



MTConnect® Standard

Part 2.0 – Device Information Model

Version 2.5.0

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

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1 Purpose of This Document

2 This document, *MTConnect Standard: Part 2.0 - Device Information Model* of the MT-
3 Connect Standard, establishes the rules and terminology to be used by designers to de-
4 scribe the function and operation of a piece of equipment and to define the data that is
5 provided by an *agent* from the equipment. The *Device Information Model* also defines the
6 structure for the *response document* that is returned from an *agent* in response to a *probe
7 request*.

8 In the MTConnect Standard, equipment represents any tangible property that is used in the
9 operations of a manufacturing facility. Examples of equipment are machine tools, ovens,
10 sensor units, workstations, software applications, and bar feeders.

11 Note: See *MTConnect Standard: Part 3.0 - Observation Information Model*
12 of the MTConnect Standard for details on the *response document* that are
13 returned from an *agent* in response to a *sample request* or *current request*.

14 2 Terminology and Conventions

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

17 2.1 General Terms

18 **adapter**

19 optional piece of hardware or software that transforms information provided by a
 20 piece of equipment into a form that can be received by an *agent*.

21 **agent**

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

26 **alarm limit**

27 limit used to trigger warning or alarm indicators.

28 **application**

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

31 **archetype**

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

34 **asset buffer**

35 *buffer* for *Assets*.

36 **attachment**

37 connection by which one thing is associated with another.

38 **buffer**

39 section of an *agent* that provides storage for information published from pieces of
 40 equipment.

41 ***cartesian coordinate system***

42 3D orthogonal coordinate system [ISO/IEC 19794-5:2011en].

43 ***characteristic***44 control placed on an element of a *feature* such as its size, location, or form, which
45 may be a specification limit, a nominal with tolerance, or some other numerical or
46 non-numerical control. *Ref QIF 3.0 3.4.29. Ref AS9102-B.*47 ***client***48 *application* that sends *request* for information to an *agent*.49 Note: Examples include software applications or a function that imple-
50 ments the *request* portion of an *interface interaction model*.51 ***combined standard uncertainty***52 *standard uncertainty* of the result of a measurement when that result is obtained
53 from the values of a number of other quantities, equal to the positive square root of a
54 sum of terms, the terms being the variances or covariances of these other quantities
55 weighted according to how the measurement result varies with changes in these
56 quantities. *Ref JCGM 100:2008 2.3.4*57 ***condition activation***

58 state transition from Normal to either Warning or Fault.

59 ***controlled vocabulary***

60 restricted set of values for a given property.

61 ***data dictionary***62 listing of standardized terms and definitions used in *MTConnect Information Model*.63 ***data model***64 organizes elements of data and standardizes how they relate to one another and to
65 the properties of real-world entities.66 ***data set***67 *key-value pairs* where each entry is uniquely identified by the *key*.68 ***data source***69 piece of equipment that can produce data that is published to an *agent*.70 ***deprecated***71 indication that specific content in an *MTConnect Document* is currently usable but
72 is regarded as being obsolete or superseded.

73 ***deprecation warning***

74 indication that specific content in an *MTConnect Document* may be changed to *depre-
75 cated* in a future release of the standard.

76 ***document***

77 piece of written, printed, or electronic matter that provides information or evidence
78 that serves as an official record.

79 ***electric current***

80 rate of flow of electric charge.

81 ***element***

82 constituent part or a basic unit of identifiable and definable data.

83 ***extensible***

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

86 ***feature***

87 topological entity(ies) or design requirements related to a geometric model. *Ref QIF
88 3.0-3.4.59*

89 ***force***

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

91 ***heartbeat***

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

95 ***higher level***

96 nested element that is above a lower level element.

97 ***implementation***

98 specific instantiation of the MTConnect Standard.

99 ***information model***

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

102 ***instance***

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

105 ***interaction model***

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

108 ***interface***

109 means by which communication is achieved between independent systems.

110 ***key***

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

112 ***key-value pair***

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

115 ***location***

116 place or named space associated with an object or that can be occupied by an object.

117 ***lower camel case***

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

120 ***lower level***

121 nested element that is below a higher level element.

122 ***lower limit***

123 lower conformance boundary for a variable.

124 ***lower warning***

125 lower boundary indicating increased concern and supervision may be required.

126 ***major***

127 identifier representing a consistent set of functionalities defined by the MTConnect
128 Standard.

129 ***maximum***

130 numeric upper constraint.

131 ***message***

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

133 ***metadata***

134 data that provides information about other data.

135 ***minimum***

136 numeric lower constraint.

137 ***minor***

138 identifier representing a specific set of functionalities defined by the MTConnect
139 Standard.

140 ***nominal***

141 ideal or desired value for a variable.

142 ***organize***

143 act of containing and owning one or more elements.

144 ***organizer***

145 entity that *organizes* one or more elements.

146 ***parameter***

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

149 ***part***

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

153 ***pascal case***

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

156 ***patch***

157 supplemental identifier representing only organizational or editorial changes to a
158 *minor* version document with no changes in the functionality described in that doc-
159 ument.

160 ***persistence***

161 method for retaining or restoring information.

162 ***position***

163 *location* that is represented by a point in space relative to a reference.

164 ***probe***

165 instrument commonly used for measuring the physical geometrical characteristics
166 of an object.

167 ***profile***

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

171 ***requester***

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

173 ***reset***

174 act of reverting back the accumulated value or statistic to their initial value.

175 Note: An *Observation* with a *data set* representation removes all *key-value pairs*, setting the *data set* to an empty set.

177 ***responder***

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

179 ***response document***

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

182 ***schema***

183 definition of the structure, rules, and vocabularies used to define the information
184 published in an electronic document.

185 ***semantic data model***

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

188 ***sensing element***

189 mechanism that provides a signal or measured value.

190 ***sequence number***

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

193 ***specification limit***

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

195 ***spindle***

196 mechanism that provides rotational capabilities to a piece of equipment.

197 Note: Typically used for either work holding, materials or cutting tools.

198 ***standard***

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

201 ***standard uncertainty***

202 *uncertainty* of the result of a measurement expressed as a standard deviation. *Ref JCGM*
 203 *100:2008 2.3.1*

204 ***stereotype***

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

206 ***subtype***

207 secondary or subordinate type of categorization or classification of information.

208 ***table***

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

210 ***table cell***

211 subdivision of a *table entry* representing a singular value.

212 ***table entry***

213 subdivision of a *table* containing a set of *key-value pairs* representing *table cells*.

214 ***top level***

215 element that represents the most significant physical or logical functions of a piece
 216 of equipment.

217 ***type***

218 classification or categorization of information.

219 ***uncertainty***

220 uncertainty (of measurement) parameter, associated with the result of a measurement,
221 that characterizes the dispersion of the values that could reasonably be attributed to the measurand. *Ref JCGM 100:2008 2.2.3*

223 Note: Use of the term uncertainty refers to uncertainty of measurement.

224 ***upper limit***

225 upper conformance boundary for a variable.

226 ***upper warning***

227 upper boundary indicating increased concern and supervision may be required.

228 ***version***

229 unique identifier of the administered item. *Ref ISO/IEC 11179-:2015*

230 2.2 Information Model Terms

231 ***Asset Information Model***

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

233 ***Device Information Model***

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

236 ***Error Information Model***

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

241 ***MTConnect Information Model***

242 *information model* that defines the semantics of the MTConnect Standard.

243 ***Observation Information Model***

244 *information model* that describes the *streaming data* reported by a piece of equipment.
245

246 2.3 Protocol Terms

247 **asset request**

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

249 **current request**

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

253 **data streaming**

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

256 **MTConnect Request**

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

258 **MTConnect Response Document**

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

260 **MTConnectAssets Response Document**

261 *response document* published by an *MTConnect Agent* in response to an *asset request*.

263 **MTConnectDevices Response Document**

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

266 **MTConnectErrors Response Document**

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

269 **MTConnectStreams Response Document**

270 *response document* published by an *MTConnect Agent* in response to a *current request* or a *sample request*.

272 **probe request**

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

275 **protocol**

276 set of rules that allow two or more entities to transmit information from one to the
277 other.

278 **publish**

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

280 **publish and subscribe**

281 asynchronous communication method in which messages are exchanged between
282 applications without knowing the identity of the sender or recipient.

283 Note: In the MTConnect Standard, a communications messaging pattern
284 that may be used to publish *streaming data* from an *agent*.

285 **request**

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

288 **request and response**

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

291 **response**

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

293 **sample request**

294 *request* to an *agent* to produce an *MTConnectStreams Response Document* contain-
295 ing the *Observation Information Model* for a set of timestamped observations made
296 by *Components*.

297 **streaming data**

298 observations published by a piece of equipment defined by the equipment metadata.

299 **subscribe**

300 receiving messages in a *publish and subscribe* pattern.

301 **transport protocol**

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

304 **2.4 HTTP Terms**305 **HTTP Body**

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

308 **HTTP Error Message**

309 response provided by an *agent* indicating that an *HTTP Request* is incorrectly for-
 310 matted or identifies that the requested data is not available from the *agent*. *Ref IETF:RFC-*
 311 *2616*

312 **HTTP Header**

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

315 **HTTP Header Field**

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

318 **HTTP Message**

319 consist of requests from client to server and responses from server to client. *Ref IETF:RFC-*
 320 *2616*

321 Note: In MTConnect Standard, it describes the information that is ex-
 322 changed between an *agent* and a *client*.

323 **HTTP Messaging**

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

325 **HTTP Method**

326 portion of a command in an *HTTP Request* that indicates the desired action to be
 327 performed on the identified resource; often referred to as verbs. *Ref IETF:RFC-*
 328 *2616*

329 **HTTP Query**

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

332 **HTTP Request**

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

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

338 ***HTTP Request Line***

339 begins with a method token, followed by the Request-URI and the protocol version,
340 and ending with CRLF. A CRLF is allowed in the definition of TEXT only as part
341 of a header field continuation. *Ref IETF:RFC-2616*

342 Note: the first line of an *HTTP Request* describing a specific *response*
343 *document* to be published by an *agent*.

344 ***HTTP Request Method***

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

347 ***HTTP Request URI***

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

350 ***HTTP Response***

351 after receiving and interpreting a request message, a server responds with an HTTP
352 response message. *Ref IETF:RFC-2616*

353 Note: In MTConnect Standard, the information published from an *agent*
354 in reply to an *HTTP Request*.

355 ***HTTP Server***

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

358 ***HTTP Status Code***

359 3-digit integer result code of the attempt to understand and satisfy the request.
360 *Ref IETF:RFC-2616*

361 ***HTTP Version***

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

363 2.5 XML Terms

364 **abstract element**

365 element that defines a set of common characteristics that are shared by a group of
 366 elements. An abstract entity cannot appear in a document. In a specific implemen-
 367 tation, an abstract entity is replaced by a derived element that is itself not an abstract
 368 entity. The characteristics for the derived element are inherited from the abstract
 369 entity.

370 **attribute**

371 additional information or property for an *element*.

372 **child element**

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

375 **document body**

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

379 **document header**

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

384 **element name**

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

387 **namespace**

388 organizes information into logical groups.

389 **parent element**

390 *element* of a data modeling structure that illustrates the relationship between itself
 391 and the lower-level *child element*.

392 **root element**

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

394 ***structural element***

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

397 ***XML Document***

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

399 ***XML Schema***

400 *schema* defining a specific document encoded in XML.

401 **2.6 MTConnect Terms**

402 ***Asset***

403 asset that is used by the manufacturing process to perform tasks.

404 Note 1 to entry: An *Asset* relies upon an *Device* to provide observations
405 and information about itself and the *Device* revises the information to
406 reflect changes to the *Asset* during their interaction. Examples of *Assets*
407 are cutting tools, Part Information, Manufacturing Processes, Fixtures,
408 and Files.

409 Note 2 to entry: A singular *assetId* uniquely identifies an *Asset* through-
410 out its lifecycle and is used to track and relate the *Asset* to other *Devices*
411 and entities.

412 Note 3 to entry: *Assets* are temporally associated with a device and can
413 be removed from the device without damage or alteration to its primary
414 functions.

415 ***Component***

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

417 ***Composition***

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

419 ***Configuration***

420 configuration for a *Component*

421 ***DataItem***

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

423 **Device**

424 *Component* not belonging to any *Component* that may have assets

425 **MTConnect Agent**

426 *agent* for the *MTConnect Information Model*.

427 **MTConnect Document**

428 *document* that represents a Part(s) of the MTConnect Standard.

429 **MTConnect Event**

430 observation of either a state or discrete value of the *Component*.

431 **MTConnect Interface**

432 *interaction model* for interoperability between pieces of equipment.

433 **Observation**

434 observation that provides telemetry data for a *DataItem*.

435 **2.7 Acronyms**

436 **2D**

437 two-dimensional

438 **3D**

439 three-dimensional

440 **AI**

441 artificial intelligence

442 **ALM**

443 application lifecycle management

444 **AMT**

445 The Association for Manufacturing Technology

446 **ANSI**

447 American National Standards Institute

448 **AP**

449 Application Protocol

450 **API**

451 application programming interface

452 **ASME**

453 American Society of Mechanical Engineers

454 **ASTM**

455 American Society for Testing and Materials

456 **AWS**

457 American Welding Society

458 **BDD**

459 block definition diagram

460 **BOM**

461 bill of materials

462 **BST**

463 Board on Standardization and Testing

464 **C&R**

465 cause and remedy

466 **CA**

467 certificate authority

468 **CAD**

469 computer-aided design

470 **CAE**

471 computer-aided engineering

472 **CAI**

473 computer-aided inspection

474 **CAM**

475 computer-aided manufacturing

476 **CAx**
477 computer-aided technologies

478 **CDATA**
479 Character Data

480 **CFD**
481 computational fluid dynamics

482 **CM**
483 configuration management

484 **CMS**
485 coordinate-measurement system

486 **CNC**
487 Computer Numerical Controller

488 **CNRI**
489 Corporation for National Research Initiatives

490 **CPM**
491 Core Product Model

492 **CPM2**
493 Revised Core Product Model

494 **CPSC**
495 Consumer Product Safety Commission

496 **cUAV**
497 configurable unmanned aerial vehicle

498 **DARPA**
499 Defense Advanced Research Projects Agency

500 **DER**
501 designated-engineering representative

502 **DFM**
503 design for manufacturing

504 **DLA**

505 Defense Logistics Agency

506 **DMC**

507 digital manufacturing certificate

508 **DMSC**

509 Dimensional Metrology Standards Consortium

510 **DNS**

511 Domain Name System

512 **DoD**

513 U.S. Department of Defense

514 **DOI**

515 Distributed Object Identifier

516 **DRM**

517 digital rights management

518 **ECR**

519 engineering change request

520 **ERP**

521 enterprise resource planning

522 **FAA**

523 Federal Aviation Administration

524 **FAIR**

525 first article inspection reporting

526 **FDA**

527 Food and Drug Administration

528 **FEA**

529 finite-element analysis

530 **GD&T**

531 geometric dimensions and tolerances

532 ***GID***

533 global identifier

534 ***HMI***

535 Human Machine Interface

536 ***HTML***

537 Hypertext Markup Language

538 ***HTTP***

539 Hypertext Transfer Protocol

540 ***HTTPS***

541 Hypertext Transfer Protocol over Secure Sockets Layer

542 ***I/O***

543 in-out

544 ***ID***

545 identifier

546 ***IEEE***

547 Institute of Electrical and Electronics Engineers

548 ***IIoT***

549 industrial internet of things

550 ***INCOSE***

551 International Council on Systems Engineering

552 ***IP***

553 intellectual property

554 ***ISO***

555 International Standards Organization

556 ***ISS***

557 International Space Station

558 ***ISV***

559 Independent Software Vendor

560 **IT**

561 information technology

562 **ITU-T**

563 Telecommunication Standardization Sector of the International Telecommunication
564 Union

565 **JSON**

566 JavaScript Object Notation

567 **JT**

568 Jupiter Tesselation

569 **LHS**

570 Lifecycle Handler System

571 **LIFT**

572 Lifecycle Information Framework and Technology

573 **LOI**

574 Lifecycle Object Identifier

575 **MAC**

576 media access control

577 **MADE**

578 Manufacturing Automation and Design Engineering

579 **MBD**

580 model-based definition

581 **MBE**

582 Model-Based Enterprise

583 **MBI**

584 model-based inspection

585 **MBM**

586 model-based manufacturing

587 ***MBSD***

588 model-based standards development

589 ***MBSE***

590 model-based systems engineering

591 ***MEDALS***

592 Military Engineering Data Asset Locator System

593 ***MES***

594 manufacturing execution system

595 ***MOI***

596 manufacturing object identifier

597 ***MOM***

598 Message Oriented Middleware

599 ***MQTT***

600 Message Queuing Telemetry Transport

601 ***MTC***

602 Manufacturing Technology Centre

603 ***NASA***

604 National Aeronautics and Space Administration

605 ***NC***

606 numerical control

607 ***NIST***

608 National Institute of Standards and Technology

609 ***NMTOKEN***

610 Name Token

611 ***NNMI***

612 National Network of Manufacturing Innovation

613 ***NSF***

614 National Science Foundation

615 **NTSC**

616 National Transportation Safety Board

617 **OASIS**

618 Organization for the Advancement of Structured Information Standards

619 **ODI**

620 Open Data Institute

621 **OEM**

622 original equipment manufacturer

623 **OOI**

624 Ocean Observatories Initiative

625 **OPC**

626 OLE for Process Control

627 **OSLC**

628 Open Services for Lifecycle Collaboration

629 **OSTP**

630 Office of Science and Technology Policy

631 **OT**

632 operational technology

633 **OWL**

634 Ontology Web Language

635 **PDF**

636 Portable Document Format

637 **PDM**

638 product-data management

639 **PDQ**

640 product-data quality

641 **PHM**

642 prognosis and health monitoring

643 ***PI***

644 principal investigator

645 ***PLC***

646 Programmable Logic Controller

647 ***PLCS***

648 Product Life Cycle Support

649 ***PLM***

650 product lifecycle management

651 ***PLOT***

652 product lifecycle of trust

653 ***PMI***

654 product and manufacturing information

655 ***PMS***

656 Production Management System

657 ***PRC***

658 Product Representation Compact

659 ***PSI***

660 Physical Science Informatics

661 ***PTAB***

662 Primary Trustworthy Digital Repository Authorization Body Ltd.

663 ***QIF***

664 Quality Information Framework

665 ***QMS***

666 quality management system

667 ***QName***

668 Qualified Name

669 ***RDF***

670 Resource Description Framework

671 ***REST***
672 Representational State Transfer

673 ***RII***
674 receiving and incoming inspection

675 ***S/MIME***
676 Secure/Multipurpose Internet Mail Extensions

677 ***SaaS***
678 software-as-a-service

679 ***SAML***
680 Security Assertion Markup Language

681 ***SC***
682 Standards Committee

683 ***SCADA***
684 Supervisory Control And Data Acquisition

685 ***SDO***
686 Standards Development Organization

687 ***SFTP***
688 Secure File Transfer Protocol

689 ***SKOS***
690 Simple Knowledge Organization System

691 ***SLH***
692 system lifecycle handler

693 ***SLR***
694 systematic literature review

695 ***SME***
696 small-to-medium enterprise

697 ***SMOPAC***
698 Smart Manufacturing Operations Planning and Control

699 ***SMS Test Bed***

700 Smart Manufacturing Systems Test Bed

701 ***SOA***

702 service-oriented architecture

703 ***SPMM***

704 semantic-based product metamodel

705 ***SSL***

706 Secure Sockets Layer

707 ***STEP***

708 Standard for the Exchange of Product Model Data

709 ***STEP AP242***

710 Standard for the Exchange of Product Model Data Application Protocol 242

711 ***STL***

712 Stereolithography

713 ***SysML***

714 Systems Modeling Language

715 ***TCP/IP***

716 Transmission Control Protocol/Internet Protocol

717 ***TDP***

718 technical data package

719 ***TLS***

720 Transport Layer Security

721 ***TSM***

722 Total System Model

723 ***UA***

724 Unified Architecture

725 ***UAL***

726 Unified Architecture Language

727 ***UML***
728 Unified Modeling Language
729 ***URI***
730 Uniform Resource Identifier
731 ***URL***
732 Uniform Resource Locator
733 ***URN***
734 Uniform Resource Name
735 ***UTC***
736 Coordinated Universal Time
737 ***UUID***
738 Universally Unique Identifier
739 ***V&V***
740 verification and validation
741 ***W3C***
742 World Wide Web Consortium
743 ***WSN***
744 Wirth Syntax Notation
745 ***WWW***
746 World Wide Web
747 ***X.509-PKI***
748 Public Key Infrastructure
749 ***X.509-PMI***
750 Privilege Management Infrastructure
751 ***XML***
752 Extensible Markup Language
753 ***XPath***
754 XML Path Language
755 ***XSD***
756 XML Schema Definitions

757 2.8 MTConnect References

758 [MTConnect Part 1.0] *MTConnect Standard Part 1.0 - Fundamentals*. Version 2.0.

759 [MTConnect Part 2.0] *MTConnect Standard: Part 2.0 - Device Information Model*. Ver-
760 sion 2.0.

761 [MTConnect Part 3.0] *MTConnect Standard: Part 3.0 - Observation Information Model*.
762 Version 2.0.

763 [MTConnect Part 4.0] *MTConnect Standard: Part 4.0 - Asset Information Model*. Ver-
764 sion 2.0.

765

766 3 Device Information Model

767 The *Device Information Model* provides a representation of the physical and logical con-
768 figuration for a piece of equipment used for a manufacturing process or for any other
769 purpose. It also provides the definition of data that may be reported by that equipment.

770 Using information defined in the *Device Information Model*, a software application can
771 determine the configuration and reporting capabilities of a piece of equipment. To do this,
772 the software application issues a *probe request* (defined in *MTConnect Standard Part 1.0 -*
773 *Fundamentals*) to an *agent* associated with a piece of equipment. An *agent* responds to the
774 *probe request* with an *MTConnectDevices Response Document* that contains information
775 describing both the physical and logical structure of the piece of equipment and a detailed
776 description of each *Observation* that can be reported by the *agent* associated with the
777 piece of equipment. This information allows the client software application to interpret
778 the document and to extract the data with the same meaning, value, and context that it had
779 at its original source.

780 The *MTConnectDevices Response Document* is comprised of two sections: Header and
781 Devices.

782 The Header section contains protocol related information as defined in *MTConnect Stan-*
783 *dard Part 1.0 - Fundamentals*.

784 The Devices section of the *MTConnectDevices Response Document* contains a Device
785 entity for each piece of equipment described in the document. Each Device is comprised
786 of two primary types of entities - *Components* and *DataItems*.

787 *Components* organize information that represents the physical and logical parts and sub-
788 parts of a piece of equipment (See *Section 4.1 - Components* for more details).

789 *DataItems* describe data that can be reported by a piece of equipment. In the *Device Infor-*
790 *mation Model*, *DataItems* are defined as *DataItem* entities (See *Section 6.5 - DataItem*
791 *Types*).

792 The *Components* and *DataItems* in the *MTConnectDevices Response Document* provide
793 information representing the physical and logical structure for a piece of equipment and
794 the types of data that the piece of equipment can report relative to that structure. The *MT-*
795 *ConnectDevices Response Document* does not contain values for the data types reported
796 by the piece of equipment. The *MTConnectStreams Response Document* defined in *MT-*
797 *Connect Standard: Part 3.0 - Observation Information Model* provides the data values that
798 are reported by the piece of equipment.

799 Note: The MTConnect Standard also defines the information model for assets.
 800 An asset is something that is used in the manufacturing process, but is not
 801 permanently associated with a single piece of equipment, can be removed
 802 from the piece of equipment without compromising its function, and can be
 803 associated with other pieces of equipment during its lifecycle. See *MTConnect*
 804 *Standard: Part 4.0 - Asset Information Model* for more details on assets.

805 3.1 Device

806 Component composed of a piece of equipment that produces observations about itself.
 807 A Device *organizes* its parts as Component entities.
 808 A Device **MUST** have a name and uuid to identify itself.
 809 A Device **MUST** have the following DataItems: Availability, AssetChanged,
 810 and AssetRemoved.
 811 See *Section 4.1 - Components* for more details on the properties of Device.
 812 See *Section 3.1.2 - Part Properties of Device* for a list of *top level* Compo-
 813 nent types for a Device.

814 3.1.1 Value Properties of Device

815 *Table 1* lists the Value Properties of Device.

Value Property name	Value Property type	Multiplicity
<<deprecated>> iso841Class	string	0..1
uuid	UUID	1
mtconnectVersion	string	0..1
name	string	1
hash	string	0..1

Table 1: Value Properties of Device

816 Descriptions for Value Properties of Device:

817 • <<deprecated>> iso841Class

818 **DEPRECATED** in *MTConnect Version 1.2*.

819 • **mtconnectVersion**

820 MTConnect version of the *Device Information Model* used to configure the information to be published for a piece of equipment in an *MTConnect Response Document*.

822 • **hash**

823 condensed message digest from a secure one-way hash function. *Ref FIPS PUB 180-4*

825 **3.1.2 Part Properties of Device**

826 Table 2 lists the Part Properties of Device.

Part Property name	Multiplicity
Auxiliary (organized by <<organizer>> Auxiliaries)	0..*
Controller (organized by <<organizer>> Controllers)	0..*
Interface (organized by <<organizer>> Interfaces)	0..*
Resource (organized by <<organizer>> Resources)	0..*
Structure (organized by <<organizer>> Structures)	0..*
System (organized by <<organizer>> Systems)	0..*
Axis (organized by <<organizer>> Axes)	0..*
Adapter (organized by <<organizer>> Adapters)	0..*

Table 2: Part Properties of Device

827 Descriptions for Part Properties of Device:

828 • **Auxiliary**
 829 abstract Component composed of removable part(s) of a piece of equipment that
 830 provides supplementary or extended functionality.

831 • **Controller**
 832 System that provides regulation or management of a system or component. *Ref ISO 16484-5:2017*

834 • **Interface**
 835 abstract Component that coordinates actions and activities between pieces of equipment.

837 • Resource

838 abstract Component composed of material or personnel involved in a manufac-
839 turing process.

840 • Structure

841 Component composed of part(s) comprising the rigid bodies of the piece of equip-
842 ment.

843 • System

844 abstract Component that is permanently integrated into the piece of equipment.

845 • Axis

846 abstract Component composed of a motion system that provides linear or rota-
847 tional motion for a piece of equipment.

848 • Adapter

849 Component that provides information about the data source for an *MTConnect*
850 *Agent*.

851 **3.1.3 Commonly Observed DataItem Types for Device**

852 *Table 3* lists the Commonly Observed DataItem Types for Device.

Commonly Observed DataItem Types	Multiplicity
Availability	1
AssetChanged	1
AssetRemoved	1

Table 3: Commonly Observed DataItem Types for Device

853 4 Components Model

854 MTConnectDevices provides the physical and logical architecture of a piece of equipment.
 855 Figure 1 provides an overview of the entities used in an example of an MTCon-
 856 nectDevices entity.

