MTconnect[®]

MTConnect[®] Standard Part 3.0 – Observation Information Model Version 2.1.0

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The normative XMI is located at the following URL: MTConnectSysMLModel.xml

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1 **1** Purpose of This Document

This document, *MTConnect Standard: Part 3.0 - Observation Information Model* of the
MTConnect Standard, establishes the rules and terminology that describes the information returned by an *MTConnect Agent* from a piece of equipment. The term(Observation
Information Model also defines, in *MTConnect Standard: Part 3.0 - Observation Infor- mation Model*, the structure for the *response documents* that are returned from an *agent* in
response to a *sample request* or *current request*. *MTConnect Standard: Part 3.0 - Observation Information Model* is not a stand-alone document. This document is used in conjunction with *MTConnect Standard Part 1.0 - Fun- damentals* which defines the fundamentals of the operation of the MTConnect Standard
and *MTConnect Standard: Part 2.0 - Device Information Model* that defines the semantic

12 model representing the information that may be returned from a piece of equipment.

- 13 Note: MTConnect Standard: Part 5.0 Interface Interaction Model provides
- 14 details on extensions to the Observation Information Model required to de-
- scribe the interactions between pieces of equipment.
- 16 In the MTConnect Standard, equipment represents any tangible property that is used in the
- 17 operation of a manufacturing facility. Examples of equipment are machine tools, ovens,
- 18 sensor units, workstations, software applications, and bar feeders.

19 2 Terminology and Conventions

- 20 Refer to MTConnect Standard Part 1.0 Fundamentals for a dictionary of terms, reserved
- 21 language, and document conventions used in the MTConnect Standard.

22 2.1 General Terms

23 adapter

24	optional piece of hardware or software that transforms information provided by a
25	piece of equipment into a form that can be received by an <i>agent</i> .

26 agent

software that collects data published from one or more piece(s) of equipment, organizes that data in a structured manner, and responds to requests for data from
client software systems by providing a structured response in the form of a *response document* that is constructed using the *semantic data model* of a Standard.

31 alarm limit

32 limit used to trigger warning or alarm indicators.

33 application

software or a program that is specific to the solution of an application problem.
 Ref ISO/IEC 20944-1:2013

36 archetype

archetype provides the requirements, constraints, and common properties for a type
 of *Asset*.

39 asset buffer

40 *buffer* for Assets.

41 attachment

42 connection by which one thing is associated with another.

43 *buffer*

section of an *agent* that provides storage for information published from pieces ofequipment.

46	cartesian coordinate system
47	3D orthogonal coordinate system [(]ISO/IEC 19794-5:2011en).
48	client
49	application that sends request for information to an agent.
50 51	Note: Examples include software applications or a function that implements the <i>request</i> portion of an <i>interface interaction model</i> .
52	controlled vocabulary
53	restricted set of values that may be published for an observation.
54	data dictionary
55	listing of standardized terms and definitions used in MTConnect Information Model.
56	data model
57 58	organizes elements of data and standardizes how they relate to one another and to the properties of real-world entities.
59	data set
60	key-value pairs where each entry is uniquely identified by the key.
61	data source
61 62	<i>data source</i> piece of equipment that can produce data that is published to an <i>agent</i> .
61 62 63	<i>data source</i> piece of equipment that can produce data that is published to an <i>agent</i> . <i>deprecated</i>
61 62 63 64 65	data source piece of equipment that can produce data that is published to an agent. deprecated indication that specific content in an MTConnect Document is currently usable but is regarded as being obsolete or superseded.
61 62 63 64 65 66	 data source piece of equipment that can produce data that is published to an <i>agent</i>. deprecated indication that specific content in an <i>MTConnect Document</i> is currently usable but is regarded as being obsolete or superseded. deprecation warning
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76 extensible

ability for an implementer to extend *MTConnect Information Model* by adding con tent not currently addressed in the MTConnect Standard.

79 *force*

⁸⁰ push or pull on a mass which results in an acceleration.

81 *heartbeat*

function that indicates to a *client* that the communications connection to an *agent* is
still viable during times when there is no new data available to report often referred
to as a "keep alive" message.

85 higher level

nested element that is above a lower level element.

87 implementation

specific instantiation of the MTConnect Standard.

89 information model

rules, relationships, and terminology that are used to define how information is struc tured.

92 instance

describes a set of *streaming data* in an *agent*. Each time an *agent* is restarted with
an empty *buffer*, data placed in the *buffer* represents a new *instance* of the *agent*.

95 interaction model

model that defines how information is exchanged across an *interface* to enable in teractions between independent systems.

98 interface

means by which communication is achieved between independent systems.

100 *key*

101 unique identifier in a *key-value pair* association.

102 key-value pair

association between an identifier referred to as the *key* and a value which taken
together create a *key-value pair*.

105 lower camel case

106 first word is lowercase and the remaining words are capitalized and all spaces be-107 tween words are removed.

108 lower level

nested element that is below a higher level element.

110 lower limit

111 lower conformance boundary for a variable.

112 lower warning

lower boundary indicating increased concern and supervision may be required.

114 *major*

identifier representing a consistent set of functionalities defined by the MTConnectStandard.

117 *maximum*

118 numeric upper constraint.

119 message

120 communication in writing, in speech, or by signals.

121 metadata

data that provides information about other data.

123 *minimum*

124 numeric lower constraint.

125 *minor*

identifier representing a specific set of functionalities defined by the MTConnectStandard.

128 nominal

ideal or desired value for a variable.

130 organize

- act of containing and owning one or more elements.
- 132 organizer
- 133 entity that *organizes* one or more elements.

134 parameter

variable that must be given a value during the execution of a program or a commu-nications command.

137 *part*

discrete item that has both defined and measurable physical characteristics including
 mass, material, and features, and is created by applying one or more manufacturing
 process steps to a workpiece

141 pascal case

first letter of each word is capitalized and the remaining letters are in lowercase. All
space is removed between letters

144 *persistence*

145 method for retaining or restoring information.

146 *probe*

instrument commonly used for measuring the physical geometrical characteristicsof an object.

149 profile

extends a reference metamodel (such as Unified Modeling Language (UML)) by
 allowing to adapt or customize the metamodel with constructs that are specific to a
 particular domain, platform, or a software development method.

153 requester

154 entity that initiates a *request* for information in a communications exchange.

155 *reset*

- act of reverting back the accumulated value or statistic to their initial value.
- 157Note: An Observation with a data set representation removes all key-158value pairs, setting the data set to an empty set.

159 responder

160 entity that responds to a *request* for information in a communications exchange.

161 response document

electronic *document* published by an *MTConnect Agent* in response to a *probe re- quest, current request, sample request* or *asset request.*

164 *revision*

supplemental identifier representing only organizational or editorial changes to a *minor* version document with no changes in the functionality described in that document.

168 schema

definition of the structure, rules, and vocabularies used to define the informationpublished in an electronic document.

171 semantic data model

methodology for defining the structure and meaning for data in a specific logical
way that can be interpreted by a software system.

174 sensing element

mechanism that provides a signal or measured value.

176 sequence number

primary key identifier used to manage and locate a specific piece of *streaming data*in an *agent*.

179 specification limit

180 limit defining a range of values designating acceptable performance for a variable.

181 spindle

- mechanism that provides rotational capabilities to a piece of equipment.
- 183 Note: Typically used for either work holding, materials or cutting tools.

184 standard

document established by consensus that provides rules, guidelines, or characteristics
 for activities or their results.. *Ref ISO/IEC Guide 2:2004*

187 *stereotype*

defines how an existing UML metaclass may be extended as part of a *profile*.

189 subtype

secondary or subordinate type of categorization or classification of information.

191 *table*

192 two dimensional set of values given by a set of *key-value pairs table entries*.

193	table cell
194	subdivision of a <i>table entry</i> representing a singular value.
195	table entry
196	subdivision of a <i>table</i> containing a set of key-value pairs representing table cells.
197	top level
198 199	element that represents the most significant physical or logical functions of a piece of equipment.
200	type
201	classification or categorization of information.
202	upper limit
203	upper conformance boundary for a variable.
204	upper warning
205	upper boundary indicating increased concern and supervision may be required.
206	version
207	unique identifier of the administered item. Ref ISO/IEC 11179-:2015

208 2.2 Information Model Terms

209 Asset Information Model

210 *information model* that provides semantic models for *Assets*.

211 Device Information Model

information model that describes the physical and logical configuration for a piece of equipment and the data that may be reported by that equipment.

214 Error Information Model

information model that describes the *response document* returned by an *agent* when
 it encounters an error while interpreting a *request* for information from a *client* or
 when an *agent* experiences an error while publishing the *response* to a *request* for
 information.

219 MTConnect Information Model

information model that defines the semantics of the MTConnect Standard.

221 Observation Information Model

information model that describes the *streaming data* reported by a piece of equipment.

224 2.3 Protocol Terms

225 asset request

226 *HTTP Request* to the *agent* regarding *Assets*.

227 current request

- *request* to an *agent* to produce an *MTConnectStreams Response Document* containing the *Observation Information Model* for a snapshot of the latest observations at
- the moment of the *request* or at a given *sequence number*.

231 data streaming

method for an *agent* to provide a continuous stream of information in response to a
single *request* from a *client*.

234 MTConnect Request

request for information issued from a *client* to an *MTConnect Agent*.

236 MTConnect Response Document

237 *response document* published by an *MTConnect Agent*.

238 MTConnectAssets Response Document

response document published by an *MTConnect Agent* in response to an *asset re- quest.*

241 MTConnectDevices Response Document

response document published by an *MTConnect Agent* in response to a probe request.

244 MTConnectErrors Response Document

response document published by an *MTConnect Agent* whenever it encounters an error while interpreting an *MTConnect Request*.

247 MTConnectStreams Response Document

response document published by an MTConnect Agent in response to a current re quest or a sample request.

250 probe request

request to an agent to produce an MTConnectDevices Response Document containing the Device Information Model.

253 *protocol*

set of rules that allow two or more entities to transmit information from one to theother.

256 *publish*

sending of messages in a *publish and subscribe* pattern.

258 publish and subscribe

- asynchronous communication method in which messages are exchanged betweenapplications without knowing the identity of the sender or recipient.
- Note: In the MTConnect Standard, a communications messaging pattern that may be used to publish *streaming data* from an *agent*.

263 request

communications method where a *client* transmits a message to an *agent*. That mes sage instructs the *agent* to respond with specific information.

266 request and response

communications pattern that supports the transfer of information between an *agent*and a *client*.

269 response

response *interface* which responds to a *request*.

271 sample request

- 272 request to an agent to produce an MTConnectStreams Response Document contain-
- ing the *Observation Information Model* for a set of timestamped observations madeby *Components*.

275 streaming data

- observations published by a piece of equipment defined by the equipment metadata.
- 277 subscribe
- receiving messages in a *publish and subscribe* pattern.

279 transport protocol

- set of capabilities that provide the rules and procedures used to transport information
- between an *agent* and a client software application through a physical connection.

282 2.4 HTTP Terms

283 HTTP Body

data bytes transmitted in an HTTP transaction message immediately following the
headers. *Ref IETF:RFC-2616*

286 HTTP Error Message

response provided by an *agent* indicating that an *HTTP Request* is incorrectly for matted or identifies that the requested data is not available from the *agent*. *Ref IETF:RFC* 2616

290 HTTP Header

header of either an *HTTP Request* from a *client* or an *HTTP Response* from an *agent*. *Ref IETF:RFC-2616*

293 HTTP Header Field

components of the header section of request and response messages in an HTTP transaction. *Ref IETF:RFC-2616*

296 HTTP Message

- consist of requests from client to server and responses from server to client. *Ref IETF:RFC-* 2616
- Note: In MTConnect Standard, it describes the information that is exchanged between an *agent* and a *client*.

301 HTTP Messaging

interface for information exchange functionality. *Ref IETF:RFC-2616*

303 HTTP Method

- portion of a command in an *HTTP Request* that indicates the desired action to be performed on the identified resource; often referred to as verbs. *Ref IETF:RFC*-2616
- 306 **2616**

307 HTTP Query

portion of a request for information that more precisely defines the specific informa tion to be published in response to the request. *Ref IETF:RFC-2616*

310 HTTP Request

- request message from a client to a server includes, within the first line of that message, the method to be applied to the resource, the identifier of the resource, and the
- 313 protocol version in use. *Ref IETF:RFC-2616*

314	Note: In MTConnect Standard, a request issued by a client to an agent
315	requesting information defined in the HTTP Request Line.

316 HTTP Request Line

- begins with a method token, followed by the Request-URI and the protocol version,
 and ending with CRLF. A CRLF is allowed in the definition of TEXT only as part
- of a header field continuation. *Ref IETF:RFC-2616*
- Note: the first line of an *HTTP Request* describing a specific *response document* to be published by an *agent*.

322 HTTP Request Method

indicates the method to be performed on the resource identified by the Request-URI.
 Ref IETF:RFC-2616

325 HTTP Request URI

Uniform Resource Identifier that identifies the resource upon which to apply the request. *Ref IETF:RFC-2616*

328 HTTP Response

- after receiving and interpreting a request message, a server responds with an HTTP response message. *Ref IETF:RFC-2616*
- 331Note: In MTConnect Standard, the information published from an *agent*332in reply to an *HTTP Request*.

333 HTTP Server

server that accepts *HTTP Request* from *client* and publishes *HTTP Response* as a
 reply to those *HTTP Request*. *Ref IETF:RFC-2616*

336 HTTP Status Code

3-digit integer result code of the attempt to understand and satisfy the request.
 Ref IETF:RFC-2616

339 HTTP Version

version of the HTTP protocol. *Ref IETF:RFC-2616*

341 2.5 XML Terms

342 abstract element

element that defines a set of common characteristics that are shared by a group of
elements. An abstract entity cannot appear in a document. In a specific implementation, an abstract entity is replaced by a derived element that is itself not an abstract
entity. The characteristics for the derived element are inherited from the abstract
entity.

348 *attribute*

additional information or property for an *element*.

350 child element

element of a data modeling structure that illustrates the relationship between itself and the higher-level *parent element* within which it is contained.

353 document body

portion of the content of an *MTConnect Response Document* that is defined by the relative *MTConnect Information Model*. The *document body* contains the *structural elements* and *Observations* or *DataItems* reported in a *response document*.

357 document header

portion of the content of an *MTConnect Response Document* that provides information from an *agent* defining version information, storage capacity, protocol, and other information associated with the management of the data stored in or retrieved from the *agent*.

362 element name

descriptive identifier contained in both the start-tag and end-tag of an XML
element that provides the name of the element.

365 *namespace*

366 organizes information into logical groups.

367 parent element

element of a data modeling structure that illustrates the relationship between itselfand the lower-level *child element*.

370 root element

371 first *structural element* provided in a *response document* encoded using XML.

372 structural element

element that organizes information that represents the physical and logical parts and sub-parts of a piece of equipment.

375 XML Document

376 structured text file encoded using Extensible Markup Language (XML).

377 XML Schema

schema defining a specific document encoded in XML.

379 2.6 MTConnect Terms

380 Asset

- asset that is used by the manufacturing process to perform tasks.
- 382Note 1 to entry: An Asset relies upon an Device to provide observations383and information about itself and the Device revises the information to384reflect changes to the Asset during their interaction. Examples of Assets385are cutting tools, Part Information, Manufacturing Processes, Fixtures,386and Files.
- 387Note 2 to entry: A singular assetId, Asset uniquely identifies an388Asset throughout its lifecycle and is used to track and relate the Asset to389other Devices and entities.
- 390Note 3 to entry: Assets are temporally associated with a device and can391be removed from the device without damage or alteration to its primary392functions.

393 Component

engineered system part of a *Device* composed of zero or more *Components*

395 *Composition*

396 *Component* belonging to a *Component* and not composed of any *Components*.

397 Configuration

398 configuration for a *Component*

399 DataItem

400 observable observed by a *Component* that may make *Observations*

401	Device
402	Component not belonging to any Component that may have assets
403	MTConnect Agent
404	agent for the MTConnect Information Model.
405	MTConnect Document
406	document that represents a Part(s) of the MTConnect Standard.
407	MTConnect Event
408	observation of either a state or discrete value of the Component.
409	MTConnect Interface
410	interaction model for interoperability between pieces of equipment.
411	Observation
412	observation that provides telemetry data for a DataItem.
413	2.7 Acronyms
4.7.4	10
414	2D two-dimensional
11J	20
41b	$\mathcal{S}\mathcal{D}$

417 three-dimensional

418 **AI**

419 artificial intelligence

420 **ALM**

- 421 application lifecycle management
- 422 **AMT**
- 423The Association for Manufacturing Technology
- 424 **ANSI**
- 425 American National Standards Institute

426	AP	
427		Application Protocol
428	API	
429		application programming interface
430	ASMI	E
431		American Society of Mechanical Engineers
432	ASTN	1
433		American Society for Testing and Materials
434	AWS	
435		American Welding Society
436	BDD	
437		block definition diagram
438	BOM	
439		bill of materials
440	BST	
441		Board on Standardization and Testing
442	C&R	
443	cun	cause and remedy
444	CA	·
445		certificate authority
446	CAD	
447		computer-aided design
448	CAE	
449		computer-aided engineering
450	CAI	
451		computer-aided inspection
452	CAM	
453		computer-aided manufacturing

454	CAx
455	computer-aided technologies
456	CDATA
457	Character Data
458	CFD
459	computational fluid dynamics
460	СМ
461	configuration management
462	CMS
463	coordinate-measurement system
464	CNC
465	Computer Numerical Controller
466	CNRI
467	Corporation for National Research Initiatives
1.0	CDM
468	CFM
468 469	Core Product Model
468 469 470	Core Product Model CPM2
468 469 470 471	Core Product Model CPM2 Revised Core Product Model
468 469 470 471 472	Core Product Model CPM2 Revised Core Product Model CPSC
468 469 470 471 472 473	CORE Product Model CPM2 Revised Core Product Model CPSC Consumer Product Safety Commission
468 469 470 471 472 473 474	CORE Product Model CPM2 Revised Core Product Model CPSC Consumer Product Safety Commission cUAV
468 469 470 471 472 473 474 475	CORE Product Model CPM2 Revised Core Product Model CPSC Consumer Product Safety Commission CUAV configurable unmanned aerial vehicle
 468 469 470 471 472 473 474 475 476 	CORE Product Model CPM2 Revised Core Product Model CPSC Consumer Product Safety Commission CUAV configurable unmanned aerial vehicle DARPA
 468 469 470 471 472 473 474 475 476 477 	CPM Core Product Model CPM2 Revised Core Product Model CPSC Consumer Product Safety Commission CUAV configurable unmanned aerial vehicle DARPA Defense Advanced Research Projects Agency
 468 469 470 471 472 473 474 475 476 477 478 	CFM Core Product Model CPM2 Revised Core Product Model CPSC Consumer Product Safety Commission cUAV configurable unmanned aerial vehicle DARPA Defense Advanced Research Projects Agency DER
 468 469 470 471 472 473 474 475 476 477 478 479 	CPM Core Product Model CPM2 Revised Core Product Model CPSC Consumer Product Safety Commission cUAV configurable unmanned aerial vehicle DARPA Defense Advanced Research Projects Agency DER designated-engineering representative
 468 469 470 471 472 473 474 475 476 477 478 479 480 	CFM Core Product Model CPM2 Revised Core Product Model CPSC Consumer Product Safety Commission CUAV configurable unmanned aerial vehicle DARPA Defense Advanced Research Projects Agency DER designated-engineering representative DFM

482	DLA
483	Defense Logistics Agency
484	DMC
485	digital manufacturing certificate
486	DMSC
487	Dimensional Metrology Standards Consortium
488	DNS
489	Domain Name System
490	DoD
491	U.S. Department of Defense
492	DOI
493	Distributed Object Identifier
494	DRM
495	digital rights management
496	ECR
497	engineering change request
498	ERP
499	enterprise resource planning
500	FAA
501	Federal Aviation Administration
502	FAIR
503	first article inspection reporting
504	FDA
505	Food and Drug Administration
506	FEA
507	finite-element analysis
500	GD&T
500	geometric dimensions and tolerances
505	5°°°°°°°°°°°°°°°°°°°°°°°°°°°°°°°°°°°°°

