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## European Metrology Network (EMN) for Advanced Manufacturing – Development of the Strategic Research Agenda (SRA)

Daniel O'Connor<sup>1</sup>, Alexander Evans<sup>2</sup>, Alessandro Balsamo<sup>3</sup>, Georges Favre<sup>4</sup>, Anita Przyklenk<sup>5</sup>, Harald Bosse<sup>5</sup>, and Dishi Phillips<sup>6</sup>

<sup>1</sup> National Physical Laboratory (NPL), Teddington, United Kingdom

<sup>2</sup> Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany

<sup>3</sup> Istituto Nazionale di Ricerca Metrologica (INRIM), Torino, Italy

<sup>4</sup> Laboratoire national de métrologie et d'essais (LNE), Paris, France

<sup>5</sup> Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany

<sup>6</sup> European Society for Precision Engineering and Nanotechnology (euspen), Cranfield, UK

[alexander.evans@bam.de](mailto:alexander.evans@bam.de)

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### Abstract

The European Commission has identified Advanced Manufacturing and Advanced Materials as two of six Key Enabling Technologies (KETs). It is considered that Metrology is a key enabler for the advancement of these KETs. Consequently, EURAMET, the association of metrology institutes in Europe, has strengthened the role of Metrology for these KETs by enabling the creation of a European Metrology Network (EMN) for Advanced Manufacturing. The EMN is comprised of National Metrology Institutes (NMIs) and Designated Institutes (Dis) from across Europe and was formally established in October 2021. The aim of the EMN is to provide a high-level coordination of European metrology activities for the Advanced Manufacturing community.

The EMN itself is organized in three sections representing the major stages of the manufacturing chain: 1) Advanced Materials, 2) Smart Manufacturing Systems, and 3) Manufactured Components & Products. The EMN for Advanced Manufacturing is engaging with stakeholders in the field of Advanced Manufacturing (large companies & SMEs, industry organisations, existing networks, and academia), as well as the wider Metrology community, including Technical Committees, to provide input for the Strategic Research Agenda (SRA) on Metrology for Advanced Manufacturing.

This contribution will give an overview about the first version of the SRA prepared by the EMN for Advanced Manufacturing.

Advanced Manufacturing, Metrology, Strategic Research Agenda (SRA), European Metrology Network (EMN)

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### 1. Metrology for Advanced Manufacturing

Advanced Manufacturing and Advanced Materials have been identified as a key enabling technologies by the European Commission, and their full use will benefit the socio-economic progress of Europe in the future. Metrology is identified as a key enabler for these technologies and has been recognised as such by the establishment of the European Metrology Network (EMN) for Advanced Manufacturing by EURAMET, the association of metrology institutes across Europe. The structure and plan of the EMN have been previously reported in [1,2]. One of the key tasks of the EMN is to understand the current metrology gaps in advanced manufacturing [2] and to address these through the development of a strategic research agenda. This paper will describe the approach of the EMN has taken to date to develop the strategic research agenda (SRA). It will firstly describe the approach taken to assess the technology gaps. It will follow with the structure of the SRA, split between cross cutting topics and key industry sector specific topics.

### 2. Strategic Research Agenda (SRA)

The SRA is a living document that will be maintained by the EMN and serves a mechanism for obtaining, integrating and sharing input from all stakeholders. The SRA should guide the development of metrology in support of advanced

manufacturing. The SRA will act as a key reference for metrology needs for any proposed future research topic related to advanced manufacturing. The SRA should also facilitate input into other initiatives, technical committees and other EMNs.

The timeline for the development of the SRA included the first iteration of the approach described below to produce the preliminary draft SRA in December 2022 as listed content. The full detail of the draft SRA can be found at <https://www.euramet.org/european-metrology-networks/advanced-manufacturing/strategic-research-agenda> [3]. This will be followed by the draft report in April 2023 and the finalised document in May 2024.

#### 2.1. Approach for the development of SRA

The approach to gather input and expertise to shape the strategic research needs of the advanced manufacturing and materials sector in terms of metrology has been multifaceted. The following stages have been followed, building on existing work by materials and manufacturing communities both on national and European levels;

- Analysis of existing strategy and technology roadmap documents
- Initial proposal of structure and content themes from EMN
- Brainstorming of EMN experts

- Questionnaires and other inputs from wider metrology community
- Key industrial sector inputs and cross cutting topics
- Open forums and discussion of content
- Cross cutting topics workshops
- Key industrial sector specific workshops/open consultations
- Periodic Stakeholder Council input, review and guidance

The strategy to achieve a robust identification of the metrology needs of the various industrial sectors is continuously being refined. An example of the 'best practice' was the Open Consultation event "Metrology for Semiconductor Technologies" organised by EURAMET and the EMN for Advanced Manufacturing which was held online in July 2022. Further examples of such stakeholder engagement and consultation covering other Key Industrial Sectors are planned over 2023 and 2024 and their input included in the final published SRA in May 2024.