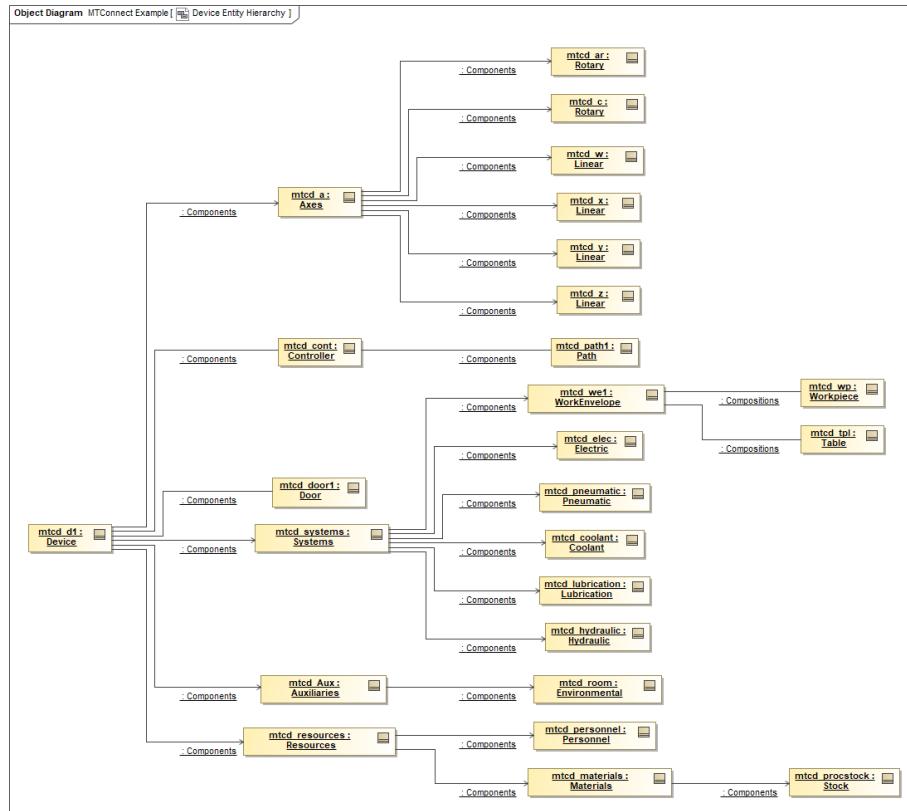


Figure 1: Device Entity Hierarchy Example

857 Note 1 to entry: See *Example 3* for the XML representation of the same ex-
 858 ample.

859 Note 2 to entry: Example above only shows the Component and Composi-
 860 tion level hierarchy. For a complete semantics on each kind see *Section 4.1*
 861 - *Components* and *Section 5.1 - Compositions*.

862 A variety of entities are defined to describe a piece of equipment. Some of these entities
 863 **MUST** always be defined for an MTConnectDevices entity, while others are optional
 864 and **MAY** be used, as required, to provide additional structure.

865 The first, or highest level, entity defined for an MTConnectDevices entity is De-
866 vices. Devices is used to group one or more pieces of equipment into a single docu-
867 ment. Devices **MUST** always be defined for an MTConnectDevices entity.

868 Device is the next entity defined for the MTConnectDevices entity. A separate De-
869 vice entity is used to identify each piece of equipment for an MTConnectDevices
870 entity. Each Device provides information on the physical and logical structure of the
871 piece of equipment and the data associated with that equipment. Device can also repre-
872 sent any logical grouping of pieces of equipment that function as a unit or any other data
873 source that provides data through an *agent*.

874 One or more Device entities **MUST** always be defined for an MTConnectDevices
875 entity.

876 Components is the next entity defined for the MTConnectDevices entity. Com-
877 ponents is used to group information describing lower level physical parts or logical
878 functions of a piece of equipment.

879 Component is the next level of entity defined for the MTConnectDevices entity.
880 Component is both an abstract type entity and an *organizer* type entity.

881 As an abstract entity, Component will always be realized by a specific Component type
882 defined in *Section 4.3 - Component Types*. Each Component can also be used to organize
883 information describing *lower level* entities or *DataItems* associated with the Component.

884 If *lower level* entities are described, these entities are by definition child Component
885 entities of a parent Component. At this next level, the *lower level* child Component
886 entities are grouped by Components.

887 A Component **MAY** be further decomposed into Composition entities that are grouped
888 by Compositions. These describe the lowest level basic structural or functional build-
889 ing blocks contained within a Component. Data provided for a Component provides
890 more specific meaning when it is associated with one of the Composition entities of
891 the Component. The different Composition types that **MAY** be defined for the MT-
892 ConnectDevices entity are defined in *Section 5.1 - Compositions*.

893 This parent-child relationship can continue to any depth required to fully define a piece of
894 equipment.

895 Note: See Figure 1 for an example.

896 4.1 Components

897 This section provides semantic information for the Component entity. Figure 2 shows
898 the Component model.

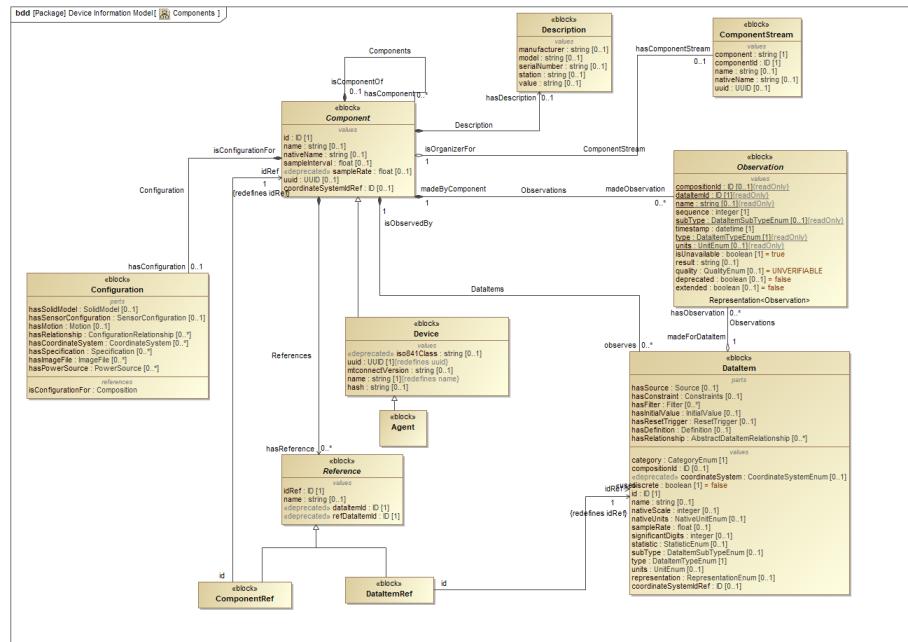


Figure 2: Components

899 Note: See *Section B.1 - Components Schema Diagrams* for XML schema.

900 4.1.1 Component

901 logical or physical entity that provides a capability.

902 Component is an abstract entity and will be realized by specific Component types for
903 an MTConnectDevices entity. See *Section 4.3 - Component Types* for more details on
904 the Component types.

905 Component also provides structure for describing the *lower level* entities associated with
906 it.

907 At least one of Component, DataItem, or Reference entities **MUST** be provided
908 for a Component.

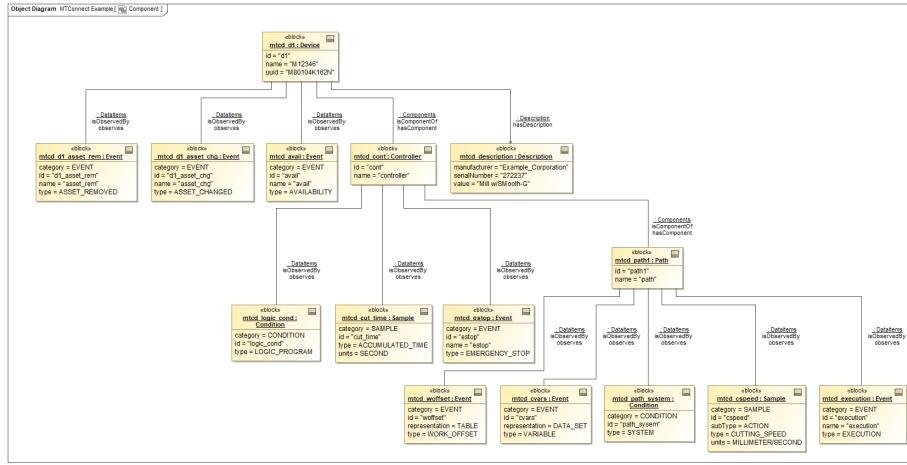


Figure 3: Component Example

909 Note: See *Example 4* for the XML representation of the same example.

910 **4.1.1.1 Value Properties of Component**

911 *Table 4* lists the Value Properties of Component.

Value Property name	Value Property type	Multiplicity
<code>id</code>	ID	1
<code>name</code>	string	0..1
<code>nativeName</code>	string	0..1
<code>sampleInterval</code>	float	0..1
<code><<deprecated>> sampleRate</code>	float	0..1
<code>uuid</code>	UUID	0..1
<code>coordinateSystemIdRef</code>	ID	0..1

Table 4: Value Properties of Component

912 Descriptions for Value Properties of Component:

913 • `id`

914 unique identifier for the Component.

915 • `name`

916 name of the Component.

917 When provided, name **MUST** be unique for all child Component entities of a
918 parent Component.

919 • nativeName
 920 common name associated with Component.

921 • sampleInterval
 922 interval in milliseconds between the completion of the reading of the data associated
 923 with the Component until the beginning of the next sampling of that data.
 924 This information may be used by client software applications to understand how
 925 often information from a Component is expected to be refreshed.
 926 The refresh rate for data from all child Component entities will be the same as for
 927 the parent Component element unless specifically overridden by another sam-
 928 pleInterval provided for the child Component.

929 • <>deprecated>> sampleRate
 930 **DEPRECATED** in *MTConnect Version 1.2*. Replaced by sampleInterval.

931 • uuid
 932 universally unique identifier for the Component.

933 • coordinateSystemIdRef
 934 specifies the CoordinateSystem for this Component and its children.

935 **4.1.1.2 Reference Properties of Component**

936 *Table 5* lists the Reference Properties of Component.

Reference Property name	Multiplicity
ComponentStream	0..1

Table 5: Reference Properties of Component

937 Descriptions for Reference Properties of Component:

938 • ComponentStream
 939 organizes the data associated with each Component entity defined for a Device
 940 in the associated *MTConnectDevices Response Document*.
 941 ComponentStream *organizes* the Observation entities associated with the
 942 Component.
 943 See *MTConnect Standard: Part 3.0 - Observation Information Model* for the Com-
 944 ponentStream model.

945 Note 1 to entry: In the XML representation, ComponentStream entities **MUST NOT** appear in the *MTConnectDevices Response Document*.
 946

947 Note 2 to entry: In the XML representation, ComponentStream entities **MUST** appear only in the *MTConnectStreams Response Document*.
 948

949 **4.1.1.3 Part Properties of Component**

950 *Table 6* lists the Part Properties of Component.

Part Property name	Multiplicity
Description	0..1
Composition (organized by Compositions)	0..*
Component (organized by Components)	0..*
Configuration	0..1
DataItem (organized by DataItems)	0..*
Observation (organized by Observations)	0..*
Reference (organized by References)	0..*

Table 6: Part Properties of Component

951 Descriptions for Part Properties of Component:

- 952 • Description
953 descriptive content.
954 See *Section 4.1.2 - Description*.
- 955 • Composition
956 functional part of a piece of equipment contained within a Component.
957 Compositions groups one or more Composition entities. See *Section 5.1 -*
958 *Compositions*.
- 959 • Component
960 logical or physical entity that provides a capability.
961 Components groups one or more Component entities.
- 962 • Configuration
963 technical information about an entity describing its physical layout, functional char-
964 acteristics, and relationships with other entities.
965 See *Section 8.1 - Configurations*.

966 • **DataItem**
 967 information reported about a piece of equipment.
 968 DataItems groups one or more DataItem entities. See *Section 6.1 - DataItems*.
 969 • **Observation**
 970 abstract entity that provides telemetry data for a DataItem at a point in time.
 971 Observations groups one or more Observations made by the Component entity.
 972 Component make Observations about observed DataItems.
 973 See *MTConnect Standard: Part 3.0 - Observation Information Model* for the Observation model.
 974
 975 Note 1 to entry: In the XML representation, Observation entities
 976 **MUST NOT** appear in the *MTConnectDevices Response Document*.
 977
 978 Note 2 to entry: In the XML representation, Observation entities
 979 **MUST** appear only in the *MTConnectStreams Response Document*.
 980 • **Reference**
 981 pointer to information that is associated with another entity defined elsewhere in the
 982 MTConnectDevices entity for a piece of equipment.
 983 References groups one or more Reference entities associated with the Component.
 984 See *Section 7.1 - References*.

985 4.1.2 Description

986 descriptive content.

987 Note 1 to entry: See Figure 3 for an example.

988 Note 2 to entry: See *Example 4* for the XML representation of the same example.
 989

990 The value of Description **MUST** be string.

991 4.1.2.1 Value Properties of Description

992 *Table 7* lists the Value Properties of Description.

Value Property name	Value Property type	Multiplicity
manufacturer	string	0..1
model	string	0..1
serialNumber	string	0..1
station	string	0..1

Table 7: Value Properties of Description

993 Descriptions for Value Properties of Description:

- 994 • manufacturer

995 name of the manufacturer of the physical or logical part of a piece of equipment
996 represented by this element.
- 997 • model

998 model description of the physical part or logical function of a piece of equipment
999 represented by this element.
- 1000 • serialNumber

1001 serial number associated with a piece of equipment.
- 1002 • station

1003 identifier where a manufacturing function takes place.

1004 4.2 Devices

1005 This section provides semantic information for the `Device` types.

1006 4.2.1 Agent

- 1007 Device composed of an *MTConnect Agent* and all its connected data sources.
- 1008 An Agent **MUST** be provided by all *MTConnect Agent* implementations.
- 1009 An Agent **MUST** provide notifications when devices are added or changed.
- 1010 An Agent **MUST** provide connection information for each data source currently supplying data to the *MTConnect Agent*.

1012 An Agent **MAY** provide information about telemetry relating to data sources.

1013 An Agent **MAY** provide information about the *MTConnect Agent* resource utilization.

1014 4.3 Component Types

1015 This section provides semantic information for the types of Component.

1016 Note: In the XML representation, Component entities are defined into two
1017 major categories:

1018 • *top level* Component entities that *organizes* the most significant physi-
1019 cal or logical functions of a piece of equipment (see *Section 3.1.2 - Part*
1020 *Properties of Device*). They **MAY** also be used as *lower level* Com-
1021 ponent entities; as required. See *Section 4.4 - Component Organizer*
1022 *Types*.

1023 • *lower level* Component entities composed of the sub-parts of the parent
1024 Component to provide more clarity and granularity to the physical or
1025 logical structure of the *top level* Component entities.

1026 This section provides guidance for the most common relationships between Component
1027 types. However, all Component types **MAY** be used in any configuration, as required, to
1028 fully describe a piece of equipment.

1029 As described in *Section 4.1 - Components*, Component is an abstract entity and will be
1030 always realized by a specific Component type.

1031 4.3.1 Adapter

1032 Component that provides information about the data source for an *MTConnect Agent*.

1033 It **MAY** contain connectivity state of the data source and additional telemetry about the
1034 data source and source-specific information.

1035 4.3.2 Amplifier

1036 leaf Component composed of an electronic component or circuit that amplifies power,
 1037 electric current, or voltage.

1038 4.3.2.1 Part Properties of Amplifier

1039 *Table 8* lists the Part Properties of Amplifier.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 8: Part Properties of Amplifier

1040 Descriptions for Part Properties of Amplifier:

- 1041 • Composition
- 1042 functional part of a piece of equipment contained within a Component.
- 1043 • Component
- 1044 logical or physical entity that provides a capability.

1045 4.3.3 Auxiliary

1046 abstract Component composed of removable part(s) of a piece of equipment that pro-
 1047 vides supplementary or extended functionality.

1048 4.3.3.1 Deposition

1049 Auxiliary that manages the addition of material or state change of material being per-
 1050 formed in an additive manufacturing process.

1051 For example, this could describe the portion of a piece of equipment that manages a mate-
 1052 rial extrusion process or a vat polymerization process.

1053 **4.3.3.2 Loader**

1054 Auxiliary that provides movement and distribution of materials, parts, tooling, and
1055 other items to or from a piece of equipment.

1056 **4.3.3.2.1 BarFeeder**

1057 Loader that delivers bar stock to a piece of equipment.

1058 **4.3.3.3 ToolingDelivery**

1059 Auxiliary that manages, positions, stores, and delivers tooling within a piece of equip-
1060 ment.

1061 **4.3.3.3.1 GangToolBar**

1062 ToolingDelivery composed of a tool mounting mechanism that holds any number of
1063 tools.

1064 Tools are located in Station entities. Tools are positioned for use in the manufacturing
1065 process by linearly positioning the GangToolBar.

1066 **4.3.3.3.2 AutomaticToolChanger**

1067 ToolingDelivery composed of a tool delivery mechanism that moves tools between
1068 a ToolMagazine and a *spindle* a Turret.

1069 AutomaticToolChanger may also transfer tools between a location outside of a piece
1070 of equipment and a ToolMagazine or Turret.

1071 **4.3.3.3.3 ToolMagazine**

1072 ToolingDelivery composed of a tool storage mechanism that holds any number of
1073 tools.

1074 Tools are located in Pots. Pots are moved into position to transfer tools into or out of the
1075 ToolMagazine by an AutomaticToolChanger.

1076 **4.3.3.4 ToolRack**

1077 ToolingDelivery composed of a linear or matrixed tool storage mechanism that holds
1078 any number of tools.

1079 Tools are located in Station entities.

1080 **4.3.3.5 Turret**

1081 ToolingDelivery composed of a tool mounting mechanism that holds any number of
1082 tools.

1083 Tools are positioned for use in the manufacturing process by rotating the Turret.

1084 **4.3.3.4 WasteDisposal**

1085 Auxiliary that removes manufacturing byproducts from a piece of equipment.

1086 **4.3.4 Axis**

1087 abstract Component composed of a motion system that provides linear or rotational mo-
1088 tion for a piece of equipment.

1089 In robotics, the term *Axis* is synonymous with *Joint*. A *Joint* is the connection between
1090 two parts of the structure that move in relation to each other.

1091 Linear and Rotary components **MUST** have name that **MUST** follow the conventions
1092 described below. Use the nativeName for the manufacturer's name of the axis if it
1093 differs from the assigned name.

1094 MTConnect has two high-level classes for automation equipment as follows: (1) Equip-
1095 ment that controls cartesian coordinate axes and (2) Equipment that controls articulated
1096 axes. There are ambiguous cases where some machines exhibit both characteristics; when
1097 this occurs, the primary control system's configuration determines the classification.

1098 Examples of cartesian coordinate equipment are CNC Machine Tools, Coordinate mea-
1099 surement machines, as specified in ISO 841, and 3D Printers. Examples of articulated
1100 automation equipment are Robotic systems as specified in ISO 8373.

1101 The following sections define the designation of names for the axes and additional guid-

1102 ance when selecting the correct scheme to use for a given piece of equipment.

1103 **4.3.4.1 Cartesian Coordinate Naming Conventions**

1104 A Three-Dimensional Cartesian Coordinate control system organizes its axes orthogonally
1105 relative to a machine coordinate system where the manufacturer of the equipment specifies
1106 the origin.

1107 Axes name **SHOULD** comply with ISO 841, if possible.

1108 **4.3.4.1.1 Linear Motion**

1109 A piece of equipment **MUST** represent prismatic motion using a **Linear** axis and assign
1110 its name using the designations X, Y, and Z. A **Linear** axis name **MUST** append a
1111 monotonically increasing suffix when there are more than one parallel axes; for example,
1112 X2, X3, and X4.

1113 **4.3.4.1.2 Rotary Motion**

1114 MTConnect **MUST** assign the name to **Rotary** axes exhibiting rotary motion using A,
1115 B, and C. A **Rotary** axis name **MUST** append a monotonically increasing suffix when
1116 more than one **Rotary** axis rotates around the same **Linear** axis; for example, A2, A3,
1117 and A4.

1118 **4.3.4.2 Articulated Machine Control Systems**

1119 An articulated control system's axes represent the connecting linkages between two ad-
1120 jacent rigid members of an assembly. The **Linear** axis represents prismatic motion,
1121 and the **Rotary** axis represents the rotational motion of the two related members. The
1122 control organizes the axes in a kinematic chain from the mounting surface (base) to the
1123 end-effector or tooling.

1124 **4.3.4.3 Articulated Machine Axis Names**

1125 The axes of articulated machines represent forward kinematic relationships between me-
1126 chanical linkages. Each axis is a connection between linkages, also referred to as joints,
1127 and **MUST** be named using a J followed by a monotonically increasing number; for ex-
1128 ample, J1, J2, J3. The numbering starts at the base axis connected or closest to the

1129 mounting surface, $J1$, incrementing to the mechanical interface, Jn , where n is the num-
 1130 ber of the last axis. The chain forms a parent-child relationship with the parent being the
 1131 axis closest to the base.

1132 A machine having an axis with more than one child **MUST** number each branch using its
 1133 numeric designation followed by a branch number and a monotonically increasing number.
 1134 For example, if $J2$ has two children, the first child branch **MUST** be named $J2.1.1$ and
 1135 the second child branch $J2.2.1$. A child of the first branch **MUST** be named $J2.1.2$,
 1136 incrementing to $J2.1.n$, where $J2.1.n$ is the number of the last axis in that branch.

1137 **4.3.4.4 Linear**

1138 Axis that provides prismatic motion along a fixed axis.

1139 **4.3.4.5 Part Properties of Linear**

1140 *Table 9* lists the Part Properties of Linear.

Part Property name	Multiplicity
observesLoad	0..1
observesTemperature	0..1
observesAxisFeedrateActual	0..1

Table 9: Part Properties of Linear

1141 Descriptions for Part Properties of Linear:

- 1142 • Load
 1143 actual versus the standard rating of a piece of equipment.
- 1144 • Temperature
 1145 degree of hotness or coldness measured on a definite scale.
- 1146 • AxisFeedrate.Actual
 1147 measured or reported value of an observation.

1148 **4.3.4.6 Rotary**

1149 Axis that provides rotation about a fixed axis.

1150 **4.3.4.7 Part Properties of Rotary**1151 *Table 10* lists the Part Properties of Rotary.

Part Property name	Multiplicity
observesLoad	0..1
observesTemperature	0..1
observesRotaryVelocity	0..1
observesAxisFeedrate	0..1

Table 10: Part Properties of Rotary

1152 Descriptions for Part Properties of Rotary:

1153 • Load

1154 actual versus the standard rating of a piece of equipment.

1155 • Temperature

1156 degree of hotness or coldness measured on a definite scale.

1157 • RotaryVelocity

1158 rotational speed of a rotary axis.

1159 • AxisFeedrate

1160 feedrate of a linear axis.

1161 **4.3.4.8 <>deprecated>>Spindle**1162 Component that provides an axis of rotation for the purpose of rapidly rotating a part or
1163 a tool to provide sufficient surface speed for cutting operations.1164 Spindle was **DEPRECATED** in *MTConnect Version 1.1* and was replaced by Ro-
1165 taryMode.1166 **4.3.5 Ballscrew**1167 leaf Component composed of a mechanical structure that transforms rotary motion into
1168 linear motion.

1169 **4.3.5.1 Part Properties of Ballscrew**1170 *Table 11* lists the Part Properties of Ballscrew.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 11: Part Properties of Ballscrew

1171 Descriptions for Part Properties of Ballscrew:

1172 • Composition

1173 functional part of a piece of equipment contained within a Component.

1174 • Component

1175 logical or physical entity that provides a capability.

1176 **4.3.6 Belt**1177 leaf Component composed of an endless flexible band that transmits motion for a piece
1178 of equipment or conveys materials and objects.1179 **4.3.6.1 Part Properties of Belt**1180 *Table 12* lists the Part Properties of Belt.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 12: Part Properties of Belt

1181 Descriptions for Part Properties of Belt:

1182 • Composition

1183 functional part of a piece of equipment contained within a Component.

1184 • Component

1185 logical or physical entity that provides a capability.

1186 4.3.7 Brake

1187 leaf Component that slows or stops a moving object by the absorption or transfer of the
 1188 energy of momentum, usually by means of friction, electrical force, or magnetic force.

1189 4.3.7.1 Part Properties of Brake

1190 *Table 13* lists the Part Properties of Brake.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 13: Part Properties of Brake

1191 Descriptions for Part Properties of Brake:

- 1192 • **Composition**
 1193 functional part of a piece of equipment contained within a Component.
- 1194 • **Component**
 1195 logical or physical entity that provides a capability.

1196 4.3.8 Chain

1197 leaf Component composed of interconnected series of objects that band together and are
 1198 used to transmit motion for a piece of equipment or to convey materials and objects.

1199 4.3.8.1 Part Properties of Chain

1200 *Table 14* lists the Part Properties of Chain.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 14: Part Properties of Chain

1201 Descriptions for Part Properties of Chain:

1202 • Composition
 1203 functional part of a piece of equipment contained within a Component.
 1204 • Component
 1205 logical or physical entity that provides a capability.

1206 4.3.9 Chopper

1207 leaf Component that breaks material into smaller pieces.

1208 4.3.9.1 Part Properties of Chopper

1209 *Table 15* lists the Part Properties of Chopper.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 15: Part Properties of Chopper

1210 Descriptions for Part Properties of Chopper:

1211 • Composition
 1212 functional part of a piece of equipment contained within a Component.
 1213 • Component
 1214 logical or physical entity that provides a capability.

1215 4.3.10 Chuck

1216 leaf Component composed of a mechanism that holds a part or stock material in place.

1217 4.3.11 Chute

1218 leaf Component composed of an inclined channel that conveys material.

1219 **4.3.11.1 Part Properties of Chute**1220 *Table 16* lists the Part Properties of Chute.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 16: Part Properties of Chute

1221 Descriptions for Part Properties of Chute:

- Composition
functional part of a piece of equipment contained within a Component.
- Component
logical or physical entity that provides a capability.

1226 **4.3.12 CircuitBreaker**

1227 leaf Component that interrupts an electric circuit.

1228 **4.3.12.1 Part Properties of CircuitBreaker**1229 *Table 17* lists the Part Properties of CircuitBreaker.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 17: Part Properties of CircuitBreaker

1230 Descriptions for Part Properties of CircuitBreaker:

- Composition
functional part of a piece of equipment contained within a Component.
- Component
logical or physical entity that provides a capability.

1235 4.3.13 Clamp

1236 leaf Component that strengthens, support, or fastens objects in place.

1237 4.3.13.1 Part Properties of Clamp

1238 *Table 18* lists the Part Properties of Clamp.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 18: Part Properties of Clamp

1239 Descriptions for Part Properties of Clamp:

1240 • Composition

1241 functional part of a piece of equipment contained within a Component.

1242 • Component

1243 logical or physical entity that provides a capability.

1244 4.3.14 Compressor

1245 leaf Component composed of a pump or other mechanism that reduces volume and in-
1246 creases pressure of gases in order to condense the gases to drive pneumatically powered
1247 pieces of equipment.

1248 4.3.14.1 Part Properties of Compressor

1249 *Table 19* lists the Part Properties of Compressor.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 19: Part Properties of Compressor

1250 Descriptions for Part Properties of Compressor:

1251 • Composition
 1252 functional part of a piece of equipment contained within a Component.
 1253 • Component
 1254 logical or physical entity that provides a capability.

1255 4.3.15 CoolingTower

1256 leaf Component composed of a heat exchange system that uses a fluid to transfer heat to
 1257 the atmosphere.

1258 4.3.15.1 Part Properties of CoolingTower

1259 *Table 20* lists the Part Properties of CoolingTower.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 20: Part Properties of CoolingTower

1260 Descriptions for Part Properties of CoolingTower:

1261 • Composition
 1262 functional part of a piece of equipment contained within a Component.
 1263 • Component
 1264 logical or physical entity that provides a capability.

1265 4.3.16 Door

1266 Component composed of a mechanical mechanism or closure that can cover a physical
 1267 access portal into a piece of equipment allowing or restricting access to other parts of the
 1268 equipment.

1269 The closure can be opened or closed to allow or restrict access to other parts of the equip-
 1270 ment.

1271 Door **MUST** have DoorState data item to indicate if the door is OPEN, CLOSED, or
 1272 UNLATCHED. A Component **MAY** contain multiple Door entities.

1273 **4.3.16.1 Commonly Observed DataItem Types for Door**

1274 *Table 21* lists the Commonly Observed DataItem Types for Door.

Commonly Observed DataItem Types	Multiplicity
DoorState	1

Table 21: Commonly Observed DataItem Types for Door

1275 **4.3.17 Drain**

1276 leaf Component that allows material to flow for the purpose of drainage from, for exam-
 1277 ple, a vessel or tank.