510	GID	
511		global identifier
512	HMI	
513		Human Machine Interface
514	HTM	L
515		Hypertext Markup Language
516	HTT	P
517		Hypertext Transfer Protocol
518	HTT	PS
519		Hypertext Transfer Protocol over Secure Sockets Layer
520	I/O	
521		in-out
522	ID	
523		identifier
524	IEEE	
525		Institute of Electrical and Electronics Engineers
526	HoT	
527		industrial internet of things
528	INCO	DSE
529		International Council on Systems Engineering
530	IP	
531		intellectual property
532	ISO	
533		International Standards Organization
534	ISS	
535		International Space Station
536	ISV	
537		Independent Software Vendor

IT
information technology
ITU-T
Telecommunication Standardization Sector of the International Telecommunication Union
JSON
JavaScript Object Notation
JT
Jupiter Tesselation
LHS
Lifecycle Handler System
LIFT
Lifecycle Information Framework and Technology
LOI
Lifecycle Object Identifier
MAC
media access control
MADE
Manufacturing Automation and Design Engineering
MBD
model-based definition
MBE
Model-Based Enterprise
MBI
model-based inspection
MBM
model-based manufacturing

565	MBSD
566	model-based standards development
567	MBSE
568	model-based systems engineering
569	MEDALS
570	Military Engineering Data Asset Locator System
571	MES
572	manufacturing execution system
573	ΜΟΙ
574	manufacturing object identifier
575	МОМ
576	Message Orienged Middleware
577	MQTT
578	Message Queuing Telemetry Transport
579	МТС
580	Manufacturing Technology Centre
581	NASA
582	National Aeronautics and Space Administration
583	NC
584	numerical control
585	NIST
586	National Institute of Standards and Technology
587	NMTOKEN
588	Name Token
589	NNMI
590	National Network of Manufacturing Innovation
591	NSF
592	National Science Foundation

593	NTSC
594	National Transportation Safety Board
595	OASIS
596	Organization for the Advancement of Structured Information Standards
597	ODI
598	Open Data Institute
599	OEM
600	original equipment manufacturer
601	001
602	Ocean Observatories Initiative
603	OPC
604	OLE for Process Control
605	OSLC
606	Open Services for Lifecycle Collaboration
607	OSTP
608	Office of Science and Technology Policy
609	ΟΤ
610	operational technology
611	OWL
612	Ontology Web Language
613	PDF
614	Portable Document Format
615	PDM
616	product-data management
617	PDQ
618	product-data quality
619	РНМ
620	prognosis and health monitoring

621	PI	
622	р	rincipal investigator
623	PLC	
624	Р	Programmable Logic Controller
625	PLCS	
626	Р	Product Life Cycle Support
627	PLM	
628	р	roduct lifecycle management
629	PLOT	
630	р	roduct lifecycle of trust
631	PMI	
632	р	roduct and manufacturing information
633	PMS	
634	Р	Production Management System
635	PRC	
636	Р	Product Representation Compact
637	PSI	
638	Р	hysical Science Informatics
639	PTAB	
640	Р	rimary Trustworthy Digital Repository Authorization Body Ltd.
641	QIF	
642	Ç	Quality Information Framework
643	QMS	
644	q	uality management system
645	QName	2
646	Ç	Qualified Name
647	RDF	
648	R	Resource Description Framework

649	REST
650	Representational State Transfer
651	RII
652	receiving and incoming inspection
653	S/MIME
654	Secure/Multipurpose Internet Mail Extensions
655	SaaS
656	software-as-a-service
657	SAML
658	Security Assertion Markup Language
659	SC
660	Standards Committee
661	SCADA
662	Supervisory Control And Data Acquisition
663	SDO
664	Standards Development Organization
665	SFTP
666	Secure File Transfer Protocol
667	SKOS
668	Simple Knowledge Organization System
669	SLH
670	system lifecycle handler
671	SLR
672	systematic literature review
673	SME
674	small-to-medium enterprise
675	SMOPAC
676	Smart Manufacturing Operations Planning and Control
677	SMS Test Bed
------------	--
678	Smart Manufacturing Systems Test Bed
679	SOA
680	service-oriented architecture
681	SPMM
682	semantic-based product metamodel
683	SSL
684	Secure Sockets Layer
685	STEP
686	Standard for the Exchange of Product Model Data
687	STEP AP242
688	Standard for the Exchange of Product Model Data Application Protocol 242
689	STL
690	Stereolithography
691	SysML
692	Systems Modeling Language
693	TCP/IP
694	Transmission Control Protocol/Internet Protocol
695	TDP
696	technical data package
697	TLS
698	Transport Layer Security
699	TSM
700	Total System Model
7.0.1	TA
/UI 702	Unified Architecture
702	
703	UAL Unified Architecture Language
104	

705	UML
706	Unified Modeling Language
707	URI
708	Uniform Resource Identifier
709	URL
710	Uniform Resource Locator
711	URN
712	Uniform Resource Name
713	UTC
714	Coordinated Universal Time
715	UUID
716	Universally Unique Identifier
717	V&V
718	verification and validation
719	<i>W3C</i>
720	World Wide Web Consortium
721	WSN
722	Wirth Syntax Notation
723	WWW
724	World Wide Web
725	X.509-PKI
726	Public Key Infrastructure
727	X.509-PMI
728	Privilege Management Infrastructure
729	XML
730	Extensible Markup Language
731	XPath
732	XML Path Language
733	XSD
734	XML Schema Definitions

735 2.8 MTConnect References

736	[MTConnect Part 1.0]	MTConnect Standard Part 1.0 - Fundamentals. Version 2.0.
737 738	[MTConnect Part 2.0]	<i>MTConnect Standard: Part 2.0 - Device Information Model.</i> Version 2.0.
739 740	[MTConnect Part 3.0]	<i>MTConnect Standard: Part 3.0 - Observation Information Model.</i> Version 2.0.
741 742	[MTConnect Part 4.0]	<i>MTConnect Standard: Part 4.0 - Asset Information Model.</i> Version 2.0.
743 744	[MTConnect Part 5.0]	<i>MTConnect Standard: Part 5.0 - Interface Interaction Model.</i> Version 2.0.

745

746 **3 Observation Information Model**

The Observation Information Model provides a representation of the data reported by a piece of equipment used for a manufacturing process, or used for any other purpose. Additional descriptive information associated with the reported data is defined by the MT-ConnectDevices entity, which is described in MTConnect Standard: Part 2.0 - Device Information Model.

Information defined in the *Observation Information Model* allows a software application
to (1) determine the *Observations* for *DataItems* returned from a piece of equipment and
(2) interpret the data associated with those *Observations* with the same meaning, value,
and context that it had at its original source. To do this, the software application issues one
of two HTTP requests to an *agent* associated with a piece of equipment. They are:

 sample: Returns a designated number of time stamped Observations from an agent associated with a piece of equipment; subject to any HTTP filtering associated with the request. See Agent in MTConnect Standard Part 1.0 - Fundamentals for details on the sample HTTP request.

current: Returns a snapshot of either the most recent values or the values at a given sequence number for all *Observations* associated with a piece of equipment from an *agent*; subject to any HTTP filtering associated with the request. See Agent in *MTConnect Standard Part 1.0 - Fundamentals* for details on the current HTTP request.

An *agent* responds to either the sample or current HTTP request with an *MTConnectStreams Response Document*. This document contains information describing *Observations* reported by an *agent* associated with a piece of equipment. A client software application may correlate the information provided in the *MTConnectStreams Response Document* with the physical and logical structure for that piece of equipment defined in the MTConnectDevices entity to form a clear and unambiguous understanding of the information provided. (See details on the structure for a piece of equipment described in *MTConnect Standard: Part 2.0 - Device Information Model*).

Streams for an MTConnectStreams entity contains a DeviceStream entity for
each piece of equipment represented in the document. Each DeviceStream is comprised of two primary types of entities – *Components* and *Observations*. The contents
of the DeviceStream container are described in detail in this document, *MTConnect Standard: Part 3.0 - Observation Information Model* of the MTConnect Standard.

779 Components are defined for both the MTConnectDevices and the MTConnectStreams

entities. These *Components* are used to provide a logical organization of the informationprovided in each entity.

- For an MTConnectDevices entity: Components organize information that represents the physical and logical parts and sub-parts of a piece of equipment. (See Component in MTConnect Standard: Part 2.0 Device Information Model for more details on Components used in the MTConnectDevices entity).
- For an MTConnectStreams entity: *Components* provide the structure to organize the data returned from a piece of equipment and establishes the proper context for that data. The *Components* specifically defined for MTConnectStreams are DeviceStream (see Section 3.1 DeviceStream) and ComponentStream (see Section 3.2 ComponentStream).
- 791 DeviceStream and ComponentStream entities have a direct correlation to each of 792 the Component defined in the MTConnectDevices entity.
- 793 Within each ComponentStream entity in the MTConnectStreams entity, *Observa-*794 *tions* are modeled as Observation entities. The three types of Observation entity 795 are Sample, Event, and Condition. (See Section 5 - Observation Types for more 796 information on these entities.)

797 3.1 DeviceStream

- 798 *organizes* data reported from a Device.
- 799 DeviceStream MUST be provided for each Device reporting data in an MTConnect-
- 800 Streams Response Document.
- 801 If the response to the request for data from an *agent* does not contain any data for a specific
- 802 Device, an empty DeviceStream entity MAY be created to indicate that the Device
- 803 exists, but there was no data available.

804 3.1.1 Value Properties of DeviceStream

805 *Table 1* lists the Value Properties of DeviceStream.

Value Property name	Value Property type	Multiplicity
name	ID	1
uuid	ID	1

Table 1: Value Properties of DeviceStream

806 Descriptions for Value Properties of DeviceStream:

- 807 name
- name of the Device.
- 809 The value reported for name, DeviceStream MUST be the same as the value 810 defined for the name, Device attribute of the same Device in the *MTConnect*-811 Devices Response Document.
- 812 uuid
- 813 uuid of the Device.

The value reported for uuid, DeviceStream MUST be the same as the value defined for the uuid, Device attribute of the same Device in the *MTConnect*-

816 Devices Response Document.

817 3.1.2 Part Properties of DeviceStream

818 Table 2 lists the Part Properties of DeviceStream.

Part Property name	Multiplicity
ComponentStream	1*

Table 2: Part Properties of DeviceStream

- 819 Descriptions for Part Properties of DeviceStream:
- 820 ComponentStream
- organizes the data associated with each Component entity defined for a Device
- in the associated *MTConnectDevices Response Document*.
- See Section 3.2 ComponentStream.

824 3.2 ComponentStream

organizes the data associated with each Component entity defined for a Device in the associated *MTConnectDevices Response Document*.

At least one of Sample, Event, or Condition MUST be organized by a ComponentStream entity.

829 3.2.1 Value Properties of ComponentStream

830 *Table 3* lists the Value Properties of ComponentStream.

Value Property name	Value Property type	Multiplicity
component	string	1
componentId	ID	1
name	string	01
nativeName	string	01
uuid	ID	01

Table 3: Value Properties of ComponentStream

831 Descriptions for Value Properties of ComponentStream:

832	• component
833	identifies the Component type associated with the ComponentStream.
834	Examples of component are Device, Controller, Linear and Loader.
835	• componentId
836 837	identifier of the Component as defined by the id attribute in the <i>MTConnectDe-</i> vices Response Document.
838	• name
839	name of the Component associated with the ComponentStream.
840	• nativeName
841	common name of the Component associated with the ComponentStream.
842	• uuid
843	uuid of the Component associated with the ComponentStream.

844 3.2.2 Reference Properties of ComponentStream

845 *Table 4* lists the Reference Properties of ComponentStream.

Reference Property name	Multiplicity
Event (organized by Events)	0*
Sample (organized by Samples)	0*
Condition (organized by Conditions)	0*

 Table 4: Reference Properties of ComponentStream

846 Descriptions for Reference Properties of ComponentStream:

847 •	Event
848	Observation that is a discrete piece of information from a piece of equipment.
849	Events groups one or more Event entities. See Section 3.5 - Event.
850 •	Sample
851	Observation that is continuously changing or analog data value.
852	Samples groups one or more Sample entities. See Section 3.4 - Sample.
853 •	Condition
854 855	Observation that provides the condition of a piece of equipment or a <i>Component</i> .
856 857	Conditions groups one or more Condition entities. See Section 3.6 - Condition.
858 859	Note: In the XML representation, Conditions MUST appear as Con- dition element in the <i>MTConnectStreams Response Document</i> .

860 3.3 Observation

abstract entity that provides telemetry data for a DataItem at a point in time.

862	Note: See Section B.1 - Observations Schema Diagrams for XML schema.
863	The XML schema also shows differences in XML representation of certain

864 MTConnect entities.



Figure 1: Observations



Figure 2: DeviceStream Example

- 865 Figure 2 shows a complete example of DeviceStream for the Device shown in *Figure*
- 2: Component Example in MTConnect Standard: Part 2.0 Device Information Model.
- Note: See *Example 1* for the XML representation of the same example.
- 868 This section provides semantic information for the Observation model.
- Note: See Section B.1 Observations Schema Diagrams for XML schema of
- 870 Observation types.

871 3.3.0.1 Observations made for DataItem

- 872 Component observes DataItem entities and creates Observation entities for the 873 DataItem entities. See Figure 1.
- 874 Observation entities made by a Component are organized by a ComponentStream 875 which is specifically created for that Component.



Figure 3: Observations made for DataItem Example

- Note: See Section C.2 Observations made for DataItem Example for how
- XML representation of the same example is separated into *MTConnectDe*-
- vices Response Document and MTConnectStreams Response Document.
- 879 Figure 3 is a subset of Figure 2. It shows an example of the association between a
- 880 DataItem Event type (EMERGENCY_STOP) and an Observation Event type (EmergencyStop).
- 881 See Section 3.3.0.2 Naming Convention for Observation types.
- 882 Figure 3 also shows example of the association between a Component type (Controller)
- 883 and related ComponentStream.

884 **3.3.0.2** Naming Convention for Observation types

- 885 The name of an Observation type MUST derive from the DataItem property type
- converted to Pascal-Case by removing underscores (_) and capitalizing each word. The
- conversion MUST NOT apply to the following abbreviated words: PH, AC, DC and URI.
- 888 MTCONNECT **MUST** be converted to MTConnect. See Figure 3 for an example.
- 889 The name of an Observation type reported in the MTConnectStreams Response Doc-
- 890 ument is extended when the representation property is used to further describe that
- 891 DataItem in the MTConnectDevices Response Document. See Section 4 Representa-
- 892 *tions* for more details.

893 3.3.1 Value Properties of Observation

Value Property name	Value Property type	Multiplicity
compositionId	ID	01
dataItemId	ID	1
name	string	01
sequence	integer	1
subType	DataItemSubTypeEnum	01
timestamp	datetime	1
type	DataItemTypeEnum	1
units	UnitEnum	01

894 Table 5 lists the Value Properties of Observation.

Table 5: Value Properties of Observation

- 895 Descriptions for Value Properties of Observation:
- 896 compositionId
- identifier of the Composition entity defined in the *MTConnectDevices Response Document* associated with the data reported for the Observation.
- 899 dataItemId
- 900 unique identifier of the DataItem associated with this Observation.
- dataItemId MUST match the id attribute of the DataItem defined in the MT *ConnectDevices Response Document*.
- 903 name
- name of the DataItem associated with this Observation.
- name MUST match the name attribute of the DataItem defined in the MTCon nectDevices Response Document.
- 907 sequence
- number representing the sequential position of an occurrence of an observation inthe data buffer of an *agent*.
- 910 sequence **MUST** have a value represented as an unsigned 64-bit value from 1 to 911 $2^{64}-1$.
- 912 subType
- 913 subtype of the DataItem associated with this Observation.

914 915	subType MUST match the subType attribute of the DataItem defined in the <i>MTConnectDevices Response Document</i> .
916 917	The value of subType MUST be one of the DataItemSubTypeEnum enumeration.
918	• timestamp
919 920	most accurate time available to a piece of equipment that represents the point in time that the data reported was measured.
921	• type
922	type of the DataItem associated with this Observation.
923 924	type MUST match the type attribute of the DataItem defined in the <i>MTCon</i> - nectDevices Response Document.
925	The value of type MUST be one of the DataItemTypeEnum enumeration.
926	• units
927	units of the DataItem associated with this Observation.
928 929	units MUST match the units attribute of the DataItem defined in the <i>MT</i> - <i>ConnectDevices Response Document</i> .
930	The value of units MUST be one of the UnitEnum enumeration.
931	• result
932	observation of the Observation entity.
933	The default value type for result is string.

934 3.4 Sample

935 Observation that is continuously changing or analog data value.

936 It provides the information and data reported from a piece of equipment for those DataItem

937 entities defined with a category, DataItem property of SAMPLE in the MTConnect-

- 938 Devices Response Document.
- 939 Sample **MUST** always be reported in float.

940 Figure 4 shows Sample type examples. It also shows an example for when the result

- 941 is not available (dataItemId=cspeed).
- Note: See *Example 4* for the XML representation of the same example.



Figure 4: Sample Example

- 943 The following Section 3.4.1 Value Properties of Sample lists the additional and/or up-
- 944 dated attributes for Sample.
- 945 The value of Sample MUST be float.
- 946 The units for Sample MUST always be specified.

947 3.4.1 Value Properties of Sample

948 *Table 6* lists the Value Properties of Sample.

Value Property name	Value Property type	Multiplicity
duration	SECOND	01
resetTriggered	ResetTriggeredEnum	01
sampleRate	float	01
statistic	StatisticEnum	01

Table 6: Value Properties of Sample

- 949 Descriptions for Value Properties of Sample:
- 950 duration
- 951 time-period over which the data was collected.
- duration MUST be provided when the statistic attribute of the DataItem
 is defined in the *MTConnectDevices Response Document*.
- 954 resetTriggered
- identifies when a reported value has been reset and what has caused that reset to
 occur for those DataItem entities that may be periodically reset to an initial value.
- resetTriggered MUST only be provided for the specific occurrence of a DataItem
 reported in the *MTConnectStreams Response Document* when the reset occurred.
- 959 ResetTriggeredEnum Enumeration:
- 960 - ACTION COMPLETE result of the Observation that is measuring an action or operation was 961 reset upon completion of that action or operation. 962 - ANNUAL 963 result of the Observation was reset at the end of a 12-month period. 964 965 - DAY result of the Observation was reset at the end of a 24-hour period. 966 967 - MAINTENANCE result of the Observation was reset upon completion of a maintenance 968 event. 969 - MANUAL 970 result of the Observation was reset based on a physical reset action. 971 972 - MONTH result of the Observation was reset at the end of a monthly period. 973

40

974	- POWER_ON
975	result of the Observation was reset when power was applied to the piece
976	of equipment after a planned or unplanned interruption of power has occurred.
977	- SHIFT
978	result of the Observation was reset at the end of a work shift.
979	- WEEK
980	result of the Observation was reset at the end of a 7-day period.
981 •	sampleRate
982	rate at which successive samples of the value are recorded.
983 •	statistic
984	$type \ of \ statistical \ calculation \ defined \ by \ the \ \texttt{statistic} \ attribute \ of \ the \ \texttt{DataItem}$
985	defined in the MTConnectDevices Response Document.

987 3.5 Event

- 988 Observation that is a discrete piece of information from a piece of equipment.
- 989 It provides the information and data reported from a piece of equipment for those DataItem
- 990 entities defined with a category, DataItem property of EVENT in the MTConnectDe-
- 991 vices Response Document.
- 992 Figure 5 shows Event type examples. It also shows an example for when the result is
- 993 not available (dataItemId=d1_asset_rem).
- Note: See *Example 5* for the XML representation of the same example.
- 995 The following *Section 3.5.1 Value Properties of Event* lists the additional and/or updated 996 attributes for Event.

