

First edition
2023-03

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

Part 3: Reference architecture of CPSMT for additive manufacturing



Reference number
ISO 23704-3:2023(E)

© ISO 2023



COPYRIGHT PROTECTED DOCUMENT

© ISO 2023

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

This is a preview of ISO 23704-3:2023. [Click here to purchase the full version from the ANSI store.](#)

Contents

	Page
Foreword	v
Introduction	vi
1 Scope	1
2 Normative references	1
3 Terms, definitions and abbreviated terms	1
3.1 Terms, definitions and abbreviations.....	2
3.2 Symbols and abbreviated terms.....	4
4 Conformance with the CPSMT reference architecture for additive manufacturing (AM)	4
5 Goals and objectives of the CPSMT reference architecture for AM	4
6 Technical requirements of a smart additive manufacturing system (SAMS) from the CPSMT perspective	6
6.1 General.....	6
6.2 Technical requirements of autonomously dealing with abnormalities.....	7
6.2.1 General.....	7
6.2.2 Dealing with hard real-time scale abnormalities during an AM process.....	7
6.2.3 Dealing with soft real-time scale abnormalities during an AM process.....	8
6.2.4 Acquisition of data related to an AM process.....	8
6.2.5 Data processing related to an AM process.....	8
6.2.6 Extraction of value-added data.....	8
6.2.7 AM process monitoring.....	9
6.2.8 AM process status prediction.....	9
6.2.9 AM process status diagnosis.....	9
6.2.10 Making decisions about the AM system to enhance AM process performance.....	10
6.2.11 Update of the AM workflow data.....	10
6.2.12 Dealing with abnormalities.....	10
6.3 Technical requirements of autonomous coordination with shop floor devices.....	11
6.3.1 General.....	11
6.3.2 Coordination among shop floor devices.....	11
6.4 Technical requirements of autonomous collaboration with a shop floor control system.....	12
6.4.1 General.....	12
6.4.2 Receiving a coordinated process plan.....	12
6.4.3 Providing the AM process data for shop floor operation.....	12
6.4.4 Interoperability for the data interface.....	12
6.5 Technical requirements of interface with AM workflow.....	13
6.5.1 General.....	13
6.5.2 Interface with AM workflow.....	13
6.5.3 Interoperability for interface with AM workflow.....	13
6.6 Technical requirement of interface with hierarchy levels.....	13
6.6.1 General.....	13
6.6.2 Interface with a hierarchy level.....	13
6.6.3 Interoperability for interface with hierarchy level.....	14
6.7 Technical requirement of interface with humans.....	14
6.7.1 General.....	14
6.7.2 Interface with humans.....	14
6.7.3 Interoperability for interface with humans.....	14
7 Reference architecture of a CPSMT for AM	14
8 Functional view of a CPCM for additive manufacturing (AM)	17
8.1 General.....	17
8.2 AM machine unit (AMU) of a CPCM.....	17

This is a preview of ISO 23704-3:2023. [Click here to purchase the full version from the ANSI store.](#)

8.2.1	General	17
8.2.2	AM function perspective	17
8.2.3	AM process perspective	17
8.2.4	AM component perspective	18
8.2.5	Abnormalities of an AM machine unit (AMU)	19
8.3	Cyber-physical system (CPS) unit	19
8.3.1	General	19
8.3.2	Inner-loop element	20
8.3.3	Intra-loop element	22
8.3.4	Inter-loop element	23
9	Functional view of a CSSM for AM	23
9.1	General	23
9.2	Data processing unit (DPU)	24
9.2.1	General	24
9.2.2	CPCM interface element	24
9.2.3	UIS interface element	24
9.2.4	Data fusion element	25
9.2.5	Data storage element	25
9.2.6	Data transformer for external entities element	25
9.3	Digital thread unit	26
9.3.1	General	26
9.3.2	AM workflow data model	26
9.3.3	AM workflow data management	30
9.3.4	AM behaviour model	30
9.3.5	Behaviour model engine	30
9.4	MAPE unit	31
9.4.1	General	31
9.4.2	Monitoring element	31
9.4.3	Analysis element	31
9.4.4	Planning element	32
9.4.5	Execution element	32
9.5	External interface unit	32
9.5.1	General	32
9.5.2	Interface schema element	33
9.5.3	Interface manager element	33
10	Interface view of a CPSMT for AM	33
10.1	General	33
10.2	CPCM interface	34
10.2.1	General	34
10.2.2	External interface with a CPCM	34
10.2.3	Internal interface with a CPCM	35
10.3	CSSM interface	35
10.3.1	General	35
10.3.2	External interface with a CSSM	36
10.3.3	Internal interface with a CSSM	36
Annex A	(informative) Collected stakeholder requirements on smart additive manufacturing system (SAMS)	38
Annex B	(informative) Concept of the digital thread in AM	40
Annex C	(informative) Types of abnormality in AM	41
Annex D	(informative) Example use cases of reference architecture of a CPSMT for additive manufacturing (AM)	43
Bibliography		49

This is a preview of ISO 23704-3:2023. [Click here to purchase the full version from the ANSI store.](#)

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.

This is a preview of ISO 23704-3:2023. [Click here to purchase the full version from the ANSI store.](#)

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

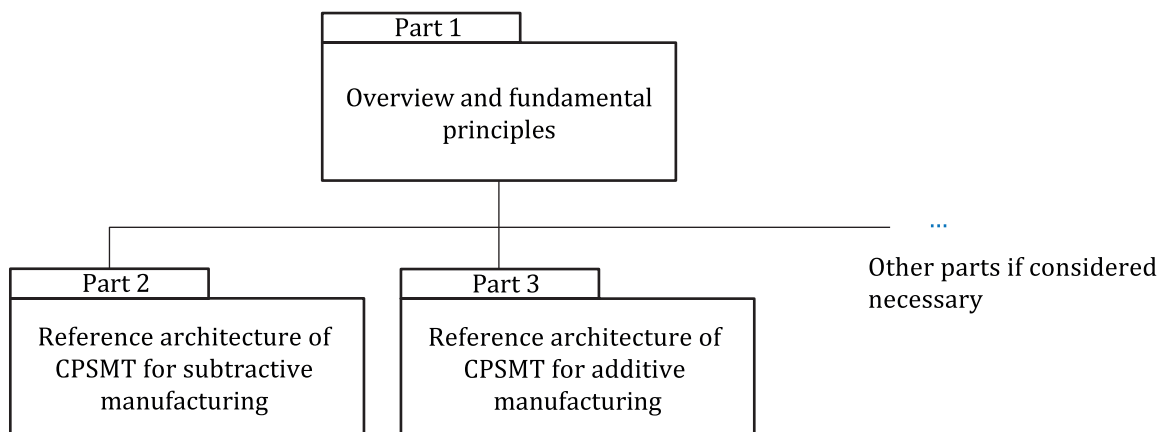


Figure 1 — Overall structure of the ISO 23704 series on general requirements for cyber-physically controlled smart machine tool systems (CPSMT)

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,

This is a preview of ISO 23704-3:2023. [Click here to purchase the full version from the ANSI store.](#)

- 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.