1278 **4.3.17.1 Part Properties of Drain**

1279 *Table 22* lists the Part Properties of Drain.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 22: Part Properties of Drain

1280 Descriptions for Part Properties of Drain:

- 1281 • Composition
functional part of a piece of equipment contained within a Component.
- 1283 • Component
logical or physical entity that provides a capability.

1285 **4.3.18 Encoder**

1286 leaf Component that measures position.

1287 **4.3.18.1 Part Properties of Encoder**1288 *Table 23* lists the Part Properties of Encoder.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 23: Part Properties of Encoder

1289 Descriptions for Part Properties of Encoder:

- Composition
functional part of a piece of equipment contained within a Component.
- Component
logical or physical entity that provides a capability.

1294 **4.3.19 Environmental**

1295 Component that observes the surroundings of another Component.

1296 Note: Environmental **SHOULD** be organized by Auxillaries, Sys-
1297 tems or Parts depending on the relationship to the Component.

1298 **4.3.20 ExpiredPot**

1299 leaf Component that is a Pot for a tool that is no longer usable for removal from a
1300 ToolMagazine or Turret.

1301 **4.3.20.1 Part Properties of ExpiredPot**1302 *Table 24* lists the Part Properties of ExpiredPot.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 24: Part Properties of ExpiredPot

1303 Descriptions for Part Properties of ExpiredPot:

1304 • Composition
 1305 functional part of a piece of equipment contained within a Component.

1306 • Component
 1307 logical or physical entity that provides a capability.

1308 4.3.21 ExposureUnit

1309 leaf Component that emits a type of radiation.

1310 4.3.21.1 Part Properties of ExposureUnit

1311 *Table 25* lists the Part Properties of ExposureUnit.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 25: Part Properties of ExposureUnit

1312 Descriptions for Part Properties of ExposureUnit:

1313 • Composition
 1314 functional part of a piece of equipment contained within a Component.

1315 • Component
 1316 logical or physical entity that provides a capability.

1317 4.3.22 ExtrusionUnit

1318 leaf Component that dispenses liquid or powdered materials.

1319 4.3.22.1 Part Properties of ExtrusionUnit

1320 *Table 26* lists the Part Properties of ExtrusionUnit.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 26: Part Properties of ExtrusionUnit

1321 Descriptions for Part Properties of ExtrusionUnit:

1322 • Composition

1323 functional part of a piece of equipment contained within a Component.

1324 • Component

1325 logical or physical entity that provides a capability.

1326 4.3.23 Fan

1327 leaf Component that produces a current of air.

1328 4.3.23.1 Part Properties of Fan

1329 *Table 27* lists the Part Properties of Fan.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 27: Part Properties of Fan

1330 Descriptions for Part Properties of Fan:

1331 • Composition
 1332 functional part of a piece of equipment contained within a Component.
 1333 • Component
 1334 logical or physical entity that provides a capability.

1335 4.3.24 Filter

1336 leaf Component through which liquids or gases are passed to remove suspended impuri-
 1337 ties or to recover solids.

1338 4.3.24.1 Part Properties of Filter

1339 *Table 28* lists the Part Properties of Filter.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 28: Part Properties of Filter

1340 Descriptions for Part Properties of Filter:

1341 • Composition
 1342 functional part of a piece of equipment contained within a Component.
 1343 • Component
 1344 logical or physical entity that provides a capability.

1345 4.3.25 Galvanomotor

1346 leaf Component composed of an electromechanical actuator that produces deflection of
 1347 a beam of light or energy in response to electric current through its coil in a magnetic field.

1348 4.3.25.1 Part Properties of Galvanomotor

1349 *Table 29* lists the Part Properties of Galvanomotor.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 29: Part Properties of Galvanomotor

1350 Descriptions for Part Properties of Galvanomotor:

1351 • Composition
 1352 functional part of a piece of equipment contained within a Component.

1353 • Component
 1354 logical or physical entity that provides a capability.

1355 4.3.26 Gripper

1356 leaf Component that holds a part, stock material, or any other item in place.

1357 4.3.26.1 Part Properties of Gripper

1358 *Table 30* lists the Part Properties of Gripper.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 30: Part Properties of Gripper

1359 Descriptions for Part Properties of Gripper:

1360 • Composition
 1361 functional part of a piece of equipment contained within a Component.

1362 • Component
 1363 logical or physical entity that provides a capability.

1364 4.3.27 Hopper

1365 leaf Component composed of a chamber or bin in which materials are stored temporarily,
 1366 typically being filled through the top and dispensed through the bottom.

1367 4.3.27.1 Part Properties of Hopper

1368 *Table 31* lists the Part Properties of Hopper.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 31: Part Properties of Hopper

1369 Descriptions for Part Properties of Hopper:

- 1370 • Composition
functional part of a piece of equipment contained within a Component.
- 1372 • Component
logical or physical entity that provides a capability.

1374 4.3.28 LinearPositionFeedback

1375 leaf Component that measures linear motion or position.

1376 **DEPRECATION WARNING :** May be deprecated in the future. Recommend using
 1377 Encoder.

1378 4.3.28.1 Part Properties of LinearPositionFeedback

1379 *Table 32* lists the Part Properties of LinearPositionFeedback.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 32: Part Properties of LinearPositionFeedback

1380 Descriptions for Part Properties of LinearPositionFeedback:

1381 • Composition
1382 functional part of a piece of equipment contained within a Component.

1383 • Component
1384 logical or physical entity that provides a capability.

1385 4.3.29 Lock

1386 Component that physically prohibits a Device or Component from opening or oper-
1387 ating.

1388 4.3.29.1 Commonly Observed DataItem Types for Lock

1389 *Table 33* lists the Commonly Observed DataItem Types for Lock.

Commonly Observed DataItem Types	Multiplicity
LockState	0..1

Table 33: Commonly Observed DataItem Types for Lock

1390 4.3.30 Motor

1391 leaf Component that converts electrical, pneumatic, or hydraulic energy into mechanical
1392 energy.

1393 4.3.30.1 Part Properties of Motor

1394 *Table 34* lists the Part Properties of Motor.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 34: Part Properties of Motor

1395 Descriptions for Part Properties of Motor:

1396 • Composition
 1397 functional part of a piece of equipment contained within a Component.

1398 • Component
 1399 logical or physical entity that provides a capability.

1400 4.3.31 Oil

1401 leaf Component composed of a viscous liquid.

1402 4.3.31.1 Part Properties of Oil

1403 *Table 35* lists the Part Properties of Oil.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 35: Part Properties of Oil

1404 Descriptions for Part Properties of Oil:

1405 • Composition
 1406 functional part of a piece of equipment contained within a Component.

1407 • Component
 1408 logical or physical entity that provides a capability.

1409 **4.3.32 Part**1410 abstract Component composed of a *part* being processed by a piece of equipment.1411 **4.3.32.1 PartOccurrence**1412 Part that exists at a specific place and time, such as a specific instance of a bracket at a
1413 specific timestamp.1414 PartId **MUST** be defined for PartOccurrence.**Example 1:** XML Device Model Example for PartOccurrence and ComponentData

```

1415 1  <Parts id="partOccSet">
1416 2    <Components>
1417 3      <PartOccurrence id="partOccur">
1418 4        <DataItems>
1419 5          <DataItem id="partSet" category="EVENT"
1420           representation="TABLE" type ="COMPONENT\
1421           textunderscore_DATA">
1422 6            <Definition>
1423 7              <EntryDefinitions>
1424 8                <EntryDefinition keyType="
1425                  PART\textunderscore_
1426                  UNIQUE\textunderscore_ID"
1427                  />
1428 9            </EntryDefinitions>
1429 10           <CellDefinitions>
1430 11             <CellDefinition key="
1431               partNumber" type="PART\
1432               textunderscore_KIND\
1433               textunderscore_ID"
1434               subType="PART\
1435               textunderscore_NUMBER"/>
1436 12             <CellDefinition key="batchId
1437               " type="PART\
1438               textunderscore_GROUP\
1439               textunderscore_ID"
1440               subType="BATCH"/>
1441 13             <CellDefinition key="
1442               quantity" type="PART\
1443               textunderscore_COUNT"
1444               subType="TARGET"/>
1445 14             <CellDefinition key="
1446               actualCompleteTime" type=
1447               "PROCESS\textunderscore_
1448               TIME" subType="COMPLETE"
1449               />

```

```

1450 15                               <CellDefinition key="
1451                                         partState" type="PROCESS\textunderscore_STATE"/>
1452
1453 16                               </CellDefinitions>
1454 17                               </Definition>
1455 18                               </DataItem>
1456 19                               </DataItems>
1457 20                               </PartOccurrence>
1458 21                               </Components>
1459 22 </Parts>

```

Example 2: XML Streams Response Example for PartOccurrence and ComponentData

```

1  <?xml version="1.0" encoding="UTF-8"?>
2  <?xml-stylesheet type="text/xsl" href="/styles/Streams.xsl"?>
3  <MTConnectStreams>
4      <Streams>
5          <DeviceStream name="VMC-3Axis" uuid="test\textunderscore27MAY">
6              <ComponentStream component="PartOccurrence" name="partSet" componentId="partOccur">
7                  <Events>
8                      <ComponentDataTable dataItemId="partSet" timestamp="2020-10-28T19:45:43.070010Z" sequence="95" count="2">
9                          <Entry key="part1">
10                             <Cell key="actualStartTime">2009-06-15T00:00:00.000000</Cell>
11                             <Cell key="partId">part1</Cell>
12                             <Cell key="partName">SomeName</Cell>
13                             <Cell key="uniqueID">abc-123</Cell>
14                         </Entry>
15                         <Entry key="part2">
16                             <Cell key="actualStartTime">2009-06-15T00:00:00.007925</Cell>
17                             <Cell key="partId">part2</Cell>
18                             <Cell key="partName">AnotherName</Cell>
19                             <Cell key="uniqueID">def-123</Cell>
20                         </Entry>
21                     </ComponentDataTable>
22                 </Events>
23             </ComponentStream>
24         </DeviceStream>
25     </Streams>
26 </MTConnectStreams>

```

4.3.32.2 Commonly Observed DataItem Types for PartOccurrence

Table 36 lists the Commonly Observed DataItem Types for PartOccurrence.

Commonly Observed DataItem Types	Multiplicity
PartId	1
PartUniqueId	0..1
PartGroupId	0..1
PartKindId	0..1
PartCount	0..1
PartStatus	0..1
ProcessOccurrenceId	0..1
ProcessTime	0..1
User	0..1

Table 36: Commonly Observed DataItem Types for PartOccurrence1492 **4.3.32.2.1 FeatureOccurrence**1493 Component that provides information related to an individual *feature*.1494 **4.3.32.3 Part Properties of FeatureOccurrence**1495 *Table 37* lists the Part Properties of FeatureOccurrence.

Part Property name	Multiplicity
observesFeaturePersistentId	0..1
observesFeatureMeasurement	0..1
observesMeasurementType	0..1
observesCharacteristicPersistentId	0..1
observesCharacteristicStatus	0..1
observesUncertainty	0..1
observesUncertaintyType	0..1
observesMeasurementUnits	0..1
observesMeasurementValue	0..1

Table 37: Part Properties of FeatureOccurrence

1496 Descriptions for Part Properties of FeatureOccurrence:

1497 • FeaturePersistentId

1498 Universally Unique Identifier (UUID) of a *feature*. Ref ISO 10303 AP 242/239.

1499 • FeatureMeasurement

1500 tabular representation of assessing elements of a *feature*.

1501 FeatureMeasurement **MAY** include a *characteristic* in which case it **MAY**
 1502 include a CHARACTERISTIC_STATUS.

- 1503 • MeasurementType
 1504 class of measurement being performed. *Ref QIF 3:2018 Section 6.3*
 1505 Examples: POINT, RADIUS, ANGLE, LENGTH, etc.
- 1506 • CharacteristicPersistentId
 1507 UUID of the *characteristic*.
- 1508 • CharacteristicStatus
 1509 pass/fail result of the measurement.
- 1510 • Uncertainty
 1511 *uncertainty* specified by UncertaintyType.
- 1512 • UncertaintyType
 1513 method used to compute *standard uncertainty*.
- 1514 • MeasurementUnits
 1515 engineering units of the measurement.
- 1516 • MeasurementValue
 1517 measurement based on the measurement type.

1518 4.3.33 Path

1519 Component that organizes an independent operation or function within a Controller.

1520 For many types of equipment, Path organizes a set of Axes, one or more Program el-
 1521 ements, and the data associated with the motion of a control point as it moves through
 1522 space. However, it **MAY** also represent any independent function within a Controller
 1523 that has unique data associated with that function.

1524 Path **SHOULD** provide an Execution data item to define the operational state of the
 1525 Controller of the piece of equipment.

1526 If the Controller is capable of performing more than one independent operation or
 1527 function simultaneously, a separate Path **MUST** be used to organize the data associated
 1528 with each independent operation or function.

1529 **4.3.33.1 Part Properties of Path**1530 *Table 38* lists the Part Properties of Path.

Part Property name	Multiplicity
observesProgram	0..1
observesPathFeedrateOverrideProgrammed	0..1
observesPathFeedrateOverrideRapid	0..1
observesRotaryVelocityOverride	0..1
observesPathFeedrate	0..1
observesPartCount	0..1

Table 38: Part Properties of Path

1531 Descriptions for Part Properties of Path:

1532 • Program

1533 name of the logic or motion program being executed by the Controller component.
15341535 • PathFeedrateOverride.Programmed
1536 directive value without offsets and adjustments.1537 • PathFeedrateOverride.Rapid
1538 performing an operation faster or in less time than nominal rate.1539 • RotaryVelocityOverride
1540 percentage change to the velocity of the programmed velocity for a Rotary axis.
1541 This command represents a percentage change to the velocity calculated by a logic
1542 or motion program or set by a switch for a Rotary type axis.1543 • PathFeedrate
1544 feedrate for the axes, or a single axis, associated with a Path component.1545 • PartCount
1546 aggregate count of parts.1547 **4.3.33.2 Commonly Observed DataItem Types for Path**1548 *Table 39* lists the Commonly Observed DataItem Types for Path.

Commonly Observed DataItem Types	Multiplicity
Execution	0..1

Table 39: Commonly Observed DataItem Types for Path**1549 4.3.34 Pot**

1550 leaf Component composed of a tool storage location associated with a ToolMagazine
 1551 or AutomaticToolChanger.

1552 4.3.34.1 Part Properties of Pot

1553 *Table 40* lists the Part Properties of Pot.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 40: Part Properties of Pot

1554 Descriptions for Part Properties of Pot:

- 1555 • Composition
 1556 functional part of a piece of equipment contained within a Component.
- 1557 • Component
 1558 logical or physical entity that provides a capability.

1559 4.3.35 <>Power

1560 Power was **DEPRECATED** in *MTConnect Version 1.1* and was replaced by Avail-
 1561 ability data item type.

1562 4.3.36 PowerSupply

1563 leaf Component that provides power to electric mechanisms.

1564 **4.3.36.1 Part Properties of PowerSupply**1565 *Table 41* lists the Part Properties of PowerSupply.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 41: Part Properties of PowerSupply

1566 Descriptions for Part Properties of PowerSupply:

1567 • Composition

1568 functional part of a piece of equipment contained within a Component.

1569 • Component

1570 logical or physical entity that provides a capability.

1571 **4.3.37 Process**1572 abstract Component composed of a manufacturing process being executed on a piece of
1573 equipment.1574 **4.3.37.1 ProcessOccurrence**1575 Process that takes place at a specific place and time, such as a specific instance of part-
1576 milling occurring at a specific timestamp.1577 ProcessOccurrenceId **MUST** be defined for ProcessOccurrence.1578 **4.3.37.2 Commonly Observed DataItem Types for ProcessOccurrence**1579 *Table 42* lists the Commonly Observed DataItem Types for ProcessOccurrence.

Commonly Observed DataItem Types	Multiplicity
ProcessOccurrenceId	1
ProcessAggregateId	0..1
ProcessTime	0..1
ProcessKindId	0..1
User	0..1
Program	0..1
PartUniqueId	0..1

Table 42: Commonly Observed DataItem Types for ProcessOccurrence**1580 4.3.38 Pulley**

1581 leaf Component composed of a mechanism or wheel that turns in a frame or block and
 1582 serves to change the direction of or to transmit force.

1583 4.3.38.1 Part Properties of Pulley

1584 *Table 43* lists the Part Properties of Pulley.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 43: Part Properties of Pulley

1585 Descriptions for Part Properties of Pulley:

- 1586 • Composition
 functional part of a piece of equipment contained within a Component.
- 1588 • Component
 logical or physical entity that provides a capability.

1590 4.3.39 Pump

1591 leaf Component that raises, drives, exhausts, or compresses fluids or gases by means of
 1592 a piston, plunger, or set of rotating vanes.

1593 **4.3.39.1 Part Properties of Pump**1594 *Table 44* lists the Part Properties of Pump.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 44: Part Properties of Pump

1595 Descriptions for Part Properties of Pump:

- Composition
functional part of a piece of equipment contained within a Component.
- Component
logical or physical entity that provides a capability.

1600 **4.3.40 Reel**

1601 leaf Component composed of a rotary storage unit for material.

1602 **4.3.40.1 Part Properties of Reel**1603 *Table 45* lists the Part Properties of Reel.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 45: Part Properties of Reel

1604 Descriptions for Part Properties of Reel:

- Composition
functional part of a piece of equipment contained within a Component.
- Component
logical or physical entity that provides a capability.

1609 4.3.41 RemovalPot

1610 leaf Component that is a Pot for a tool that has to be removed from a ToolMagazine
 1611 or Turret to a location outside of the piece of equipment.

1612 4.3.41.1 Part Properties of RemovalPot

1613 *Table 46* lists the Part Properties of RemovalPot.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 46: Part Properties of RemovalPot

1614 Descriptions for Part Properties of RemovalPot:

- 1615 • Composition
1616 functional part of a piece of equipment contained within a Component.
- 1617 • Component
1618 logical or physical entity that provides a capability.

1619 4.3.42 Resource

1620 abstract Component composed of material or personnel involved in a manufacturing
 1621 process.

1622 4.3.42.1 Material

1623 Resource composed of material that is consumed or used by the piece of equipment for
 1624 production of parts, materials, or other types of goods.

1625 4.3.42.1.1 Stock

1626 Material that is used in a manufacturing process and to which work is applied in a
 1627 machine or piece of equipment to produce parts.

1628 Stock may be either a continuous piece of material from which multiple parts may be
 1629 produced or it may be a discrete piece of material that will be made into a part or a set of
 1630 parts.

1631 **4.3.42.2 Part Properties of Stock**

1632 *Table 47* lists the Part Properties of Stock.

Part Property name	Multiplicity
observesMaterial	0..1
observesLengthRemaining	0..1
observesLengthStandard	0..1

Table 47: Part Properties of Stock

1633 Descriptions for Part Properties of Stock:

- 1634 • Material
1635 identifier of a material used or consumed in the manufacturing process.
- 1636 • Length.Remaining
1637 remaining total length of an object.
- 1638 • Length.Standard
1639 standard or original length of an object.

1640 **4.3.42.3 Personnel**

1641 Resource composed of an individual or individuals who either control, support, or oth-
 1642 erwise interface with a piece of equipment.

1643 **4.3.42.4 Part Properties of Personnel**

1644 *Table 48* lists the Part Properties of Personnel.

Part Property name	Multiplicity
observesUserOperator	0..1
observesUserMaintenance	0..1

Table 48: Part Properties of Personnel

1645 Descriptions for Part Properties of Personnel:

1646 • `User.Operator`
 1647 identifier of the person currently responsible for operating the piece of equipment.

1648 • `User.Maintenance`
 1649 identifier of the person currently responsible for performing maintenance on the
 1650 piece of equipment.

1651 **4.3.43 ReturnPot**

1652 leaf Component that is a Pot for a tool that has been removed from *spindle* or *Turret*
 1653 and awaiting for return to a *ToolMagazine*.

1654 **4.3.43.1 Part Properties of ReturnPot**

1655 *Table 49* lists the Part Properties of ReturnPot.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 49: Part Properties of ReturnPot

1656 Descriptions for Part Properties of ReturnPot:

1657 • `Composition`
 1658 functional part of a piece of equipment contained within a *Component*.

1659 • `Component`
 1660 logical or physical entity that provides a capability.

1661 4.3.44 SensingElement

1662 leaf Component that provides a signal or measured value.

1663 4.3.44.1 Part Properties of SensingElement

1664 *Table 50* lists the Part Properties of SensingElement.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 50: Part Properties of SensingElement

1665 Descriptions for Part Properties of SensingElement:

1666 • Composition

1667 functional part of a piece of equipment contained within a Component.

1668 • Component

1669 logical or physical entity that provides a capability.

1670 4.3.45 Sensor

1671 Component that responds to a physical stimulus and transmits a resulting impulse or
1672 value from a sensing unit.

1673 If modeling individual sensors, then sensor should be associated with the Component
1674 that the measured value is most closely associated.

1675 When modeled as an Auxiliary, sensor **SHOULD** represent an integrated sensor unit
1676 system that provides signal processing, conversion, and communications. A sensor unit
1677 may have multiple *sensing elements*.

1678 See SensorConfiguration for more details on the use and configuration of a Sen-
1679 sor.

1680 **4.3.45.1 <<deprecated>>Thermostat**

1681 Component composed of a sensor or an instrument that measures temperature.

1682 Thermostat was **DEPRECATED** in *MTConnect Version 1.2* and was replaced by
1683 Temperature.1684 **4.3.45.2 <<deprecated>>Vibration**1685 Component composed of a sensor or an instrument that measures the amount and/or
1686 frequency of vibration within a system.1687 Vibration was **DEPRECATED** in *MTConnect Version 1.2* and was replaced by Dis-
1688 placement, Frequency etc.1689 **4.3.46 Spreader**

1690 leaf Component that flattens or spreading materials.

1691 **4.3.46.1 Part Properties of Spreader**1692 *Table 51* lists the Part Properties of Spreader.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 51: Part Properties of Spreader

1693 Descriptions for Part Properties of Spreader:

1694 • Composition

1695 functional part of a piece of equipment contained within a Component.

1696 • Component

1697 logical or physical entity that provides a capability.

1698 4.3.47 StagingPot

1699 leaf Component that is a Pot for a tool that is awaiting transfer to a ToolMagazine
 1700 or Turret from outside of the piece of equipment.

1701 4.3.47.1 Part Properties of StagingPot

1702 *Table 52* lists the Part Properties of StagingPot.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 52: Part Properties of StagingPot

1703 Descriptions for Part Properties of StagingPot:

- 1704 • Composition
1705 functional part of a piece of equipment contained within a Component.
- 1706 • Component
1707 logical or physical entity that provides a capability.

1708 4.3.48 Station

1709 leaf Component composed of a storage or mounting location for a tool associated with a
 1710 Turret, GangToolBar, or ToolRack.

1711 4.3.48.1 Part Properties of Station

1712 *Table 53* lists the Part Properties of Station.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 53: Part Properties of Station

1713 Descriptions for Part Properties of Station:

1714 • Composition
 1715 functional part of a piece of equipment contained within a Component.
 1716 • Component
 1717 logical or physical entity that provides a capability.

1718 4.3.49 StorageBattery

1719 leaf Component composed of one or more cells in which chemical energy is converted
 1720 into electricity and used as a source of power.

1721 4.3.49.1 Part Properties of StorageBattery

1722 *Table 54* lists the Part Properties of StorageBattery.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 54: Part Properties of StorageBattery

1723 Descriptions for Part Properties of StorageBattery:

1724 • Composition
 1725 functional part of a piece of equipment contained within a Component.
 1726 • Component
 1727 logical or physical entity that provides a capability.

1728 4.3.50 Structure

1729 Component composed of part(s) comprising the rigid bodies of the piece of equipment.

1730 4.3.50.1 Link

1731 Structure that provides a connection between Component entities.

1732 4.3.51 Switch

1733 leaf Component that turns on or off an electric current or makes or breaks a circuit.

1734 4.3.51.1 Part Properties of Switch

1735 *Table 55* lists the Part Properties of Switch.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 55: Part Properties of Switch

1736 Descriptions for Part Properties of Switch:

1737 • Composition

1738 functional part of a piece of equipment contained within a Component.

1739 • Component

1740 logical or physical entity that provides a capability.

1741 4.3.52 System

1742 abstract Component that is permanently integrated into the piece of equipment.

1743 4.3.52.1 Actuator

1744 Component composed of a physical apparatus that moves or controls a mechanism or
1745 system.

1746 It takes energy usually provided by air, electric current, or liquid and converts the energy
1747 into some kind of motion.

1748 4.3.52.1.1 Hydraulic

1749 System that provides movement and distribution of pressurized liquid throughout the
1750 piece of equipment.

1751 **4.3.52.2 Part Properties of Hydraulic**1752 *Table 56* lists the Part Properties of Hydraulic.

Part Property name	Multiplicity
observesPressure	0..1

Table 56: Part Properties of Hydraulic

1753 Descriptions for Part Properties of Hydraulic:

1754 • Pressure

1755 force per unit area measured relative to atmospheric pressure.

1756 Commonly referred to as gauge pressure.

1757 **4.3.52.2.1 Pneumatic**1758 System that uses compressed gasses to actuate components or do work within the piece
1759 of equipment.

1760 Note: Actuation is usually performed using a cylinder.

1761 **4.3.52.3 Part Properties of Pneumatic**1762 *Table 57* lists the Part Properties of Pneumatic.

Part Property name	Multiplicity
observesPressure	0..1

Table 57: Part Properties of Pneumatic

1763 Descriptions for Part Properties of Pneumatic:

1764 • Pressure

1765 force per unit area measured relative to atmospheric pressure.

1766 Commonly referred to as gauge pressure.

1767 **4.3.52.4 Controller**

1768 System that provides regulation or management of a system or component. *Ref ISO*
 1769 *16484-5:2017*

1770 Typical types of controllers for a piece of equipment include CNC (Computer Numerical
 1771 Control), PAC (Programmable Automation Control), IPC (Industrialized Computer), or IC
 1772 (Imbedded Computer).

1773 Note: In XML representation, `Controller` is a *top level* element.

1774 **4.3.52.5 Part Properties of Controller**

1775 *Table 58* lists the Part Properties of Controller.

Part Property name	Multiplicity
Path	0..*
observesEmergencyStop	0..1
observesSystemCondition	0..1
observesControllerMode	0..1
observesCommunicationsCondition	0..1
observesLogicProgramCondition	0..1

Table 58: Part Properties of Controller

1776 Descriptions for Part Properties of Controller:

1777 • Path

1778 Component that organizes an independent operation or function within a Controller.
 1779

1780 • EmergencyStop

1781 state of the emergency stop signal for a piece of equipment, controller path, or any
 1782 other component or subsystem of a piece of equipment.

1783 • System

1784 general purpose indication associated with an electronic component of a piece of
 1785 equipment or a controller that represents a fault that is not associated with the operator,
 1786 program, or hardware.

1787 • ControllerMode

1788 current mode of the Controller component.

1789 • Communications

1790 indication that the piece of equipment has experienced a communications failure.

1791 • LogicProgram

1792 indication that an error occurred in the logic program or programmable logic controller (PLC) associated with a piece of equipment.

1793

1794 **4.3.52.6 Coolant**

1795 System that provides distribution and management of fluids that remove heat from a

1796 piece of equipment.

1797 **4.3.52.7 Part Properties of Coolant**

1798 *Table 59* lists the Part Properties of Coolant.

Part Property name	Multiplicity
observesConcentration	0..1

Table 59: Part Properties of Coolant

1799 Descriptions for Part Properties of Coolant:

1800 • Concentration

1801 percentage of one component within a mixture of components.

1802 **4.3.52.8 Dielectric**

1803 System that manages a chemical mixture used in a manufacturing process being per-

1804 formed at that piece of equipment.

1805 For example, this could describe the dielectric system for an EDM process or the chemical

1806 bath used in a plating process.