997 3.5.1 Value Properties of Event

998 Table 7 lists the Value Properties of Event.



Figure 5: Event Example

Value Property name	Value Property type	Multiplicity
resetTriggered	ResetTriggeredEnum	01

 Table 7: Value Properties of Event

999 Descriptions for Value Properties of Event:

1000	• resetTriggered
1001	identifies when a reported value has been reset and what has caused that reset to
1002	occur for those DataItem entities that may be periodically reset to an initial value.
1003	resetTriggered MUST only be provided for the specific occurrence of a DataItem
1004	reported in the MTConnectStreams Response Document when the reset occurred.
1005	The value of <code>resetTriggered</code> MUST be one of the <code>ResetTriggeredEnum</code>
1006	enumeration.

1007 **3.6 Condition**

1008	Observation that provides the condition of a piece of equipment or a <i>Component</i> .
1009 1010 1011	It provides the information and data reported from a piece of equipment for those DataItem entities defined with a category, DataItem property of CONDITION in the <i>MTConnectDevices Response Document</i> .
1012 1013 1014	Figure 6 shows Condition type examples for various state: Normal (dataItemId = path_system) and Warning (dataItemId = logic_cond). It also shows an example for when the state is not available (dataItemId = cont_system).

1015 Note: See *Example 6* for the XML representation of the same example.

- 1016 The following Section 3.6.1 Value Properties of Condition lists the additional and/or
- 1017 updated attributes for Condition.

1018 3.6.1 Value Properties of Condition

1019 *Table 8* lists the Value Properties of Condition.

Value Property name	Value Property type	Multiplicity
nativeCode	string	01
nativeSeverity	string	01
qualifier	QualifierEnum	01
statistic	StatisticEnum	01
xs:lang	xslang	01
state	ConditionStateEnum	01

Table 8: Value Properties of Condition



Figure 6: Condition Example

1020 Descriptions for Value Properties of Condition:

1021	• nativeCode
1022 1023	native code (usually an alpha-numeric value) generated by the controller of a piece of equipment providing a reference identifier for a Condition.
1024 1025	This is the same information an operator or maintenance personnel may see as a reference code designating a specific fault code provided by the piece of equipment.
1026	• nativeSeverity
1027 1028	severity information to a client software application if the piece of equipment desig- nates a severity level to a fault.
1029	• qualifier
1030 1031	additional information regarding a condition state associated with the measured value of a process variable.
1032 1033	qualifier defines whether the condition state represented indicates a measured value that is above or below an expected value of a process variable.
1034	QualifierEnum Enumeration:
1035	- HIGH
1036	measured value is greater than the expected value for a process variable.
1037	- LOW
1038	measured value is less than the expected value for a process variable.
1039	• statistic
1040 1041	statistic provides additional information describing the meaning of the Con- dition element.
1042 1043	statistic MUST match the statistic attribute of the DataItem entity defined in the <i>MTConnectDevices Response Document</i> .
1044	The value of statistic MUST be one of the StatisticEnum enumeration.
1045	• xs:lang
1046	specifies the language of the result returned for the Condition.
1047	See Ref IETF RFC 4646 (http://www.ietf.org/rfc/rfc4646.txt).
1048	• state
1049	condition state of the piece of equipment or Component.
1050	ConditionStateEnum Enumeration:

1051	- Fault
1052	condition state that requires intervention to continue operation to function prop-
1053	erly.
1054	- Normal
1055	condition state that indicates operation within specified limits.
1056	- Warning
1057	condition state that requires concern and supervision and may become haz-
1058	ardous if no action is taken.

1059 4 Representations



1060 This section provides semantic information for the Representation model.



1061 Note: See Section B.2 - Representation Schema Diagrams for XML schema.

1062 4.1 Representation

- 1063 specifies the format and structure of the result for an Observation.
- 1064 The Representation type for an Observation is defined by the associated DataItem's
- 1065 property representation in the MTConnectDevices Response Document.
- 1066 Value is the default Representation type for all Observation types.
- 1067 The name of the Observation type is modified for all Representation types other
- 1068 than Value by appending the pascal case of the Representation type.
- 1069 Example: The name for Sample Observation type Temperature with Repre-
- 1070 sentation type of TimeSeries becomes TemperatureTimeSeries.

1071 **4.2 Value**

1072 default Representation type for all Observation types where result of the 1073 Observation types is an MTConnect data type. See *Section 6.1 - DataTypes*.

1074 4.3 TimeSeries

- 1075 Representation for an Observation composed of a series of sampled data.
- 1076 TimeSeries for an Observation is defined by the associated DataItem's property
- 1077 representation as TIME_SERIES.

1078 DataItem with TIME_SERIES representation ${\bf MUST}$ have a category of 1079 SAMPLE.

1080 Figure 8 shows the model for Temperature (Sample type) with a Representation 1081 type of TimeSeries.



Figure 8: TemperatureTimeSeries

1082 Note: See Section B.2 - Representation Schema Diagrams for XML schema.

TimeSeries MUST report multiple values at fixed intervals in a single Observation. At minimum, one of DataItem or Observation MUST specify the sampleRate in Hertz(values/second); fractional rates are permitted. When the Observation and the DataItem specify the sampleRate, the Observation sampleRate supersedes the DataItem.
The Observation MUST set the timestamp to the time the last value was observed.

1089 The duration MAY indicate the time interval from the first to the last value in the series.

1090 *Section 4.3.1 - Value Properties of TimeSeries* defines additional attributes for an Obser-1091 vation with TimeSeries Representation type.

1092 4.3.1 Value Properties of TimeSeries

1093 Table 9 lists the Value Properties of TimeSeries.

Value Property name	Value Property type	Multiplicity
sampleCount	integer	1

Table 9: Value Properties of TimeSeries

- 1094 Descriptions for Value Properties of TimeSeries:
- 1095 sampleCount
- 1096 number of values given for the Observation.

1097 4.4 <<deprecated>>Discrete

1098 **DEPRECATED** Representation for an Observation where each discrete occur-1099 rence of the data may have the same value as the previous occurrence of the data.

- 1100 Discrete for an Observation is defined by the associated DataItem's property 1101 representation as DISCRETE.
- 1102 DataItem with DISCRETE representation MUST have a category of EVENT.
- 1103 *MTConnect Version 1.5* replaced representation DISCRETE with a discrete 1104 property for DataItem.
- 1105 Each occurrence of the Observation MAY have the same value as the previous occur-1106 rence, and MUST NOT suppress duplicates.
- 1107 Examples of Discrete: A PartCount reporting the completion of each part using a 1 1108 to indicate completion of a single part, a Message that occurs each time a door opens.

1109 **4.5 DataSet**

1110 Representation for an Observation composed of value(s) represented as a set of 1111 key-value pairs.

1112 DataSet for an Observation is defined by the associated DataItem's property 1113 representation as DATA_SET.

1114 DataItem with DATA_SET representation MUST have a category of SAM-

- 1115 PLE or EVENT.
- 1116 Figure 9 shows the model for Variable (Event type) with a Representation type
- 1117 of DataSet.



Figure 9: VariableDataSet

1118 Note: See Section B.2 - Representation Schema Diagrams for XML schema.

DataSet reports multiple values as a set of *key-value pair* where each *key* **MUST** be unique. The representation of the *key-value pair* is an Entry. The value of each Entry **MUST** have the same constraints and format as the Observation defined for the

1122 VALUE representation for the DataItem type (See Value).

1123 The meaning of each Entry MAY be provided as the DataItem EntryDefinition.

1124 Figure 10 shows Event Observation type Variable with a Representation 1125 type of DataSet.

1126 Note: See *Example 7* for the XML representation of the same example.



Figure 10: DataSet Example

1127 4.5.0.1 Management of Data Set Observations

1128 An agent MUST maintain the current state of the DataSet as described in MTConnect

1129 Standard Part 1.0 - Fundamentals.

1130 One or more key-value pairs MAY be added, removed, or changed in an Observation.

1131 An agent MUST publish the changes to one or more key-value pairs as a single Obser-

1132 vation. An agent MUST indicate the removal of a key-value pair from a DataSet

- 1133 using the removed attribute equal true.
- 1134 When the DataItem discrete, DataItem attribute is false or is not present, an
- 1135 *agent* in response to a *sample request* **MUST** only publish the changed *key-value pair*
- 1136 since the previous state of the DataSet.
- 1137 When the DataItem discrete, DataItem attribute is true, an *agent*, in response
- 1138 to a *sample request*, **MUST** report all *key-value pairs* ignoring the state of the DataSet.
- 1139 When an agent responds to a current request, the response document MUST include the
- 1140 full set of key-value pairs. If the current request includes an at query parameter, the agent

- 1141 **MUST** provide the set of *key-value pairs* at the *sequence number*.
- 1142 When an Observation reset occurs, the DataSet MUST remove all key-value pairs
- 1143 making the set empty. The Observation MAY simultaneously populate the DataSet
- 1144 with new key-value pairs. The previous entries MUST NOT be included and MUST NOT
- 1145 have removed attribute equal true.

1146 When the Observation is UNAVAILABLE the DataSet ${\bf MUST}$ remove all key-value

1147 *pairs* making the set empty.

1148 4.5.1 Value Properties of DataSet

1149 Table 10 lists the Value Properties of DataSet.

Value Property name	Value Property type	Multiplicity
count	integer	1

Table 10: Value Properties of DataSet

- 1150 Descriptions for Value Properties of DataSet:
- 1151 count
- number of Entry elements for the Observation.

1153 4.5.2 Part Properties of DataSet

1154 Table 11 lists the Part Properties of DataSet.

Part Property name	Multiplicity
Entry	0*

Table 11: Part Properties of DataSet

- 1155 Descriptions for Part Properties of DataSet:
- 1156 Entry
- 1157 *key-value pair* published as part of a DataSet.
- 1158 See *Section 4.7 Entry*.

1159 4.6 Table

- 1160 Representation for an Observation composed of two-dimensional sets of key-
- *value pairs* where the Entry represents rows containing sets of *key-value pairs* given by Cell entities.
- 1163 Table for an Observation is defined by the associated DataItem's property rep-
- 1164 resentation as TABLE.
- 1165 DataItem with TABLE representation **MUST** have a category of SAMPLE or 1166 EVENT.
- 1167 Figure 11 shows the model for WorkOffset (Event type) with a Representation
- 1168 type of Table.



Figure 11: WorkOffsetTable

54

- 1169 Note: See Section B.2 Representation Schema Diagrams for XML schema.
- 1170 Table has the same behavior as the DataSet for change tracking, clearing, and history.
- 1171 When an Entry changes, all Cell entities update at the same time; they are not tracked
- 1172 separately like Entry.
- 1173 The meaning of each Entry and Cell MAY be provided as the DataItem Entry-1174 Definition and CellDefinition.
- 1175 The Entry key attribute **MUST** be the unique identity of the Entry within an Obser-1176 vation. The Cell key attribute **MUST** be the unique identity of the Cell within an 1177 Entry.
- 1178 Figure 12 shows Event Observation type WorkOffset with a Representation
- 1179 type of Table.



Figure 12: Table Example

1180 Note: See *Example 8* for the XML representation of the same example.

1181 4.6.1 Value Properties of Table

1182 *Table 12* lists the Value Properties of Table.

Value Property name	Value Property type	Multiplicity
count	integer	1

Table 12: Value Properties of Table

1183 Descriptions for Value Properties of Table:

- 1184 count
- number of *key-value pairs* represented as Entry entities.

1186 4.6.2 Part Properties of Table

1187 *Table 13* lists the Part Properties of Table.

Part Property name	Multiplicity
TableEntry	0*

Table 13: Part Properties of Table

- 1188 Descriptions for Part Properties of Table:
- 1189 TableEntry
- 1190 *key-value pair* published as part of a Table.
- 1191Note: In the XML representation, TableEntry MUST appear as En-1192try.
- 1193 See Section 4.8 TableEntry.

1194 4.7 Entry

1195 key-value pair published as part of a DataSet.

1196 4.7.0.1 Constraints for Entry Values

1197 The value of each Entry MUST have the same restrictions as the value of an observation 1198 with representation of VALUE.

An Entry MAY be further constrained by the DataItem definition (see *MTConnect Standard: Part 2.0 - Device Information Model*), for example a VariableDataSet having a string value MAY have a floating-point Temperature value. A restriction **MUST NOT** be broadened or removed, for example, the value "READY" **MUST NOT** occur with a TemperatureDataSet constrained to floating-point numbers.

1204 The *MTConnect Standard: Part 2.0 - Device Information Model* DataItem Defini-1205 tion **MAY** provide the type and units of an Entry for a key.

1206 4.7.1 Value Properties of Entry

1207 Table 14 lists the Value Properties of Entry.

Value Property name	Value Property type	Multiplicity
key	ID	1
removed	boolean	01

Table 14: Value Properties of Entry

1208 Descriptions for Value Properties of Entry:

- 1209 key
- 1210 unique identifier for each *key-value pair*.
- 1211 removed
- 1212 removal indicator of a *key-value pair*.

1213 4.8 TableEntry

- 1214 *key-value pair* published as part of a Table.
- 1215 Note: In the XML representation, TableEntry MUST appear as Entry.

1216 4.8.1 Value Properties of TableEntry

1217 *Table 15* lists the Value Properties of TableEntry.

Value Property name	Value Property type	Multiplicity
key	ID	1
removed	boolean	01

Table 15: Value Properties of TableEntry

- 1218 Descriptions for Value Properties of TableEntry:
- 1219 key
- 1220 unique identifier for each *key-value pair*.

- 1221 removed
- removal indicator of a *key-value pair*.

1223 4.8.2 Part Properties of TableEntry

1224 *Table 16* lists the Part Properties of TableEntry.

Part Property name	Multiplicity
Cell	0*

Table 16: Part Properties of TableEntry

1225 Descriptions for Part Properties of TableEntry:

1226 • Cell

1227 *key-value pair* published as part of a TableEntry.

1228 See Section 4.9 - Cell.

1229 4.9 Cell

1230 *key-value pair* published as part of a TableEntry.

1231 4.9.0.1 Constraints for Cell Values

1232 The value of each Cell MUST have the same restrictions as the value of an observation

1233 with representation of VALUE.

1234 An Cell MAY be further constrained by the DataItem definition (see MTConnect Stan-

1235 *dard: Part 2.0 - Device Information Model*), for example a VariableDataSet having

1236 a string value MAY have a floating-point Temperature value. A restriction MUST

1237 NOT be broadened or removed, for example, the value READY MUST NOT occur with a

1238 TemperatureDataSet constrained limited to floating-point numbers.

1239 The MTConnect Standard: Part 2.0 - Device Information Model DataItem Defini-

1240 tion **MAY** provide the type and units of a Cell for a key.

1241 4.9.1 Value Properties of Cell

1242 Table 17 lists the Value Properties of Cell.

Value Property name	Value Property type	Multiplicity
key	ID	1

Table 17: Value Properties of Cell

- 1243 Descriptions for Value Properties of Cell:
- 1244 key
- 1245 unique identifier for each *key-value pair*.

1246 **5 Observation Types**

- 1247 This section provides semantic information for the Observation types.
- 1248 Observation entities are instantiated as Sample, Event or Condition entities 1249 based upon the category and type attributes defined for the corresponding DataItem.
- 1250 See Figure 2 for examples on how the Observation types are organized within Com-1251 ponentStream.

1252 5.1 Condition Types

- 1253 This section provides semantic information for Condition types.
- 1254 Condition types are reported differently from other Observation types. They are 1255 reported based on the condition state for each Condition.
- 1256 The type and subType (where applicable) properties for a Condition MAY be any
- 1257 of the type and subType attributes defined for SAMPLE category or EVENT cat-
- 1258 egory DataItem listed in the Device Information Model.
- 1259 This section lists additional Condition types that have been defined to represent the 1260 health and fault status of *Components*.

1261 5.1.1 Actuator

1262 indication of a fault associated with an actuator.

1263 5.1.2 Communications

indication that the piece of equipment has experienced a communications failure.

1265 5.1.3 DataRange

indication that the value of the data associated with a measured value or a calculation isoutside of an expected range.

1268 5.1.4 LogicProgram

indication that an error occurred in the logic program or programmable logic controller(PLC) associated with a piece of equipment.

1271 5.1.5 MotionProgram

indication that an error occurred in the motion program associated with a piece of equip-ment.

1274 5.1.6 System

1275 general purpose indication associated with an electronic component of a piece of equip-

1276 ment or a controller that represents a fault that is not associated with the operator, program,

1277 or hardware.

1278 5.2 Event Types

1279 This section provides semantic information for Event types.

1280 5.2.1 ActivationCount

- accumulation of the number of times a function has attempted to, or is planned to attempt to, activate or be performed.
- 1283 The default subType of ActivationCount is ALL.
- 1284 The value of ActivationCount MUST be integer.

1285 5.2.1.1 Subtypes of ActivationCount

- 1286 ABORTED
- accumulation of actions or activities that were attempted, but terminated before theycould be completed.

61

1289	• ALL
1290 1291	accumulation of all actions, items, or activities being counted independent of the outcome.
1292	• BAD
1293 1294	accumulation of actions, items, or activities being counted that do not conform to specification or expectation.
1295	• COMPLETE
1296 1297	accumulation of actions, items, or activities that have been completed, independent of the outcome.
1298	• FAILED
1299 1300	accumulation of actions or activities that were attempted, but failed to complete or resulted in an unexpected or unacceptable outcome.
1301	• GOOD
1302 1303	accumulation of actions, items, or activities being counted that conform to specifi- cation or expectation.
1304	• REMAINING
1305	accumulation of actions, items, or activities yet to be counted.
1306	• TARGET
1307	goal of the operation or process.

1308 5.2.2 ActiveAxes

- 1309 set of axes currently associated with a Path or Controller.
- 1310 The value of ActiveAxes MUST be a list of string of size 0..*.

1311 5.2.3 ActuatorState

- 1312 operational state of an apparatus for moving or controlling a mechanism or system.
- 1313 ActuatorStateEnum Enumeration:
- 1314 ACTIVE
- 1315 Actuator is operating.
- 1316 INACTIVE
- 1317 Actuator is not operating.

1318 5.2.4 AdapterSoftwareVersion

1319 originator's software version of the *adapter*.

1320 **5.2.5** AdapterURI

1321 Uniform Resource Identifier (URI) of the *adapter*.

1322 5.2.6 <<deprecated>>Alarm

1323 **DEPRECATED:** Replaced with CONDITION category data items in Version 1.1.0.

1324 5.2.6.1 Value Properties of Alarm

1325 Table 18 lists the Value Properties of Alarm.

Value Property name	Value Property type	Multiplicity
< <deprecated>> code</deprecated>	AlarmCodeEnum	1
< <deprecated>> severity</deprecated>	AlarmSeverityEnum	1
< <deprecated>> nativeCode</deprecated>	string	1
< <deprecated>> state</deprecated>	AlarmStateEnum	1
< <deprecated>> lang</deprecated>	xslang	01

Table 18: Value Properties of Alarm

- 1326 Descriptions for Value Properties of Alarm:
- 1327 <<deprecated>> code
- type of alarm.

1329	<pre><<deprecated>> severity</deprecated></pre>
1330	severity of the alarm.
1331	< <deprecated>> nativeCode</deprecated>
1332	native code for the piece of equipment.
1333	< <deprecated>> state</deprecated>
1334	state of the alarm.
1335	< <deprecated>> lang</deprecated>
1336	specifies the language of the alarm text.
1337	See Ref IETF RFC 4646 (http://www.ietf.org/rfc/rfc4646.txt).

1338 5.2.7 AlarmLimit

- 1339 set of limits used to trigger warning or alarm indicators.
- 1340 The Entry key MUST be one or more from the AlarmLimitResult keys.
- 1341 AlarmLimitResult keys:
- UPPER LIMIT 1342 upper conformance boundary for a variable. 1343 Note: immediate concern or action may be required. 1344 The value of UPPER LIMIT MUST be float. 1345 • UPPER WARNING 1346 upper boundary indicating increased concern and supervision may be required. 1347 The value of UPPER_WARNING MUST be float. 1348 • LOWER_WARNING 1349 lower boundary indicating increased concern and supervision may be required. 1350 The value of LOWER_WARNING MUST be float. 1351 • LOWER_LIMIT 1352 lower conformance boundary for a variable. 1353 1354 Note: immediate concern or action may be required. The value of LOWER_LIMIT MUST be float. 1355

1356 5.2.8 Application

- 1357 application on a Component.
- 1358 A subType **MUST** always be specified.

