
**General requirements for cyber-
physically controlled smart machine
tool systems (CPSMT) —**

**Part 3:
Reference architecture of CPSMT for
additive manufacturing**



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 1, *Industrial cyber and physical device control*.

A list of all parts in the ISO 23704 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

According to ISO/ASTM 52900, additive manufacturing (AM) is the process of joining materials to make a part from 3D model data usually layer by layer. With the advancement of various feedstocks, process technologies, and product design methodologies, AM contributes to realizing customized production, which is the key objective of Industry 4.0. Also, AM allows construction of complex geometry and other features that were previously impossible or impractical to manufacture.

Many institutions have long been devoted to technological development from the viewpoint of reducing downtime and defects and are considering smart technologies such as Internet-of-Things (IoT) as a new means to achieve this.

From the market perspective, many institutions have released various smart additive manufacturing systems (SAMS) based on their own concepts and local terminologies. This makes stakeholders confused about the common concept of SAMS, including end-users. For this reason, standards and substantial modelling for a SAMS are needed.

From the standards perspective, for standards on contemporary AM technology, there is a set of standards and a roadmap from ISO TC261/ASTM F42. For standards on smart manufacturing, RAMI 4.0 (IEC/PAS 63088) and IEC TR 63319 TR-SMRM provide a reference model for smart manufacturing on a high level. Even though some standards deal with Industry 4.0 enabling technologies, e.g. OPC-UA (IEC/TR 62541-1 and Reference [67]), MTConnect (ANSI/MTC1.4-2018), ISO/IEC 30141, IEC 62769, there are no standards specifying the SAMS.

The ISO 23704 series specifies general requirements on smart machine tools for supporting smart manufacturing in the shop floor via cyber-physical system control scheme, namely cyber-physically controlled smart machine tool systems (CPSMT).

Figure 1 shows the overall structure of the ISO 23704 series, including:

- Overview and fundamental principles of CPSMT in ISO 23704-1;
- Reference architecture of CPSMT for subtractive manufacturing in ISO 23704-2;
- Reference architecture of CPSMT for AM in ISO 23704-3.

Other related parts such as implementation guideline or reference architecture for other types of manufacturing will be added if and when necessary

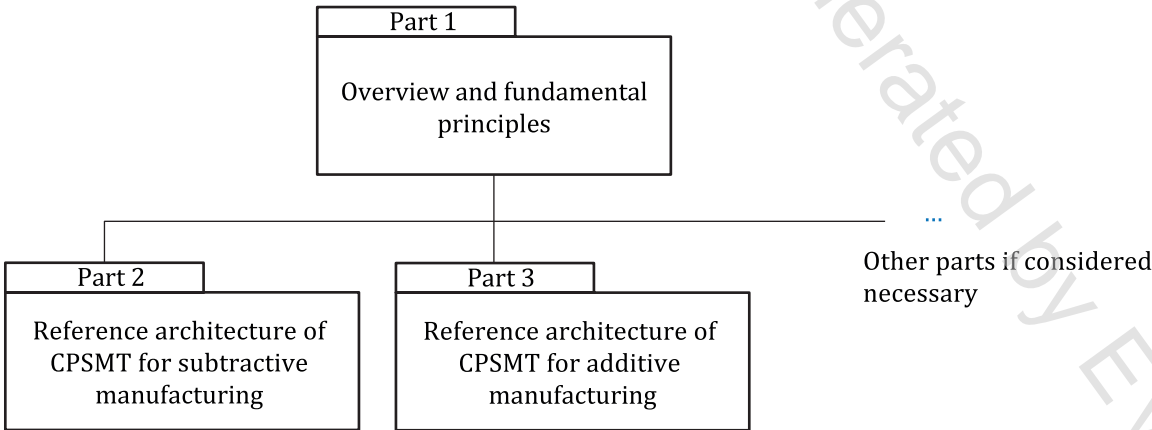


Figure 1 — Overall structure of the ISO 23704 series on general requirements for cyber-physically controlled smart machine tool systems (CPSMT)

This document can be used as a reference and guidelines for stakeholders such as, but not limited to:

- Design engineers in the area of SAMS,

- System architects in the area of SAMS,
- Software engineers working with the AM machine builders in the area of SAMS,
- Machine tool control vendors in the area of SAMS,
- Solution and service providers in the area of SAMS, and
- End users such as factory operators working with SAMS.

General requirements for cyber-physically controlled smart machine tool systems (CPSMT) —

Part 3: Reference architecture of CPSMT for additive manufacturing

1 Scope

This document specifies a reference architecture of cyber-physically controlled smart machine tool systems (CPSMT) for additive manufacturing (AM) based on the reference architecture of CPSMT as provided in ISO 23704-1 and the requirements for cyber-physically controlled smart additive manufacturing system.

The reference architecture of a CPSMT for AM includes:

- the technical requirements for the smart additive manufacturing system (SAMS),
- the reference architecture of the cyber-physically controlled machine tools (CPCM) for AM,
- the reference architecture of the cyber-supporting system for machine tools (CSSM) for AM, and
- the interface view of the CPSMT for AM.

This document also provides:

- stakeholder requirements for the SAMS,
- the concept of the digital thread,
- types of abnormality in AM, and
- use cases of reference architecture of a CPSMT for AM.

This document does not specify physical or implementation architecture.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements for this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 23704-1, *General requirements for cyber-physically controlled smart machine tool systems (CPSMT) — Part 1: Overview and fundamental principles*

ISO 23704-2, *General requirements for cyber-physically controlled smart machine tool systems (CPSMT) — Part 2: Reference architecture of CPSMT for subtractive manufacturing*

ISO/ASTM 52900, *Additive manufacturing — General principles — Fundamentals and vocabulary*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in ISO 23704-1, ISO 23704-2, ISO/ASTM 52900, and the following apply.