1807 **4.3.52.9 Electric**

1808 System composed of the main power supply for the piece of equipment that provides
 1809 distribution of that power throughout the equipment.

1810 The electric system will provide all the data with regard to electric current, voltage, fre-
 1811 quency, etc. that applies to the piece of equipment as a functional unit. Data regarding
 1812 electric power that is specific to a Component will be reported for that specific Compo-
 1813 nent.

1814 **4.3.52.10 Part Properties of Electric**

1815 *Table 60* lists the Part Properties of Electric.

Part Property name	Multiplicity
observesWattage	0..1

Table 60: Part Properties of Electric

1816 Descriptions for Part Properties of Electric:

1817 • Wattage

1818 power flowing through or dissipated by an electrical circuit or piece of equipment.

1819 **4.3.52.11 Enclosure**

1820 System composed of a structure that is used to contain or isolate a piece of equipment or
 1821 area.

1822 Enclosure may provide information regarding access to the internal components of a
 1823 piece of equipment or the conditions within the enclosure. For example, Door may be
 1824 defined as a *lower level* Component or Composition entity of the Enclosure.

1825 **4.3.52.12 EndEffector**

1826 System composed of functions that form the last link segment of a piece of equipment.

1827 It is the part of a piece of equipment that interacts with the manufacturing process.

1828 **4.3.52.13 Feeder**

1829 System that manages the delivery of materials within a piece of equipment.

1830 For example, this could describe the wire delivery system for an EDM or welding process;
1831 conveying system or pump and valve system distributing material to a blending station; or
1832 a fuel delivery system feeding a furnace.

1833 **4.3.52.14 Lubrication**

1834 System that provides distribution and management of fluids used to lubricate portions of
1835 the piece of equipment.

1836 **4.3.52.15 ProcessPower**

1837 System composed of a power source associated with a piece of equipment that supplies
1838 energy to the manufacturing process separate from the Electric system.

1839 For example, this could be the power source for an EDM machining process, an electro-
1840 plating line, or a welding system.

1841 **4.3.52.16 Protective**

1842 System that provides functions used to detect or prevent harm or damage to equipment
1843 or personnel.

1844 Protective does not include the information relating to the Enclosure.

1845 **4.3.52.17 Heating**

1846 System that delivers controlled amounts of heat to achieve a target temperature at a spec-
1847 ified heating rate.

1848 Note: As an example, Energy Delivery Method can be either through Electric
1849 heaters or Gas burners.

1850 **4.3.52.18 Vacuum**

1851 System that evacuates gases and liquids from an enclosed and sealed space to a controlled
1852 negative pressure or a molecular density below the prevailing atmospheric level.

1853 **4.3.52.19 Cooling**

1854 System that extracts controlled amounts of heat to achieve a target temperature at a spec-
1855 ified cooling rate.

1856 Note: As an example, Energy Extraction Method can be via cooling water
1857 pipes running through the chamber.

1858 **4.3.52.20 Pressure**

1859 System that delivers compressed gas or fluid and controls the pressure and rate of pres-
1860 sure change to a desired target set-point.

1861 Note: For example, Delivery Method can be a Compressed Air or N2 tank
1862 that is piped via an inlet valve to the chamber.

1863 **4.3.52.21 WorkEnvelope**

1864 System composed of the physical process execution space within a piece of equipment.

1865 WorkEnvelope **MAY** provide information regarding the physical workspace and the
1866 conditions within that workspace.

1867 **4.3.52.22 AirHandler**

1868 system that circulates air or regulates airflow without altering temperature or humidity.

1869 **4.3.53 Table**

1870 leaf Component composed of a surface for holding an object or material.

1871 **4.3.53.1 Part Properties of Table**1872 *Table 61* lists the Part Properties of Table.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 61: Part Properties of Table

1873 Descriptions for Part Properties of Table:

1874 • Composition

1875 functional part of a piece of equipment contained within a Component.

1876 • Component

1877 logical or physical entity that provides a capability.

1878 **4.3.54 Tank**

1879 leaf Component generally composed of an enclosed container.

1880 **4.3.54.1 Part Properties of Tank**1881 *Table 62* lists the Part Properties of Tank.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 62: Part Properties of Tank

1882 Descriptions for Part Properties of Tank:

1883 • Composition

1884 functional part of a piece of equipment contained within a Component.

1885 • Component

1886 logical or physical entity that provides a capability.

1887 4.3.55 Tensioner

1888 leaf Component that provides or applies a stretch or strain to another mechanism.

1889 4.3.55.1 Part Properties of Tensioner

1890 *Table 63* lists the Part Properties of Tensioner.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 63: Part Properties of Tensioner

1891 Descriptions for Part Properties of Tensioner:

1892 • Composition

1893 functional part of a piece of equipment contained within a Component.

1894 • Component

1895 logical or physical entity that provides a capability.

1896 4.3.56 TransferArm

1897 leaf Component that physically moves a tool from one location to another.

1898 4.3.56.1 Part Properties of TransferArm

1899 *Table 64* lists the Part Properties of TransferArm.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 64: Part Properties of TransferArm

1900 Descriptions for Part Properties of TransferArm:

1901 • Composition
 1902 functional part of a piece of equipment contained within a Component.
 1903 • Component
 1904 logical or physical entity that provides a capability.

1905 4.3.57 TransferPot

1906 leaf Component that is a Pot for a tool that is awaiting transfer from a ToolMagazine
 1907 to *spindle* or *Turret*.

1908 4.3.57.1 Part Properties of TransferPot

1909 *Table 65* lists the Part Properties of TransferPot.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 65: Part Properties of TransferPot

1910 Descriptions for Part Properties of TransferPot:

1911 • Composition
 1912 functional part of a piece of equipment contained within a Component.
 1913 • Component
 1914 logical or physical entity that provides a capability.

1915 4.3.58 Transformer

1916 leaf Component that transforms electric energy from a source to a secondary circuit.

1917 4.3.58.1 Part Properties of Transformer

1918 *Table 66* lists the Part Properties of Transformer.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 66: Part Properties of Transformer

1919 Descriptions for Part Properties of Transformer:

1920 • Composition
 1921 functional part of a piece of equipment contained within a Component.

1922 • Component
 1923 logical or physical entity that provides a capability.

1924 4.3.59 Valve

1925 leaf Component that halts or controls the flow of a liquid, gas, or other material through
 1926 a passage, pipe, inlet, or outlet.

1927 4.3.59.1 Part Properties of Valve

1928 *Table 67* lists the Part Properties of Valve.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 67: Part Properties of Valve

1929 Descriptions for Part Properties of Valve:

1930 • Composition
 1931 functional part of a piece of equipment contained within a Component.

1932 • Component
 1933 logical or physical entity that provides a capability.

1934 4.3.60 Vat

1935 leaf Component generally composed of an open container.

1936 4.3.60.1 Part Properties of Vat

1937 *Table 68* lists the Part Properties of Vat.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 68: Part Properties of Vat

1938 Descriptions for Part Properties of Vat:

1939 • Composition

1940 functional part of a piece of equipment contained within a Component.

1941 • Component

1942 logical or physical entity that provides a capability.

1943 4.3.61 Water

1944 leaf Component composed of H_2O .

1945 4.3.61.1 Part Properties of Water

1946 *Table 69* lists the Part Properties of Water.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 69: Part Properties of Water

1947 Descriptions for Part Properties of Water:

1948 • Composition
 1949 functional part of a piece of equipment contained within a Component.
 1950 • Component
 1951 logical or physical entity that provides a capability.

1952 4.3.62 Wire

1953 leaf Component composed of a string like piece or filament of relatively rigid or flexible material provided in a variety of diameters.
 1954

1955 4.3.62.1 Part Properties of Wire

1956 *Table 70* lists the Part Properties of Wire.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 70: Part Properties of Wire

1957 Descriptions for Part Properties of Wire:

1958 • Composition
 1959 functional part of a piece of equipment contained within a Component.
 1960 • Component
 1961 logical or physical entity that provides a capability.

1962 4.3.63 Workpiece

1963 leaf Component composed of an object or material on which a form of work is performed.
 1964

1965 4.3.63.1 Part Properties of Workpiece

1966 *Table 71* lists the Part Properties of Workpiece.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 71: Part Properties of Workpiece

1967 Descriptions for Part Properties of Workpiece:

- 1968 • Composition
1969 functional part of a piece of equipment contained within a Component.
- 1970 • Component
1971 logical or physical entity that provides a capability.

1972 4.4 Component Organizer Types

1973 This section provides semantic information for the types of Component that are used to
1974 organize other Component types.

1975 4.4.1 <>Adapters

1976 Component that *organizes* Adapter types.

1977 4.4.2 <>Auxiliaries

1978 Component that *organizes* Auxiliary types.

1979 4.4.3 <>Axes

1980 Component that *organizes* Axis types.

1981 4.4.4 <>Controllers

1982 Component that *organizes* Controller entities.

1983 **4.4.5 <<organizer>>Interfaces**

1984 Component that *organizes* Interface types.

1985 **4.4.6 <<organizer>>Parts**

1986 Component that *organizes* Part types.

1987 **4.4.7 <<organizer>>Processes**

1988 Component that *organizes* Process types.

1989 **4.4.8 <<organizer>>Resources**

1990 Component that *organizes* Resource types.

1991 **4.4.8.1 <<organizer>>Materials**

1992 Resources that *organizes* Material types.

1993 **4.4.9 <<organizer>>Structures**

1994 Component that *organizes* Structure types.

1995 **4.4.10 <<organizer>>Systems**

1996 Component that *organizes* System types.

1997 5 Compositions Model

1998 Composition entities are used to describe the lowest level physical building blocks of
 1999 a piece of equipment contained within a Component. By referencing a specific Com-
 2000 position entity, further clarification and meaning to data associated with a specific
 2001 Component can be achieved.

2002 Both Component and Composition entities are *lower level* entities representing the
 2003 sub-parts of the parent Component. However, there are distinct differences between
 2004 Component and Composition type entities.

2005 Component entities may be further defined with *lower level* Component entities and
 2006 may have associated *DataItems*.

2007 Composition entities represent the lowest level physical part of a piece of equipment.
 2008 They **MUST NOT** be further defined with *lower level* Component entities and they
 2009 **MUST NOT** have *DataItems* directly associated with them. They do provide additional
 2010 information that can be used to enhance the specificity of *DataItems* associated with the
 2011 parent Component.

2012 5.1 Compositions

2013 This section provides semantic information for the Composition entity.

2014 See Figure 2 for the Composition model diagram.

2015 Note: See *Example 5* for the XML representation of the same example.

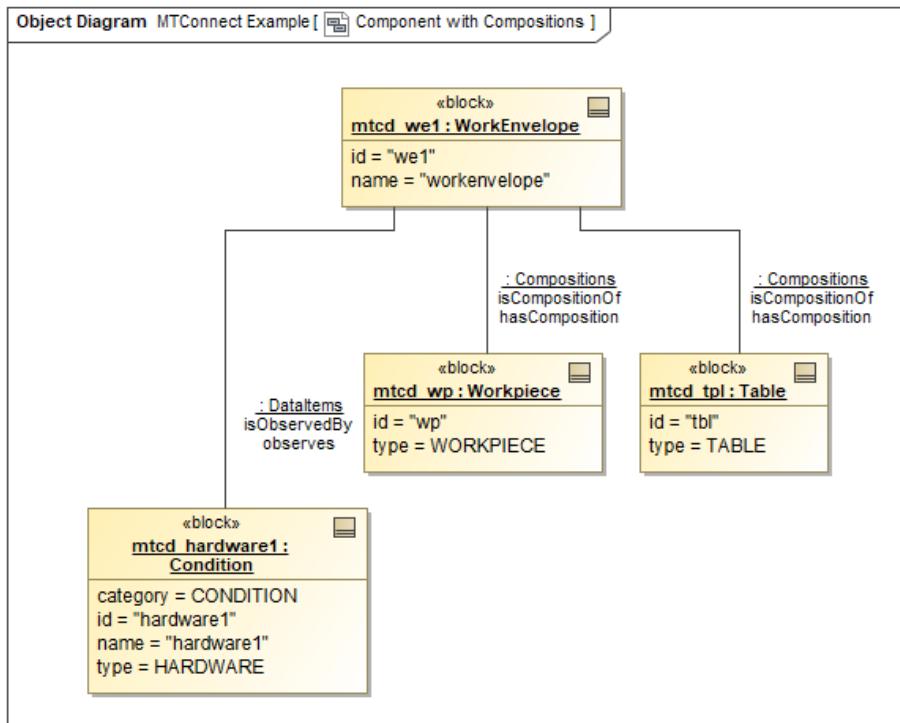
2016 5.1.1 Composition

2017 functional part of a piece of equipment contained within a Component.

2018 Composition **MUST NOT** have child Component, Composition, or DataItems
 2019 elements.

2020 5.1.1.1 Value Properties of Composition

2021 *Table 72* lists the Value Properties of Composition.

**Figure 4:** Component with Compositions Example

Value Property name	Value Property type	Multiplicity
id	ID	1
type	CompositionTypeEnum	1
name	string	0..1
uuid	UUID	0..1

Table 72: Value Properties of Composition

2022 Descriptions for Value Properties of Composition:

2023 • id
2024 unique identifier for the Composition element.

2025 • type
2026 type of Composition.
2027 The value of type **MUST** be one of the CompositionTypeEnum enumeration.

2028 • name
2029 name of the Composition element.

2030 • **uuid**
 2031 universally unique identifier for the Composition.

2032 **5.1.1.2 Part Properties of Composition**

2033 *Table 73* lists the Part Properties of Composition.

Part Property name	Multiplicity
Description	0..1
Configuration	0..1

Table 73: Part Properties of Composition

2034 Descriptions for Part Properties of Composition:

2035 • **Description**
 2036 descriptive content.
 2037 See *Section 4.1.2 - Description*.
 2038 • **Configuration**
 2039 technical information about an entity describing its physical layout, functional char-
 2040 acteristics, and relationships with other entities.
 2041 See *Section 8 - Configurations Model*.

2042 6 DataItems Model

2043 For an MTConnectDevices entity, *DataItems* describe data that can be reported by a
 2044 piece of equipment and are associated with Device and Component entities. While the
 2045 *DataItems* describe the data that can be reported by a piece of equipment as an MTCon-
 2046 nectDevices entity, the actual data values are provided by the MTConnectStreams
 2047 entity in the *MTConnectStreams Response Document*. See *MTConnect Standard: Part 3.0*
 2048 - *Observation Information Model* for detail on the reported values.

2049 Each *DataItem* **SHOULD** be modeled for the MTConnectDevices entity such that it
 2050 is associated with the entity that the reported data directly applies.

2051 DataItem describes specific types of *DataItems* that represent a numeric value, a func-
 2052 tioning state, or a health status reported by a piece of equipment. DataItem provides a
 2053 detailed description for each *DataItem* that is reported; it defines the type of data being
 2054 reported and an array of optional attributes that further describe that data. The different
 2055 types of DataItem elements are defined in *Section 6.5 - DataItem Types*.

2056 6.1 DataItems

2057 This section provides semantic information for the DataItem entity. Figure 5 shows the
 2058 DataItem model.

2059 Note: See *Section B.2 - DataItems Schema Diagrams* for XML schema.

2060 6.1.1 DataItem

2061 information reported about a piece of equipment.

2062 6.1.1.1 Value Properties of DataItem

2063 *Table 74* lists the Value Properties of DataItem.

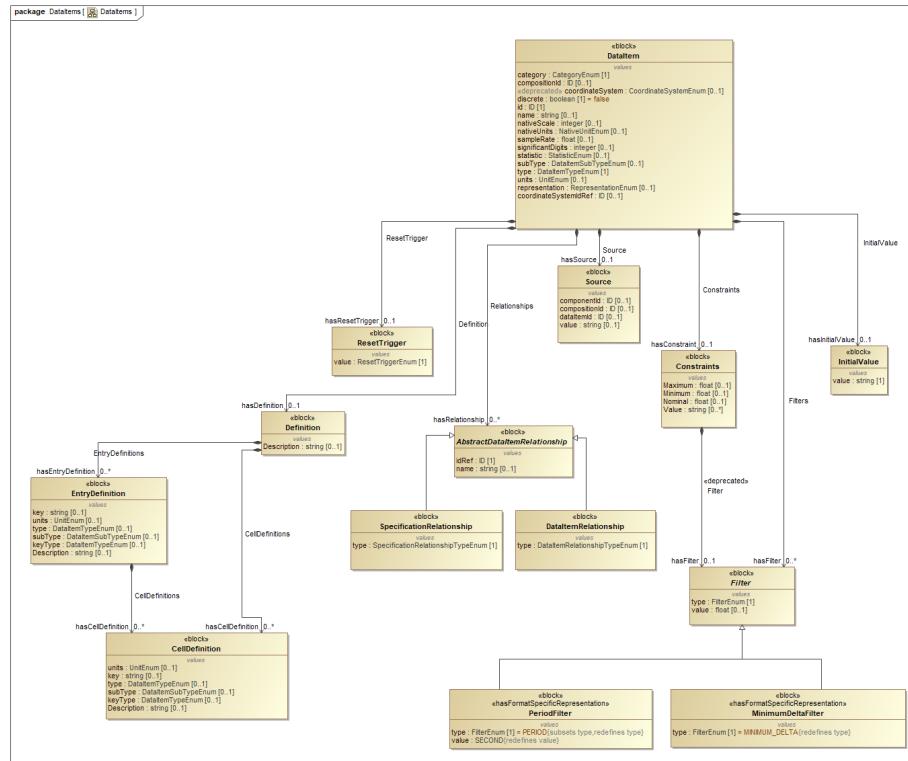


Figure 5: DataItems

Value Property name	Value Property type	Multiplicity
category	CategoryEnum	1
compositionId	ID	0..1
<<deprecated>> coordinateSystem	CoordinateSystemEnum	0..1
discrete	boolean	1
id	ID	1
name	string	0..1
nativeScale	integer	0..1
nativeUnits	NativeUnitEnum	0..1
sampleRate	float	0..1
significantDigits	integer	0..1
statistic	StatisticEnum	0..1
subType	DataItemSubTypeEnum	0..1
type	DataItemTypeEnum	1
units	UnitEnum	0..1
representation	RepresentationEnum	0..1
coordinateSystemIdRef	ID	0..1

Table 74: Value Properties of DataItem

2064 Descriptions for Value Properties of DataItem:

2065 • category

2066 specifies the kind of information provided by a data item.

2067 CategoryEnum Enumeration:

2068 • CONDITION

2069 information about the health of a piece of equipment and its ability to function.

2070 • EVENT

2071 discrete piece of information from the piece of equipment.

2072 • SAMPLE

2073 continuously variable or analog data value.

2074 A continuous value can be measured at any point-in-time and will always produce a result.

2076 • compositionId

2077 identifier attribute of the Composition that the reported data is most closely associated.

2079 • <>deprecated>> coordinateSystem

2080 for measured values relative to a coordinate system like Position, the coordinate system used may be reported.

2082 **DEPRECATED** in Version 2.0. Replaced by coordinateSystemIdRef.

2083 • discrete

2084 indication signifying whether each value reported for the *Observation* is significant and whether duplicate values are to be suppressed.

2086 If a value is not defined for discrete, the default value **MUST** be false.

2087 • id

2088 unique identifier for this data item.

2089 • name

2090 name of the data item.

2091 • nativeScale

2092 used to convert the reported value to represent the original measured value.

2093 • nativeUnits
2094 native units of measurement for the reported value of the data item.
2095 <<extensible>> NativeUnitEnum Enumeration:
2096 - AMPERE_HOUR
2097 electric charge in ampere hour.
2098 - BAR
2099 pressure in bar.
2100 - CENTIPOISE
2101 viscosity in centipoise.
2102 - CUBIC_FOOT
2103 geometric volume in cubic foot.
2104 - CUBIC_FOOT/HOUR
2105 change of geometric volume in cubic foot per hour.
2106 - CUBIC_FOOT/MINUTE
2107 change of geometric volume in cubic foot per minute.
2108 - DEGREE/MINUTE
2109 rotational velocity in degree per minute.
2110 - FAHRENHEIT
2111 temperature in Fahrenheit.
2112 - FOOT
2113 length in foot.
2114 - FOOT/MINUTE
2115 speed in foot per minute.
2116 - FOOT/SECOND
2117 speed in foot per second.
2118 - FOOT/SECOND²
2119 acceleration in foot per second squared.
2120 - FOOT_3D
2121 point in space identified by X, Y, and Z positions and represented by a space-delimited set of numbers each expressed in feet.
2122
2123 - GALLON/MINUTE
2124 volumetric flow in gallon per minute.
2125 - GRAVITATIONAL_ACCELERATION
2126 acceleration relative to earth's gravity given in meter per second squared.

2127 Note 1 to entry: At different points on Earth's surface, the free-fall
2128 acceleration ranges from 9.764 to 9.834 m/s² (Wikipedia: Gravita-
2129 tional Acceleration). The constant can be customized depending on
2130 the location in the universe.

2131 Note 2 to entry: In the standard, it is assumed that Earth's average
2132 value of gravitational acceleration is 9.90665 m/s².

- 2133 - GRAVITATIONAL_FORCE
2134 MASS times GRAVITATIONAL_ACCELERATION (g).
- 2135 - HOUR
2136 time in hour.
- 2137 - INCH
2138 length in inch.
- 2139 - INCH/MINUTE
2140 speed in inch per minute.
- 2141 - INCH/REVOLUTION
2142 feedrate per revolution in inch per revolution.
- 2143 - INCH/SECOND
2144 speed in inch per second.
- 2145 - INCH/SECOND²
2146 acceleration in inch per second squared.
- 2147 - INCH_3D
2148 point in space identified by X, Y, and Z positions and represented by a space-
2149 delimited set of numbers each expressed in inches.
- 2150 - INCH_POUND
2151 torque in inch pound.
- 2152 - KELVIN
2153 temperature in Kelvin.
- 2154 - KILOWATT
2155 power in kilowatt.
- 2156 - KILOWATT_HOUR
2157 energy in kilowatt-hour.
- 2158 - LITER/MINUTE
2159 volumetric flow in liter per minute.
- 2160 - MICROMETER
2161 length in micrometer.

- 2162 - MICROTORR
2163 pressure in microtorr.
- 2164 - MILLIMETER/MINUTE
2165 speed in millimeter per minute.
- 2166 - MILLIMETER_MERCURY
2167 pressure in millimeter of mercury (mmHg).
- 2168 - MINUTE
2169 time in minute.
- 2170 - OTHER
2171 unsupported unit.
- 2172 - PASCAL/MINUTE
2173 pressurization rate in pascal per minute.
- 2174 - POUND
2175 mass in pound.
- 2176 - POUND/INCH²
2177 pressure in pound per square inch (PSI).
- 2178 - RADIAN
2179 angle in radian.
- 2180 - RADIAN/MINUTE
2181 angular velocity in radian per minute.
- 2182 - RADIAN/SECOND
2183 angular velocity in radian per second.
- 2184 - RADIAN/SECOND²
2185 angular acceleration in radian per second squared.
- 2186 - RANKINE
2187 temperature in Rankine.
- 2188 - SQUARE_INCH
2189 geometric area in inch squared.
- 2190 - TORR
2191 pressure in torr.

- 2192 • sampleRate
2193 rate at which successive samples of a data item are recorded by a piece of equipment.
- 2194 • significantDigits
2195 number of significant digits in the reported value.

2196 • statistic

2197 type of statistical calculation performed on a series of data samples to provide the
2198 reported data value.

2199 StatisticEnum Enumeration:

2200 - AVERAGE
2201 mathematical average value calculated for the data item during the calculation
2202 period.

2203 - <<deprecated>> KURTOSIS
2204 **DEPRECATED** in *Version 1.6*. ~~A measure of the “peakedness” of a prob-
2205 ability distribution; i.e., the shape of the distribution curve.~~

2206 - MAXIMUM
2207 maximum or peak value recorded for the data item during the calculation pe-
2208 riod.

2209 - MEDIAN
2210 middle number of a series of numbers.

2211 - MINIMUM
2212 minimum value recorded for the data item during the calculation period.

2213 - MODE
2214 number in a series of numbers that occurs most often.

2215 - RANGE
2216 difference between the maximum and minimum value of a data item during the
2217 calculation period. Also represents Peak-to-Peak measurement in a waveform.

2218 - ROOT_MEAN_SQUARE
2219 mathematical Root Mean Square (RMS) value calculated for the data item dur-
2220 ing the calculation period.

2221 - STANDARD_DEVIATION
2222 statistical Standard Deviation value calculated for the data item during the cal-
2223 culation period.

2224 • subType

2225 sub-categorization of the type.

2226 <<extensible>> DataItemSubTypeEnum Enumeration:

2227 - ABORTED
2228 actions or activities that were attempted, but terminated before they could be
2229 completed.

- 2230 - ABSOLUTE
2231 relating to or derived in the simplest manner from the fundamental units or
2232 measurements.
- 2233 - ACTION
2234 indication of the operating state of a mechanism.
- 2235 - ACTIVE
2236 relating to logic or motion program currently executing.
- 2237 - ACTIVITY
2238 phase or segment of a recipe or program.
- 2239 - ACTUAL
2240 reported value of an observation.
- 2241 - ALL
2242 all actions, items, or activities being counted independent of the outcome.
- 2243 - <>^{deprecated} ALTERNATING
2244 measurement of alternating voltage or current. If not specified further in statistic, defaults to RMS voltage.
- 2245 **DEPRECATED** in *Version 1.6*.
- 2246 - AUXILIARY
2247 when multiple locations on a piece of bar stock being feed by a bar feeder are
2248 referenced as the indication of whether the end of that piece of bar stock has
2249 been reached.
- 2250 - A_SCALE
2251 A-Scale weighting factor on the frequency scale.
- 2252 - BAD
2253 actions, items, or activities being counted that do not conform to specification
2254 or expectation.
- 2255 - BATCH
2256 group of parts produced in a batch.
- 2257 - BINARY
2258 observed as a binary data type.
- 2259 - BOOLEAN
2260 observed as a boolean data type.
- 2261 - BRINELL
2262 scale to measure the resistance to deformation of a surface.
- 2263 - B_SCALE
2264 B-Scale weighting factor on the frequency scale.
- 2265

- 2266 - COMMANDED
2267 directive value including adjustments such as an offset or overrides.
- 2268 - COMPLETE
2269 associated with the completion of an activity or event.
- 2270 - CONSUMED
2271 amount of material consumed from an object or container during a manufac-
2272 turing process.
- 2273 - CONTROL
2274 state of the enabling signal or control logic that enables or disables the function
2275 or operation of the entity.
- 2276 - C_SCALE
2277 C-Scale weighting factor on the frequency scale.
- 2278 - DELAY
2279 elapsed time of a temporary halt of action.
- 2280 - DETECT
2281 indicated by the presence or existence of something.
- 2282 - <>~~deprecated~~ DIRECT
2283 DC current or voltage.
2284 **DEPRECATED** in *Version 1.6*.
- 2285 - DRY_RUN
2286 setting or operator selection used to execute a test mode to confirm the execu-
2287 tion of machine functions.
- 2288 - D_SCALE
2289 D-Scale weighting factor on the frequency scale.
- 2290 - ENDED
2291 boundary when an activity or an event terminates.
- 2292 - ENUMERATED
2293 observed as a set containing a restricted number of discrete values where each
2294 discrete value is named and unique. *Ref ISO 21961:2003, 013*
- 2295 - EXPIRATION
2296 relating to the expiration or end of useful life for a material or other physical
2297 item.
- 2298 - FAILED
2299 actions or activities that were attempted , but failed to complete or resulted in
2300 an unexpected or unacceptable outcome.