1359 5.2.8.1 Subtypes of Application

- 1360 INSTALL_DATE
- 1361 date the hardware or software was installed.
- 1362 The value of Application **MUST** be datetime. See Section 6.1.5 datetime.
- 1363 datetime Enumeration:
- 1364 LICENSE
- license code to validate or activate the hardware or software.
- 1366 MANUFACTURER
- 1367 corporate identity for the maker of the hardware or software.
- 1368 RELEASE_DATE
- date the hardware or software was released for general use.
- 1370 The value of Application **MUST** be datetime. See Section 6.1.5 datetime.
- 1371 datetime Enumeration:
- 1372 VERSION
- 1373 version of the hardware or software.

1374 5.2.9 AssetChanged

1375 assetId of the Asset that has been added or changed.

1376 5.2.9.1 Value Properties of AssetChanged

1377 Table 19 lists the Value Properties of AssetChanged.

Value Property name	Value Property type	Multiplicity
assetType	string	01

Table 19: Value Properties of AssetChanged

1378 Descriptions for Value Properties of AssetChanged:

1379 • assetType
1380 type of Asset changed. See MTConnect Standard: Part 4.0 - Asset Information 1381 Model for details on the Asset model.

1382 5.2.10 AssetCount

- 1383 *data set* of the number of *Assets* of a given type for a *Device*.
- 1384 The value of AssetCount MUST be integer.

1385 5.2.11 AssetRemoved

1386 assetId of the Asset that has been removed.

1387 5.2.11.1 Value Properties of AssetRemoved

1388 Table 20 lists the Value Properties of AssetRemoved.

Value Property name	Value Property type	Multiplicity
assetType	string	01

Table 20: Value Properties of AssetRemoved

- 1389 Descriptions for Value Properties of AssetRemoved:
- 1390 assetType
- type of Asset removed. See *MTConnect Standard: Part 4.0 Asset Information Model* for details on the Asset model.

1393 5.2.12 Availability

- 1394 *agent*'s ability to communicate with the data source.
- 1395 AvailabilityEnum Enumeration:
- 1396 AVAILABLE
- data source is active and capable of providing data.
- 1398 UNAVAILABLE
- data source is either inactive or not capable of providing data.

1400 5.2.13 AxisCoupling

- 1401 describes the way the axes will be associated to each other.
- 1402 This is used in conjunction with COUPLED_AXES to indicate the way they are interacting.
- 1403 AxisCouplingEnum Enumeration:

1404	• MASTER
1405	axis is the master of the CoupledAxes.
1406	• SLAVE
1407	axis is a slave to the CoupledAxes.
1408	• SYNCHRONOUS
1409	axes are not physically connected to each other but are operating together in lock-
1410	step.
1411	• TANDEM

1412 axes are physically connected to each other and operate as a single unit.

1413 5.2.14 AxisFeedrateOverride

value of a signal or calculation issued to adjust the feedrate of an individual linear typeaxis.

1416 The value of <code>AxisFeedrateOverride</code> MUST be float.

1417 5.2.14.1 Subtypes of AxisFeedrateOverride

1418	• JOG
1419	relating to momentary activation of a function or a movement.
1420	DEPRECATION WARNING: May be deprecated in the future.
1421 1422 1423 1424	When the JOG subtype of AxisFeedrateOverride is applied, the resulting commanded feedrate for the axis is limited to the value of the original JOG subtype of the AxisFeedrate multiplied by the value of the JOG subtype of AxisFeedrateOverride.
1425 1426	• PROGRAMMED directive value without offsets and adjustments.
1427 1428	• RAPID performing an operation faster or in less time than nominal rate.

1429 5.2.15 AxisInterlock

state of the axis lockout function when power has been removed and the axis is allowed tomove freely.

- 1432 AxisInterlockEnum Enumeration:
- 1433 ACTIVE
- 1434axis lockout function is activated, power has been removed from the axis, and the1435axis is allowed to move freely.
- 1436 INACTIVE
- 1437axis lockout function has not been activated, the axis may be powered, and the axis1438is capable of being controlled by another component.

1439 **5.2.16** AxisState

- 1440 state of a Linear or Rotary component representing an axis.
- 1441 AxisStateEnum Enumeration:

1442	• HOME
1443	axis is in its home position.
1444	• PARKED
1445 1446	axis has been moved to a fixed position and is being maintained in that position either electrically or mechanically.
1447	Action is required to release the axis from this position.
1448	• STOPPED
1449	axis is stopped.
1450	• TRAVEL
1451	axis is in motion.

1452 **5.2.17** BatteryState

- 1453 present status of the battery.
- 1454 BatteryStateEnum Enumeration:
- 1455 CHARGED
- 1456 Component is at it's maximum rated charge level.
- 1457 CHARGING
- 1458 Component's charge is increasing.
- 1459 DISCHARGED
- 1460 Component is at it's minimum charge level.
- 1461 DISCHARGING
- 1462 Component's charge is decreasing.

1463 5.2.18 Block

1464 line of code or command being executed by a Controller entity.

1465 5.2.19 BlockCount

total count of the number of blocks of program code that have been executed since execu-tion started.

1468 The value of BlockCount MUST be integer.

1469 5.2.20 ChuckInterlock

1470 state of an interlock function or control logic state intended to prevent the associated 1471 Chuck component from being operated.

- 1472 ChuckInterlockEnum Enumeration:
- 1473 ACTIVE
- 1474 chuck cannot be unclamped.
- 1475 INACTIVE
- 1476 chuck can be unclamped.

1477 5.2.20.1 Subtypes of ChuckInterlock

- 1478 MANUAL_UNCLAMP
- indication of the state of an operator controlled interlock that can inhibit the ability
 to initiate an unclamp action of an electronically controlled chuck.
- 1481When ChuckInterlockManualUnclamp is ACTIVE, it is expected that a chuck1482cannot be unclamped until ChuckInterlockManualUnclamp is set to INAC-1483TIVE.

1484 **5.2.21** ChuckState

operating state of a mechanism that holds a part or stock material during a manufacturingprocess.

1487 It may also represent a mechanism that holds any other mechanism in place within a piece 1488 of equipment.

1489 ChuckStateEnum Enumeration:

1490	• CLOSED
1491	Chuck is closed to the point of a positive confirmation.
1492	• OPEN
1493	Chuck is open to the point of a positive confirmation.
1494	• UNLATCHED
1495	Chuck is not closed to the point of a positive confirmation and not open to the point
1496	of a positive confirmation.
1497	It is in an intermediate position.

1498 5.2.22 ClockTime

- 1499 time provided by a timing device at a specific point in time.
- 1500 The value of ClockTime MUST be datetime. See Section 6.1.5 datetime.

1501 5.2.23 <<deprecated>>Code

- 1502 programmatic code being executed.
- 1503 **DEPRECATED** in Version 1.1.

1504 5.2.24 CompositionState

- 1505 operating state of a mechanism represented by a Composition entity.
- 1506 A subType **MUST** always be specified.

1507 5.2.24.1 Subtypes of CompositionState

1508 • ACTION

1509	indication of the operating state of a mechanism.
1510	CompositionStateActionEnum Enumeration:
1511	- ACTIVE
1512	Composition is operating.
1513	- INACTIVE
1514	Composition is not operating.
1515	• LATERAL
1516	indication of the position of a mechanism that may move in a lateral direction.
1517	CompositionStateLateralEnum Enumeration:
1518	- LEFT
1519 1520	position of the Composition is oriented to the left to the point of a positive confirmation.
1521	- RIGHT
1522	position of the Composition is oriented to the right to the point of a positive
1523	confirmation.
1524	- TRANSITIONING
1525	position of the Composition is not oriented to the right to the point of a
1526 1527	confirmation.
1528	It is in an intermediate position.
1529	• MOTION
1530	indication of the open or closed state of a mechanism.
1531	CompositionStateMotionEnum Enumeration:
1532	- CLOSED
1533	position of the Composition is closed to the point of a positive confirmation.
1534	- OPEN
1535	position of the Composition is open to the point of a positive confirmation.
1536	- UNLATCHED
1537	position of the Composition is not open to the point of a positive confirma-
1538	tion and is not closed to the point of a positive confirmation.
1539	It is in an intermediate position.

1540	• SWITCHED
1541	indication of the activation state of a mechanism.
1542	CompositionStateSwitchedEnum Enumeration:
1543	- OFF
1544 1545	activation state of the Composition is in an OFF condition, it is not operat- ing, or it is not powered.
1546	– ON
1547 1548	activation state of the Composition is in an ON condition, it is operating, or it is powered.
1549	• VERTICAL
1550	indication of the position of a mechanism that may move in a vertical direction.
1551	CompositionStateVerticalEnum Enumeration:
1552	- DOWN
1553 1554	position of the Composition element is oriented in a downward direction to the point of a positive confirmation.
1555	- TRANSITIONING
1556	position of the Composition element is not oriented in an upward direc-
1557	tion to the point of a positive confirmation and is not oriented in a downward
1558	direction to the point of a positive confirmation.
1559	It is in an intermediate position.
1560	– UP
1561	position of the Composition element is oriented in an upward direction to
1562	the point of a positive confirmation.

1563 5.2.25 ConnectionStatus

- 1564 status of the connection between an *adapter* and an *agent*.
- 1565 ConnectionStatusEnum Enumeration:
- 1566 CLOSED
- no connection at all.

1568	• ESTABLISHED
1569	open connection.
1570	The normal state for the data transfer phase of the connection.
1571	• LISTEN

agent is waiting for a connection request from an *adapter*.

1573 5.2.26 ControlLimit

- 1574 set of limits used to indicate whether a process variable is stable and in control.
- 1575 The Entry key MUST be one or more from the ControlLimitResult keys.
- 1576 ControlLimitResult keys:

1577	• UPPER_LIMIT
1578	upper conformance boundary for a variable.
1579	Note: immediate concern or action may be required.
1580	The value of UPPER_LIMIT MUST be float.
1581	• UPPER_WARNING
1582	upper boundary indicating increased concern and supervision may be required.
1583	The value of UPPER_WARNING MUST be float.
1584	• NOMINAL
1585	ideal or desired value for a variable.
1586	The value of NOMINAL MUST be float.
1587	• LOWER_WARNING
1588	lower boundary indicating increased concern and supervision may be required.
1589	The value of LOWER_WARNING MUST be float.
1590	• LOWER_LIMIT
1591	lower conformance boundary for a variable.
1592	Note: immediate concern or action may be required.
1593	The value of LOWER_LIMIT MUST be float.

1594 5.2.27 ControllerMode

1595 current mode of the Controller component. ControllerModeEnum Enumeration: 1596 1597 • AUTOMATIC Controller is configured to automatically execute a program. 1598 1599 • EDIT Controller is currently functioning as a programming device and is not capable 1600 of executing an active program. 1601 • <<deprecated>> FEED_HOLD 1602 axes of the device are commanded to stop, but the spindle continues to function. 1603 • MANUAL 1604 1605 Controller is not executing an active program. It is capable of receiving instructions from an external source – typically an operator. 1606 1607 The Controller executes operations based on the instructions received from the external source. 1608 1609 • MANUAL_DATA_INPUT operator can enter a series of operations for the Controller to perform. 1610 The Controller will execute this specific series of operations and then stop. 1611 • SEMI AUTOMATIC 1612 Controller is operating in a mode that restricts the active program from process-1613 ing its next process step without operator intervention. 1614

1615 **5.2.28** ControllerModeOverride

- 1616 setting or operator selection that changes the behavior of a piece of equipment.
- 1617 ControllerModeOverrideEnum Enumeration:
- 1618 OFF
- 1619 ControllerModeOverride is in the OFF state and the mode override is inac-1620 tive.

1621 • ON

1622 ControllerModeOverride is in the ON state and the mode override is active.

1623 A subType **MUST** always be specified.

1624 5.2.28.1 Subtypes of ControllerModeOverride

- 1625 DRY_RUN
- setting or operator selection used to execute a test mode to confirm the execution ofmachine functions.
- When DRY_RUN is ON, the equipment performs all of its normal functions, except no part or product is produced. If the equipment has a spindle, spindle operation is suspended.
- 1631 MACHINE_AXIS_LOCK
- setting or operator selection that changes the behavior of the controller on a piece ofequipment.
- 1634 When MACHINE_AXIS_LOCK is ON, program execution continues normally, but 1635 no equipment motion occurs.
- 1636 OPTIONAL_STOP
- setting or operator selection that changes the behavior of the controller on a piece ofequipment.
- 1639The program execution is stopped after a specific program block is executed when1640OPTIONAL_STOP is ON.
- 1641In the case of a G-Code program, a program block containing a M01 code designates1642the command for an OPTIONAL_STOP.
- 1643 Execution **MUST** change to OPTIONAL_STOP after a program block speci-1644 fying an optional stop is executed and the ControllerModeOverride OP-
- 1645 TIONAL STOP selection is ON.
- 1646 SINGLE_BLOCK
- setting or operator selection that changes the behavior of the controller on a piece ofequipment.
- 1649Program execution is paused after each block of code is executed when SINGLE_BLOCK1650is ON.
- 1651 When SINGLE_BLOCK is ON, Execution MUST change to INTERRUPTED 1652 after completion of each block of code.

- 1653 TOOL_CHANGE_STOP
- setting or operator selection that changes the behavior of the controller on a piece ofequipment.
- Program execution is paused when a command is executed requesting a cutting tool to be changed.
- 1658 Execution **MUST** change to INTERRUPTED after completion of the command 1659 requesting a cutting tool to be changed and TOOL_CHANGE_STOP is ON.

1660 5.2.29 CoupledAxes

- 1661 set of associated axes.
- 1662 The value of CoupledAxes MUST be a list of string of size 0..*.

1663 5.2.30 CycleCount

accumulation of the number of times a cyclic function has attempted to, or is planned to attempt to execute.

- 1666 The default subType of CycleCount is ALL.
- 1667 The value of CycleCount MUST be integer.

1668 5.2.30.1 Subtypes of CycleCount

- 1669 ABORTED
- accumulation of actions or activities that were attempted, but terminated before theycould be completed.
- 1672 ALL
- accumulation of all actions, items, or activities being counted independent of theoutcome.
- 1675 BAD
- accumulation of actions, items, or activities being counted that do not conform tospecification or expectation.

1678	• COMPLETE
1679 1680	accumulation of actions, items, or activities that have been completed, independen of the outcome.
1681	• FAILED
1682	accumulation of actions or activities that were attempted, but failed to complete or
1683	resulted in an unexpected or unacceptable outcome.
1684	• GOOD
1685	accumulation of actions, items, or activities being counted that conform to specific
1686	cation or expectation.
1687	• REMAINING
1688	accumulation of actions, items, or activities yet to be counted.
1689	• TARGET
1690	goal of the operation or process.

1691 5.2.31 DateCode

- 1692 time and date code associated with a material or other physical item.
- 1693 The value of DateCode MUST be datetime. See Section 6.1.5 datetime.

1694 5.2.31.1 Subtypes of DateCode

- 1695 EXPIRATION
- time and date code relating to the expiration or end of useful life for a material orother physical item.
- 1698 FIRST_USE
- time and date code relating the first use of a material or other physical item.
- 1700 MANUFACTURE
- 1701 time and date code relating to the production of a material or other physical item.

1702 5.2.32 DeactivationCount

accumulation of the number of times a function has attempted to, or is planned to attemptto, deactivate or cease.

- 1705 The default subType of DeactivationCount is ALL.
- 1706 The value of DeactivationCount MUST be integer.

1707 5.2.32.1 Subtypes of DeactivationCount

- 1708 ABORTED 1709 accumulation of actions or activities that were attempted, but terminated before they could be completed. 1710 • ALL 1711 accumulation of all actions, items, or activities being counted independent of the 1712 outcome. 1713 • BAD 1714 accumulation of actions, items, or activities being counted that do not conform to 1715 specification or expectation. 1716 • COMPLETE 1717 accumulation of actions, items, or activities that have been completed, independent 1718 of the outcome. 1719 • FAILED 1720 accumulation of actions or activities that were attempted, but failed to complete or 1721 resulted in an unexpected or unacceptable outcome. 1722 • GOOD 1723 accumulation of actions, items, or activities being counted that conform to specifi-1724 cation or expectation. 1725 • REMAINING 1726 accumulation of actions, items, or activities yet to be counted. 1727 • TARGET 1728
- goal of the operation or process.

1730 5.2.33 DeviceAdded

1731 Universally Unique Identifier (UUID) of new device added to an *MTConnect Agent*.

1732 5.2.34 DeviceChanged

1733 UUID of the device whose *metadata* has changed.

1734 5.2.35 DeviceRemoved

1735 UUID of a device removed from an *MTConnect Agent*.

1736 5.2.36 DeviceUuid

identifier of another piece of equipment that is temporarily associated with a componentof this piece of equipment to perform a particular function.

1739 5.2.37 Direction

- 1740 direction of motion.
- 1741 <<deprecated>> DirectionEnum Enumeration:
- 1742 <<deprecated>> CLOCKWISE
- 1743 clockwise rotation using the right-hand rule.
- 1744 <<deprecated>> COUNTER_CLOCKWISE
- 1745 counter-clockwise rotation using the right-hand rule.
- 1746 <<deprecated>> NEGATIVE
- 1747 <<deprecated>> POSITIVE
- 1748 A subType **MUST** always be specified.

1749 **5.2.37.1 Subtypes of Direction**

1750	• LINEAR
1751	direction of motion of a linear motion.
1752	DirectionLinearEnum Enumeration:
1753	- NEGATIVE
1754	linear position is decreasing.
1755	- NONE
1756	no direction.
1757	- POSITIVE
1758	linear position is increasing.
1759	• ROTARY
1760	rotational direction of a rotary motion using the right hand rule convention.
1761	DirectionRotaryEnum Enumeration:
1762	- CLOCKWISE
1763	clockwise rotation using the right-hand rule.
1764	- COUNTER_CLOCKWISE
1765	counter-clockwise rotation using the right-hand rule.
1766	- NONE
1767	no direction.

1768 5.2.38 DoorState

- 1769 operational state of a Door component or composition element.
- 1770 DoorStateEnum Enumeration:

1771	• CLOSED
1772	Door is closed to the point of a positive confirmation.

- 1773 OPEN
- Door is open to the point of a positive confirmation.

81

- 1775 UNLATCHED
- Door is not closed to the point of a positive confirmation and not open to the point of a positive confirmation.
- 1778 It is in an intermediate position.

1779 5.2.39 EmergencyStop

state of the emergency stop signal for a piece of equipment, controller path, or any othercomponent or subsystem of a piece of equipment.

- 1782 EmergencyStopEnum Enumeration:
- 1783 ARMED
- emergency stop circuit is complete and the piece of equipment, component, or composition is allowed to operate.
- 1786 TRIGGERED
- operation of the piece of equipment, component, or composition is inhibited.

1788 **5.2.40 EndOfBar**

indication of whether the end of a piece of bar stock being feed by a bar feeder has beenreached.

1791 EndOfBarEnum Enumeration:

- 1792 NO
- 1793 EndOfBar has not been reached.
- 1794 YES
- 1795 EndOfBar has been reached.

1796 The default subType of EndOfBar is PRIMARY.

1797 5.2.40.1 Subtypes of EndOfBar

1798 • AUXILIARY

when multiple locations on a piece of bar stock are referenced as the indication for
the EndOfBar, the additional location(s) MUST be designated as AUXILIARY
indication(s) for the EndOfBar.

- 1802 PRIMARY
- specific applications MAY reference one or more locations on a piece of bar stock
 as the indication for the EndOfBar.
- 1805The main or most important location MUST be designated as the PRIMARY indica-1806tion for the EndOfBar.
- 1807 If no subType is specified, PRIMARY MUST be the default EndOfBar indica-1808 tion.

