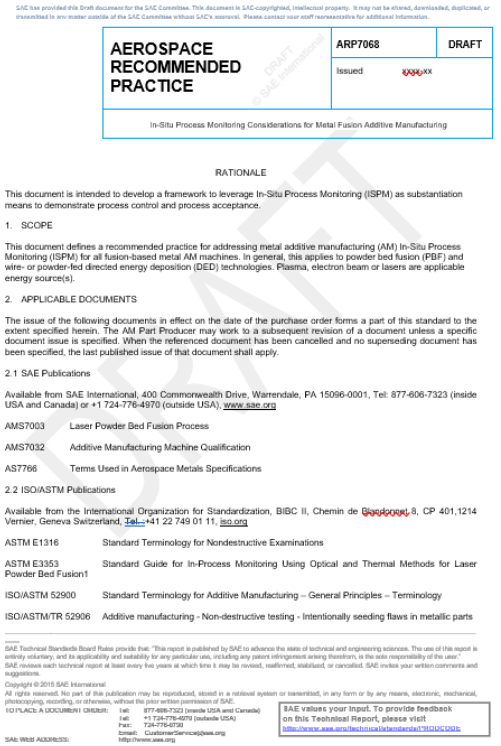
WG3 BREAKOUT SESSION DAY 1

1. **To present and discuss the progress on the ARP7068**

ARP7068 CONTENT

1. Scope
2. Applicable Documents
3. Introduction
4. General guidance
   1. Definitions/Scope
   2. The ISPM System: Considerations, Data cycle, Calibration, Qualification…
   3. ISPM Data and ISPM Qualification: IKPV-POM, dimensionality of evaluation, applications…
   4. ISPM Integration into Quality Systems
5. Good Practices
   1. FMEA
   2. Quality Assurance



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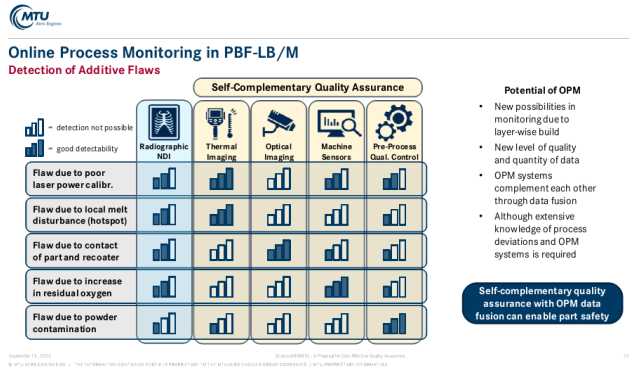

OUTCOME:

- Close-loop implementation will be needed for DED and may be an improvement for L-PBF process.
- Several ISPM sensors are needed to complement and get the full process picture.
  - Machine sensors should complement this.

ARP7065

The level hierarchy is identified as:

Level 0: Machine KPIV Verification

Level 1: KPGV Verification

Level 2: Process Execution Monitoring, Passive

Level 3: Process Execution Monitoring, Active with Authorized FFC

Level 4: In-Process Anomaly Identification, Passive

Level 5: In-Process Anomaly Detection and Defect Characterization, Passive

Level 6: In-Process or Post-Process OMI

(X) Level 7: In-Process Anomaly Detection, Active with Authorized Autonomous Process Repair

(X) Level 8: In-Process Material Characterization, Passive

(X) Level 9: In-Process Material Modification, Active

(X) Level 10: In-Process Material Characterization, Active with Authorized Generative Design

Levels identified with (X) represent hypothetical applications with technologies not yet demonstrated at readiness levels appropriate for implementation in a production environment at the time of this document's publication.

ARP7068

Level (ARP7065)	Level Name	Application / Quality Assurance concept	Reference / Ground truth	Qualification (besides 4.2.4)	Specific Gain	Acceptance type
0	Machine input monitoring	Machine health	External Measurement	Only basic	Machine issue detection	-
1	IKPV monitoring / Condition mon.	Process capability of machine	External Measurement	Only basic, eventually gap mitigation	Early scrap detection, issue detection	Process acceptance
2A	POM monitoring for SPC	Global SPC of AM process	Process statistics	Only basic	Issue detection	Process acceptance
2B	POM monitoring for acceptance	Global indirect AM Process capability	Acceptance tolerances from process qualification	Sensitivity study, eventually detection-gap mitigation	Early scrap detection, drop witness samples, alternative inspection frequency	Process acceptance
3	Not applicable see ARP7065					
4	Localized process anomaly detection	Local part quality	CT	PoD studies for anomalies	NDI reduction	Part approval
5	In-situ NDI / Defect detection	Local part quality	CT	PoD study for flaw families	NDI reduction	Part approval

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WG3 BREAKOUT SESSION DAY 2

2. To discuss the ISPM development in Industry: ISPM desired outcomes & challenges

- OBJECTIVE: Implement ISPM to support the manufacturing of more critical parts.