### 3. Structure of the SRA

The SRA is structured into an introduction and scene setting followed by the content for cross-cutting sectors and key industrial sector (KIS) specific topics.

#### 3.1. Cross-Cutting Topics (CCT)

The cross-cutting topics broadly cover the key steps in manufacturing. The cross-cutting topics are the shown in Figure 1, illustrating their interdependency.

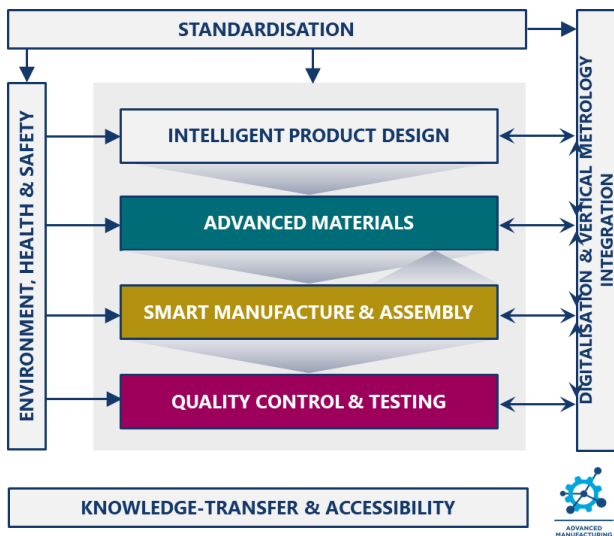


Figure 2. Cross-cutting topics along the manufacturing process chain.

#### 3.2. Key Industry Sectors (KIS) specific topics

In addition to the cross-cutting topics, there are specific metrology needs for the diverse range of key industrial sectors encompassed by advanced manufacturing and materials. The definition of these key industrial sectors is described in [1] and listed below. For each KIS, the specific metrology challenges have been identified in the draft SRA.

- Metrology equipment & service
- Machine tools & robotics
- Digitalized & integrated manufacturing systems
- Energy generation, transmission & storage
- Advanced materials & processing
- Nano- & microelectronics
- Nano- & microtechnology

- Optics & photonics
- Land & sea-based mobility
- Aerospace
- Complex infrastructure & civil engineering
- Life science technology
- Defense & security

### 4. Topics related to precision engineering

One key sector of Advanced Manufacturing which already utilise the latest digital tools is Additive Manufacturing. This topic is captured in the SRA under the KIS of Machine Tools Robotics, although it is also prevalent in several other KIS and encompasses many of the challenges raised in the cross-cutting topics. Research for additive manufacturing has already been funded by EURAMET through the EMPIR joint research project MetAMMI [4], focusing of the metrology of medical implants manufactured by additive manufacturing methods. However further metrology challenges remain for this growing manufacturing technology which have been identified in the SRA, including the following:

- Developing reliable defect detection and characterisation in additively manufactured parts
- Developing methods for reliable determination of the link between process parameters & product quality
- Developing application specific process control for AM machine tools and metrology for post processing
- Developing new traceable surface temperature measurement
- Developing methods to investigate correlations of in-process tool metrology to surface roughness/topography, microstructure, residual stress for digital twin of process and workpiece and use of AI to predict impact on product function

### 5. Perspective

This paper has provided an overview of the work of the EMN for Advanced Manufacturing to develop the first strategic research agenda (SRA) for metrology for advanced manufacturing. It has described the approach taken to assess the metrology gaps which currently exist within advanced manufacturing and materials. The structure of the draft SRA has been described in this paper and the substructure of generic cross cutting topics and key industry sector specific challenges. The draft SRA will be developed into a full document and the final version published in May 2024 following further engagement with Stakeholders and the Advanced Manufacturing and Materials communities.

### Acknowledgements

We would like to thank Dr. Karl-Dietrich Imkamp, ZEISS Industrial Quality Solutions Germany and the EMN Stakeholder Council for giving advice and support. The project [JNP 19NET01 AdvManuNet](#) has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme.

### References

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