1809 5.2.41 EquipmentMode

- 1810 indication that a piece of equipment, or a sub-part of a piece of equipment, is performing
- 1811 specific types of activities.
- 1812 EquipmentModeEnum Enumeration:
- 1813 OFF
- equipment is not functioning in the mode designated by the subType.
- 1815 ON
- 1816 equipment is functioning in the mode designated by the subType.
- 1817 A subType **MUST** always be specified.

1818 5.2.41.1 Subtypes of EquipmentMode

- 1819 DELAY
- elapsed time of a temporary halt of action.

1821 • LOADED indication that the sub-parts of a piece of equipment are under load. 1822 Example: For traditional machine tools, this is an indication that the cutting tool is 1823 assumed to be engaged with the part. 1824 • OPERATING 1825 indication that the major sub-parts of a piece of equipment are powered or perform-1826 ing any activity whether producing a part or product or not. 1827 Example: For traditional machine tools, this includes when the piece of equipment 1828 is WORKING or it is idle. 1829 POWERED 1830 indication that primary power is applied to the piece of equipment and, as a min-1831 imum, the controller or logic portion of the piece of equipment is powered and 1832 functioning or components that are required to remain on are powered. 1833 Example: Heaters for an extrusion machine that required to be powered even when 1834 1835 the equipment is turned off. • WORKING 1836 indication that a piece of equipment is performing any activity, the equipment is 1837 1838 active and performing a function under load or not. 1839 Example: For traditional machine tools, this includes when the piece of equipment 1840 is LOADED, making rapid moves, executing a tool change, etc.

1841 5.2.42 Execution

1842 execution status of the Component.

- 1843 ExecutionEnum Enumeration:
- 1844 ACTIVE
- 1845 Component is actively executing an instruction.
- 1846 FEED_HOLD
- 1847 motion of the active axes are commanded to stop at their current position.
- 1848 INTERRUPTED
- 1849 Component suspends the execution of the program due to an external signal.
- 1850 Action is required to resume execution.

1851	• OPTIONAL_STOP
1852	command from the program has intentionally interrupted execution.
1853 1854	The Component MAY have another state that indicates if the execution is interrupted or the execution ignores the interrupt instruction.
1855	• PROGRAM_COMPLETED
1856	program completed execution.
1857	• PROGRAM_STOPPED
1858	command from the program has intentionally interrupted execution.
1859	Action is required to resume execution.
1860	• READY
1861	Component is ready to execute instructions.
1862	It is currently idle.
1863	• STOPPED
1864	Component program is not READY to execute.
1865	• WAIT
1866	Component suspends execution while a secondary operation executes.
1867	Execution resumes automatically once the secondary operation completes.

1868 5.2.43 Firmware

- 1869 embedded software of a Component.
- 1870 A subType **MUST** always be specified.

1871 5.2.43.1 Subtypes of Firmware

- 1872 • INSTALL_DATE
- date the hardware or software was installed. 1873
- The value of Firmware MUST be datetime. See Section 6.1.5 datetime. 1874
- datetime Enumeration: 1875

1876	• LICENSE
1877	license code to validate or activate the hardware or software.
1878	• MANUFACTURER
1879	corporate identity for the maker of the hardware or software.
1880	• RELEASE_DATE
1881	date the hardware or software was released for general use.
1882	The value of Firmware MUST be datetime. See Section 6.1.5 - datetime.
1883	datetime Enumeration:
1884	• VERSION
1885	version of the hardware or software.

1886 **5.2.44** FixtureId

1887 identifier for a fixture.

1888 5.2.45 FunctionalMode

- 1889 current intended production status of the Component.
- 1890 FunctionalModeEnum Enumeration:
- 1891 MAINTENANCE
- 1892 Component is not currently producing product.
- 1893 It is currently being repaired, waiting to be repaired, or has not yet been returned to 1894 a normal production status after maintenance has been performed.
- 1895 PROCESS_DEVELOPMENT
- 1896 Component is being used to prove-out a new process, testing of equipment or 1897 processes, or any other active use that does not result in the production of product.
- 1898 PRODUCTION
- 1899 Component is currently producing product, ready to produce product, or its current 1900 intended use is to be producing product.

1901	• SETUP
1902	Component is not currently producing product.
1903	It is being prepared or modified to begin production of product.
1904	• TEARDOWN
1905	Component is not currently producing product.
1906	Typically, it has completed the production of a product and is being modified or
1907	returned to a neutral state such that it may then be prepared to begin production of a
1908	different product.

1909 5.2.46 Hardness

- 1910 hardness of a material.
- 1911 The value of Hardness MUST be float.
- 1912 A subType **MUST** always be specified.

1913 5.2.46.1 Subtypes of Hardness

1914	• BRINELL
1915	scale to measure the resistance to deformation of a surface.
1916	• LEEB
1917	scale to measure the elasticity of a surface.
1918	MOHS
1919	scale to measure the resistance to scratching of a surface.
1920	• ROCKWELL
1921	scale to measure the resistance to deformation of a surface.
1922	• SHORE
1923	scale to measure the resistance to deformation of a surface.
1924	• VICKERS
1925	scale to measure the resistance to deformation of a surface.

1926 5.2.47 Hardware

- 1927 hardware of a Component.
- 1928 A subType **MUST** always be specified.

1929 5.2.47.1 Subtypes of Hardware

1930	• INSTALL_DATE
1931	date the hardware or software was installed.
1932	The value of Hardware MUST be datetime. See Section 6.1.5 - datetime.
1933	datetime Enumeration:
1934	• LICENSE
1935	license code to validate or activate the hardware or software.
1936	• MANUFACTURER
1937	corporate identity for the maker of the hardware or software.
1938	• RELEASE_DATE
1939	date the hardware or software was released for general use.
1940	The value of Hardware MUST be datetime. See Section 6.1.5 - datetime.
1941	datetime Enumeration:
1942	• VERSION
1943	version of the hardware or software.

1944 5.2.48 HostName

1945 name of the host computer supplying data.

1946 5.2.49 LeakDetect

- 1947 indication designating whether a leak has been detected.
- 1948 LeakDetectEnum Enumeration:

- 1949 DETECTED
- 1950 leak is currently being detected.
- 1951 NOT_DETECTED
- 1952 leak is currently not being detected.

1953 5.2.50 Library

- 1954 software library on a Component
- 1955 A subType **MUST** always be specified.

1956 5.2.50.1 Subtypes of Library

1957 • INSTALL_DATE

1958	date the hardware or software was installed.
1959	The value of Library MUST be datetime. See Section 6.1.5 - datetime.
1960	datetime Enumeration:
1961	• LICENSE
1962	license code to validate or activate the hardware or software.
1963	• MANUFACTURER
1964	corporate identity for the maker of the hardware or software.
1965	• RELEASE_DATE
1966	date the hardware or software was released for general use.
1967	The value of Library MUST be datetime. See Section 6.1.5 - datetime.
1968	datetime Enumeration:
1969	• VERSION
1970	version of the hardware or software.

1971 **5.2.51** <<deprecated>>Line

- 1972 current line of code being executed.
- 1973 **DEPRECATED** in Version 1.4.0.

1974 **5.2.51.1 Subtypes of Line**

- 1975 MAXIMUM
- 1976 maximum line number of the code being executed.
- 1977 MINIMUM
- 1978 minimum line number of the code being executed.

1979 **5.2.52** LineLabel

1980 identifier for a Block of code in a Program.

1981 5.2.53 LineNumber

- 1982 position of a block of program code within a control program.
- 1983 The value of LineNumber MUST be integer.

1984 5.2.53.1 Subtypes of LineNumber

 ABSOLUTE
 position of a block of program code relative to the beginning of the control program.
 INCREMENTAL
 position of a block of program code relative to the occurrence of the last LineLabel encountered in the control program.

1990 5.2.54 LoadCount

accumulation of the number of times an operation has attempted to, or is planned to attempt

- 1992 to, load materials, parts, or other items.
- 1993 The default subType of LoadCount is ALL.
- 1994 The value of LoadCount MUST be integer.

1995 5.2.54.1 Subtypes of LoadCount

- 1996 ABORTED
- 1997accumulation of actions or activities that were attempted, but terminated before they1998could be completed.
- 1999 ALL
- accumulation of all actions, items, or activities being counted independent of the outcome.
- 2002 BAD
- accumulation of actions, items, or activities being counted that do not conform to specification or expectation.
- 2005 COMPLETE
- accumulation of actions, items, or activities that have been completed, independent of the outcome.
- 2008 FAILED
- accumulation of actions or activities that were attempted, but failed to complete or resulted in an unexpected or unacceptable outcome.
- 2011 GOOD
- accumulation of actions, items, or activities being counted that conform to specification or expectation.
- 2014 REMAINING
- accumulation of actions, items, or activities yet to be counted.
- 2016 TARGET
- 2017 goal of the operation or process.

2018 5.2.55 LockState

- 2019 state or operating mode of a Lock.
- 2020 LockStateEnum Enumeration:

2021	• LOCKED
2022 2023	mechanism is engaged and preventing the associated Component from being opened or operated.
2024	• UNLOCKED
2025 2026	mechanism is disengaged and the associated Component is able to be opened or operated.

2027 5.2.56 MTConnectVersion

2028 reference version of the MTConnect Standard supported by the *adapter*.

2029 5.2.57 MaintenanceList

- actions or activities to be performed in support of a piece of equipment.
- 2031 If the INTERVAL key is not provided, it is assumed ABSOLUTE.
- 2032 If the DIRECTION key is not provided, it is assumed UP.
- 2033 If the UNITS key is not provided, it is assumed to be COUNT.
- 2034 The Entry key MUST be one or more from the MaintenanceListResult keys.
- 2035 MaintenanceListResult keys:
- 2036 VALUE
- 2037 current interval value of the activity.
- 2038 The value of VALUE MUST be float.
- 2039 INTERVAL

2040	interval of the value observed.
2041	MaintenanceListIntervalEnum Enumeration:
2042	- ABSOLUTE
2043	- INCREMENTAL
2044	• NEXT_SERVICE_DATE
2045	next date/time stamp that maintenance should be performed.
2046 2047	The value of NEXT_SERVICE_DATE MUST be datetime. See Section 6.1.5 - datetime.
2048	• RESET
2049	last date/time stamp of the observation was reset.
2050	The value of RESET MUST be datetime. See Section 6.1.5 - datetime.
2051	• SEVERITY
2052	level of severity on a scale of 1-10.
2053	The value of SEVERITY MUST be integer.
2054	• DIRECTION
2055	direction of the value observed.
2056	MaintenanceListDirectionEnum Enumeration:
2057	- DOWN
2058	– UP
2059	• NAME
2060	identifier of the maintenance activity.
2061	The value of NAME MUST be string.
2062	• LAST_SERVICE_DATE
2063	last date/time stamp that maintenance was performed.
2064 2065	The value of LAST_SERVICE_DATE MUST be datetime. See Section 6.1.5 - datetime.
2066	• UNITS
2067	same as DataItem units. See MTConnect Standard: Part 2.0 - Device Informa-
2068	tion Model.
2069	The value of UNITS MUST be one of the UnitEnum enumeration.

- 2070 TARGET
- target value of the next maintenance.
- 2072 The value of TARGET MUST be float.

2073 5.2.58 Material

2074 identifier of a material used or consumed in the manufacturing process.

2075 5.2.59 MaterialLayer

2076 identifies the layers of material applied to a part or product as part of an additive manufac-

- 2077 turing process.
- 2078 The value of MaterialLayer MUST be integer.

2079 5.2.59.1 Subtypes of MaterialLayer

- 2080 ACTUAL
- 2081 measured or reported value of an observation.
- 2082 TARGET
- 2083 goal of the operation or process.

2084 5.2.60 Message

information to be transferred from a piece of equipment to a client software application.

2086 5.2.60.1 Value Properties of Message

2087 *Table 21* lists the Value Properties of Message.

Value Property name	Value Property type	Multiplicity
nativeCode	string	01

Table 21: Value Properties of Message

2088 Descriptions for Value Properties of Message:

- 2089 nativeCode
- 2090 control system local identification of the information being transferred.

2091 5.2.61 Network

- 2092 network details of a Component.
- 2093 A subType **MUST** always be specified.

2094 5.2.61.1 Subtypes of Network

- 2095 GATEWAY
- 2096 Gateway for the component network.
- 2097 IPV4_ADDRESS
- IPV4 network address of the component.
- 2099 IPV6_ADDRESS
- 2100 IPV6 network address of the component.
- MAC_ADDRESS
- 2102 Media Access Control Address.
- 2103 The unique physical address of the network hardware.
- SUBNET_MASK
- 2105 SubNet mask for the component network.
- 2106 VLAN_ID
- 2107 layer2 Virtual Local Network (VLAN) ID for the component network.

- WIRELESS
 identifies whether the connection type is wireless.
 NetworkWirelessEnum Enumeration:
 NO
- 2112 **–** YES

2113 5.2.62 NetworkPort

- 2114 number of the TCP/IP or UDP/IP port for the connection endpoint.
- 2115 The value of NetworkPort MUST be integer.

2116 5.2.63 OperatingMode

state of Component or Composition that describes the automatic or manual operation
of the entity.

- 2119 OperatingModeEnum Enumeration:
- AUTOMATIC
 automatically execute instructions from a recipe or program.
- 2122 Note: Setpoint comes from a recipe.
- MANUAL
- execute instructions from an external agent or person.
- 2125 Note 1 to entry: Valve or switch is manipulated by an agent/person.
- 2126Note 2 to entry: Direct control of the PID output. % of the range: A user2127manually sets the % output, not the setpoint.
- SEMI_AUTOMATIC
- executes a single instruction from a recipe or program.
- Note 1 to entry: Setpoint is entered and fixed, but the PID is controlling.
- 2131 Note 2 to entry: Still goes through the PID control system.
- 2132 Note 3 to entry: Manual fixed entry from a recipe.

2133 5.2.64 OperatingSystem

- 2134 Operating System (OS) of a Component.
- 2135 A subType **MUST** always be specified.

2136 5.2.64.1 Subtypes of OperatingSystem

- 2137 INSTALL_DATE
- date the hardware or software was installed.
- 2139 The value of OperatingSystem MUST be datetime. See Section 6.1.5 -
- *datetime.*
- 2141 datetime Enumeration:
- 2142 LICENSE
- license code to validate or activate the hardware or software.
- MANUFACTURER
- corporate identity for the maker of the hardware or software.
- 2146 RELEASE_DATE
- date the hardware or software was released for general use.
- The value of OperatingSystem **MUST** be datetime. See Section 6.1.5 datetime.
- 2150 datetime Enumeration:
- 2151 VERSION
- version of the hardware or software.

2153 5.2.65 OperatorId

identifier of the person currently responsible for operating the piece of equipment.

2155 **5.2.66** PalletId

2156 identifier for a pallet.

2157 5.2.67 PartCount

- 2158 aggregate count of parts.
- 2159 The value of PartCount MUST be integer.
- 2160 The default subType of PartCount is ALL.

2161 5.2.67.1 Subtypes of PartCount

- 2162 ABORTED
- accumulation of actions or activities that were attempted, but terminated before they could be completed.
- 2165 ALL
- accumulation of all actions, items, or activities being counted independent of the outcome.
- 2168 BAD
- accumulation of actions, items, or activities being counted that do not conform to specification or expectation.
- COMPLETE
- accumulation of actions, items, or activities that have been completed, independent of the outcome.
- FAILED
- accumulation of actions or activities that were attempted, but failed to complete or resulted in an unexpected or unacceptable outcome.
- 2177 GOOD
- accumulation of actions, items, or activities being counted that conform to specification or expectation.
- 2180 REMAINING
- accumulation of actions, items, or activities yet to be counted.
- 2182 TARGET
- 2183 goal of the operation or process.

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97
2184 5.2.68 PartCountType

- 2185 interpretation of PART_COUNT.
- 2186 PartCountTypeEnum Enumeration:
- 2187 BATCH
- 2188 pre-specified group of items.
- 2189 EACH
- count is of individual items.

2191 5.2.69 PartDetect

- indication designating whether a part or work piece has been detected or is present.
- 2193 PartDetectEnum Enumeration:
- NOT_PRESENT
- 2195 part or work piece is not detected or is not present.
- 2196 PRESENT
- 2197 part or work piece is detected or is present.

2198 5.2.70 PartGroupId

- 2199 identifier given to a collection of individual parts.
- 2200 If no subType is specified, UUID is default.
- 2201 The default subType of PartGroupId is UUID.

2202 5.2.70.1 Subtypes of PartGroupId

- 2203 BATCH
- identifier that references a group of parts produced in a batch.

2205	• HEAT_TREAT
2206	identifier used to reference a material heat number.
2207	• LOT
2208	identifier that references a group of parts tracked as a lot.
2209	• RAW_MATERIAL
2210	material that is used to produce parts.
2211	• UUID
2212	universally unique identifier as specified in ISO 11578 or RFC 4122.

2213 5.2.71 PartId

identifier of a part in a manufacturing operation.

2215 5.2.72 PartKindId

identifier given to link the individual occurrence to a class of parts, typically distinguished

- 2217 by a particular part design.
- 2218 If no subType is specified, UUID is default.
- 2219 The default subType of PartKindId is UUID.

2220 5.2.72.1 Subtypes of PartKindId

- 2221 PART_FAMILY
- identifier given to a group of parts having similarities in geometry, manufacturing process, and/or functions.
- 2224 PART_NAME
- word or set of words by which a part is known, addressed, or referred to.
- 2226 PART_NUMBER
- identifier of a particular part design or model.
- 2228 UUID
- universally unique identifier as specified in ISO 11578 or RFC 4122.

2230 5.2.73 <<deprecated>>PartNumber

- identifier of a part or product moving through the manufacturing process.
- 2232 **DEPRECATED** in *Version 1.7.* PART_NUMBER is now a subType of PART_KIND_ID.

2233 5.2.74 PartProcessingState

- 2234 particular condition of the part occurrence at a specific time.
- 2235 PartProcessingStateEnum Enumeration:
- 2236 IN_PROCESS
- 2237 part occurrence is actively being processed.
- 2238 IN_TRANSIT
- part occurrence is being transported to its destination.
- NEEDS_PROCESSING
- part occurrence is not actively being processed, but the processing has not ended.

Processing requirements exist that have not yet been fulfilled. This is the default entry state when the part occurrence is originally received. In some cases, the part occurrence may return to this state while it waits for additional processing to be performed.

- 2246 PROCESSING_ENDED
- part occurrence is no longer being processed.
- A general state when the reason for termination is unknown.
- 2249 PROCESSING_ENDED_ABORTED
- processing of the part occurrence has come to a premature end.
- 2251 PROCESSING_ENDED_COMPLETE
- part occurrence has completed processing successfully.
- 2253 PROCESSING_ENDED_LOST
- terminal state when the part occurrence has been removed from the equipment by an external entity and it no longer exists at the equipment.

2256	• PROCESSING_ENDED_REJECTED
2257 2258	part occurrence has been processed completely. However, the processing may have a problem.
2259	• PROCESSING_ENDED_SKIPPED
2260	part occurrence has been skipped for processing on the piece of equipment.
2261	• PROCESSING_ENDED_STOPPED
2262	process has been stopped during the processing.
2263	The part occurrence will require special treatment.
2264	• TRANSIT_COMPLETE
2265	part occurrence has been placed at its designated destination.
2266	• WAITING_FOR_TRANSIT
2267	part occurrence is waiting for transit.

2268 5.2.75 PartStatus

- 2269 state or condition of a part.
- 2270 If unique identifier is given, part status is for that individual. If group identifier is given
- 2271 without a unique identifier, then the status is assumed to be for the whole group.
- 2272 PartStatusEnum Enumeration:
- 2273 FAIL
- part does not conform to some given requirements.
- 2275 PASS
- part conforms to given requirements.

2277 5.2.76 PartUniqueId

- 2278 identifier given to a distinguishable, individual part.
- 2279 If no subType is specified, UUID is default.
- 2280 The default subType of PartUniqueId is UUID.

2281 5.2.76.1 Subtypes of PartUniqueId

2282	• RAW_MATERIAL
2283	material that is used to produce parts.
2284	• SERIAL_NUMBER
2285	serial number that uniquely identifies a specific part.
2286	• UUID
2287	universally unique identifier as specified in ISO 11578 or RFC 4122

2288 5.2.77 PathFeedrateOverride

value of a signal or calculation issued to adjust the feedrate for the axes associated with a Path component that may represent a single axis or the coordinated movement of multiple axes.

