

# ISO 23704-3:2023-03 (E)

## General requirements for cyber-physically controlled smart machine tool systems (CPSMT) - Part 3: Reference architecture of CP SMT for additive manufacturing

---

### 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

<b>8</b>	<b>Functional view of a CPCM for additive manufacturing (AM) .....</b>	<b>17</b>
8.1	General .....	17
8.2	AM machine unit (AMU) of a CPCM .....	17
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
<b>9</b>	<b>Functional view of a CSSM for AM .....</b>	<b>23</b>
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
<b>10</b>	<b>Interface view of a CPSMT for AM .....</b>	<b>33</b>
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
<b>Annex A (informative)</b>	<b>Collected stakeholder requirements on smart additive manufacturing system (SAMS) .....</b>	<b>38</b>
<b>Annex B (informative)</b>	<b>Concept of the digital thread in AM .....</b>	<b>40</b>
<b>Annex C (informative)</b>	<b>Types of abnormality in AM .....</b>	<b>41</b>
<b>Annex D (informative)</b>	<b>Example use cases of reference architecture of a CPSMT for additive manufacturing (AM) .....</b>	<b>43</b>
<b>Bibliography .....</b>		<b>49</b>