DISCUSSION:

- Regulator's voice:
  - Focus ISPM resources to ensure safety.
  - Develop ISPM to implement it when needed → Manufacturing of more critical parts.
  - Data with a proper correlation will be required to support ISPM.
- Industry's voice:
  - Not possible to share ISPM IP across Industry.
    - But lessons learned will be shared to support standardization, and a potential DEMO
  - Desired outcomes of ISPM implementation were agreed.
  - Some challenges will need to be addressed.

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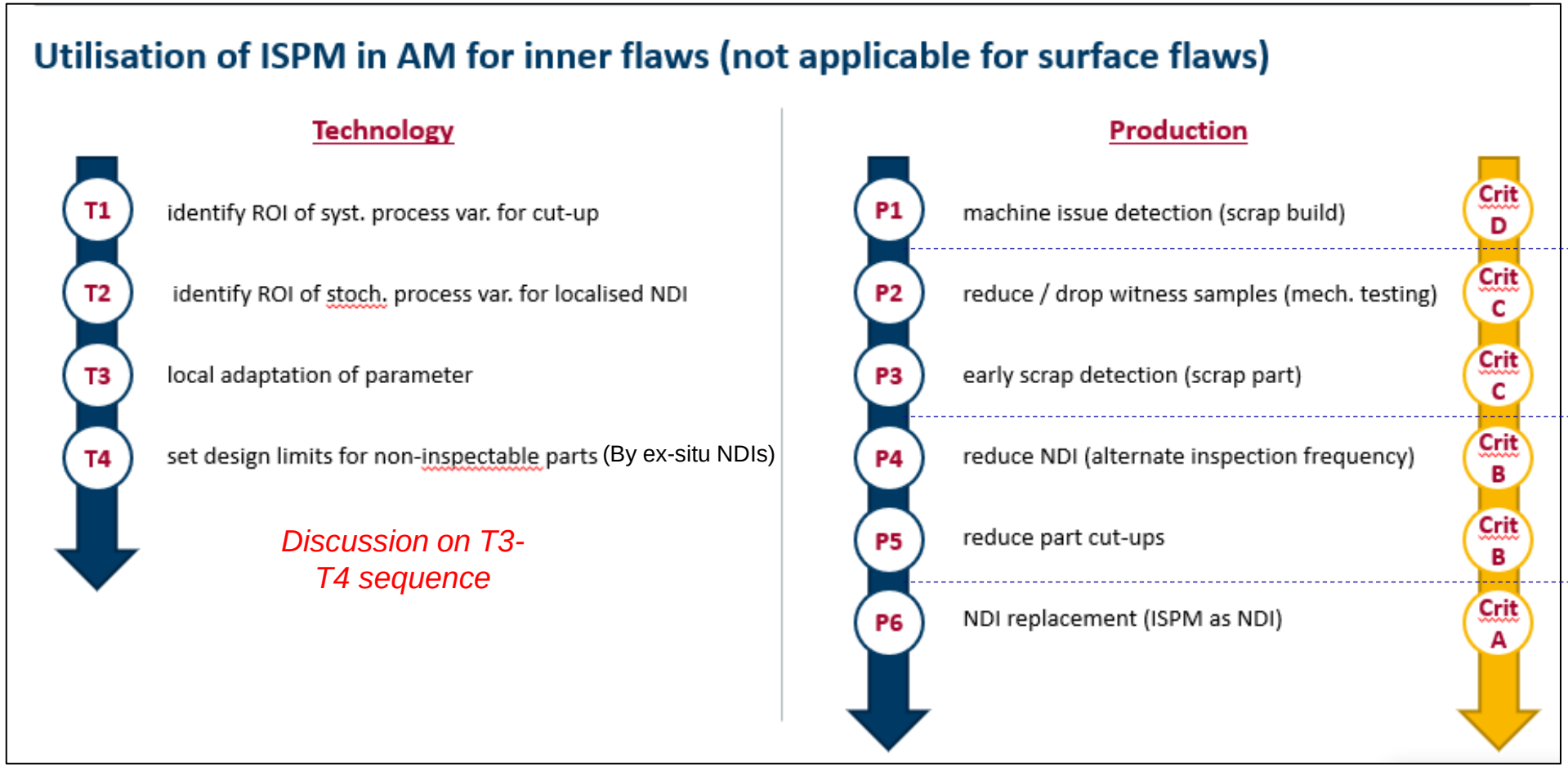