2292 The value of PathFeedrateOverride MUST be float.

2293 5.2.77.1 Subtypes of PathFeedrateOverride

- 2294 JOG
- relating to momentary activation of a function or a movement.
- DEPRECATION WARNING: May be deprecated in the future.
- PROGRAMMED
- directive value without offsets and adjustments.
- 2299 RAPID
- performing an operation faster or in less time than nominal rate.

2301 5.2.78 PathMode

describes the operational relationship between a Path entity and another Path entity for pieces of equipment comprised of multiple logical groupings of controlled axes or other logical operations. 2305 PathModeEnum Enumeration:

2306	•	INDEPENDENT
2307		path is operating independently and without the influence of another path.
2308	•	MASTER
2309 2310		path provides information or state values that influences the operation of other DataItem of similar type.
2311	•	MIRROR
2312		axes associated with the path are mirroring the motion of the MASTER path.
2313	•	SYNCHRONOUS
2314		physical or logical parts which are not physically connected to each other but are
2313		operating together.

2316 **5.2.79** PowerState

indication of the status of the source of energy for an entity to allow it to perform itsintended function or the state of an enabling signal providing permission for the entity to

2319 perform its functions.

2320 PowerStateEnum Enumeration:

- 2321 OFF
- source of energy for an entity or the enabling signal providing permission for the entity to perform its function(s) is not present or is disconnected.
- 2324 ON
- source of energy for an entity or the enabling signal providing permission for the entity to perform its function(s) is present and active.

2327 5.2.79.1 Subtypes of PowerState

- 2328 CONTROL
- state of the enabling signal or control logic that enables or disables the function oroperation of the entity.

- 2331 LINE
- state of the power source for the entity.

2333 5.2.80 <<deprecated>>PowerStatus

- 2334 status of the Component.
- 2335 **DEPRECATED** in Version 1.1.0.
- 2336 <<deprecated>> PowerStatusEnum Enumeration:
- 2337 <<deprecated>> OFF
- 2338 <<deprecated>> ON

2339 5.2.81 ProcessAggregateId

identifier given to link the individual occurrence to a group of related occurrences, such asa process step in a process plan.

2342 5.2.81.1 Subtypes of ProcessAggregateId

- ORDER_NUMBER
- identifier of the authorization of the process occurrence. Synonyms include "job id",
 "work order".
- 2346 PROCESS_PLAN
- identifier of the process plan that this occurrence belongs to. Synonyms include"routing id", "job id".
- PROCESS_STEP
- identifier of the step in the process plan that this occurrence corresponds to. Syn-onyms include "operation id".

2352 5.2.82 ProcessKindId

identifier given to link the individual occurrence to a class of processes or process defini-tion.

2355 5.2.82.1 Subtypes of ProcessKindId

- 2356 ISO_STEP_EXECUTABLE
- reference to a ISO 10303 Executable.
- 2358 PROCESS_NAME
- word or set of words by which a process being executed (process occurrence) by the device is known, addressed, or referred to.
- 2361 UUID
- universally unique identifier as specified in ISO 11578 or RFC 4122.

2363 5.2.83 ProcessOccurrenceId

identifier of a process being executed by the device.

2365 5.2.83.1 Subtypes of ProcessOccurrenceId

- 2366 ACTIVITY
- phase or segment of a recipe or program.
- 2368 OPERATION
- step of a discrete manufacturing process.
- 2370 RECIPE
- process as part of product production; can be a subprocess of a larger process.
- 2372 SEGMENT
- phase of a recipe process.

2374 5.2.84 ProcessState

2375 particular condition of the process occurrence at a specific time.

2376 ProcessStateEnum Enumeration:

2377	• ABORTED
2378	process occurrence has come to a premature end and cannot be resumed.
2379	• ACTIVE
2380	process occurrence is actively executing.
2381	• COMPLETE
2382	process occurrence is now finished.
2383	• INITIALIZING
2384	device is preparing to execute the process occurrence.
2385	• INTERRUPTED
2386	process occurrence has been stopped and may be resumed.
2387	• READY
2388	process occurrence is ready to be executed.

2389 **5.2.85 ProcessTime**

- 2390 time and date associated with an activity or event.
- 2391 A subType **MUST** always be specified.

2392 5.2.85.1 Subtypes of ProcessTime

- COMPLETE
 time and date associated with the completion of an activity or event.
- 2395 START
- boundary when an activity or an event commences.
- 2397 TARGET_COMPLETION
- projected time and date associated with the end or completion of an activity or event.

2399 5.2.86 Program

2400 name of the logic or motion program being executed by the Controller component.

2401 5.2.86.1 Subtypes of Program

2402	• ACTIVE
2403	identity of the logic or motion program currently executing.
2404	• ACTIVITY
2405	phase or segment of a recipe or program.
2406	• MAIN
2407	identity of the primary logic or motion program currently being executed.
2408	It is the starting nest level in a call structure and may contain calls to sub programs.
2409	• OPERATION
2410	step of a discrete manufacturing process.
2411	• RECIPE
2412	process as part of product production; can be a subprocess of a larger process.
2413	• SCHEDULE
2414	identity of a control program that is used to specify the order of execution of other
2415	programs.
2416	• SEGMENT
2417	phase of a recipe process.

2418 5.2.87 ProgramComment

2419 comment or non-executable statement in the control program.

2420 5.2.87.1 Subtypes of ProgramComment

2421	•	ACTIVE
2422		identity of the logic or motion program currently executing.
2423	•	MAIN
2424		identity of the primary logic or motion program currently being executed.
2425		It is the starting nest level in a call structure and may contain calls to sub programs.
2426	•	SCHEDULE
2427		identity of a control program that is used to specify the order of execution of other
2428		programs.

2429 5.2.88 ProgramEdit

- 2430 indication of the status of the Controller components program editing mode.
- A program may be edited while another is executed.
- 2432 ProgramEditEnum Enumeration:
- 2433 ACTIVE
- 2434 Controller is in the program edit mode.
- 2435 NOT_READY
- 2436 Controller is being inhibited by a function from entering the program edit mode.
- 2437 READY
- 2438 Controller is capable of entering the program edit mode and no function is 2439 inhibiting a change to that mode.

2440 5.2.89 ProgramEditName

- 2441 name of the program being edited.
- 2442 This is used in conjunction with ProgramEdit when in ACTIVE state.

2443 5.2.90 ProgramHeader

- 2444 non-executable header section of the control program.
- 2445 The default subType of ProgramHeader is MAIN.

2446 5.2.90.1 Subtypes of ProgramHeader

- ACTIVE
 identity of the logic or motion program currently executing.
 MAIN
 identity of the primary logic or motion program currently being executed.
 It is the starting nest level in a call structure and may contain calls to sub programs.
 SCHEDULE
 identity of a control program that is used to specify the order of execution of other
- programs.

2455 5.2.91 ProgramLocation

2456 URI for the source file associated with Program.

2457 5.2.91.1 Subtypes of ProgramLocation

2458 • ACTIVE identity of the logic or motion program currently executing. 2459 2460 • MAIN identity of the primary logic or motion program currently being executed. 2461 2462 It is the starting nest level in a call structure and may contain calls to sub programs. • SCHEDULE 2463 identity of a control program that is used to specify the order of execution of other 2464 programs. 2465

2466 5.2.92 ProgramLocationType

- defines whether the logic or motion program defined by Program is being executed fromthe local memory of the controller or from an outside source.
- 2469 ProgramLocationTypeEnum Enumeration:
- EXTERNALnot managed by the controller.
- 2472 LOCAL
- 2473 managed by the controller.

2474 5.2.92.1 Subtypes of ProgramLocationType

- 2475 ACTIVE
- identity of the logic or motion program currently executing.
- 2477 MAIN
- identity of the primary logic or motion program currently being executed.
- It is the starting nest level in a call structure and may contain calls to sub programs.
- SCHEDULE
- identity of a control program that is used to specify the order of execution of otherprograms.

2483 5.2.93 ProgramNestLevel

indication of the nesting level within a control program that is associated with the code orinstructions that is currently being executed.

If an initial value is not defined, the nesting level associated with the highest or initial nesting level of the program **MUST** default to zero (0).

2488 The value of ProgramNestLevel MUST be integer.

2489 **5.2.94** RotaryMode

- 2490 current operating mode for a Rotary type axis.
- 2491 RotaryModeEnum Enumeration:

2492	• CONTOUR
2493	position of the axis is being interpolated.
2494	• INDEX
2495	axis is configured to index.
2496	• SPINDLE
2497	axis is functioning as a spindle.

2498 5.2.95 RotaryVelocityOverride

- 2499 percentage change to the velocity of the programmed velocity for a Rotary axis.
- This command represents a percentage change to the velocity calculated by a logic or motion program or set by a switch for a Rotary type axis.
- 2502 The value of RotaryVelocityOverride MUST be float.

2503 5.2.96 Rotation

- three space angular displacement of an object or coordinate system relative to a *cartesian* coordinate system.
- 2506 The units of Rotation MUST be DEGREE_3D.
- 2507 The value of Rotation MUST be a list of float of size 0..3.

2508 5.2.97 SensorAttachment

2509 *attachment* between a sensor and an entity.

2510 The Entry key MUST be one or more from the SensorAttachmentResult keys.

2511 SensorAttachmentResult keys:

2512 • SENSOR_ID

The identity of a sensor used to observe some measurement of an item.

The value of SENSOR_ID MUST be string.

2515 5.2.98 SerialNumber

2516 serial number associated with a Component, Asset, or Device.

2517 5.2.99 SpecificationLimit

set of limits defining a range of values designating acceptable performance for a variable.

2519 The Entry key MUST be one or more from the SpecificationLimitResult keys.

2521 SpecificationLimitResult keys:

TIM	UPPER_	٠	2522
IMI	UPPER_	٠	2522

- 2523 upper conformance boundary for a variable.
- Note: immediate concern or action may be required.
- 2525 The value of UPPER_LIMIT MUST be float.
- 2526 NOMINAL
- ideal or desired value for a variable.
- 2528 The value of NOMINAL MUST be float.
- 2529 LOWER_LIMIT
- lower conformance boundary for a variable.
- Note: immediate concern or action may be required.
- 2532 The value of LOWER_LIMIT MUST be float.

2533 5.2.100 SpindleInterlock

indication of the status of the spindle for a piece of equipment when power has beenremoved and it is free to rotate.

- 2536 SpindleInterlockEnum Enumeration:
- 2537 ACTIVE
- power has been removed and the spindle cannot be operated.
- INACTIVE
- spindle has not been deactivated.

2541 5.2.101 ToolAssetId

2542 identifier of an individual tool asset.

2543 5.2.102 ToolGroup

identifier for the tool group associated with a specific tool. Commonly used to designatespare tools.

2546 5.2.103 <<deprecated>>ToolId

- 2547 identifier of the tool currently in use for a given Path.
- 2548 **DEPRECATED** in Version 1.2.0. See TOOL_ASSET_ID.

2549 5.2.104 ToolNumber

identifier assigned by the Controller component to a cutting tool when in use by a piece of equipment.

2552 **5.2.105** ToolOffset

reference to the tool offset variables applied to the active cutting tool associated with a Path in a Controller type component.

- 2555 The value of ToolOffset MUST be float.
- 2556 A subType **MUST** always be specified.

2557 5.2.105.1 Subtypes of ToolOffset

- 2558 LENGTH
- reference to a length type tool offset variable.
- 2560 RADIAL
- reference to a radial type tool offset variable.

2562 5.2.106 TransferCount

- accumulation of the number of times an operation has attempted to, or is planned to attempt
- to, transfer materials, parts, or other items from one location to another.
- 2565 The default subType of TransferCount is ALL.
- 2566 The value of TransferCount MUST be integer.

2567 5.2.106.1 Subtypes of TransferCount

- 2568 ABORTED
- accumulation of actions or activities that were attempted, but terminated before they could be completed.
- 2571 ALL
- accumulation of all actions, items, or activities being counted independent of the outcome.

2574 • BAD accumulation of actions, items, or activities being counted that do not conform to 2575 specification or expectation. 2576 • COMPLETE 2577 accumulation of actions, items, or activities that have been completed, independent 2578 of the outcome. 2579 2580 • FAILED 2581 accumulation of actions, items, or activities being counted that do not conform to 2582 specification or expectation. • GOOD 2583 2584 accumulation of actions, items, or activities being counted that conform to specification or expectation. 2585 • REMAINING 2586 accumulation of actions, items, or activities yet to be counted. 2587 • TARGET 2588 goal of the operation or process. 2589

2590 **5.2.107** Translation

three space linear displacement of an object or coordinate system relative to a *cartesian coordinate system*.

2593 The units of Translation MUST be MILLIMETER_3D.

2594 The value of Translation MUST be a list of float of size 0..3.

2595 5.2.108 UnloadCount

- accumulation of the number of times an operation has attempted to, or is planned to attempt
- 2597 to, unload materials, parts, or other items.
- 2598 The default subType of UnloadCount is ALL.
- 2599 The value of UnloadCount ${\bf MUST}$ be integer.

2600 5.2.108.1 Subtypes of UnloadCount

• ABORTED 2601 accumulation of actions or activities that were attempted, but terminated before they 2602 could be completed. 2603 • ALL 2604 2605 accumulation of all actions, items, or activities being counted independent of the outcome. 2606 2607 • BAD accumulation of actions, items, or activities being counted that do not conform to 2608 specification or expectation. 2609 2610 • COMPLETE accumulation of actions, items, or activities that have been completed, independent 2611 of the outcome. 2612 • FAILED 2613 2614 accumulation of actions, items, or activities being counted that do not conform to 2615 specification or expectation. • GOOD 2616 2617 accumulation of actions, items, or activities being counted that conform to specification or expectation. 2618 2619 • REMAINING accumulation of actions, items, or activities yet to be counted. 2620 2621 • TARGET goal of the operation or process. 2622

2623 5.2.109 User

- identifier of the person currently responsible for operating the piece of equipment.
- 2625 A subType **MUST** always be specified.

2626 5.2.109.1 Subtypes of User

- 2627 MAINTENANCE
- identifier of the person currently responsible for performing maintenance on thepiece of equipment.
- OPERATOR
- identifier of the person currently responsible for operating the piece of equipment.
- 2632 SET_UP
- identifier of the person currently responsible for preparing a piece of equipment forproduction or restoring the piece of equipment to a neutral state after production.

2635 5.2.110 ValveState

state of a valve is one of open, closed, or transitioning between the states.

2637 ValveStateEnum Enumeration:

• CLOSED 2638 ValveState where flow is not possible, the aperture is static, and the valve is 2639 completely shut. 2640 2641 • CLOSING valve is transitioning from an OPEN state to a CLOSED state. 2642 • OPEN 2643 ValveState where flow is allowed and the aperture is static. 2644 Note: For a binary value, OPEN indicates the valve has the maximum 2645 possible aperture. 2646 • OPENING 2647 valve is transitioning from a CLOSED state to an OPEN state. 2648

2649 5.2.110.1 Subtypes of ValveState

- 2650 ACTUAL
- 2651 measured or reported value of an observation.
- PROGRAMMED
- directive value without offsets and adjustments.

2654 5.2.111 Variable

data whose meaning may change over time due to changes in the operation of a piece of equipment or the process being executed on that piece of equipment.

2657 5.2.112 WaitState

- 2658 indication of the reason that Execution is reporting a value of WAIT.
- 2659 WaitStateEnum Enumeration:

2660	• MATERIAL_LOAD
2661	execution is waiting while material is being loaded.
2662	• MATERIAL_UNLOAD
2663	execution is waiting while material is being unloaded.
2664	• PART_LOAD
2665	execution is waiting while one or more discrete workpieces are being loaded.
2666	• PART_UNLOAD
2667	execution is waiting while one or more discrete workpieces are being unloaded.
2668	• PAUSING
2669	execution is waiting while the equipment is pausing but the piece of equipment has
2670	not yet reached a fully paused state.
2671	• POWERING_DOWN
2672	execution is waiting while the equipment is powering down but has not fully reached
2673	a stopped state.

- 2674 POWERING_UP
- execution is waiting while the equipment is powering up and is not currently available to begin producing parts or products.
- 2677 RESUMING
- execution is waiting while the equipment is resuming the production cycle but has not yet resumed execution.
- 2680 SECONDARY_PROCESS
- execution is waiting while another process is completed before the execution can resume.
- TOOL_LOAD

execution is waiting while a tool or tooling is being loaded.

• TOOL_UNLOAD

execution is waiting while a tool or tooling is being unloaded.

2687 5.2.113 Wire

identifier for the type of wire used as the cutting mechanism in Electrical Discharge Ma-chining or similar processes.

2690 5.2.114 WorkOffset

offset variables for a work piece or part associated with a Path in a Controller type component.

2693 5.2.115 WorkholdingId

identifier for the current workholding or part clamp in use by a piece of equipment.

2695 5.3 Sample Types

2696 This section provides semantic information for Sample types.

2697 5.3.1 Acceleration

- 2698 positive rate of change of velocity.
- 2699 The units of Acceleration MUST be MILLIMETER/SECOND².
- 2700 The default subType of Acceleration is ACTUAL.

2701 5.3.1.1 Subtypes of Acceleration

- ACTUAL
- 2703 measured or reported value of an observation.
- COMMANDED
- directive value including adjustments such as an offset or overrides.
- PROGRAMMED
- directive value without offsets and adjustments.

2708 5.3.2 AccumulatedTime

- 2709 accumulated time for an activity or event.
- 2710 The units of AccumulatedTime MUST be SECOND.

2711 5.3.3 <<deprecated>>Amperage

- 2712 strength of electrical current.
- 2713 **DEPRECATED** in *Version 1.6*. Replaced by AMPERAGE_AC and AMPERAGE_DC.
- 2714 The units of Amperage MUST be AMPERE.

2715 5.3.3.1 Subtypes of Amperage

2716	• ACTUAL
2717	measured or reported value of an observation.
2718	DEPRECATED in Version 1.6.
2719	• ALTERNATING
2720	measurement of alternating voltage or current.
2721	If not specified further in statistic, defaults to RMS voltage.
2722	DEPRECATED in Version 1.6.
2723	• DIRECT
2724	measurement of DC current or voltage.
2725	DEPRECATED in Version 1.6.
2726	• TARGET
2727	goal of the operation or process.
2728	DEPRECATED in Version 1.6.

2729 **5.3.4** AmperageAC

- 2730 electrical current that reverses direction at regular short intervals.
- 2731 The units of AmperageAC MUST be AMPERE.
- 2732 A subType **MUST** always be specified.

2733 5.3.4.1 Subtypes of AmperageAC

- 2734 ACTUAL
- measured or reported value of an observation.
- COMMANDED
- directive value including adjustments such as an offset or overrides.
- PROGRAMMED
- directive value without offsets and adjustments.

2740 5.3.5 AmperageDC

- 2741 electric current flowing in one direction only.
- 2742 The units of AmperageDC MUST be AMPERE.
- 2743 A subType **MUST** always be specified.

2744 5.3.5.1 Subtypes of AmperageDC

ACTUAL
measured or reported value of an observation.
COMMANDED
directive value including adjustments such as an offset or overrides.
PROGRAMMED
directive value without offsets and adjustments.

2751 5.3.6 Angle

- 2752 angular position.
- 2753 The units of Angle **MUST** be DEGREE.

2754 **5.3.6.1 Subtypes of Angle**

- 2755 ACTUAL
- measured or reported value of an observation.
- 2757 COMMANDED
- directive value including adjustments such as an offset or overrides.

2759 5.3.7 AngularAcceleration

- 2760 positive rate of change of angular velocity.
- 2761 The units of AngularAcceleration MUST be DEGREE/SECOND².
- 2762 The default subType of AngularAcceleration is ACTUAL.

2763 5.3.7.1 Subtypes of AngularAcceleration

2764	• ACTUAL
2765	measured or reported value of an observation.
2766	• COMMANDED
2767	directive value including adjustments such as an offset or overrides.
2768	• PROGRAMMED
2769	directive value without offsets and adjustments.