- 2301 - FIRST_USE
2302 relating to the first use of a material or other physical item.
- 2303 - GAS
2304 fluid that has no definite shape or volume.
- 2305 - GATEWAY
2306 Gateway for the Component network.
- 2307 - GOOD
2308 actions, items, or activities being counted that conform to specification or ex-
2309 pectation.
- 2310 - HEAT_TREAT
2311 material heat number.
- 2312 - INCREMENTAL
2313 relating to or derived from the last observation.
- 2314 - INSTALL_DATE
2315 date the hardware or software was installed.
- 2316 - IPV4_ADDRESS
2317 IPV4 network address of the Component.
- 2318 - IPV6_ADDRESS
2319 IPV6 network address of the Component.
- 2320 - ISO_STEP_EXECUTABLE
2321 reference to a ISO 10303 Executable.
- 2322 - JOG
2323 relating to momentary activation of a function or a movement.
- 2324 **DEPRECATION WARNING:** May be deprecated in the future.
- 2325 - LATERAL
2326 indication of the position of a mechanism that may move in a lateral direction.
- 2327 - LEEB
2328 scale to measure the elasticity of a surface.
- 2329 - LENGTH
2330 reference to a length type tool offset variable.
- 2331 - LICENSE
2332 license code to validate or activate the hardware or software.
- 2333 - LINE
2334 state of the power source.

- 2335 - LINEAR
2336 direction of motion of a linear motion.
- 2337 - LIQUID
2338 fluid that has a definite volume but no definite shape.
- 2339 - LOADED
2340 indication that the subparts of a piece of equipment are under load.
- 2341 - LOT
2342 group of parts tracked as a lot.
- 2343 - MACHINE_AXIS_LOCK
2344 setting or operator selection that changes the behavior of the controller on a
2345 piece of equipment.
- 2346 - MAC_ADDRESS
2347 Media Access Control Address. The unique physical address of the network
2348 hardware.
- 2349 - MAIN
2350 relating to the primary logic or motion program currently being executed.
- 2351 - MAINTENANCE
2352 relating to maintenance on the piece of equipment.
- 2353 - MANUAL_UNCLAMP
2354 indication of the state of an operator controlled interlock that can inhibit the
2355 ability to initiate an unclamp action of an electronically controlled chuck.
- 2356 - MANUFACTURE
2357 related to the production of a material or other physical item.
- 2358 - MANUFACTURER
2359 corporate identity for the maker of the hardware or software.
- 2360 - MAXIMUM
2361 maximum value.
- 2362 - MEASURED
2363 that has *uncertainty*.
- 2364 - MINIMUM
2365 minimum value.
- 2366 - MODEL
2367 model info of the hardware or software.
- 2368 - MOHS
2369 scale to measure the resistance to scratching of a surface.

- 2370 - MOTION
2371 indication of the open or closed state of a mechanism.
- 2372 - NO_SCALE
2373 no weighting factor on the frequency scale.
- 2374 - OPERATING
2375 piece of equipment that is powered or performing any activity.
- 2376 - OPERATION
2377 step of a discrete manufacturing process.
- 2378 - OPERATOR
2379 relating to the person currently responsible for operating the piece of equipment.
- 2380
2381 - OPTIONAL_STOP
2382 setting or operator selection that changes the behavior of the controller on a piece of equipment.
- 2383
2384 - ORDER_NUMBER
2385 authorization of a process occurrence.
- 2386 - OVERRIDE
2387 overridden value.
- 2388 - PART
2389 amount included in the *part*.
- 2390 - PART_FAMILY
2391 group of parts having similarities in geometry, manufacturing process, and/or functions.
- 2392
2393 - PART_NAME
2394 word or set of words by which a part is known, addressed, or referred to.
- 2395 - PART_NUMBER
2396 particular part design or model.
- 2397 - POWERED
2398 piece of equipment is powered and functioning or Component that are required to remain on are powered.
- 2399
2400 - PRIMARY
2401 main or principle.
- 2402 - PROBE
2403 position provided by a measurement probe.
- 2404 **DEPRECATION WARNING:** May be deprecated in the future.

- 2405 - PROCESS
2406 relating to production of a part or product on a piece of equipment.
- 2407 - PROCESS_NAME
2408 word or set of words by which a process being executed (process occurrence)
2409 by the device is known, addressed, or referred to.
- 2410 - PROCESS_PLAN
2411 process plan that a process occurrence belongs to.
- 2412 - PROCESS_STEP
2413 step in the process plan that this occurrence corresponds to.
- 2414 - PROGRAMMED
2415 directive value without offsets and adjustments.
- 2416 - RADIAL
2417 reference to a radial type tool offset variable.
- 2418 - RAPID
2419 performing an operation faster or in less time than nominal rate.
- 2420 - RAW_MATERIAL
2421 material that is used to produce parts.
- 2422 - RECIPE
2423 process as part of product production; can be a subprocess of a larger process.
- 2424 - RELEASE_DATE
2425 date the hardware or software was released for general use.
- 2426 - REMAINING
2427 remaining measure or count of an action, object or activity.
- 2428 - REQUEST
2429 *request* by an Interface for a task.
- 2430 - RESPONSE
2431 *response* by an Interface to a *request* for a task.
- 2432 - ROCKWELL
2433 scale to measure the resistance to deformation of a surface.
- 2434 - ROTARY
2435 direction of a rotary motion using the right hand rule convention.
- 2436 - SCHEDULE
2437 identity of a control program that is used to specify the order of execution of
2438 other programs.

- 2439 - SEGMENT
- 2440 phase of a recipe process.
- 2441 - SERIAL_NUMBER
- 2442 serial number that uniquely identifies a specific part.
- 2443 - SET_UP
- 2444 relating to the preparation of a piece of equipment for production or restoring
- 2445 the piece of equipment to a neutral state after production.
- 2446 - SHORE
- 2447 scale to measure the resistance to deformation of a surface.
- 2448 - SINGLE_BLOCK
- 2449 setting or operator selection that changes the behavior of the controller on a
- 2450 piece of equipment.
- 2451 - SOLID
- 2452 matter that has a definite shape and a definite volume.
- 2453 - STANDARD
- 2454 standard measure of an object or an action.
- 2455 - START
- 2456 boundary when an activity or an event commences.
- 2457 - SUBNET_MASK
- 2458 SubNet mask for the Component network.
- 2459 - SWITCHED
- 2460 indication of the activation state of a mechanism represented by a Composi-
- 2461 tion.
- 2462 - TARGET
- 2463 goal of the operation or process.
- 2464 - TARGET_COMPLETION
- 2465 relating to the end or completion of an activity or event.
- 2466 - TOOL_CHANGE_STOP
- 2467 setting or operator selection that changes the behavior of the controller on a
- 2468 piece of equipment.
- 2469 - USEABLE
- 2470 remaining usable measure of an object or action.
- 2471 - UUID
- 2472 universally unique identifier as specified in ISO 11578 or RFC 4122.

- 2473 - VERSION
 - 2474 version of the hardware or software.
- 2475 - VERTICAL
 - 2476 indication of the position of a mechanism that may move in a vertical direction.
- 2477 - VICKERS
 - 2478 scale to measure the resistance to deformation of a surface.
- 2479 - VLAN_ID
 - 2480 layer2 Virtual Local Network (VLAN) ID for the Component network.
- 2481 - WASTE
 - 2482 amount discarded.
- 2483 - WIRELESS
 - 2484 identifies whether the connection type is wireless.
- 2485 - WORKING
 - 2486 piece of equipment performing any activity, the equipment is active and performing a function under load or not.

2488 • type

2489 type of data being measured. See *Section 6.5 - DataItem Types*.

2490 The value of type **MUST** be one of the DataItemTypeEnum enumeration.

- 2491 • units

2492 unit of measurement for the reported value of the data item.

2493 <<extensible>> UnitEnum Enumeration:
 - 2494 - AMPERE
 - 2495 electric current in ampere.
 - 2496 - CELSIUS
 - 2497 temperature in degree Celsius.
 - 2498 - COULOMB
 - 2499 electric charge in coulomb.
 - 2500 - COUNT
 - 2501 count of something.
 - 2502 - COUNT/SECOND
 - 2503 frequency in count per second.
 - 2504 - CUBIC_METER
 - 2505 geometric volume in meter.

- 2506 - CUBIC_MILLIMETER
2507 geometric volume in millimeter.
- 2508 - CUBIC_MILLIMETER/SECOND
2509 change of geometric volume per second.
- 2510 - CUBIC_MILLIMETER/SECOND²
2511 change in geometric volume per second squared.
- 2512 - DECIBEL
2513 sound level in decibel.
- 2514 - DEGREE
2515 angle in degree.
- 2516 - DEGREE/SECOND
2517 angular velocity in degree per second.
- 2518 - DEGREE/SECOND²
2519 angular acceleration in degree per second squared.
- 2520 - DEGREE_3D
2521 space-delimited, floating-point representation of the angular rotation in degrees
2522 around the X, Y, and Z axes relative to a cartesian coordinate system respec-
2523 tively in order as A, B, and C.
2524 If any of the rotations is not known, it **MUST** be zero (0).
- 2525 - GRAM
2526 mass in gram.
- 2527 - GRAM/CUBIC_METER
2528 density in gram per cubic meter.
- 2529 - HERTZ
2530 frequency in cycles per second.
- 2531 - JOULE
2532 energy in joule.
- 2533 - KILOGRAM
2534 mass in kilogram.
- 2535 - LITER
2536 volume in liter.
- 2537 - LITER/SECOND
2538 volumetric flow in liter per second.
- 2539 - METER/SECOND²
2540 acceleration in meter per second squared.

- 2541 - MICRO_RADIAN
2542 tilt in micro radian.
- 2543 - MILLIGRAM
2544 mass in milligram.
- 2545 - MILLIGRAM/CUBIC_MILLIMETER
2546 density in milligram per cubic millimeter.
- 2547 - MILLILITER
2548 volume in milliliter.
- 2549 - MILLIMETER
2550 length in millimeter.
- 2551 - MILLIMETER/REVOLUTION
2552 feedrate per revolution in millimeter per revolution.
- 2553 - MILLIMETER/SECOND
2554 speed in millimeter per second.
- 2555 - MILLIMETER/SECOND²
2556 acceleration in millimeter per second squared.
- 2557 - MILLIMETER_3D
2558 point in space identified by X, Y, and Z positions and represented by a space-delimited set of numbers each expressed in millimeters.
- 2559 - NEWTON
2560 force in newton.
- 2561 - NEWTON_METER
2562 torque in newton-meter.
- 2563 - OHM
2564 electrical resistance in ohm.
- 2565 - OHM_METER
2566 resistivity in ohm-meter.
- 2567 - PASCAL
2568 pressure or stress in pascal.
- 2569 - PASCAL/SECOND
2570 pressurization rate in pascal per second.
- 2571 - PASCAL_SECOND
2572 viscosity in pascal-second.
- 2573 - PERCENT
2574 amount in or for every hundred.
- 2575

2576 - PH
2577 acidity or alkalinity of a solution in pH.

2578 - REVOLUTION/MINUTE
2579 rotational velocity in revolution per minute.

2580 - REVOLUTION/SECOND
2581 rotational velocity in revolution per second.

2582 - REVOLUTION/SECOND²
2583 rotational acceleration in revolution per second squared.

2584 - SECOND
2585 time in second.

2586 - SIEMENS/METER
2587 electrical conductivity in siemens per meter.

2588 - SQUARE_MILLIMETER
2589 geometric area in millimeter.

2590 - UNIT_VECTOR_3D
2591 3D Unit Vector.
2592 Space delimited list of three floating point numbers.

2593 - VOLT
2594 electric potential, electric potential difference or electromotive force in volt.

2595 - VOLT_AMPERE
2596 apparent power in an electrical circuit, equal to the product of root-mean-square (RMS) voltage and RMS current (commonly referred to as VA) in volt-ampere.

2599 - VOLT_AMPERE_REACTIVE
2600 reactive power in an AC electrical circuit (commonly referred to as VAR) in volt-ampere-reactive.

2602 - WATT
2603 power in watt.

2604 - WATT_SECOND
2605 electrical energy in watt-second

2606 • representation
2607 description of a means to interpret data consisting of multiple data points or samples
2608 reported as a single value.
2609 If representation is not specified, it **MUST** be determined to be VALUE.
2610 RepresentationEnum Enumeration:

2611 - DATA_SET
 2612 reported value(s) are represented as a set of *key-value pairs*.
 2613 Each reported value in the *data set* **MUST** have a unique key.

2614 - <>deprecated>> DISCRETE
 2615 **DEPRECATED** as representation type in *MTConnect Version 1.5*. Re-
 2616 placed by the discrete.

2617 - TABLE
 2618 two dimensional set of *key-value pairs* where the Entry represents a row, and
 2619 the value is a set of *key-value pair* Cell elements.
 2620 A *table* follows the same behavior as the *data set* for change tracking, clearing,
 2621 and history. When an Entry changes, all Cell elements update as a single
 2622 unit following the behavior of a *data set*.

2623 Note: It is best to use Variable if the Cell entities represent mul-
 2624 tiple semantic types.

2625 Each Entry in the *table* **MUST** have a unique key. Each Cell of each En-
 2626 try in the *table* **MUST** have a unique key.

2627 See Representation in *MTConnect Standard: Part 3.0 - Observation In-*
 2628 *formation Model*, for a description of Entry and Cell elements.

2629 - TIME_SERIES
 2630 series of sampled data.
 2631 The data is reported for a specified number of samples and each sample is
 2632 reported with a fixed period.

2633 - VALUE
 2634 measured value of the sample data.
 2635 If no representation is specified for a data item, the representation
 2636 **MUST** be determined to be VALUE.

2637 • coordinateSystemIdRef
 2638 associated CoordinateSystem context for the DataItem.

2639 **6.1.1.2 Reference Properties of DataItem**

2640 *Table 75* lists the Reference Properties of DataItem.

Reference Property name	Multiplicity
Observation (organized by Observations)	0..*

Table 75: Reference Properties of DataItem

2641 Descriptions for Reference Properties of DataItem:

2642 • Observation

2643 abstract entity that provides telemetry data for a DataItem at a point in time.

2644 Observations groups one or more Observation entities made for the DataItem
2645 entity.

2646 Component observes DataItem entities to create Observation entities for
2647 the DataItem entities.

2648 See *MTConnect Standard: Part 3.0 - Observation Information Model* for the Ob-
2649 servation model.

2650 Note 1 to entry: In the XML representation, Observation entities
2651 **MUST NOT** appear in the *MTConnectDevices Response Document*.

2652 Note 2 to entry: In the XML representation, Observation entities
2653 **MUST** appear only in the *MTConnectStreams Response Document*.

2654 **6.1.1.3 Part Properties of DataItem**

2655 *Table 76* lists the Part Properties of DataItem.

Part Property name	Multiplicity
Source	0..1
Constraints	0..1
Filter (organized by Filters)	0..*
InitialValue	0..1
ResetTrigger	0..1
Definition	0..1
AbstractDataItemRelationship (organized by Relationships)	0..*

Table 76: Part Properties of DataItem

2656 Descriptions for Part Properties of DataItem:

- 2657 • **Source**
- 2658 identifies the Component, DataItem, or Composition from which a mea-
2659 sured value originates.
- 2660 See *Section 6.2.2 - Source*.
- 2661 • **Constraints**
- 2662 *organizes* a set of expected values that can be reported for a DataItem.
- 2663 Constraints organizes a set of expected values that can be reported for the
2664 DataItem. See *Section 6.2.7 - Constraints*.
- 2665 • **Filter**
- 2666 provides a means to control when an *agent* records updated information for a DataItem.
- 2667 Filters groups one or more Filter entities associated with the DataItem.
- 2668 • **InitialValue**
- 2669 starting value for a DataItem as well as the value to be set for the DataItem
2670 after a reset event.
- 2671 • **ResetTrigger**
- 2672 type of event that may cause a reset to occur.
- 2673 • **Definition**
- 2674 defines the meaning of Entry and Cell entities when the associated represen-
2675 tation is either DATA_SET or TABLE.
- 2676 See *Section 6.2.8 - Definition*.
- 2677 • **AbstractDataItemRelationship**
- 2678 association between a DataItem and another entity.
- 2679 Relationships groups one or more DataItemRelationship and Spec-
2680 ificationRelationship. See *Section 8.4 - Relationships*.

2681 6.2 Properties of DataItem

2682 This section provides additional semantic information for the Part Properties of DataItem.

2683 Note: See *Section B.2 - DataItems Schema Diagrams* for XML schema of the
2684 elements for DataItem.

2685 6.2.1 ResetTrigger

2686 type of event that may cause a reset to occur.

2687 ResetTriggerEnum Enumeration:

2688 • ACTION_COMPLETE

2689 observation of the DataItem that is measuring an action or operation is to be reset
2690 upon completion of that action or operation.

2691 • ANNUAL

2692 observation of the DataItem is to be reset at the end of a 12-month period.

2693 • DAY

2694 observation of the DataItem is to be reset at the end of a 24-hour period.

2695 • LIFE

2696 observation of the DataItem is not reset and accumulates for the entire life of the
2697 piece of equipment.

2698 • MAINTENANCE

2699 observation of the DataItem is to be reset upon completion of a maintenance
2700 event.

2701 • MONTH

2702 observation of the DataItem is to be reset at the end of a monthly period.

2703 • POWER_ON

2704 observation of the DataItem is to be reset when power was applied to the piece of
2705 equipment after a planned or unplanned interruption of power has occurred.

2706 • SHIFT

2707 observation of the DataItem is to be reset at the end of a work shift.

2708 • WEEK

2709 observation of the DataItem is to be reset at the end of a 7-day period.

2710 6.2.2 Source

2711 identifies the Component, DataItem, or Composition from which a measured value
 2712 originates.

2713 The value of **Source** **MUST** be string.

2714 6.2.2.1 Value Properties of Source

2715 *Table 77* lists the Value Properties of Source.

Value Property name	Value Property type	Multiplicity
componentId	ID	0..1
compositionId	ID	0..1
dataItemId	ID	0..1

Table 77: Value Properties of Source

2716 Descriptions for Value Properties of Source:

2717 • componentId

2718 identifier of the Component that represents the physical part of a piece of equipment
 2719 where the data represented by the DataItem originated.

2720 • compositionId

2721 identifier of the Composition that represents the physical part of a piece of equipment
 2722 where the data represented by the DataItem originated.

2723 • dataItemId

2724 identifier of the DataItem that represents the originally measured value of the data
 2725 referenced by this DataItem.

2726 6.2.3 initialValue

2727 starting value for a DataItem as well as the value to be set for the DataItem after a
 2728 reset event.

2729 The value of **InitialValue** **MUST** be string.

2730 6.2.4 Filter

2731 provides a means to control when an *agent* records updated information for a DataItem.

2732 The value of Filter **MUST** be float.

2733 6.2.4.1 Value Properties of Filter

2734 *Table 78* lists the Value Properties of Filter.

Value Property name	Value Property type	Multiplicity
type	FilterEnum	1

Table 78: Value Properties of Filter

2735 Descriptions for Value Properties of Filter:

2736 • type

2737 type of Filter.

2738 FilterEnum Enumeration:

2739 – MINIMUM_DELTA

2740 new value **MUST NOT** be reported for a data item unless the measured value
 2741 has changed from the last reported value by at least the delta given as the value
 2742 of this element.

2743 The value of Filter **MUST** be an absolute value using the same units as the
 2744 reported data.

2745 – PERIOD

2746 data reported for a data item is provided on a periodic basis. The PERIOD for
 2747 reporting data is defined in the value of the Filter.

2748 The value of Filter **MUST** be an absolute value reported in seconds repre-
 2749 senting the time between reported samples of the value of the data item.

2750 6.2.5 <>hasFormatSpecificRepresentation>>MinimumDeltaFilter

2751 new value **MUST NOT** be reported for a data item unless the measured value has changed
 2752 from the last reported value by at least the delta given as the value of this element.

2753 The value of `Filter` **MUST** be an absolute value using the same units as the reported
 2754 data.

2755 6.2.6 <>hasFormatSpecificRepresentation>>PeriodFilter

2756 data reported for a data item is provided on a periodic basis. The `PERIOD` for reporting
 2757 data is defined in the value of the `Filter`.

2758 The value of `Filter` **MUST** be an absolute value reported in seconds representing the
 2759 time between reported samples of the value of the data item.

2760 The value of `PeriodFilter` **MUST** be `SECOND`. See *Section 9.1.9 - SECOND*.

2761 6.2.7 Constraints

2762 *organizes* a set of expected values that can be reported for a `DataItem`.

2763 6.2.7.1 Value Properties of Constraints

2764 *Table 79* lists the Value Properties of Constraints.

Value Property name	Value Property type	Multiplicity
Maximum	float	0..1
Minimum	float	0..1
Nominal	float	0..1
Value	string	0..*

Table 79: Value Properties of Constraints

2765 Descriptions for Value Properties of Constraints:

2766 • Maximum

2767 numeric upper constraint.

2768 If the data reported for a data item is a range of numeric values, the expected value
 2769 reported **MAY** be described with an upper limit defined by this constraint.

2770 • Minimum

2771 numeric lower constraint.

2772 If the data reported for a data item is a range of numeric values, the expected value
2773 reported **MAY** be described with a lower limit defined by this constraint.

2774 • Nominal

2775 numeric target or expected value.

2776 • Value

2777 single data value that is expected to be reported for a DataItem.

2778 Value **MUST NOT** be used in conjunction with any other Constraint ele-
2779 ments.

2780 6.2.7.2 Part Properties of Constraints

2781 *Table 80* lists the Part Properties of Constraints.

Part Property name	Multiplicity
<<deprecated>> Filter	0..1

Table 80: Part Properties of Constraints

2782 Descriptions for Part Properties of Constraints:

2783 • Filter

2784 provides a means to control when an *agent* records updated information for a DataItem.

2785 **DEPRECATED** in *MTConnect Version 1.4*. Moved to the Filters. See Sec-
2786 tion 6.2 - *Properties of DataItem*.

2787 6.2.8 Definition

2788 defines the meaning of Entry and Cell entities when the associated representa-
2789 tion is either DATA_SET or TABLE.

2790 6.2.8.1 Part Properties of Definition

2791 *Table 81* lists the Part Properties of Definition.

Part Property name	Multiplicity
CellDefinition (organized by CellDefinitions)	0..*
EntryDefinition (organized by EntryDefinitions)	0..*

Table 81: Part Properties of Definition

2792 Descriptions for Part Properties of Definition:

- 2793 • CellDefinition
2794 semantic definition of a Cell.
2795 CellDefinitions groups one or more CellDefinition entities. See *Section 6.3.1 - CellDefinition*.
- 2797 • EntryDefinition
2798 semantic definition of an Entry.
2799 EntryDefinitions groups one or more EntryDefinition entities. See
2800 *Section 6.3.2 - EntryDefinition*.

2801 **6.3 Properties of Definition**

2802 This section provides semantic information for the elements of the Definition for a
2803 DataItem.

2804 **6.3.1 CellDefinition**

2805 semantic definition of a Cell.

2806 **6.3.1.1 Value Properties of CellDefinition**

2807 *Table 82* lists the Value Properties of CellDefinition.

Value Property name	Value Property type	Multiplicity
units	UnitEnum	0..1
key	string	0..1
type	DataItemTypeEnum	0..1
subType	DataItemSubTypeEnum	0..1
keyType	DataItemTypeEnum	0..1

Table 82: Value Properties of CellDefinition

2808 Descriptions for Value Properties of CellDefinition:

2809 • units

2810 same as units. See *Section 6.1.1.1 - Value Properties of DataItem*.

2811 The value of units **MUST** be one of the UnitEnum enumeration.

2812 • key

2813 unique identification of the Cell in the Definition.

2814 The description applies to all Cell observations having this key.

2815 • type

2816 same as type. See *Section 6.5 - DataItem Types*.

2817 The value of type **MUST** be one of the DataItemTypeEnum enumeration.

2818 • subType

2819 same as subType. See *Section 6.1.1 - DataItem*.

2820 The value of subType **MUST** be one of the DataItemSubTypeEnum enumeration.

2822 • keyType

2823 type that defines the meaning of key.

2824 The value of keyType **MUST** be one of the DataItemTypeEnum enumeration.

2825 6.3.2 EntryDefinition

2826 semantic definition of an Entry.

2827 **6.3.2.1 Value Properties of EntryDefinition**2828 *Table 83* lists the Value Properties of EntryDefinition.

Value Property name	Value Property type	Multiplicity
key	string	0..1
units	UnitEnum	0..1
type	DataItemTypeEnum	0..1
subType	DataItemSubTypeEnum	0..1
keyType	DataItemTypeEnum	0..1

Table 83: Value Properties of EntryDefinition

2829 Descriptions for Value Properties of EntryDefinition:

2830 • key

2831 unique identification of the Entry in the Definition.

2832 The description applies to all Entry observations having this key.

2833 • units2834 same as units. See *Section 6.1.1.1 - Value Properties of DataItem*.2835 The value of units **MUST** be one of the UnitEnum enumeration.2836 • type2837 same as type. See *Section 6.5 - DataItem Types*.2838 The value of type **MUST** be one of the DataItemTypeEnum enumeration.2839 • subType2840 same as subType. See *Section 6.1.1 - DataItem*.2841 The value of subType **MUST** be one of the DataItemSubTypeEnum enumeration.
28422843 • keyType

2844 type that defines the meaning of key.

2845 The value of keyType **MUST** be one of the DataItemTypeEnum enumeration.2846 **6.3.2.2 Part Properties of EntryDefinition**2847 *Table 84* lists the Part Properties of EntryDefinition.

Part Property name	Multiplicity
CellDefinition (organized by CellDefinitions)	0..*

Table 84: Part Properties of EntryDefinition

2848 Descriptions for Part Properties of EntryDefinition:

2849 • CellDefinition
 2850 semantic definition of a Cell.
 2851 CellDefinitions groups one or more CellDefinition entities if repre-
 2852 sentation is TABLE. See *Section 6.3.1 - CellDefinition*.

2853 6.4 Relationship Types for DataItem

2854 This section provides semantic information for the types of AbstractDataItemRe-
 2855 lationship that can be defined for a DataItem.

2856 6.4.1 AbstractDataItemRelationship

2857 association between a DataItem and another entity.

2858 AbstractDataItemRelationship is an abstract entity and hence will be realized
 2859 by specific AbstractDataItemRelationship types in an MTConnectDevices
 2860 entity. See *Section 6.4 - Relationship Types for DataItem*.

2861 6.4.1.1 Value Properties of AbstractDataItemRelationship

2862 *Table 85* lists the Value Properties of AbstractDataItemRelationship.

Value Property name	Value Property type	Multiplicity
idRef	ID	1
name	string	0..1

Table 85: Value Properties of AbstractDataItemRelationship

2863 Descriptions for Value Properties of AbstractDataItemRelationship:

2864 • idRef
 2865 reference to the related entity's id.
 2866 • name
 2867 descriptive name associated with this AbstractDataItemRelationship.

2868 6.4.2 SpecificationRelationship

2869 AbstractDataItemRelationship that provides a semantic reference to another
 2870 Specification described by type and idRef.

2871 6.4.2.1 Value Properties of SpecificationRelationship

2872 *Table 86* lists the Value Properties of SpecificationRelationship.

Value Property name	Value Property type	Multiplicity
type	SpecificationRelationshipTypeEnum	1

Table 86: Value Properties of SpecificationRelationship

2873 Descriptions for Value Properties of SpecificationRelationship:

2874 • type
 2875 specifies how the Specification is related.
 2876 SpecificationRelationshipTypeEnum Enumeration:
 2877 - LIMIT
 2878 referenced Specification provides process limits.

2879 6.4.3 DataItemRelationship

2880 AbstractDataItemRelationship that provides a semantic reference to another
 2881 DataItem described by type.

2882 6.4.3.1 Value Properties of DataItemRelationship

2883 *Table 87* lists the Value Properties of DataItemRelationship.

Value Property name	Value Property type	Multiplicity
type	DataItemRelationshipTypeEnum	1

Table 87: Value Properties of DataItemRelationship

2884 Descriptions for Value Properties of DataItemRelationship:

2885 • type

2886 specifies how the DataItem is related.

2887 DataItemRelationshipTypeEnum Enumeration:

2888 – ATTACHMENT

2889 reference to a DataItem that associates the values with an external entity.

2890 – COORDINATE_SYSTEM

2891 referenced DataItem provides the id of the effective Coordinate System.