Proposal

Level 0-1

Level 2-A

Level 2-B

Level 4-5

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WG3 BREAKOUT SESSION DAY 2

2. To discuss the ISPM development in Industry: ISPM desired outcomes & challenges

IDENTIFIED CHALLENGES / GAPS:

- How many NDTs /DTs samples should be reduced?
- Could mechanical testing be completely dropped?
- What is the substantiation level required to reduced other inspections?
  - Consequence of a false negative should be adressed.

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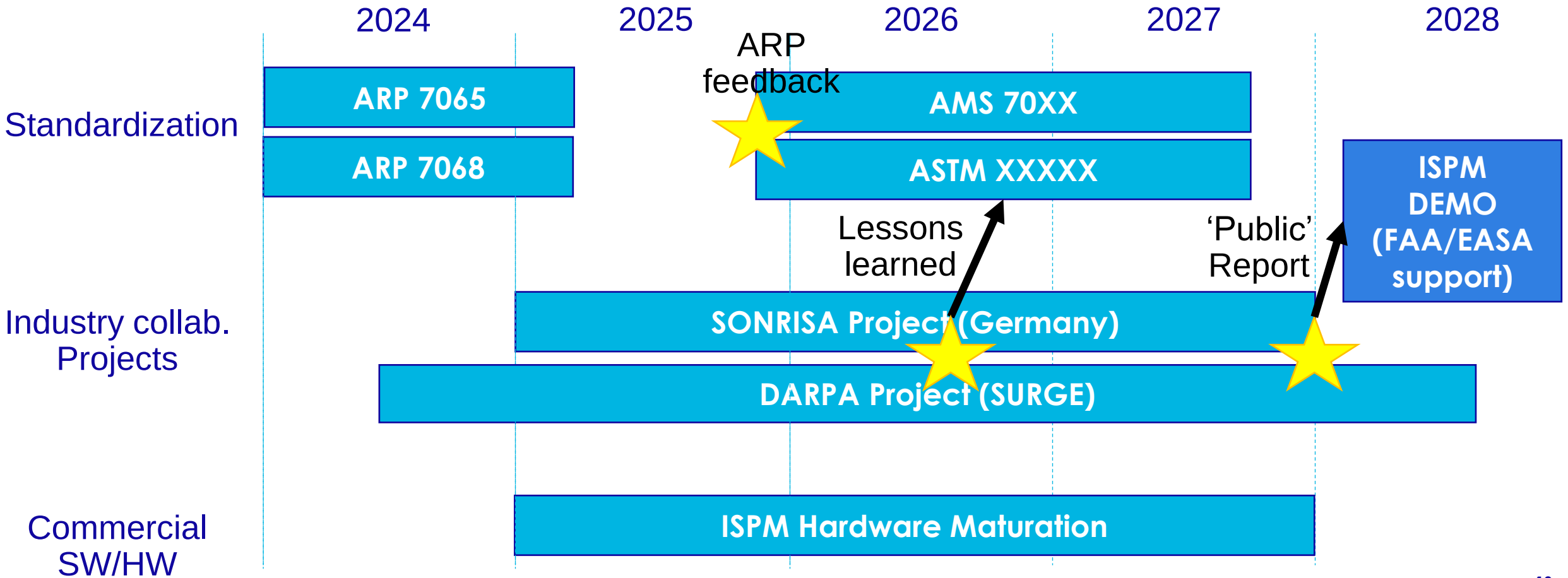
WG3 BREAKOUT SESSION DAY 3

3. To define next steps in 5-year plan



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NEXT STEPS

- Release ARP7065 and ARP7068
- ARPs content to be shared with WG3 colleagues
- Periodical meetings to:
  - Discuss how to address the identified challenges & gaps
  - State of the art (ISPM)
    - Option of a whitepaper (funded?) to be edited?