2770 5.3.8 AngularDeceleration

- 2771 negative rate of change of angular velocity.
- 2772 The units of AngularDeceleration MUST be DEGREE/SECOND².
- 2773 The default subType of AngularDeceleration is ACTUAL.

2774 5.3.8.1 Subtypes of AngularDeceleration

- 2775 ACTUAL
- measured or reported value of an observation.
- COMMANDED
- directive value including adjustments such as an offset or overrides.
- PROGRAMMED
- directive value without offsets and adjustments.

2781 5.3.9 AngularVelocity

- 2782 rate of change of angular position.
- 2783 The units of AngularVelocity MUST be DEGREE/SECOND.

2784 5.3.10 AssetUpdateRate

- average rate of change of values for assets in the MTConnect streams.
- ²⁷⁸⁶ The average is computed over a rolling window defined by the implementation.
- 2787 The units of AssetUpdateRate MUST be COUNT/SECOND.

2788 5.3.11 AxisFeedrate

- 2789 feedrate of a linear axis.
- 2790 The units of AxisFeedrate ${
 m MUST}$ be MILLIMETER/SECOND.

2791 5.3.11.1 Subtypes of AxisFeedrate

- ACTUAL 2792 measured or reported value of an observation. 2793 • COMMANDED 2794 directive value including adjustments such as an offset or overrides. 2795 • JOG 2796 2797 relating to momentary activation of a function or a movement. 2798 **DEPRECATION WARNING:** May be deprecated in the future. • OVERRIDE 2799 operator's overridden value. 2800 2801 • PROGRAMMED
- directive value without offsets and adjustments.

- 2803 RAPID
- 2804 performing an operation faster or in less time than nominal rate.

2805 5.3.12 BatteryCapacity

maximum rated charge a battery is capable of maintaining based on the battery dischargingat a specified current over a specified time period.

- 2808 The units of BatteryCapacity MUST be COULOMB.
- 2809 The default subType of BatteryCapacity is ACTUAL.

2810 5.3.12.1 Subtypes of BatteryCapacity

- 2811 ACTUAL
- 2812 measured or reported value of an observation.
- 2813 TARGET
- 2814 goal of the operation or process.

2815 5.3.13 BatteryCharge

- value of the battery's present capacity expressed as a percentage of the battery's maximumrated capacity.
- 2818 The units of BatteryCharge MUST be PERCENT.
- 2819 The default subType of BatteryCharge is ACTUAL.

2820 5.3.13.1 Subtypes of BatteryCharge

- 2821 ACTUAL
- measured or reported value of an observation.
- 2823 TARGET
- 2824 goal of the operation or process.

2825 5.3.14 CapacityFluid

- 2826 fluid capacity of an object or container.
- 2827 The units of CapacityFluid MUST be MILLILITER.

2828 5.3.15 CapacitySpatial

- 2829 geometric capacity of an object or container.
- 2830 The units of CapacitySpatial MUST be CUBIC_MILLIMETER.

2831 5.3.16 ChargeRate

- value of the current being supplied to the Component for the purpose of charging.
- 2833 The units of ChargeRate MUST be AMPERE.
- 2834 The default subType of ChargeRate is ACTUAL.

2835 5.3.16.1 Subtypes of ChargeRate

- 2836 ACTUAL
- 2837 measured or reported value of an observation.
- 2838 TARGET
- 2839 goal of the operation or process.

2840 5.3.17 Concentration

- 2841 percentage of one component within a mixture of components.
- 2842 The units of Concentration MUST be PERCENT.

2843 5.3.18 Conductivity

- ability of a material to conduct electricity.
- 2845 The units of Conductivity MUST be SIEMENS/METER.

2846 5.3.19 CuttingSpeed

- speed difference (relative velocity) between the cutting mechanism and the surface of theworkpiece it is operating on.
- 2849 The units of CuttingSpeed MUST be MILLIMETER/SECOND.

2850 5.3.19.1 Subtypes of CuttingSpeed

- 2851 ACTUAL
- measured or reported value of an observation.
- 2853 COMMANDED
- directive value including adjustments such as an offset or overrides.
- 2855 PROGRAMMED
- directive value without offsets and adjustments.

2857 5.3.20 Deceleration

- 2858 negative rate of change of velocity.
- 2859 The units of Deceleration **MUST** be MILLIMETER/SECOND².
- 2860 The default subType of Deceleration is ACTUAL.

2861 5.3.20.1 Subtypes of Deceleration

- 2862 ACTUAL
- measured or reported value of an observation.

- COMMANDED
- directive value including adjustments such as an offset or overrides.
- 2866 PROGRAMMED
- directive value without offsets and adjustments.

2868 5.3.21 Density

- volumetric mass of a material per unit volume of that material.
- 2870 The units of Density MUST be MILLIGRAM/CUBIC_MILLIMETER.

2871 5.3.22 DepositionAccelerationVolumetric

- rate of change in spatial volume of material deposited in an additive manufacturing process.
- 2874 The units of DepositionAccelerationVolumetric MUST be CUBIC_MILLIMETER/SECOND²

2875 5.3.22.1 Subtypes of DepositionAccelerationVolumetric

- 2876 ACTUAL
- 2877 measured or reported value of an observation.
- 2878 COMMANDED
- directive value including adjustments such as an offset or overrides.

2880 5.3.23 DepositionDensity

- density of the material deposited in an additive manufacturing process per unit of volume.
- 2882 The units of DepositionDensity MUST be <code>MILLIGRAM/CUBIC_MILLIMETER</code>.

2883 5.3.23.1 Subtypes of DepositionDensity

- 2884 ACTUAL
- measured or reported value of an observation.
- 2886 COMMANDED
- directive value including adjustments such as an offset or overrides.

2888 5.3.24 DepositionMass

- 2889 mass of the material deposited in an additive manufacturing process.
- 2890 The units of DepositionMass MUST be MILLIGRAM.

2891 5.3.24.1 Subtypes of DepositionMass

- 2892 ACTUAL
- 2893 measured or reported value of an observation.
- COMMANDED
- directive value including adjustments such as an offset or overrides.

2896 5.3.25 DepositionRateVolumetric

rate at which a spatial volume of material is deposited in an additive manufacturing process.

2899 The units of DepositionRateVolumetric MUST be CUBIC_MILLIMETER/SECOND.

2900 5.3.25.1 Subtypes of DepositionRateVolumetric

- 2901 ACTUAL
- measured or reported value of an observation.
- 2903 COMMANDED
- directive value including adjustments such as an offset or overrides.

2905 5.3.26 DepositionVolume

- spatial volume of material to be deposited in an additive manufacturing process.
- 2907 The units of DepositionVolume MUST be CUBIC_MILLIMETER.

2908 5.3.26.1 Subtypes of DepositionVolume

- 2909 ACTUAL
- 2910 measured or reported value of an observation.
- 2911 COMMANDED
- directive value including adjustments such as an offset or overrides.

2913 5.3.27 DewPoint

- temperature at which moisture begins to condense, corresponding to saturation for a given absolute humidity.
- 2916 The units of DewPoint MUST be CELSIUS.

2917 5.3.28 Diameter

- 2918 dimension of a diameter.
- 2919 The units of Diameter MUST be MILLIMETER.

2920 5.3.29 DischargeRate

- 2921 value of current being drawn from the Component.
- 2922 The units of DischargeRate MUST be AMPERE.
- 2923 The default subType of DischargeRate is ACTUAL.

2924 5.3.29.1 Subtypes of DischargeRate

- ACTUAL
 measured or reported value of an observation.
 TARGET
- 2928 goal of the operation or process.

2929 5.3.30 Displacement

- 2930 change in position of an object.
- 2931 The units of Displacement **MUST** be MILLIMETER.

2932 5.3.31 DisplacementAngular

- absolute value of the change in angular position around a vector
- 2934Note: The displacement vector MAY be defined by the motion of the owning2935Component.
- 2936 The units of DisplacementAngular MUST be DEGREE.

2937 5.3.32 DisplacementLinear

- absolute value of the change in position along a vector.
- 2939Note: The displacement vector MAY be defined by the motion of the owning2940Component.
- 2941 The units of DisplacementLinear ${\bf MUST}\ be$ MILLIMETER.

2942 5.3.33 ElectricalEnergy

- 2943 Wattage used or generated by a component over an interval of time.
- 2944 The units of ElectricalEnergy MUST be WATT_SECOND.

2945 5.3.34 EquipmentTimer

- amount of time a piece of equipment or a sub-part of a piece of equipment has performed specific activities.
- 2948 The units of EquipmentTimer MUST be SECOND.
- 2949 A subType **MUST** always be specified.

2950 5.3.34.1 Subtypes of EquipmentTimer

• DELAY 2951 2952 elapsed time of a temporary halt of action. 2953 • LOADED time that the sub-parts of a piece of equipment are under load. 2954 Example: For traditional machine tools, this is a measurement of the time that the 2955 2956 cutting tool is assumed to be engaged with the part. • OPERATING 2957 time that the major sub-parts of a piece of equipment are powered or performing any 2958 activity whether producing a part or product or not. 2959 Example: For traditional machine tools, this includes WORKING, plus idle time. 2960 • POWERED 2961 time that primary power is applied to the piece of equipment and, as a minimum, the 2962 controller or logic portion of the piece of equipment is powered and functioning or 2963 components that are required to remain on are powered. 2964 Example: Heaters for an extrusion machine that are required to be powered even 2965 when the equipment is turned off. 2966

- 2967 WORKING
- time that a piece of equipment is performing any activity the equipment is active and performing a function under load or not.
- Example: For traditional machine tools, this includes LOADED, plus rapid moves, tool changes, etc.

2972 5.3.35 FillLevel

amount of a substance remaining compared to the planned maximum amount of that substance.

2975 The units of FillLevel MUST be PERCENT.

2976 5.3.36 Flow

- 2977 rate of flow of a fluid.
- 2978 The units of Flow MUST be LITER/SECOND.

2979 5.3.37 FollowingError

difference between actual and commanded position at any specific point in time during amotion.

2982 The units of FollowingError MUST be COUNT.

2983 5.3.37.1 Subtypes of FollowingError

- 2984 ACTUAL
- 2985 measured or reported value of an observation.
2986 5.3.38 FollowingErrorAngular

- angular difference between the commanded encoder/resolver position and the actual encoder/resolver position at any specified point in time during a motion.
- 2989 The units of FollowingErrorAngular MUST be DEGREE.

2990 5.3.38.1 Subtypes of FollowingErrorAngular

- 2991 ACTUAL
- measured or reported value of an observation.

2993 5.3.39 FollowingErrorLinear

- difference between the commanded encoder/resolver position and the actual encoder/resolver position at any specified point in time during a motion.
- 2996 The units of FollowingErrorLinear MUST be MILLIMETER.

2997 5.3.39.1 Subtypes of FollowingErrorLinear

- 2998 ACTUAL
- measured or reported value of an observation.

3000 5.3.40 Frequency

- 3001 number of occurrences of a repeating event per unit time.
- 3002 The units of Frequency MUST be HERTZ.

3003 5.3.41 <<deprecated>>GlobalPosition

3004 position in three-dimensional space.

3005 **DEPRECATED** in Version 1.1.

3006 The units of GlobalPosition MUST be MILLIMETER.

3007 5.3.41.1 Subtypes of GlobalPosition

- 3008 ACTUAL
- 3009 measured or reported value of an observation.
- 3010 COMMANDED
- directive value including adjustments such as an offset or overrides.

3012 5.3.42 GravitationalAcceleration

- 3013 acceleration relative to Earth's gravity of 9.80665 METER/SECOND².
- 3014 The units of Gravitational Acceleration MUST be GRAVITATIONAL_ACCELERATION.

3015 5.3.43 GravitationalForce

- 3016 force relative to earth's gravity.
- 3017 Note: *Mass* × *GravitationalAcceleration*
- 3018 The units of GravitationalForce MUST be GRAVITATIONAL_FORCE.

3019 5.3.44 HumidityAbsolute

- amount of water vapor expressed in grams per cubic meter.
- 3021 The units of HumidityAbsolute MUST be GRAM/CUBIC_METER.

3022 5.3.44.1 Subtypes of HumidityAbsolute

- 3023 ACTUAL
- measured or reported value of an observation.
- 3025 COMMANDED
- directive value including adjustments such as an offset or overrides.

3027 5.3.45 HumidityRelative

amount of water vapor present expressed as a percent to reach saturation at the same tem-perature.

3030 The units of HumidityRelative MUST be PERCENT.

3031 5.3.45.1 Subtypes of HumidityRelative

- 3032 ACTUAL
- 3033 measured or reported value of an observation.
- 3034 COMMANDED
- directive value including adjustments such as an offset or overrides.

3036 5.3.46 HumiditySpecific

ratio of the water vapor present over the total weight of the water vapor and air presentexpressed as a percent.

3039 The units of HumiditySpecific MUST be PERCENT.

3040 5.3.46.1 Subtypes of HumiditySpecific

- 3041 ACTUAL
- measured or reported value of an observation.

- 3043 COMMANDED
- directive value including adjustments such as an offset or overrides.

3045 5.3.47 Length

- 3046 length of an object.
- 3047 The units of Length MUST be MILLIMETER.

3048 5.3.47.1 Subtypes of Length

- REMAINING
 remaining total length of an object.
 STANDARD
 standard or original length of an object.
 USEABLE
- remaining usable length of an object.

3055 5.3.48 <<deprecated>>Level

- 3056 level of a resource.
- 3057 **DEPRECATED** in Version 1.2. See FILL_LEVEL.
- 3058 The units of Level MUST be PERCENT.

3059 5.3.49 LinearForce

- 3060 *force* applied to a mass in one direction only.
- 3061 The units of LinearForce **MUST** be NEWTON.

3062 5.3.50 Load

- 3063 actual versus the standard rating of a piece of equipment.
- 3064 The units of Load MUST be PERCENT.

3065 5.3.51 Mass

- 3066 mass of an object(s) or an amount of material.
- 3067 The units of Mass MUST be KILOGRAM.

3068 5.3.52 ObservationUpdateRate

- average rate of change of values for data items in the MTConnect streams. The average iscomputed over a rolling window defined by the implementation.
- 3071 The units of ObservationUpdateRate MUST be COUNT/SECOND.

3072 5.3.53 Openness

- 3073 percentage open where 100% is fully open and 0% is fully closed.
- 3074 The units of Openness MUST be PERCENT.

3075 **5.3.54** Orientation

- 3076 angular position of a plane or vector relative to a *cartesian coordinate system*
- 3077 The units of Orientation MUST be DEGREE_3D.
- 3078 The value of Orientation MUST be a list of float of size 0..3.

3079 5.3.54.1 Subtypes of Orientation

139

3080	• ACTUAL
3081	measured or reported value of an observation.
3082	• COMMANDED
3083	directive value including adjustments such as an offset or overrides.

3084 5.3.55 PH

- 3085 acidity or alkalinity of a solution.
- 3086 The units of PH MUST be PH.

3087 5.3.56 PathFeedrate

- 3088 feedrate for the axes, or a single axis, associated with a Path component.
- 3089 The units of PathFeedrate **MUST** be MILLIMETER/SECOND.

3090 5.3.56.1 Subtypes of PathFeedrate

3091 •	ACTUAL
3092	measured or reported value of an observation.
3093 •	COMMANDED
3094	directive value including adjustments such as an offset or overrides.
3095 •	JOG
3096	relating to momentary activation of a function or a movement.
3097	DEPRECATION WARNING : May be deprecated in the future.
3098 •	OVERRIDE
3099	operator's overridden value.
3100	DEPRECATED in Version 1.3.
3101 •	PROGRAMMED
3102	directive value without offsets and adjustments.

- 3103 RAPID
- performing an operation faster or in less time than nominal rate.

3105 5.3.57 PathFeedratePerRevolution

3106 feedrate for the axes, or a single axis.

3107 The units of PathFeedratePerRevolution MUST be MILLIMETER/REVO-3108 LUTION.

3109 5.3.57.1 Subtypes of PathFeedratePerRevolution

- 3110 ACTUAL
- 3111 measured or reported value of an observation.
- 3112 COMMANDED
- directive value including adjustments such as an offset or overrides.
- 3114 PROGRAMMED
- directive value without offsets and adjustments.

3116 5.3.58 PathPosition

- 3117 position of a control point associated with a Controller or a Path.
- 3118 The units of PathPosition MUST be MILLIMETER_3D.
- 3119 The value of PathPosition MUST be a list of float of size 0..3.

3120 5.3.58.1 Subtypes of PathPosition

- 3121 ACTUAL
- measured or reported value of an observation.
- 3123 COMMANDED
- directive value including adjustments such as an offset or overrides.

- 3125 PROBE
- 3126 position provided by a measurement probe.
- 3127 **DEPRECATION WARNING:** May be deprecated in the future.
- 3128 TARGET
- 3129 goal of the operation or process.

3130 5.3.59 Position

- 3131 point along an axis in a *cartesian coordinate system*.
- 3132 The units of Position MUST be MILLIMETER.

3133 5.3.59.1 Subtypes of Position

- 3134 ACTUAL
- measured or reported value of an observation.
- 3136 COMMANDED
- directive value including adjustments such as an offset or overrides.
- 3138 PROGRAMMED
- directive value without offsets and adjustments.
- 3140 TARGET
- 3141 goal of the operation or process.

3142 5.3.60 PositionCartesian

- 3143 point in a cartesian coordinate system.
- 3144 The units of PositionCartesian MUST be MILLIMETER_3D.
- 3145 The value of PositionCartesian MUST be a list of float of size 0..3.

3146 5.3.61 PowerFactor

- ratio of real power flowing to a load to the apparent power in that AC circuit.
- 3148 The units of PowerFactor MUST be PERCENT.

3149 5.3.62 Pressure

- 3150 force per unit area measured relative to atmospheric pressure.
- 3151 Commonly referred to as gauge pressure.
- 3152 The units of Pressure MUST be PASCAL.

3153 5.3.63 PressureAbsolute

- 3154 The force per unit area measured relative to a vacuum.
- 3155 The units of PressureAbsolute MUST be PASCAL.

3156 5.3.64 PressurizationRate

- 3157 change of pressure per unit time.
- 3158 The units of PressurizationRate MUST be PASCAL/SECOND.

3159 5.3.64.1 Subtypes of PressurizationRate

- 3160 ACTUAL
- measured or reported value of an observation.
- 3162 COMMANDED
- directive value including adjustments such as an offset or overrides.
- 3164 PROGRAMMED
- directive value without offsets and adjustments.

3166 5.3.65 ProcessTimer

- amount of time a piece of equipment has performed different types of activities associated
- 3168 with the process being performed at that piece of equipment.
- 3169 The units of ProcessTimer MUST be SECOND.
- 3170 A subType **MUST** always be specified.

3171 5.3.65.1 Subtypes of ProcessTimer

- 3172 DELAY
- elapsed time of a temporary halt of action.
- PROCESS
- time from the beginning of production of a part or product on a piece of equipment
 until the time that production is complete for that part or product on that piece of
 equipment.
- This includes the time that the piece of equipment is running, producing parts or products, or in the process of producing parts.

3180 5.3.66 Resistance

- 3181 degree to which a substance opposes the passage of an electric current.
- 3182 The units of Resistance MUST be OHM.

3183 5.3.67 RotaryVelocity

- 3184 rotational speed of a rotary axis.
- 3185 The units of RotaryVelocity MUST be REVOLUTION/MINUTE.

3186 5.3.67.1 Subtypes of RotaryVelocity

3187	• ACTUAL
3188	measured or reported value of an observation.
3189	• COMMANDED
3190	directive value including adjustments such as an offset or overrides.
3191	• OVERRIDE
3192	The operators overridden value.
3193	• PROGRAMMED
3194	directive value without offsets and adjustments.

3195 5.3.68 SettlingError

- 3196 difference between actual and commanded position at the end of a motion.
- 3197 The units of SettlingError MUST be COUNT.

3198 5.3.68.1 Subtypes of SettlingError

- 3199 ACTUAL
- 3200 measured or reported value of an observation.