2892 – LIMIT

2893 referenced DataItem provides process limits.

2894 – OBSERVATION

2895 referenced DataItem provides the observed values.

2896 6.5 DataItem Types

2897 This section provides semantic information for the types of a DataItem.

2898 In the MTConnect Standard, DataItem are defined and organized based upon the category and type. The category provides a high level grouping for DataItems based 2899 on the kind of information that is reported by the data item.

2900 These categories are:

2901 • SAMPLE: A SAMPLE reports a continuously variable or analog data value.

2902 • EVENT: An EVENT reports information representing a functional state, with two or 2903 more discrete values, associated with a component or it contains a message. The 2904 data provided may be a numeric value or text.

2905 • CONDITION: A CONDITION reports information about the health of a piece of 2906 equipment and its ability to function.

2908 The `type` specifies the specific kind of data that is reported. For some types of data
 2909 items, a `subType` may also be used to differentiate between multiple data items of the
 2910 same `type` where the information reported by the data item has a different, but related,
 2911 meaning.

2912 Many types of data items provide two forms of data: a value (reported as either a `SAMPLE`
 2913 or `EVENT`) and a health status (reported as a `CONDITION`). These `DataItem` types **MAY**
 2914 be defined in more than one `category` based on the data that they report.

2915 **6.5.1 Condition**

2916 abstract `DataItem` that is about an entity's status regarding its ability to operate or it
 2917 provides an indication whether the data reported for the entity is within an expected range.

2918 Condition is reported differently than Sample or Event. Condition **MUST** be
 2919 reported as Normal, Warning, or Fault.

2920 All Samples **MAY** have associated Condition states. Condition states indicate
 2921 whether the value for the data is within an expected range and **MUST** be reported as
 2922 Normal, or the value is unexpected or out of tolerance for the data and a Warning or
 2923 Fault **MUST** be provided.

2924 **6.5.1.1 Value Properties of Condition**

2925 *Table 88* lists the Value Properties of Condition.

Value Property name	Value Property type	Multiplicity
<code>category</code>	<code>CONDITION</code>	1
<code>type</code>	<code>ConditionEnum</code>	1

Table 88: Value Properties of Condition

2926 Descriptions for Value Properties of Condition:

2927 • `type`

2928 <<extensible>> `ConditionEnum` Enumeration:

2929 – `ACTUATOR`

2930 indication of a fault associated with an actuator.

2931 - COMMUNICATIONS
 2932 indication that the piece of equipment has experienced a communications fail-
 2933 ure.

2934 - DATA_RANGE
 2935 indication that the value of the data associated with a measured value or a
 2936 calculation is outside of an expected range.

2937 - LOGIC_PROGRAM
 2938 indication that an error occurred in the logic program or programmable logic
 2939 controller (PLC) associated with a piece of equipment.

2940 - MOTION_PROGRAM
 2941 indication that an error occurred in the motion program associated with a piece
 2942 of equipment.

2943 - SYSTEM
 2944 general purpose indication associated with an electronic component of a piece
 2945 of equipment or a controller that represents a fault that is not associated with
 2946 the operator, program, or hardware.

2947 6.5.2 Event

2948 abstract DataItem that is a discrete piece of information from a piece of equipment. It
 2949 does not have intermediate values that vary over time.

2950 An Event is information that, when provided at any specific point in time, represents the
 2951 current state of the piece of equipment.

2952 6.5.2.1 Value Properties of Event

2953 *Table 89* lists the Value Properties of Event.

Value Property name	Value Property type	Multiplicity
category	EVENT	1
type	EventEnum	1

Table 89: Value Properties of Event

2954 Descriptions for Value Properties of Event:

2955 • type

2956 <<extensible>> EventEnum Enumeration:

2957 - ACTIVATION_COUNT
 2958 accumulation of the number of times a function has attempted to, or is planned
 2959 to attempt to, activate or be performed.

2960 - ACTIVE_AXES
 2961 set of axes currently associated with a Path or Controller.

2962 - ACTIVE_POWER_SOURCE
 2963 active energy source for the Component.

2964 - ACTUATOR_STATE
 2965 operational state of an apparatus for moving or controlling a mechanism or
 2966 system.

2967 - ADAPTER_SOFTWARE_VERSION
 2968 originator's software version of the *adapter*.

2969 - ADAPTER_URI
 2970 Uniform Resource Identifier (URI) of the *adapter*.

2971 - <<deprecated>> ALARM
 2972 **DEPRECATED:** Replaced with CONDITION category data items in Version
 2973 1.1.0.

2974 - <<deprecated>> ALARM_LIMIT
 2975 set of limits used to trigger warning or alarm indicators.
 2976 **DEPRECATED** in Version 2.5. Replaced by ALARM_LIMITS.

2977 - ALARM_LIMITS
 2978 set of limits used to trigger warning or alarm indicators.

2979 - APPLICATION
 2980 application on a Component.

2981 - ASSET_CHANGED
 2982 assetId of the Asset that has been added or changed.

2983 - ASSET_COUNT
 2984 *data set* of the number of Assets of a given type for a *Device*.

2985 - ASSET_REMOVED
 2986 assetId of the Asset that has been removed.

2987 - AVAILABILITY
 2988 *agent*'s ability to communicate with the data source.

- 2989 - AXIS_COUPLING
 - 2990 describes the way the axes will be associated to each other.
 - 2991 This is used in conjunction with COUPLED_AXES to indicate the way they are
 - 2992 interacting.
- 2993 - AXIS_FEEDRATE_OVERRIDE
 - 2994 value of a signal or calculation issued to adjust the feedrate of an individual
 - 2995 linear type axis.
- 2996 - AXIS_INTERLOCK
 - 2997 state of the axis lockout function when power has been removed and the axis
 - 2998 is allowed to move freely.
- 2999 - AXIS_STATE
 - 3000 state of a Linear or Rotary component representing an axis.
- 3001 - BATTERY_STATE
 - 3002 present status of the battery.
- 3003 - BLOCK
 - 3004 line of code or command being executed by a Controller entity.
- 3005 - BLOCK_COUNT
 - 3006 total count of the number of blocks of program code that have been executed
 - 3007 since execution started.
- 3008 - CHARACTERISTIC_PERSISTENT_ID
 - 3009 UUID of the *characteristic*.
- 3010 - CHARACTERISTIC_STATUS
 - 3011 pass/fail result of the measurement.
- 3012 - CHUCK_INTERLOCK
 - 3013 state of an interlock function or control logic state intended to prevent the as-
 - 3014 sociated Chuck component from being operated.
- 3015 - CHUCK_STATE
 - 3016 operating state of a mechanism that holds a part or stock material during a
 - 3017 manufacturing process.
 - 3018 It may also represent a mechanism that holds any other mechanism in place
 - 3019 within a piece of equipment.
- 3020 - CLOCK_TIME
 - 3021 time provided by a timing device at a specific point in time.
- 3022 - <<deprecated>> CODE
 - 3023 programmatic code being executed.
 - 3024 **DEPRECATED** in *Version 1.1*.

- 3025 - COMPONENT_DATA

3026 Event that represents a Component where the EntryDefinition identifies the Component and the CellDefinitions define the Component's

3027 observed DataItems.
- 3029 - COMPOSITION_STATE

3030 operating state of a mechanism represented by a Composition entity.
- 3031 - CONNECTION_STATUS

3032 status of the connection between an *adapter* and an *agent*.
- 3033 - CONTROLLER_MODE

3034 current mode of the Controller component.
- 3035 - CONTROLLER_MODE_OVERRIDE

3036 setting or operator selection that changes the behavior of a piece of equipment.
- 3037 - <>^{deprecated} CONTROL_LIMIT

3038 set of limits used to indicate whether a process variable is stable and in control.

3039 **DEPRECATED** in *Version 2.5*. Replaced by CONTROL_LIMITS.
- 3040 - CONTROL_LIMITS

3041 set of limits used to indicate whether a process variable is stable and in control.
- 3042 - COUPLED_AXES

3043 set of associated axes.
- 3044 - CYCLE_COUNT

3045 accumulation of the number of times a cyclic function has attempted to, or is

3046 planned to attempt to execute.
- 3047 - DATE_CODE

3048 time and date code associated with a material or other physical item.
- 3049 - DEACTIVATION_COUNT

3050 accumulation of the number of times a function has attempted to, or is planned

3051 to attempt to, deactivate or cease.
- 3052 - DEVICE_ADDED

3053 UUID of new device added to an *MTConnect Agent*.
- 3054 - DEVICE_CHANGED

3055 UUID of the device whose *metadata* has changed.
- 3056 - DEVICE_REMOVED

3057 UUID of a device removed from an *MTConnect Agent*.
- 3058 - DEVICE_UUID

3059 identifier of another piece of equipment that is temporarily associated with a

3060 component of this piece of equipment to perform a particular function.

- 3061 - DIRECTION
3062 direction of motion.
- 3063 - DOOR_STATE
3064 operational state of a Door component or composition element.
- 3065 - EMERGENCY_STOP
3066 state of the emergency stop signal for a piece of equipment, controller path, or
3067 any other component or subsystem of a piece of equipment.
- 3068 - END_OF_BAR
3069 indication of whether the end of a piece of bar stock being feed by a bar feeder
3070 has been reached.
- 3071 - EQUIPMENT_MODE
3072 indication that a piece of equipment, or a sub-part of a piece of equipment, is
3073 performing specific types of activities.
- 3074 - EXECUTION
3075 operating state of a Component.
- 3076 - FEATURE_MEASUREMENT
3077 assessing elements of a *feature*.
- 3078 - FEATURE_PERSISTENT_ID
3079 UUID of a *feature*. Ref ISO 10303 AP 242/239.
- 3080 - FIRMWARE
3081 embedded software of a Component .
- 3082 - FIXTURE_ID
3083 identifier for the current workholding or part clamp in use by a piece of equip-
3084 ment.
- 3085 - FUNCTIONAL_MODE
3086 current intended production status of the Component.
- 3087 - HARDNESS
3088 hardness of a material.
- 3089 - HARDWARE
3090 hardware of a Component.
- 3091 - HOST_NAME
3092 name of the host computer supplying data.
- 3093 - LEAK_DETECT
3094 indication designating whether a leak has been detected.

3095 - LIBRARY
3096 software library on a Component

3097 - <<deprecated>> LINE
3098 current line of code being executed.
3099 **DEPRECATED** in *Version 1.4.0*.

3100 - LINE_LABEL
3101 identifier for a Block of code in a Program.

3102 - LINE_NUMBER
3103 position of a block of program code within a control program.

3104 - LOAD_COUNT
3105 accumulation of the number of times an operation has attempted to, or is
3106 planned to attempt to, load materials, parts, or other items.

3107 - LOCATION_ADDRESS
3108 structured information that allows the unambiguous determination of an object
3109 for purposes of identification and location. *Ref ISO 19160-4:2017*

3110 - LOCATION_NARRATIVE
3111 textual description of the location of an object or activity.

3112 - LOCATION_SPATIAL_GEOGRAPHIC
3113 absolute geographic location defined by two coordinates, longitude and lati-
3114 tude and an elevation.

3115 - LOCK_STATE
3116 state or operating mode of a Lock.

3117 - MAINTENANCE_LIST
3118 actions or activities to be performed in support of a piece of equipment.

3119 - MATERIAL
3120 identifier of a material used or consumed in the manufacturing process.

3121 - MATERIAL_LAYER
3122 identifies the layers of material applied to a part or product as part of an additive
3123 manufacturing process.

3124 - MEASUREMENT_TYPE
3125 class of measurement being performed. *Ref QIF 3:2018 Section 6.3*

3126 - MEASUREMENT_UNITS
3127 engineering units of the measurement.

3128 - MEASUREMENT_VALUE
3129 measurement based on the measurement type.

- 3130 - MESSAGE
 - 3131 information to be transferred from a piece of equipment to a client software
 - 3132 application.
- 3133 - MTCONNECT_VERSION
 - 3134 reference version of the MTConnect Standard supported by the *adapter*.
- 3135 - NETWORK
 - 3136 network details of a Component.
- 3137 - NETWORK_PORT
 - 3138 number of the TCP/IP or UDP/IP port for the connection endpoint.
- 3139 - OPERATING_MODE
 - 3140 state of Component or Composition that describes the automatic or man-
 - 3141 ual operation of the entity.
- 3142 - OPERATING_SYSTEM
 - 3143 Operating System (OS) of a Component.
- 3144 - OPERATOR_ID
 - 3145 identifier of the person currently responsible for operating the piece of equip-
 - 3146 ment.
- 3147 - PALLET_ID
 - 3148 identifier for a pallet.
- 3149 - PART_COUNT
 - 3150 aggregate count of parts.
- 3151 - PART_COUNT_TYPE
 - 3152 interpretation of PART_COUNT.
- 3153 - PART_DETECT
 - 3154 indication designating whether a part or work piece has been detected or is
 - 3155 present.
- 3156 - PART_GROUP_ID
 - 3157 identifier given to a collection of individual parts.
- 3158 - PART_ID
 - 3159 identifier of a part in a manufacturing operation.
- 3160 - PART_INDEX
 - 3161 sequence of a part in a group of parts.
- 3162 - PART_KIND_ID
 - 3163 identifier given to link the individual occurrence to a class of parts, typically
 - 3164 distinguished by a particular part design.

- 3165 - <>deprecated>> PART_NUMBER
 - 3166 identifier of a part or product moving through the manufacturing process.
 - 3167 **DEPRECATED** in *Version 1.7*. PART_NUMBER is now a subType of PART_KIND_ID.
- 3168 - PART_PROCESSING_STATE
 - 3169 particular condition of the part occurrence at a specific time.
- 3170 - PART_STATUS
 - 3171 state or condition of a part.
- 3172 - PART_UNIQUE_ID
 - 3173 identifier given to a distinguishable, individual part.
- 3174 - PATH_FEEDRATE_OVERRIDE
 - 3175 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.
- 3176 - PATH_MODE
 - 3177 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.
- 3178 - POWER_STATE
 - 3179 indication of the status of the source of energy for an entity to allow it to perform its intended function or the state of an enabling signal providing permission for the entity to perform its functions.
- 3180 - <>deprecated>> POWER_STATUS
 - 3181 status of the Component.
- 3182 **DEPRECATED** in *Version 1.1.0*.
- 3183 - PROCESS_AGGREGATE_ID
 - 3184 identifier given to link the individual occurrence to a group of related occurrences, such as a process step in a process plan.
- 3185 - PROCESS_KIND_ID
 - 3186 identifier given to link the individual occurrence to a class of processes or process definition.
- 3187 - PROCESS_OCCURRENCE_ID
 - 3188 identifier of a process being executed by the device.
- 3189 - PROCESS_STATE
 - 3190 particular condition of the process occurrence at a specific time.
- 3191 - PROCESS_TIME
 - 3192 time and date associated with an activity or event.

- 3201 - PROGRAM
3202 name of the logic or motion program being executed by the Controller
3203 component.
- 3204 - PROGRAM_COMMENT
3205 comment or non-executable statement in the control program.
- 3206 - PROGRAM_EDIT
3207 indication of the status of the Controller components program editing
3208 mode.
3209 A program may be edited while another is executed.
- 3210 - PROGRAM_EDIT_NAME
3211 name of the program being edited.
3212 This is used in conjunction with ProgramEdit when in ACTIVE state.
- 3213 - PROGRAM_HEADER
3214 non-executable header section of the control program.
- 3215 - PROGRAM_LOCATION
3216 URI for the source file associated with Program.
- 3217 - PROGRAM_LOCATION_TYPE
3218 defines whether the logic or motion program defined by Program is being
3219 executed from the local memory of the controller or from an outside source.
- 3220 - PROGRAM_NEST_LEVEL
3221 indication of the nesting level within a control program that is associated with
3222 the code or instructions that is currently being executed.
- 3223 - ROTARY_MODE
3224 current operating mode for a Rotary type axis.
- 3225 - ROTARY_VELOCITY_OVERRIDE
3226 percentage change to the velocity of the programmed velocity for a Rotary
3227 axis.
- 3228 - ROTATION
3229 three space angular displacement of an object or coordinate system relative to
3230 a *cartesian coordinate system*.
- 3231 - SENSOR_ATTACHMENT
3232 *attachment* between a sensor and an entity.
- 3233 - SENSOR_STATE
3234 detection result of a sensor.
- 3235 - SERIAL_NUMBER
3236 serial number associated with a Component, Asset, or Device.

3237 - <<deprecated>> SPECIFICATION_LIMIT
3238 set of limits defining a range of values designating acceptable performance for
3239 a variable.
3240 **DEPRECATED** in *Version 2.5*. Replaced by SPECIFICATION_LIMITS.
3241 - SPECIFICATION_LIMITS
3242 set of limits defining a range of values designating acceptable performance for
3243 a variable.
3244 - SPINDLE_INTERLOCK
3245 indication of the status of the spindle for a piece of equipment when power has
3246 been removed and it is free to rotate.
3247 - THICKNESS
3248 dimension between two surfaces of an object, usually the dimension of smallest
3249 measure, for example an additive layer, or a depth of cut.
3250 - TOOL_ASSET_ID
3251 identifier of an individual tool asset.
3252 - TOOL_CUTTING_ITEM
3253 references the CuttingToolLifeCycle CuttingItem index related to
3254 the indices of the currently active cutting tool edge.
3255 - TOOL_GROUP
3256 identifier for the tool group associated with a specific tool. Commonly used to
3257 designate spare tools.
3258 - <<deprecated>> TOOL_ID
3259 identifier of the tool currently in use for a given Path.
3260 **DEPRECATED** in *Version 1.2.0*. See TOOL_NUMBER.
3261 - TOOL_NUMBER
3262 identifier assigned by the Controller component to a cutting tool when in
3263 use by a piece of equipment.
3264 - TOOL_OFFSET
3265 reference to the tool offset variables applied to the active cutting tool.
3266 - TOOL_OFFSETS
3267 properties of each addressable tool offset.
3268 - TRANSFER_COUNT
3269 accumulation of the number of times an operation has attempted to, or is
3270 planned to attempt to, transfer materials, parts, or other items from one lo-
3271 cation to another.

- 3272 - TRANSLATION
 - 3273 three space linear displacement of an object or coordinate system relative to a
3274 *cartesian coordinate system*.
- 3275 - UNCERTAINTY
 - 3276 *uncertainty* specified by `UncertaintyType`.
- 3277 - UNCERTAINTY_TYPE
 - 3278 method used to compute *standard uncertainty*.
- 3279 - UNLOAD_COUNT
 - 3280 accumulation of the number of times an operation has attempted to, or is
3281 planned to attempt to, unload materials, parts, or other items.
- 3282 - USER
 - 3283 identifier of the person currently responsible for operating the piece of equip-
3284 ment.
- 3285 - VALVE_STATE
 - 3286 state of a valve is one of open, closed, or transitioning between the states.
- 3287 - VARIABLE
 - 3288 data whose meaning may change over time due to changes in the operation of
3289 a piece of equipment or the process being executed on that piece of equipment.
- 3290 - WAIT_STATE
 - 3291 indication of the reason that `Execution` is reporting a value of `WAIT`.
- 3292 - WIRE
 - 3293 identifier for the type of wire used as the cutting mechanism in Electrical Dis-
3294 charge Machining or similar processes.
- 3295 - WORKHOLDING_ID
 - 3296 identifier for the current workholding or part clamp in use by a piece of equip-
3297 ment.
- 3298 **DEPRECATION WARNING:** Recommend using `Fixture_ID` instead.
- 3299 - WORK_OFFSET
 - 3300 reference to offset variables for a work piece or part.
- 3301 - WORK_OFFSETS
 - 3302 properties of each addressable work offset.

3303 6.5.3 Sample

- 3304 abstract `DataItem` that is continuously changing or analog data value.

3305 This data can be measured at any point-in-time and will always produce a result.

3306 The units for Sample **MUST** always be specified.

3307 **6.5.3.1 Value Properties of Sample**

3308 *Table 90* lists the Value Properties of Sample.

Value Property name	Value Property type	Multiplicity
category	SAMPLE	1
type	SampleEnum	1

Table 90: Value Properties of Sample

3309 Descriptions for Value Properties of Sample:

3310 • type

3311 <<extensible>> SampleEnum Enumeration:

3312 – ACCELERATION

3313 positive rate of change of velocity.

3314 – ACCUMULATED_TIME

3315 accumulated time for an activity or event.

3316 – <<deprecated>> AMPERAGE

3317 strength of electrical current.

3318 **DEPRECATED** in *Version 1.6*. Replaced by AMPERAGE_AC and AMPERAGE_DC.

3320 – AMPERAGE_AC

3321 electrical current that reverses direction at regular short intervals.

3322 – AMPERAGE_DC

3323 electric current flowing in one direction only.

3324 – ANGLE

3325 angular position.

3326 – ANGULAR_ACCELERATION

3327 positive rate of change of angular velocity.

3328 – ANGULAR_DECELERATION

3329 negative rate of change of angular velocity.

- 3330 - ANGULAR_VELOCITY
- 3331 rate of change of angular position.
- 3332 - ASSET_UPDATE_RATE
- 3333 average rate of change of values for assets in the MTConnect streams.
- 3334 The average is computed over a rolling window defined by the implementation.
- 3335 - AXIS_FEEDRATE
- 3336 feedrate of a linear axis.
- 3337 - BATTERY_CAPACITY
- 3338 maximum rated charge a battery is capable of maintaining based on the battery
- 3339 discharging at a specified current over a specified time period.
- 3340 - BATTERY_CHARGE
- 3341 value of the battery's present capacity expressed as a percentage of the battery's
- 3342 maximum rated capacity.
- 3343 - CAPACITY_FLUID
- 3344 maximum amount of fluid that can be held by a container.
- 3345 - CAPACITY_SPATIAL
- 3346 maximum amount of material that can be held by a container.
- 3347 - CHARGE_RATE
- 3348 value of the current being supplied to the Component for the purpose of
- 3349 charging.
- 3350 - CONCENTRATION
- 3351 percentage of one component within a mixture of components.
- 3352 - CONDUCTIVITY
- 3353 ability of a material to conduct electricity.
- 3354 - CUTTING_SPEED
- 3355 speed difference (relative velocity) between the cutting mechanism and the
- 3356 surface of the workpiece it is operating on.
- 3357 - DECELERATION
- 3358 negative rate of change of velocity.
- 3359 - DENSITY
- 3360 volumetric mass of a material per unit volume of that material.
- 3361 - DEPOSITION_ACCELERATION_VOLUMETRIC
- 3362 rate of change in spatial volume of material deposited in an additive manufac-
- 3363 turing process.

- 3364 - DEPOSITION_DENSITY
 - 3365 density of the material deposited in an additive manufacturing process per unit
 - 3366 of volume.
- 3367 - DEPOSITION_MASS
 - 3368 mass of the material deposited in an additive manufacturing process.
- 3369 - DEPOSITION_RATE_VOLUMETRIC
 - 3370 rate at which a spatial volume of material is deposited in an additive manufac-
 - 3371 turing process.
- 3372 - DEPOSITION_VOLUME
 - 3373 spatial volume of material to be deposited in an additive manufacturing pro-
 - 3374 cess.
- 3375 - DEW_POINT
 - 3376 temperature at which moisture begins to condense, corresponding to saturation
 - 3377 for a given absolute humidity.
- 3378 - DIAMETER
 - 3379 dimension of a diameter.
- 3380 - DISCHARGE_RATE
 - 3381 value of current being drawn from the Component.
- 3382 - DISPLACEMENT
 - 3383 change in position of an object.
- 3384 - DISPLACEMENT_ANGULAR
 - 3385 absolute value of the change in angular position around a vector
- 3386 - DISPLACEMENT_LINEAR
 - 3387 absolute value of the change in position along a vector.
- 3388 - ELECTRICAL_ENERGY
 - 3389 Wattage used or generated by a component over an interval of time.
- 3390 - EQUIPMENT_TIMER
 - 3391 amount of time a piece of equipment or a sub-part of a piece of equipment has
 - 3392 performed specific activities.
- 3393 - FILL_HEIGHT
 - 3394 amount of a substance in a container.
- 3395 - FILL_LEVEL
 - 3396 amount of a substance remaining compared to the planned maximum amount
 - 3397 of that substance.
- 3398 - FLOW
 - 3399 rate of flow of a fluid.

- 3400 - FOLLOWING_ERROR
3401 difference between actual and commanded position at any specific point in
3402 time during a motion.
- 3403 - FOLLOWING_ERROR_ANGULAR
3404 angular difference between the commanded encoder/resolver position and the
3405 actual encoder/resolver position at any specified point in time during a motion.
- 3406 - FOLLOWING_ERROR_LINEAR
3407 difference between the commanded encoder/resolver position and the actual
3408 encoder/resolver position at any specified point in time during a motion.
- 3409 - FREQUENCY
3410 number of occurrences of a repeating event per unit time.
- 3411 - <>deprecated>> GLOBAL_POSITION
3412 position in three-dimensional space.
3413 **DEPRECATED** in Version 1.1.
- 3414 - GRAVITATIONAL_ACCELERATION
3415 acceleration relative to Earth's gravity of 9.80665 METER/SECOND².
- 3416 - GRAVITATIONAL_FORCE
3417 force relative to earth's gravity.
- 3418 - HUMIDITY_ABSOLUTE
3419 amount of water vapor expressed in grams per cubic meter.
- 3420 - HUMIDITY_RELATIVE
3421 amount of water vapor present expressed as a percent to reach saturation at the
3422 same temperature.
- 3423 - HUMIDITY_SPECIFIC
3424 ratio of the water vapor present over the total weight of the water vapor and air
3425 present expressed as a percent.
- 3426 - LENGTH
3427 length of an object.
- 3428 - <>deprecated>> LEVEL
3429 level of a resource.
3430 **DEPRECATED** in Version 1.2. See FILL_LEVEL.
- 3431 - LINEAR_FORCE
3432 *force* applied to a mass in one direction only.
- 3433 - LOAD
3434 actual versus the standard rating of a piece of equipment.

- 3435 - MASS
- 3436 mass of an object(s) or an amount of material.
- 3437 - OBSERVATION_UPDATE_RATE
- 3438 average rate of change of values for data items in the MTConnect streams. The
- 3439 average is computed over a rolling window defined by the implementation.
- 3440 - OPENNESS
- 3441 percentage open where 100% is fully open and 0% is fully closed.
- 3442 - ORIENTATION
- 3443 angular position of a plane or vector relative to a *cartesian coordinate system*
- 3444 - PARTICLE_COUNT
- 3445 number of particles counted by their size or other characteristics.
- 3446 - PARTICLE_SIZE
- 3447 size of particles counted by their size or other characteristics.
- 3448 - PATH_FEEDRATE
- 3449 feedrate for the axes, or a single axis, associated with a Path component.
- 3450 - PATH_FEEDRATE_PER_REVOLUTION
- 3451 feedrate for the axes, or a single axis.
- 3452 - PATH_POSITION
- 3453 position of a control point associated with a Controller or a Path.
- 3454 - PH
- 3455 acidity or alkalinity of a solution.
- 3456 - POSITION
- 3457 point along an axis in a *cartesian coordinate system*.
- 3458 - POSITION_CARTESIAN
- 3459 point in a *cartesian coordinate system*.
- 3460 - POWER_FACTOR
- 3461 ratio of real power flowing to a load to the apparent power in that AC circuit.
- 3462 - PRESSURE
- 3463 force per unit area measured relative to atmospheric pressure.
- 3464 Commonly referred to as gauge pressure.
- 3465 - PRESSURE_ABSOLUTE
- 3466 force per unit area measured relative to a vacuum.
- 3467 - PRESSURIZATION_RATE
- 3468 change of pressure per unit time.

- 3469 - PROCESS_TIMER
 - 3470 amount of time a piece of equipment has performed different types of activities
 - 3471 associated with the process being performed at that piece of equipment.
- 3472 - RESISTANCE
 - 3473 degree to which a substance opposes the passage of an electric current.
- 3474 - RESISTIVITY
 - 3475 inability of a material to conduct electricity.
- 3476 - ROTARY_VELOCITY
 - 3477 rotational speed of a rotary axis.
- 3478 - SETTLING_ERROR
 - 3479 difference between actual and commanded position at the end of a motion.
- 3480 - SETTLING_ERROR_ANGULAR
 - 3481 angular difference between the commanded encoder/resolver position, and the
 - 3482 actual encoder/resolver position when motion is complete.
- 3483 - SETTLING_ERROR_LINEAR
 - 3484 difference between the commanded encoder/resolver position, and the actual
 - 3485 encoder/resolver position when motion is complete.
- 3486 - SOUND_LEVEL
 - 3487 sound level or sound pressure level relative to atmospheric pressure.
- 3488 - <>~~SPINDLE_SPEED~~
 - 3489 rotational speed of the rotary axis.
- 3490 - **DEPRECATED** in *Version 1.2*. Replaced by ROTARY_VELOCITY.
- 3491 - STRAIN
 - 3492 amount of deformation per unit length of an object when a load is applied.
- 3493 - TEMPERATURE
 - 3494 degree of hotness or coldness measured on a definite scale.
- 3495 - TENSION
 - 3496 force that stretches or elongates an object.
- 3497 - TILT
 - 3498 angular displacement.
- 3499 - TORQUE
 - 3500 turning force exerted on an object or by an object.
- 3501 - VELOCITY
 - 3502 rate of change of position of a Component.

3503 - VISCOSEITY
3504 fluid's resistance to flow.

3505 - <<deprecated>> VOLTAGE
3506 electrical potential between two points.

3507 **DEPRECATED** in *Version 1.6*. Replaced by VOLTAGE_AC and VOLTAGE_DC.

3508 - VOLTAGE_AC
3509 electrical potential between two points in an electrical circuit in which the cur-
3510 rent periodically reverses direction.

3511 - VOLTAGE_DC
3512 electrical potential between two points in an electrical circuit in which the cur-
3513 rent is unidirectional.

3514 - VOLT_AMPERE
3515 apparent power in an electrical circuit, equal to the product of root-mean-
3516 square (RMS) voltage and RMS current (commonly referred to as VA).

3517 - VOLT_AMPERE_REACTIVE
3518 reactive power in an AC electrical circuit (commonly referred to as VAR).

3519 - VOLUME_FLUID
3520 fluid volume of an object or container.

3521 - VOLUME_SPATIAL
3522 geometric volume of an object or container.

3523 - WATTAGE
3524 power flowing through or dissipated by an electrical circuit or piece of equip-
3525 ment.

3526 - X_DIMENSION
3527 dimension of an entity relative to the X direction of the referenced coordinate
3528 system.

3529 - Y_DIMENSION
3530 dimension of an entity relative to the Y direction of the referenced coordinate
3531 system.

3532 - Z_DIMENSION
3533 dimension of an entity relative to the Z direction of the referenced coordinate
3534 system.

3535 7 References Model

3536 References *organizes* pointers to information defined elsewhere within the MTCon-
 3537 nectDevices entity for a piece of equipment. It is an efficient method to associate
 3538 information with an element without duplicating any of the data or structure.

3539 7.1 References

3540 This section provides semantic information for the Reference entity. Figure 6 shows
 3541 the Reference model.

3542 Reference may be modeled as part of a Device, Component or Interface type.

3543 Note: See *Section B.3 - References Schema Diagrams* for XML schema of
 3544 Reference and its types.

3545 7.1.1 Reference

3546 pointer to information that is associated with another entity defined elsewhere in the MT-
 3547 ConnectDevices entity for a piece of equipment.

3548 Reference is an abstract entity and will be realized by a specific Reference type for
 3549 an MTConnectDevices entity. See *Section 7.1.3 - ComponentRef* and *Section 7.1.2 -*
 3550 *DataItemRef*.

3551 7.1.1.1 Value Properties of Reference

3552 *Table 91* lists the Value Properties of Reference.

Value Property name	Value Property type	Multiplicity
idRef	ID	1
name	string	0..1

Table 91: Value Properties of Reference

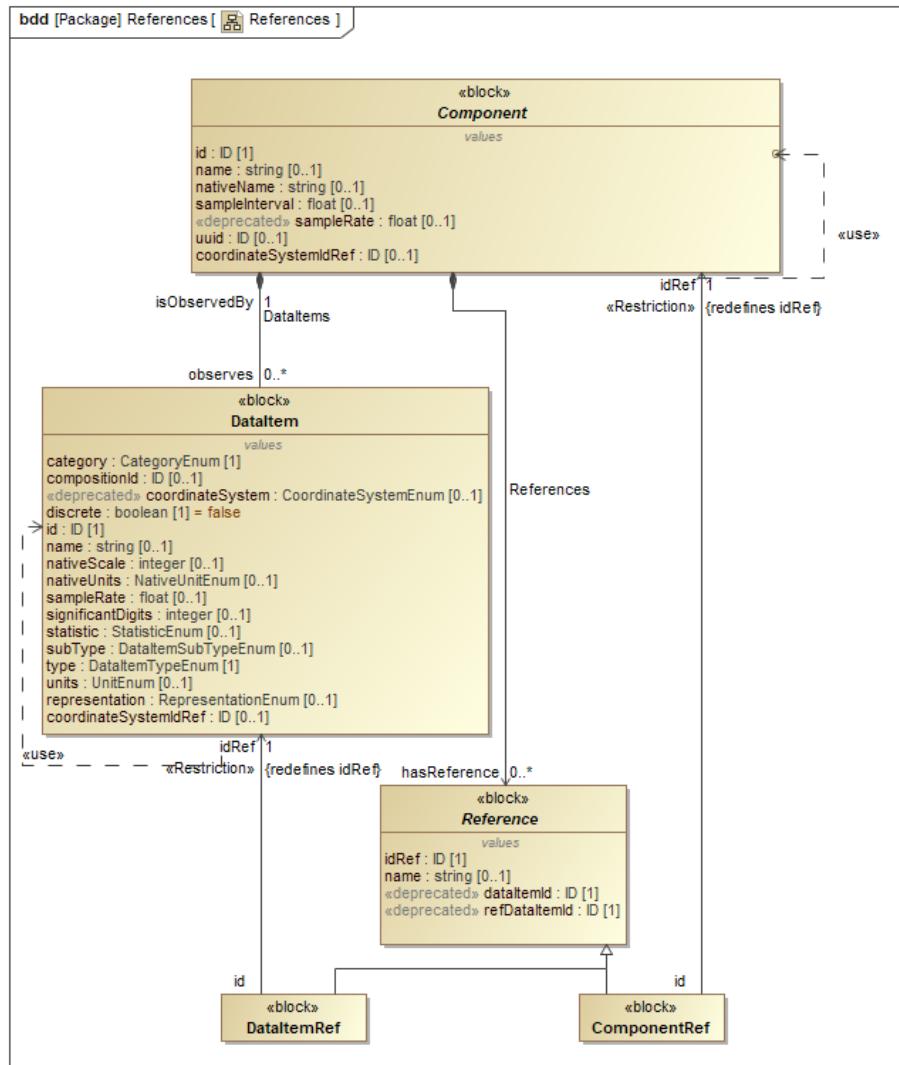


Figure 6: References

3553 Descriptions for Value Properties of Reference:

3554 • **idRef**

3555 pointer to the **id** of an entity that contains the information to be associated with this
3556 entity.

3557 • **name**

3558 name of an element or a piece of equipment.

3559 7.1.2 DataItemRef

3560 Reference that is a pointer to a DataItem associated with another entity defined for
3561 a piece of equipment.

3562 DataItemRef allows the data associated with a DataItem defined in another entity to
3563 be directly associated with this entity.

3564 7.1.3 ComponentRef

3565 Reference that is a pointer to all of the information associated with another entity de-
3566 fined for a piece of equipment.

3567 ComponentRef allows all of the information of (*lower level* Component entities that
3568 is associated with the other entity to be directly associated with this entity.

3569 8 Configurations Model

3570 This section provides semantic information for the Configuration entity that is used
 3571 to model technical information about a Component.

3572 8.1 Configurations

3573 Figure 7 shows the abstract Configuration and its types.

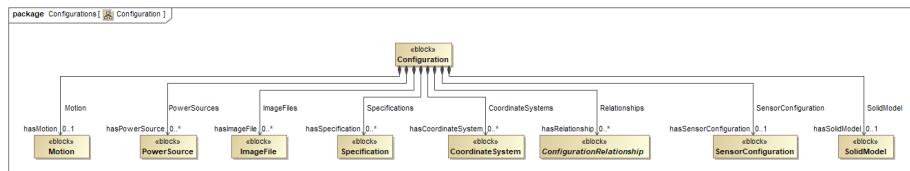


Figure 7: Configuration

3574 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

3575 8.1.1 Configuration

3576 technical information about an entity describing its physical layout, functional characteristics, and relationships with other entities.
 3577

3578 8.1.1.1 Part Properties of Configuration

3579 *Table 92* lists the Part Properties of Configuration.

Part Property name	Multiplicity
SolidModel	0..1
SensorConfiguration	0..1
Motion	0..1
ConfigurationRelationship (organized by Relationships)	0..*
CoordinateSystem (organized by CoordinateSystems)	0..*
Specification (organized by Specifications)	0..*
ImageFile (organized by ImageFiles)	0..*
PowerSource (organized by PowerSources)	0..*

Table 92: Part Properties of Configuration

3580 Descriptions for Part Properties of Configuration:

- 3581 • SolidModel

3582 references to a file with the three-dimensional geometry of the Component or
3583 Composition.

3584 See *Section 8.6 - SolidModel*.
- 3585 • SensorConfiguration

3586 configuration for a Sensor.

3587 See *SensorConfiguration*.
- 3588 • Motion

3589 movement of the component relative to a coordinate system.

3590 See *Section 8.3 - Motion*.
- 3591 • ConfigurationRelationship

3592 association between two pieces of equipment that function independently but to-
3593 gether perform a manufacturing operation.

3594 Relationships groups one or more ConfigurationRelationship types.
3595 See *Section 8.4 - Relationships*.
- 3596 • CoordinateSystem

3597 reference system that associates a unique set of n parameters with each point in an
3598 n-dimensional space. *Ref ISO 10303-218:2004*

3599 CoordinateSystems groups one or more CoordinateSystem entities. See
3600 *Section 8.2 - CoordinateSystems*.

3601 • Specification

3602 design characteristics for a piece of equipment.

3603 Specifications groups one or more Specification entities. See *Section 8.7 - Specifications*.

3604

3605 • ImageFile

3606 reference to a file containing an image of the Component.

3607 ImageFiles groups one or more ImageFile entities. See *Section 8.8 - ImageFiles*.

3608

3609 • PowerSource

3610 potential energy sources for the Component.

3611 PowerSources groups one or more PowerSource entities. See *Section 8.9 - PowerSources*.

3612

3613 8.2 CoordinateSystems

3614 This section provides semantic information for the CoordinateSystem entity.

3615 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

3616 Note: See *Example 6* for the XML representation of the same example.

3617 8.2.1 CoordinateSystem

3618 reference system that associates a unique set of n parameters with each point in an n-dimensional space. *Ref ISO 10303-218:2004*

3620 At most only one of Origin or Transformation **MUST** be defined for a CoordinateSystem.

3622 8.2.1.1 Value Properties of CoordinateSystem

3623 *Table 93* lists the Value Properties of CoordinateSystem.

Value Property name	Value Property type	Multiplicity
id	ID	1
name	string	0..1
nativeName	string	0..1
parentIdRef	ID	0..1
type	CoordinateSystemTypeEnum	1
uuid	UUID	0..1
Description	string	0..1

Table 93: Value Properties of CoordinateSystem

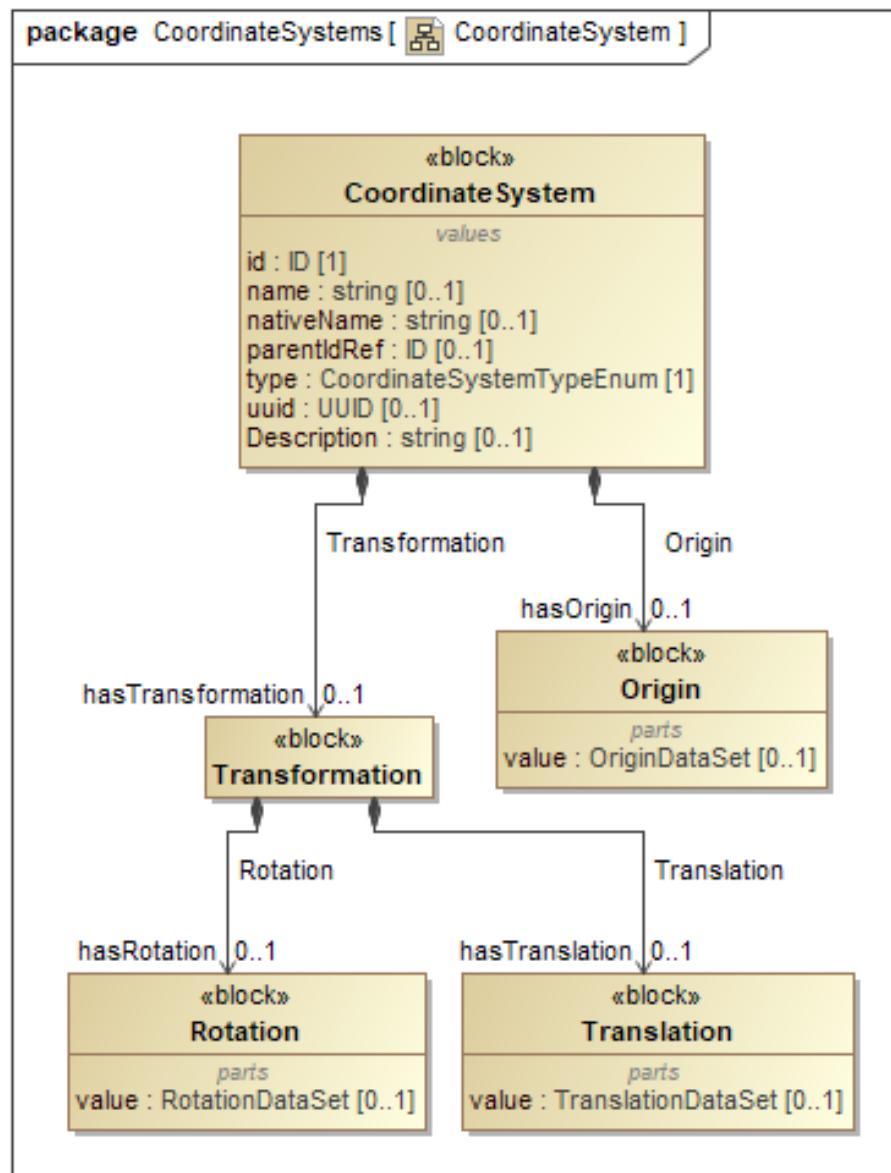


Figure 8: CoordinateSystem

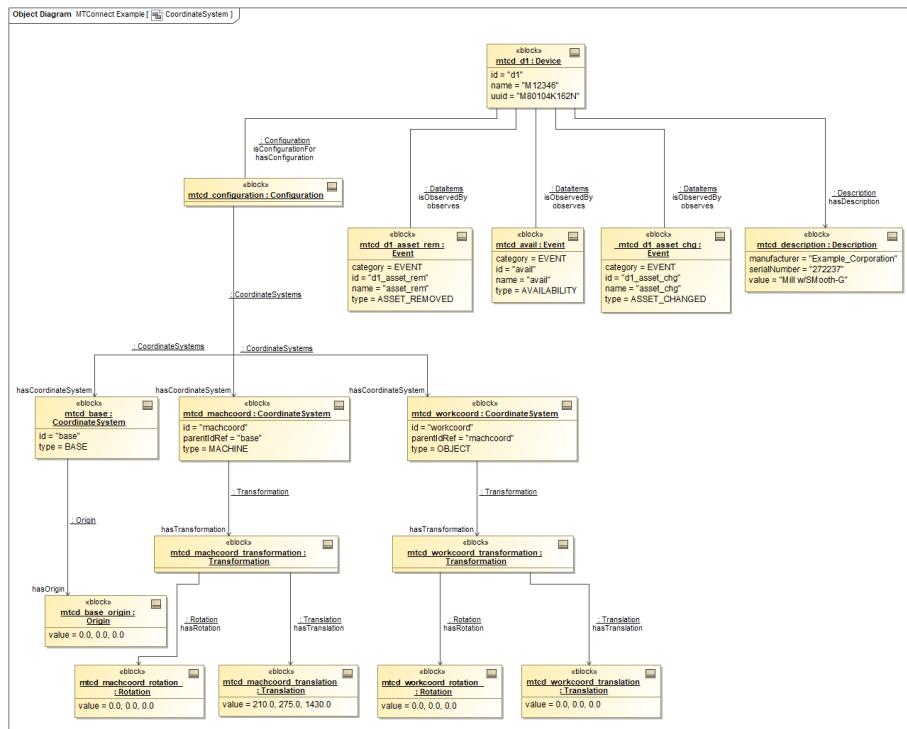


Figure 9: CoordinateSystem Example

3624 Descriptions for Value Properties of CoordinateSystem:

- 3625 • id
 - 3626 unique identifier for the coordinate system.
- 3627 • name
 - 3628 name of the coordinate system.
- 3629 • nativeName
 - 3630 manufacturer's name or users name for the coordinate system.
- 3631 • parentIdRef
 - 3632 pointer to the id.
- 3633 • type
 - 3634 type of coordinate system.

3635 CoordinateSystemTypeEnum:

- 3636 - BASE
 - 3637 coordinate system referenced to the base mounting surface. *Ref ISO 9787:2013*
 - 3638 A base mounting surface is a connection surface between the arm and its sup-
 - 3639 porting structure. *Ref ISO 9787:2013*
 - 3640 For non-robotic devices, it is the connection surface between the device and its
 - 3641 supporting structure.
- 3642 - CAMERA
 - 3643 coordinate system referenced to the sensor which monitors the site of the task.
 - 3644 *Ref ISO 9787:2013*
- 3645 - MACHINE
 - 3646 coordinate system referenced to the home position and orientation of the pri-
 - 3647 mary axes of a piece of equipment.
- 3648 - MECHANICAL_INTERFACE
 - 3649 coordinate system referenced to the mechanical interface. *Ref ISO 9787:2013*
- 3650 - MOBILE_PLATFORM
 - 3651 coordinate system referenced to one of the components of a mobile platform.
 - 3652 *Ref ISO 8373:2012*
- 3653 - OBJECT
 - 3654 coordinate system referenced to the object. *Ref ISO 9787:2013*

3655 - TASK
 3656 coordinate system referenced to the site of the task. *Ref ISO 9787:2013*

3657 - TOOL
 3658 coordinate system referenced to the tool or to the end effector attached to the
 3659 mechanical interface. *Ref ISO 9787:2013*

3660 - WORLD
 3661 stationary coordinate system referenced to earth, which is independent of the
 3662 robot motion. *Ref ISO 9787:2013*

3663 For non-robotic devices, stationary coordinate system referenced to earth, which
 3664 is independent of the motion of a piece of equipment.

3665 • uuid
 3666 UUID for the coordinate system.

3667 • Description
 3668 natural language description of the CoordinateSystem.

3669 **8.2.1.2 Part Properties of CoordinateSystem**

3670 *Table 94* lists the Part Properties of CoordinateSystem.

Part Property name	Multiplicity
Origin	0..1
Transformation	0..1

Table 94: Part Properties of CoordinateSystem

3671 Descriptions for Part Properties of CoordinateSystem:

3672 • Origin
 3673 coordinates of the origin position of a coordinate system.
 3674 See *Section 8.2.2 - Origin*.

3675 • Transformation
 3676 process of transforming to the origin position of the coordinate system from a parent
 3677 coordinate system using Translation and Rotation.
 3678 See *Section 8.2.3 - Transformation*.

3679 8.2.2 Origin

3680 coordinates of the origin position of a coordinate system.

3681 8.2.2.1 Part Properties of Origin

3682 *Table 95* lists the Part Properties of Origin.

Part Property name	Multiplicity
value	0..1

Table 95: Part Properties of Origin

3683 Descriptions for Part Properties of Origin:

3684 • OriginDataSet

3685 x-coordinate.

3686 8.2.3 Transformation

3687 process of transforming to the origin position of the coordinate system from a parent co-
3688 ordinate system using Translation and Rotation.

3689 At a minimum, a Translation or a Rotation **MUST** be defined for a Transfor-
3690 mation.

3691 8.2.3.1 Part Properties of Transformation

3692 *Table 96* lists the Part Properties of Transformation.

Part Property name	Multiplicity
Translation	0..1
Rotation	0..1

Table 96: Part Properties of Transformation

3693 Descriptions for Part Properties of Transformation:

3694 • Translation
 3695 translations along X, Y, and Z axes are expressed as x,y, and z respectively within a
 3696 3-dimensional vector.
 3697 See *Section 8.2.5 - Translation*.
 3698 • Rotation
 3699 rotations about X, Y, and Z axes are expressed in A, B, and C respectively within a
 3700 3-dimensional vector.
 3701 See *Section 8.2.4 - Rotation*.

3702 8.2.4 Rotation

3703 rotations about X, Y, and Z axes are expressed in A, B, and C respectively within a 3-
 3704 dimensional vector.

3705 8.2.4.1 Part Properties of Rotation

3706 *Table 97* lists the Part Properties of Rotation.

Part Property name	Multiplicity
value	0..1

Table 97: Part Properties of Rotation

3707 Descriptions for Part Properties of Rotation:

3708 • RotationDataSet
 3709 rotation about X axis.

3710 8.2.5 Translation

3711 translations along X, Y, and Z axes are expressed as x,y, and z respectively within a 3-
 3712 dimensional vector.

3713 8.2.5.1 Part Properties of Translation

3714 *Table 98* lists the Part Properties of Translation.

Part Property name	Multiplicity
value	0..1

Table 98: Part Properties of Translation

3715 Descriptions for Part Properties of Translation:

3716 • TranslationDataSet

3717 translation along X axis.

3718 8.3 Motion

3719 This section provides semantic information for the Motion entity.

3720 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

3721 Note: See *Example 7* for the XML representation of the same example.

3722 8.3.1 Motion

3723 movement of the component relative to a coordinate system.

3724 Motion specifies the kinematic chain of the component entities.

3725 At most only one of Origin or Transformation **MUST** be defined for a Motion.

3726 8.3.1.1 Value Properties of Motion

3727 *Table 99* lists the Value Properties of Motion.

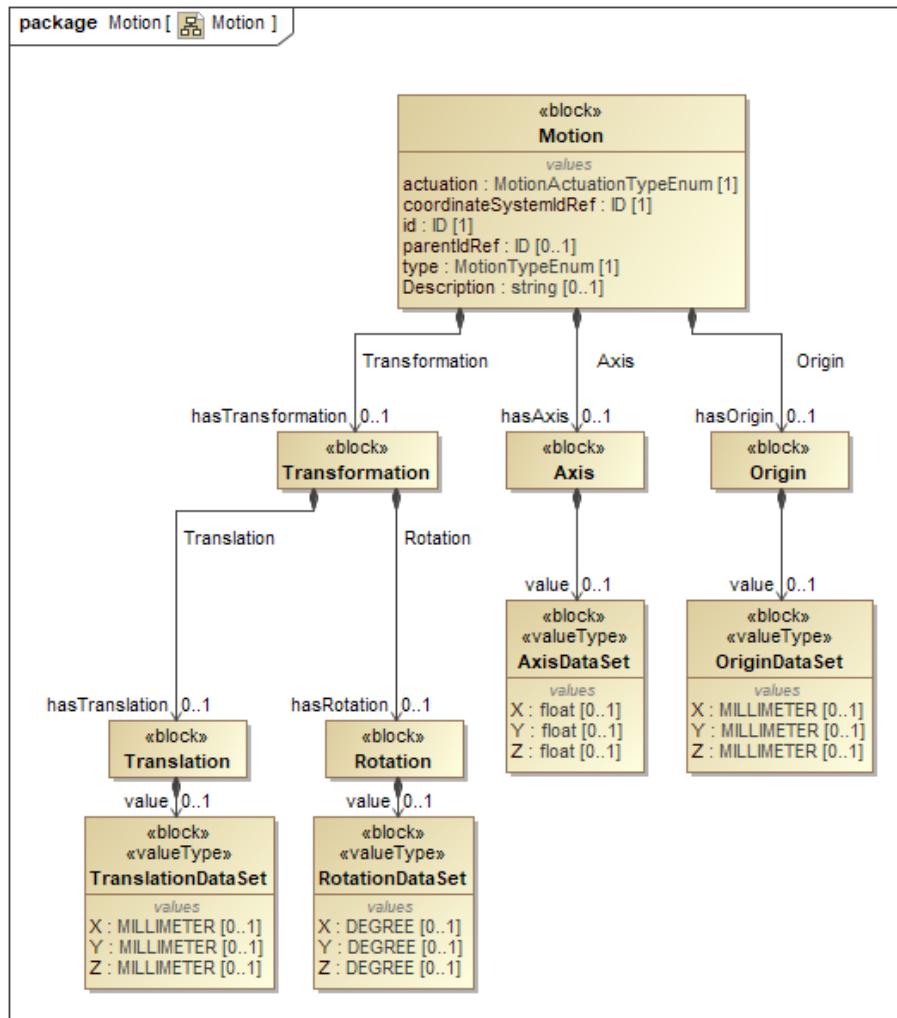


Figure 10: Motion

Value Property name	Value Property type	Multiplicity
actuation	MotionActuationTypeEnum	1
coordinateSystemIdRef	ID	1
id	ID	1
parentIdRef	ID	0..1
type	MotionTypeEnum	1

Table 99: Value Properties of Motion

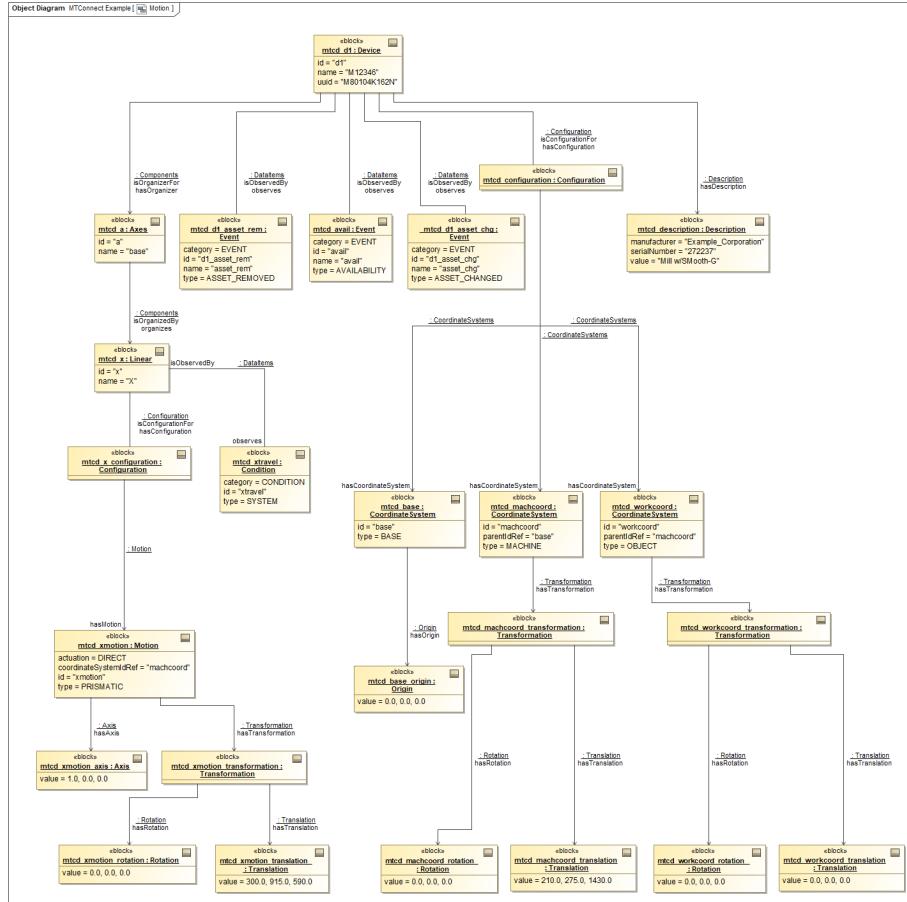


Figure 11: Motion Example

3728 Descriptions for Value Properties of Motion:

- 3729 • actuation

3730 describes if this component is actuated directly or indirectly as a result of other
3731 motion.