3201 5.3.69 SettlingErrorAngular

- 3202 angular difference between the commanded encoder/resolver position, and the actual en-
- 3203 coder/resolver position when motion is complete.
- 3204 The units of SettlingErrorAngular MUST be DEGREE.

3205 5.3.69.1 Subtypes of SettlingErrorAngular

- 3206 ACTUAL
- 3207 measured or reported value of an observation.

3208 5.3.70 SettlingErrorLinear

- 3209 difference between the commanded encoder/resolver position, and the actual encoder/re-3210 solver position when motion is complete.
- 3211 The units of SettlingErrorLinear MUST be MILLIMETER.

3212 5.3.70.1 Subtypes of SettlingErrorLinear

- 3213 ACTUAL
- 3214 measured or reported value of an observation.

3215 5.3.71 SoundLevel

- 3216 sound level or sound pressure level relative to atmospheric pressure.
- 3217 The units of SoundLevel MUST be DECIBEL.
- 3218 The default subType of SoundLevel is A_SCALE.

3219 5.3.71.1 Subtypes of SoundLevel

- 3220 A_SCALE
- A Scale weighting factor. This is the default weighting factor if no factor is specified
- 3222 B_SCALE
- 3223 B Scale weighting factor
- 3224 C_SCALE
- 3225 C Scale weighting factor
- 3226 D_SCALE
- 3227 D Scale weighting factor
- 3228 NO_SCALE
- No weighting factor on the frequency scale

3230 5.3.72 <<deprecated>>SpindleSpeed

- 3231 rotational speed of the rotary axis.
- 3232 **DEPRECATED** in Version 1.2. Replaced by ROTARY_VELOCITY.
- 3233 The units of SpindleSpeed MUST be <code>REVOLUTION/MINUTE</code>.

3234 5.3.72.1 Subtypes of SpindleSpeed

3235 • ACTUAL measured or reported value of an observation. 3236 **DEPRECATED** in Version 1.3. 3237 • COMMANDED 3238 directive value including adjustments such as an offset or overrides. 3239 **DEPRECATED** in Version 1.3. 3240 • OVERRIDE 3241 operator's overridden value. 3242 **DEPRECATED** in Version 1.3. 3243

3244 5.3.73 Strain

- 3245 amount of deformation per unit length of an object when a load is applied.
- 3246 The units of Strain MUST be PERCENT.

3247 5.3.74 Temperature

- 3248 degree of hotness or coldness measured on a definite scale.
- 3249 The units of Temperature MUST be CELSIUS.

3250 5.3.75 Tension

- 3251 force that stretches or elongates an object.
- 3252 The units of Tension MUST be NEWTON.

3253 5.3.76 Tilt

- 3254 angular displacement.
- 3255 The units of Tilt MUST be MICRO_RADIAN.

3256 5.3.77 Torque

- 3257 turning force exerted on an object or by an object.
- 3258 The units of Torque MUST be NEWTON_METER.

3259 5.3.78 Velocity

- 3260 rate of change of position of a Component.
- 3261 The units of Velocity MUST be MILLIMETER/SECOND.

3262 5.3.79 Viscosity

- 3263 fluid's resistance to flow.
- 3264 The units of Viscosity MUST be PASCAL_SECOND.

3265 5.3.80 VoltAmpere

apparent power in an electrical circuit, equal to the product of root-mean-square (RMS)
voltage and RMS current (commonly referred to as VA).

3268 The units of VoltAmpere MUST be VOLT_AMPERE.

3269 5.3.81 VoltAmpereReactive

- 3270 reactive power in an AC electrical circuit (commonly referred to as VAR).
- 3271 The units of VoltAmpereReactive MUST be VOLT_AMPERE_REACTIVE.

3272 5.3.82 <<deprecated>>Voltage

- 3273 electrical potential between two points.
- 3274 **DEPRECATED** in *Version 1.6*. Replaced by VOLTAGE_AC and VOLTAGE_DC.
- 3275 The units of Voltage MUST be VOLT.

3276 5.3.82.1 Subtypes of Voltage

3277 • ACTUAL measured or reported value of an observation. 3278 **DEPRECATED** in Version 1.6. 3279 3280 • ALTERNATING alternating voltage or current. 3281 3282 If not specified further in statistic, defaults to RMS voltage. 3283 **DEPRECATED** in Version 1.6. • DIRECT 3284 DC current or voltage. 3285 **DEPRECATED** in Version 1.6. 3286 • TARGET 32.87 goal of the operation or process. 3288 **DEPRECATED** in Version 1.6. 3289

3290 5.3.83 VoltageAC

3291 electrical potential between two points in an electrical circuit in which the current period-

- 3292 ically reverses direction.
- 3293 The units of VoltageAC MUST be VOLT.
- 3294 A subType **MUST** always be specified.

3295 5.3.83.1 Subtypes of VoltageAC

- 3296 ACTUAL
- 3297 measured or reported value of an observation.
- 3298 COMMANDED
- directive value including adjustments such as an offset or overrides.
- 3300 PROGRAMMED
- directive value without offsets and adjustments.

3302 5.3.84 VoltageDC

electrical potential between two points in an electrical circuit in which the current is uni-directional.

- 3305 The units of VoltageDC MUST be VOLT.
- 3306 A subType **MUST** always be specified.

3307 5.3.84.1 Subtypes of VoltageDC

- 3308 ACTUAL
- measured or reported value of an observation.
- 3310 COMMANDED
- directive value including adjustments such as an offset or overrides.
- 3312 PROGRAMMED
- directive value without offsets and adjustments.

3314 5.3.85 VolumeFluid

- 3315 fluid volume of an object or container.
- 3316 The units of VolumeFluid MUST be MILLILITER.

3317 5.3.85.1 Subtypes of VolumeFluid

3318 • ACTUAL measured or reported value of an observation. 3319 3320 • CONSUMED reported or measured value of the amount used in the manufacturing process. 3321 • ENDED 3322 3323 boundary when an activity or an event terminates. • PART 3324 reported or measured value of amount included in the part. 3325 • START 3326 boundary when an activity or an event commences. 3327 3328 • WASTE reported or measured value of the amount discarded. 3329

3330 5.3.86 VolumeSpatial

- 3331 geometric volume of an object or container.
- 3332 The units of VolumeSpatial MUST be CUBIC_MILLIMETER.

3333 5.3.86.1 Subtypes of VolumeSpatial

- 3334 ACTUAL
- measured or reported value of an observation.

3336	• CONSUMED
3337	reported or measured value of the amount used in the manufacturing process.
3338	• ENDED
3339	boundary when an activity or an event terminates.
3340	• PART
3341	reported or measured value of amount included in the part.
3342	• START
3343	boundary when an activity or an event commences.
3344	• WASTE
3345	reported or measured value of the amount discarded

3346 5.3.87 Wattage

3347 power flowing through or dissipated by an electrical circuit or piece of equipment.

3348 The units of Wattage MUST be WATT.

3349 5.3.87.1 Subtypes of Wattage

- 3350 ACTUAL
- 3351 measured or reported value of an observation.
- 3352 TARGET
- 3353 goal of the operation or process.

3354 5.3.88 XDimension

- 3355 dimension of an entity relative to the X direction of the referenced coordinate system.
- 3356 The units of XDimension **MUST** be MILLIMETER.

3357 5.3.89 YDimension

- dimension of an entity relative to the Y direction of the referenced coordinate system.
- 3359 The units of YDimension **MUST** be MILLIMETER.

3360 5.3.90 ZDimension

- dimension of an entity relative to the Z direction of the referenced coordinate system.
- 3362 The units of ZDimension MUST be MILLIMETER.

3363 6 **Profile**

3364 MTConnect Profile is a *profile* that extends the Systems Modeling Language (SysML)

metamodel for the MTConnect domain using additional data types and *stereotypes*.

3366 6.1 DataTypes

bdd [Package] DataTypes [R PrimitiveValueTypes]		
	«Model.ibrary»	
	PrimitiveValueTypes	
	unthur Turne	
	Nimhar	
	4	
	<pre>«valueTvpe» «valueTvpe» «valueTvpe»</pre>	
	Real Integer Boolean String	
«valueTvpe»	«valueTvpe» «valueTvpe»	
float	integer boolean string	
«valueType»	«valueType» «value	«valueType»
unit	int64 int32 version x509 ID xlinkhref xlinktype IDREF xslang	dateTime
«valueType» «valueType» «valueType»	«valueType» «valueType» «valueType»	
DEGREE CUBIC_MILLIMETER SECOND	MILLIMETER uint64 uint32	

Figure 13: DataTypes

3367 6.1.1 boolean

3368 primitive type.

3369 6.1.2 ID

3370 string that represents an identifier (ID).

3371 6.1.3 string

3372 primitive type.

3373 6.1.4 float

3374 primitive type.

3375 6.1.5 datetime

3376 string that represents timestamp in ISO 8601 format.

3377 6.1.6 integer

3378 primitive type.

3379 6.1.7 xlinktype

3380 string that represents the type of an XLink element. See https://www.w3.org/TR/ 3381 xlink11/.

3382 6.1.8 xslang

3383 string that represents a language tag. See http://www.ietf.org/rfc/rfc4646. 3384 txt.

3385 6.1.9 SECOND

3386 float that represents time in seconds.

3387 6.1.10 IDREF

3388 string that represents a reference to an ID.

3389 6.1.11 xlinkhref

string that represents the locator attribute of an XLink element. See https://www.w3. org/TR/xlink11/.

3392 6.1.12 x509

string that represents an x509 data block. *Ref ISO/IEC* 9594-8:2020.

3394 6.1.13 int32

3395 32-bit integer.

3396 6.1.14 int64

3397 64-bit integer.

3398 6.1.15 version

series of four numeric values, separated by a decimal point, representing a *major*, *minor*,
and *revision* number of the MTConnect Standard and the revision number of a specific *schema*.

3402 6.1.16 uint32

3403 32-bit unsigned integer.

3404 6.1.17 uint64

3405 64-bit unsigned integer.

3406 6.2 Stereotypes

3407 6.2.1 organizer

3408 element that *organizes* other elements of a type.

156

3409 6.2.2 deprecated

3410 element that has been deprecated.

3411 6.2.3 extensible

3412 enumeration that can be extended.

3413 6.2.4 informative

3414 element that is descriptive and non-normative.

3415 6.2.5 valueType

3416 extends SysML <<ValueType>> to include Class as a value type.

3417 6.2.6 normative

3418 element that has been added to the standard.

3419 6.2.7 observes

3420 association in which a *Component* makes *Observations* about an observable *DataItem*.



Figure 14: Stereotypes

3421 Appendices

3422 A Bibliography

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3472 B XML Schema Diagrams

3473 B.1 Observations Schema Diagrams

- 3474 See Streams element in MTConnectStreams schema.
- 3475 See DeviceStream element in MTConnectStreams schema.
- 3476 See ComponentStream element in MTConnectStreams schema.
- 3477 See Sample element in MTConnectStreams schema.
- 3478 See Event element in MTConnectStreams schema.
- 3479 See Condition element in MTConnectStreams schema.

3480 B.2 Representation Schema Diagrams

- 3481 See AbsTimeSeries element in MTConnectStreams schema.
- 3482 See PartCountDiscrete element in MTConnectStreams schema.
- 3483 See VariableDataSet element in MTConnectStreams schema.
- 3484 See Entry element in MTConnectStreams schema.
- 3485 See WorkOffsetTable element in MTConnectStreams schema.

3486 C XML Examples

3487 C.1 DeviceStream Example

Example 1: DeviceStream Example

```
3488
     1 <Streams>
     2
           <DeviceStream name="M12346" uuid="M8010W4194N">
3489
3490 3
             <ComponentStream component="Device" name="M12346" componentId="</pre>
3491
                d1">
    4
3492
               <Events>
     5
3493
                 <Availability dataItemId="avail" sequence="156" timestamp="</pre>
3494
            2021-10-01T14:26:38.668505Z">AVAILABLE</Availability>
```

3495	6	<pre><assetchanged <="" assettype="CuttingTool" dataitemid="d1\</pre></th></tr><tr><td>3496</td><td></td><td>textunderscore_asset\textunderscore_chg" td=""></assetchanged></pre>
3497		timestamp="2021-10-07T05:08:53.870206Z">M8010W4194N1
3498		.120
3499	7	<pre><assetremoved <="" assettype="CuttingTool" dataitemid="d1\</pre></td></tr><tr><td>3500</td><td></td><td>textunderscore_asset\textunderscore_rem" td=""></assetremoved></pre>
3501		timestamp="2021-10-01T11:40:08.101461Z">UNAVAILABLE </td
3502		AssetRemoved>
3503	8	
3504	9	
3505	10	<pre><componentstream <="" component="Controller" name="controller" pre=""></componentstream></pre>
3506		<pre>componentId="cont"></pre>
3507	11	<events></events>
3508	12	<pre><emergencystop dataitemid="estop" sequence="159" timestamp="</pre></td></tr><tr><td>3509</td><td></td><td>2021-10-01T14:26:38.66869Z">ARMED</emergencystop></pre>
3510	13	
3511	14	<samples></samples>
3512	15	<pre><accumulatedtime <="" dataitemid="cut\textunderscore_time" pre=""></accumulatedtime></pre>
3513		<pre>sequence="75437" timestamp="2021-10-07T05:08:28.221704Z"></pre>
3514		1763070.0
3515	16	
3516	17	<condition></condition>
3517	18	<pre><unavailable <="" dataitemid="cont\textunderscore_system" pre=""></unavailable></pre>
3518		<pre>sequence="72" timestamp="2021-10-11T21:04:03.251999Z" type="</pre>
3519		SYSTEM"/>
3520	19	<pre><warning dataitemid="cont\textunderscore_system" nativecode="</pre"></warning></pre>
3521		"313" nativeSeverity="50" sequence="75573" timestamp="
3522		2021-10-07T05:08:58.518317Z"
3523		PROGRAM">PALLET ARM DOWN RS. MALF.
3524	20	
3525	21	
3526	22	<pre><componentstream component="Path" componentid="path1</pre></td></tr><tr><td>3527</td><td></td><td>" name="path"></componentstream></pre>
3528	23	<events></events>
3529	24	<pre><execution dataitemid="execution" name="execution" sequence="</pre"></execution></pre>
3530		"222623" timestamp="2021-10-12T06:04:32.761198Z">INTERRUPTED </td
3531		Execution>
3532	25	<pre><variabledataset count="2" dataitemid="cvars" sequence="</pre></td></tr><tr><td>3533</td><td></td><td>126513" timestamp="2021-10-12T03:57:31.106559Z"></variabledataset></pre>
3534	26	<pre><entry key="100">66.3314</entry></pre>
3535	27	<pre><entry key="101">167.2</entry></pre>
3536	28	
3537	29	<pre><workoffsettable count="2" dataitemid="woffset" sequence="</pre></td></tr><tr><td>3538</td><td></td><td>222101" timestamp="2021-10-12T06:04:11.990531Z"></workoffsettable></pre>
3539	30	<pre><entry key="G53.1"></entry></pre>
3540	31	<cell key="X">1</cell>
3541	32	<cell key="Y">2</cell>
3542	33	<cell key="Z">3</cell>
3543	34	
3544	35	<pre><entry key="G53.2"></entry></pre>
3545	36	<cell key="X">4</cell>

3546	37	<cell key="Y">5</cell>
3547	38	<cell key="Z">6</cell>
3548	39	
3549	40	
3550	41	
3551	42	<samples></samples>
3552	43	<pre><cuttingspeed dataitemid="cspeed" sequence="112" subtype="ACTUAL" timestamp="</pre></td></tr><tr><td>3553</td><td></td><td>2021-10-07T05:08:28.221704Z">UNAVAILABLE<!--</td--></cuttingspeed></pre>
3554		CuttingSpeed>
3555	44	
3556	45	<condition></condition>
3557	46	<pre><normal dataitemid="path\textunderscore_system" sequence="</pre></td></tr><tr><td>3558</td><td></td><td>153" timestamp="2021-10-11T21:04:03.262845Z" type="SYSTEM"></normal></pre>
3559	47	
3560	48	
3561	49	
3562	50	

3563 C.2 Observations made for DataItem Example

3564	1	<components></components>
3565	2	<controller id="cont" name="controller"></controller>
3566	3	<dataitems></dataitems>
3567	4	<pre><dataitem category="EVENT" id="estop" name="estop" type="</pre></td></tr><tr><td>3568</td><td></td><td>EMERGENCY\textunderscore_STOP"></dataitem></pre>
3569	5	
3570	6	
3571	7	

Example 3: MTConnectStreams Response Document

```
3572 1 <ComponentStream component="Controller" name="controller"
3573 componentId="cont">
3574 2 <Events>
3575 3 <Events>
3576 2021-10-01T14:26:38.668692">ARMED</EmergencyStop" timestamp="
3577 4 </Events>
3578 5 </ComponentStream>
```

3579 C.3 Sample Example

Example 4: Sample Example

3580 1 <Samples>

2	<pre><accumulatedtime dataitemid="cut\textunderscore_time" sequence="</pre></th></tr><tr><td></td><td>75437" timestamp="2021-10-07T05:08:28.221704Z">1763070.0<!--</td--></accumulatedtime></pre>
	AccumulatedTime>
3	<pre><cuttingspeed dataitemid="cspeed" sequence="112" subtype="ACTUAL" timestamp="</pre></td></tr><tr><td></td><td>2021-10-07T05:08:28.221704Z">UNAVAILABLE<!--</td--></cuttingspeed></pre>
	CuttingSpeed>
4	
	2 3 4

3588 C.4 Event Example

Example 5: Event Example

3589	1	<events></events>
3590	2	<pre><availability dataitemid="avail" sequence="156" timestamp="</pre></td></tr><tr><td>3591</td><td></td><td>2021-10-01T14:26:38.668505Z">AVAILABLE</availability></pre>
3592	3	<pre><assetremoved <="" assettype="CuttingTool" dataitemid="d1\</pre></td></tr><tr><td>3593</td><td></td><td>textunderscore_asset\textunderscore_rem" td=""></assetremoved></pre>
3594		timestamp="2021-10-01T11:40:08.101461Z">UNAVAILABLE </td
3595		AssetRemoved>
3596	4	

3597 C.5 Condition Example

Condition types are represented differently in XML when compared to Sample and Event types. The element name is the condition state of the Condition type in Pascal Case. The name of the Condition type is represented by the attribute type.

3601 If the condition state is unavailable then the element name is represented by Unavail-3602 able.

Example 6: Condition Example

3603	1	<condition></condition>
3604	2	<pre>Unavailable dataItemId="cont\textunderscore_system" sequence="72"</pre>
3605		<pre>timestamp="2021-10-11T21:04:03.251999Z" type="SYSTEM"/></pre>
3606	3	<normal <="" dataitemid="path\textunderscore_system" sequence="153" td=""></normal>
3607		<pre>timestamp="2021-10-11T21:04:03.262845Z" type="SYSTEM"/></pre>
3608	4	<pre><warning <="" dataitemid="cont\textunderscore_system" nativecode="313" pre=""></warning></pre>
3609		<pre>nativeSeverity="50" sequence="75573" timestamp="2021-10-07T05</pre>
3610		:08:58.518317Z" type="LOGIC\textunderscore_PROGRAM">PALLET ARM
3611		DOWN RS. MALF.
3612	5	

3613 C.6 DataSet Example

Example 7: DataSet Example

3621 C.7 Table Example

Example 8: Table Example

3622	1	<events></events>
3623	2	<pre><workoffsettable <="" count="2" dataitemid="woffset" pre="" sequence="222101"></workoffsettable></pre>
3624		<pre>timestamp="2021-10-12T06:04:11.990531Z"></pre>
3625	3	<entry key="G53.1"></entry>
3626	4	<cell key="X">1</cell>
3627	5	<cell key="Y">2</cell>
3628	6	<cell key="Z">3</cell>
3629	7	
3630	8	<pre><entry key="G53.2"></entry></pre>
3631	9	<cell key="X">4</cell>
3632	10	<cell key="Y">5</cell>
3633	11	<cell key="Z">6</cell>
3634	12	
3635	13	
3636	14	