3732 MotionActuationTypeEnum Enumeration:

 - 3733 – DIRECT

3734 movement is initiated by the component.
 - 3735 – NONE

3736 no actuation of this axis.

3737 Note: Actuation of NONE can be either a derived REVOLUTE or
3738 PRISMATIC motion or static FIXED relationship.
 - 3739 – VIRTUAL

3740 motion is computed and is used for expressing an imaginary movement.
- 3741 • coordinateSystemIdRef

3742 coordinate system within which the kinematic motion occurs.
- 3743 • id

3744 unique identifier for this element.
- 3745 • parentIdRef

3746 pointer to the id.

3747 The kinematic chain connects all components using the parent relations. All motion
3748 is connected to the motion of the parent. The first node in the chain will not have a
3749 parent.
- 3750 • type

3751 type of motion.

3752 MotionTypeEnum Enumeration:

 - 3753 – CONTINUOUS

3754 revolves around an axis with a continuous range of motion.
 - 3755 – FIXED

3756 axis does not move.
 - 3757 – PRISMATIC

3758 sliding linear motion along an axis with a fixed range of motion.
 - 3759 – REVOLUTE

3760 rotates around an axis with a fixed range of motion.

3761 **8.3.1.2 Part Properties of Motion**3762 *Table 100* lists the Part Properties of Motion.

Part Property name	Multiplicity
Axis	0..1
Origin	0..1
Transformation	0..1

Table 100: Part Properties of Motion

3763 Descriptions for Part Properties of Motion:

3764 • Axis

3765 axis along or around which the Component moves relative to a coordinate system.

3766 See *Section 4.3.4 - Axis*.

3767 • Origin

3768 coordinates of the origin position of a coordinate system.

3769 See *Section 8.2.2 - Origin*.

3770 • Transformation

3771 process of transforming to the origin position of the coordinate system from a parent
3772 coordinate system using Translation and Rotation.3773 See *Section 8.2.3 - Transformation*.3774 **8.3.2 Axis**

3775 axis along or around which the Component moves relative to a coordinate system.

3776 **8.3.2.1 Part Properties of Axis**3777 *Table 101* lists the Part Properties of Axis.

Part Property name	Multiplicity
value	0..1

Table 101: Part Properties of Axis

3778 Descriptions for Part Properties of Axis:

3779 • AxisDataSet
 3780 x-component of Axis.

3781 8.4 Relationships

3782 This section provides semantic information for the ConfigurationRelationship entity.

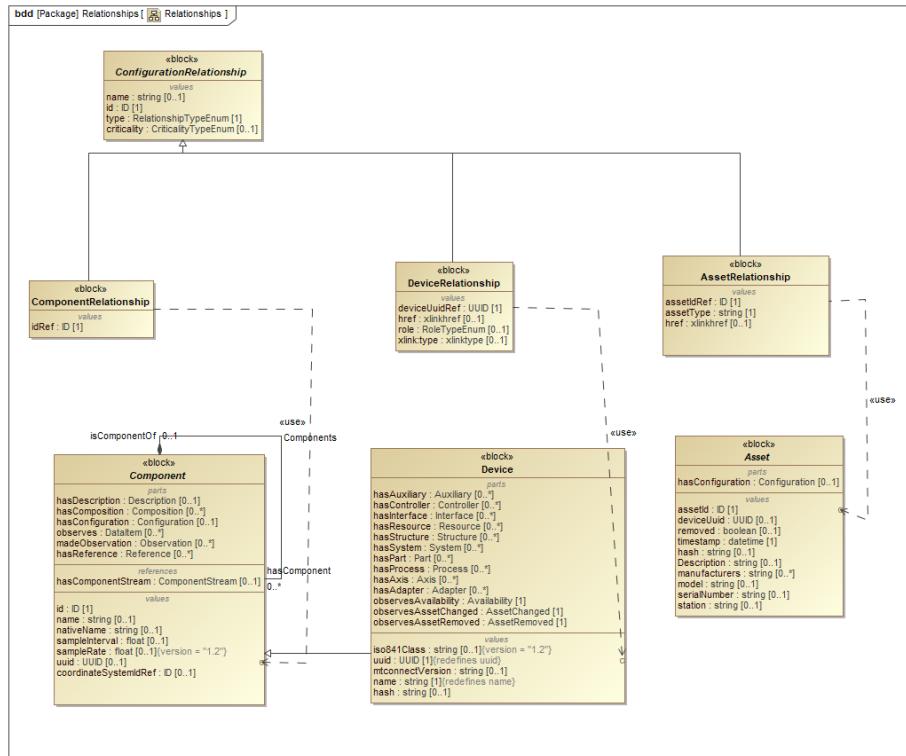


Figure 12: Relationships

3784 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

3785 Note: See *Example 8* for the XML representation of the same example.

3786 8.4.1 ConfigurationRelationship

3787 association between two pieces of equipment that function independently but together
 3788 perform a manufacturing operation.

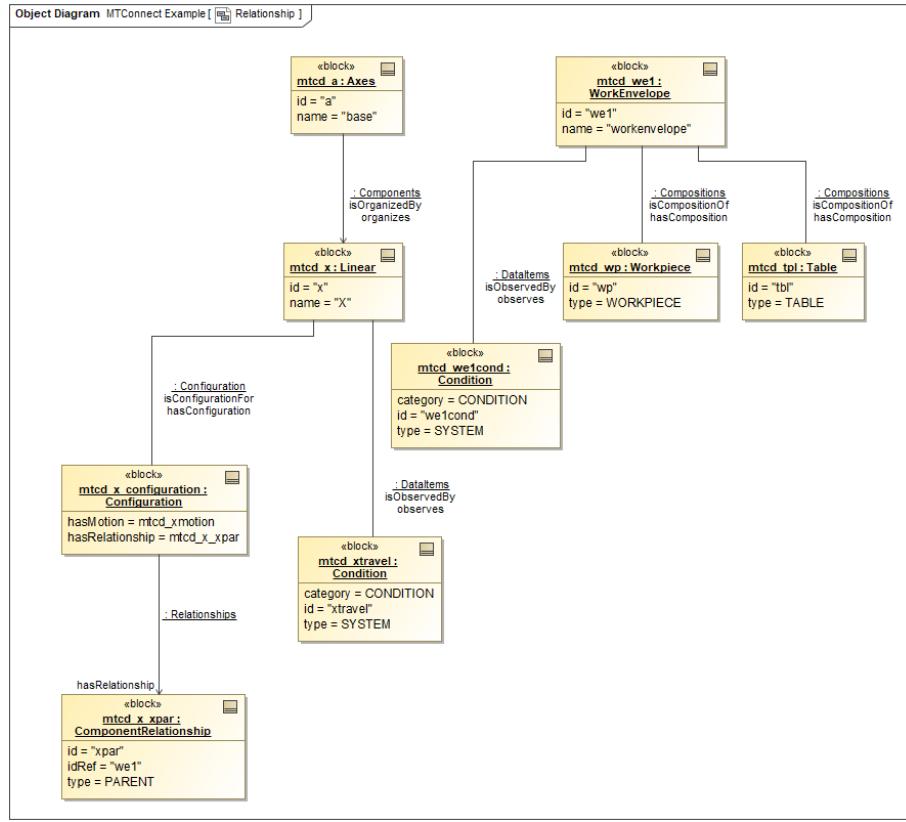


Figure 13: Relationship Example

3789 ConfigurationRelationship is an abstract entity and hence will be realized by
 3790 specific ConfigurationRelationship types in an MTConnectDevices entity.
 3791 See *Section 8.4.2 - ComponentRelationship* and *Section 8.4.3 - DeviceRelationship*.

8.4.1.1 Value Properties of ConfigurationRelationship

3793 Table 102 lists the Value Properties of ConfigurationRelationship.

Value Property name	Value Property type	Multiplicity
name	string	0..1
id	ID	1
type	RelationshipTypeEnum	1
criticality	CriticalityTypeEnum	0..1

Table 102: Value Properties of ConfigurationRelationship

3794 Descriptions for Value Properties of ConfigurationRelationship:

3795 • name
 3796 name associated with this ConfigurationRelationship.

3797 • id
 3798 unique identifier for this ConfigurationRelationship.

3799 • type
 3800 defines the authority that this piece of equipment has relative to the associated piece
 3801 of equipment.

3802 RelationshipTypeEnum Enumeration:

- 3803 - CHILD
 3804 functions as a child in the relationship with the associated element.
- 3805 - PARENT
 3806 functions as a parent in the relationship with the associated element.
- 3807 - PEER
 3808 functions as a peer which provides equal functionality and capabilities in the
 3809 relationship with the associated element.

3810 • criticality
 3811 defines whether the services or functions provided by the associated piece of equip-
 3812 ment is required for the operation of this piece of equipment.

3813 CriticalityTypeEnum Enumeration:

- 3814 - CRITICAL
 3815 services or functions provided by the associated element is required for the
 3816 operation of this element.
- 3817 - NONCRITICAL
 3818 services or functions provided by the associated element is not required for the
 3819 operation of this element.

3820 8.4.2 ComponentRelationship

3821 ConfigurationRelationship that describes the association between two compo-
 3822 nents within a piece of equipment that function independently but together perform a ca-
 3823 pability or service within a piece of equipment.

3824 **8.4.2.1 Value Properties of ComponentRelationship**3825 *Table 103* lists the Value Properties of ComponentRelationship.

Value Property name	Value Property type	Multiplicity
idRef	ID	1

Table 103: Value Properties of ComponentRelationship

3826 Descriptions for Value Properties of ComponentRelationship:

3827 • idRef
 3828 reference to the associated Component.

3829 **8.4.3 DeviceRelationship**3830 ConfigurationRelationship that describes the association between two pieces of
 3831 equipment that function independently but together perform a manufacturing operation.3832 **8.4.3.1 Value Properties of DeviceRelationship**3833 *Table 104* lists the Value Properties of DeviceRelationship.

Value Property name	Value Property type	Multiplicity
deviceUuidRef	UUID	1
href	xlink:href	0..1
role	RoleTypeEnum	0..1
xlink:type	xlink:type	0..1

Table 104: Value Properties of DeviceRelationship

3834 Descriptions for Value Properties of DeviceRelationship:

3835 • deviceUuidRef
 3836 reference to the `uuid` of the associated piece of equipment.
 3837 • href
 3838 URI identifying the *agent* that is publishing information for the associated piece of
 3839 equipment.

3840 • **role**
 3841 defines the services or capabilities that the referenced piece of equipment provides
 3842 relative to this piece of equipment.
 3843 RoleTypeEnum Enumeration:
 3844 – AUXILIARY
 3845 associated element performs the functions as an Auxiliary for this element.
 3846 – SYSTEM
 3847 associated element performs the functions of a System for this element.
 3848 • **xlink:type**
 3849 xlink:type**MUST** have a fixed value of locator as defined in W3C XLink
 3850 1.1 *Ref*<https://www.w3.org/TR/xlink11/>.

3851 8.4.4 AssetRelationship

3852 ConfigurationRelationship that describes the association between a Component and an Asset.

3854 8.4.4.1 Value Properties of AssetRelationship

3855 *Table 105* lists the Value Properties of AssetRelationship.

Value Property name	Value Property type	Multiplicity
assetIdRef	ID	1
assetType	string	1
href	xlink:href	0..1

Table 105: Value Properties of AssetRelationship

3856 Descriptions for Value Properties of AssetRelationship:

3857 • assetIdRef
 3858 uuid of the related Asset.
 3859 • assetType
 3860 type of Asset being referenced.
 3861 • href
 3862 URI reference to the associated Asset.

3863 8.5 Sensor

3864 This section provides semantic information for the SensorConfiguration entity.

3865 sensor is a unique type of a piece of equipment. A sensor is typically comprised of two
 3866 major components: a sensor unit that provides signal processing, conversion, and commu-
 3867 nications and the *sensing elements* that provides a signal or measured value.

3868 The sensor unit is modeled as a *lower level* Component called Sensor. The *sensing*
 3869 *element* may be modeled as a Composition element of a Sensor element and the
 3870 measured value would be modeled as a DataItem (See *Section 6.1 - DataItems* for more
 3871 information on DataItem elements). Each sensor unit may have multiple *sensing ele-
 3872 ments*; each representing the data for a variety of measured values.

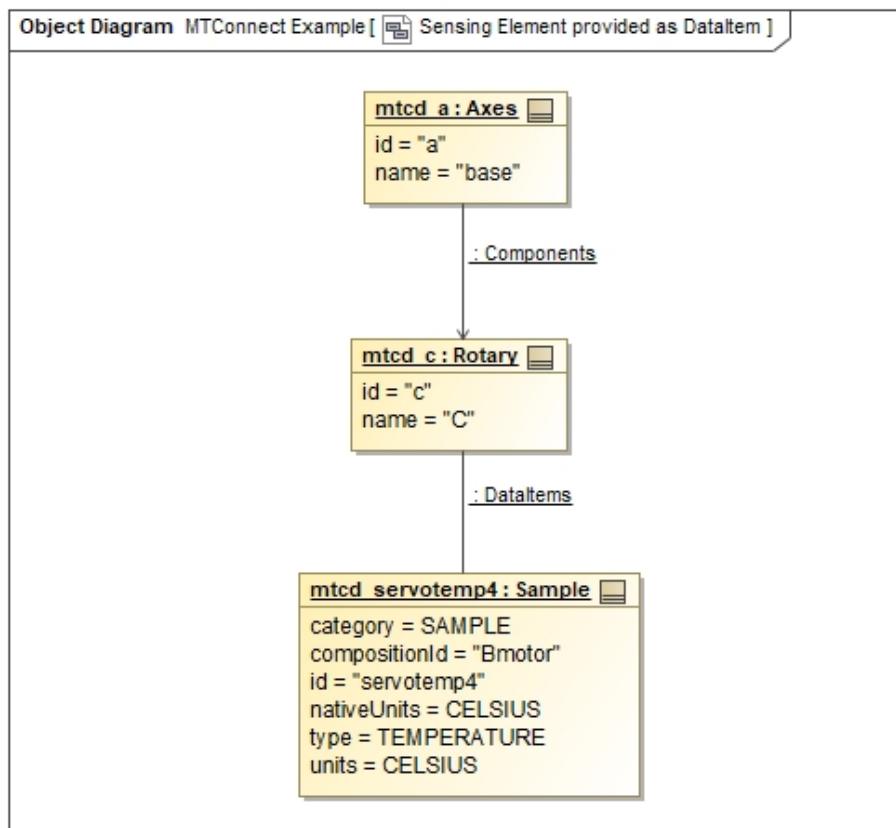


Figure 14: Sensing Element provided as a DataItem Example

3873 Note: See *Example 11* for an XML example.

3874 When a sensor unit is modeled as a Component or as a separate piece of equipment, it

3875 may provide additional configuration information for the sensor elements and the sensor
3876 unit itself.

3877 Note: If a `Sensor` provides vibration measurement data for the spindle on a
3878 piece of equipment, it could be modeled as a `Sensor` for rotary axis named
3879 C. See *Example 12* for an XML example.

3880 Note: If a `Sensor` provides measurement data for multiple `Component` el-
3881 ements within a piece of equipment and is not associated with any particular
3882 `Component`, it **MAY** be modeled as an independent `Component` and the
3883 data associated with measurements are associated with their associated `Com-`
3884 `ponent` entities. See *Example 13* for an XML example.

3885 Configuration data provides information required for maintenance and support of the
3886 sensor.

3887 When `Sensor` represents the sensor unit for multiple *sensing element(s)*, each sensing
3888 element is represented by a `Channel`. The sensor unit itself and each `Channel` repre-
3889 senting one *sensing element* **MAY** have its own configuration data.

3890 Note: See *Example 14* for an XML example.

3891 8.5.1 SensorConfiguration

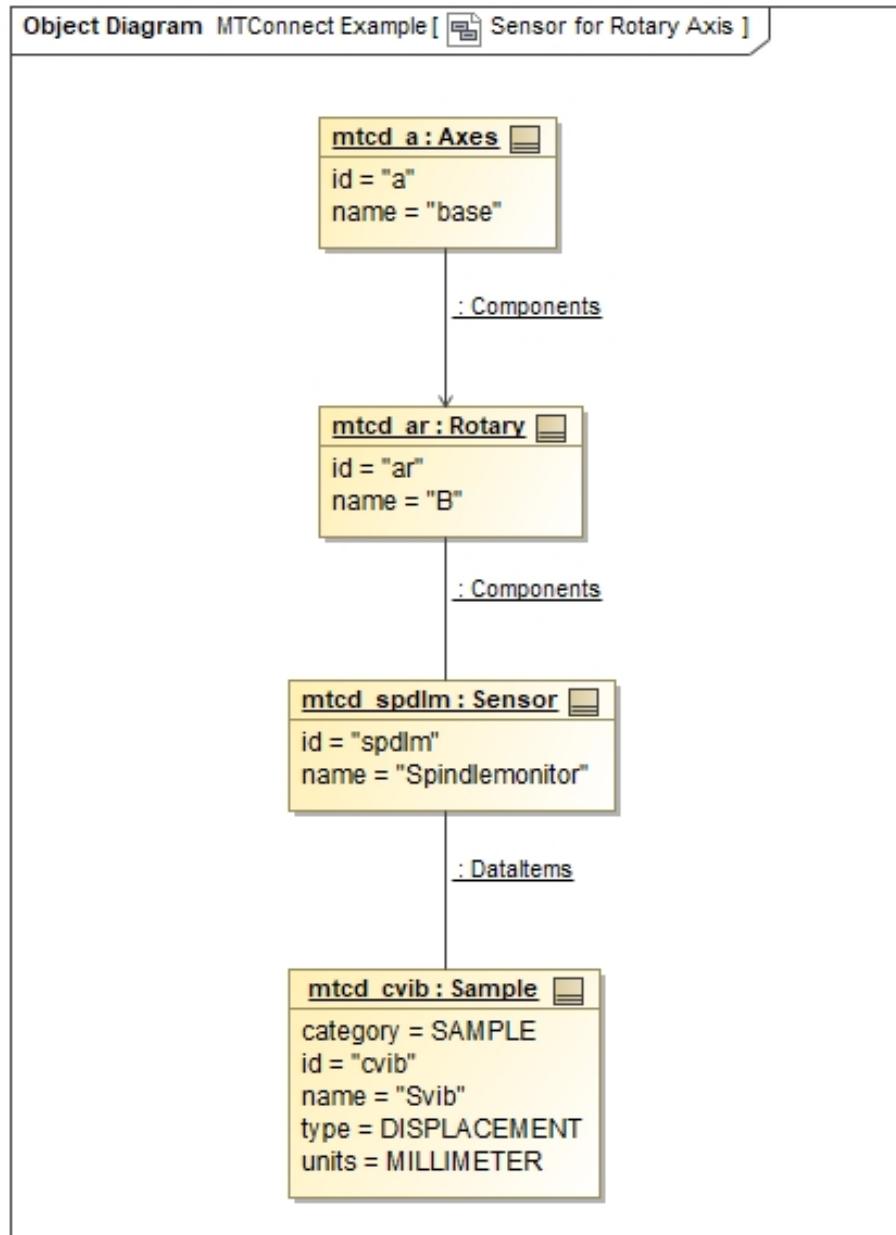
3892 configuration for a `Sensor`.

3893 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

3894 8.5.1.1 Value Properties of SensorConfiguration

3895 *Table 106* lists the Value Properties of `SensorConfiguration`.

Value Property name	Value Property type	Multiplicity
CalibrationDate	datetime	0..1
CalibrationInitials	string	0..1
FirmwareVersion	string	1
NextCalibrationDate	datetime	0..1

Table 106: Value Properties of SensorConfiguration**Figure 15:** Sensor for Rotary Axis Example

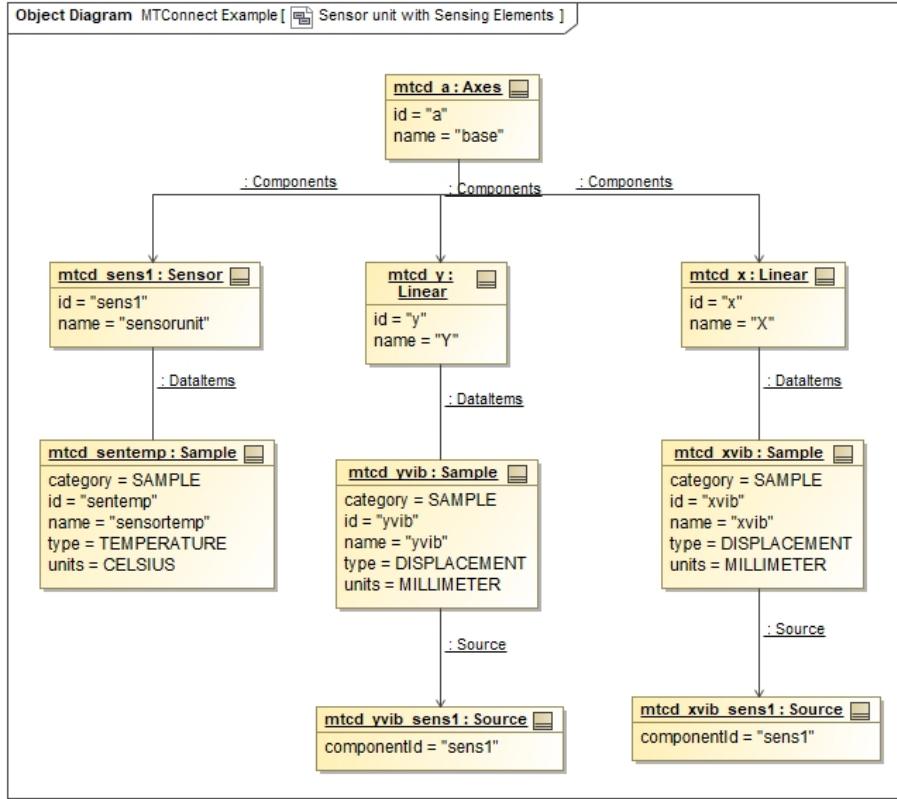


Figure 16: Sensor unit with Sensing Elements Example

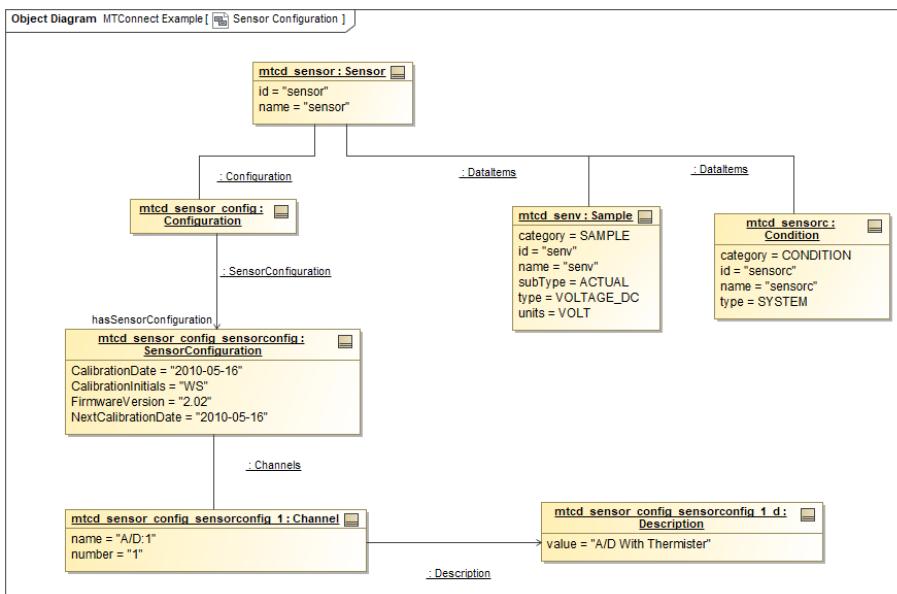


Figure 17: Sensor Configuration Example

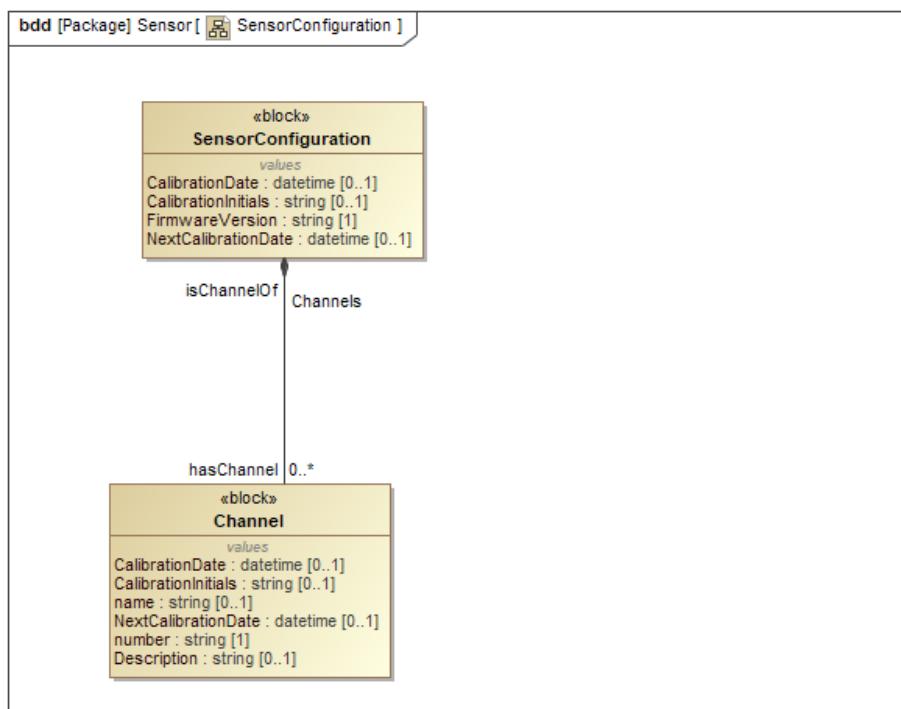


Figure 18: SensorConfiguration

3896 Descriptions for Value Properties of SensorConfiguration:

- 3897 • CalibrationDate
- 3898 Date upon which the sensor unit was last calibrated.
- 3899 • CalibrationInitials
- 3900 The initials of the person verifying the validity of the calibration data.
- 3901 • FirmwareVersion
- 3902 Version number for the sensor unit as specified by the manufacturer.
- 3903 • NextCalibrationDate
- 3904 Date upon which the sensor unit is next scheduled to be calibrated.

3905 **8.5.1.2 Part Properties of SensorConfiguration**

3906 *Table 107* lists the Part Properties of SensorConfiguration.

Part Property name	Multiplicity
Channel (organized by Channels)	0..*

Table 107: Part Properties of SensorConfiguration

3907 Descriptions for Part Properties of SensorConfiguration:

- 3908 • Channel
- 3909 *sensing element of a Sensor.*
- 3910 Channels groups one or more Channel entities. See Channel.

3911 **8.5.2 Channel**

3912 *sensing element of a Sensor.*

3913 When Sensor has multiple *sensing elements*, each *sensing element* is modeled as a
3914 Channel for the Sensor.

3915 **8.5.2.1 Value Properties of Channel**

3916 *Table 108* lists the Value Properties of Channel.

Value Property name	Value Property type	Multiplicity
CalibrationDate	datetime	0..1
CalibrationInitials	string	0..1
name	string	0..1
NextCalibrationDate	datetime	0..1
number	string	1

Table 108: Value Properties of Channel

3917 Descriptions for Value Properties of Channel:

- 3918 • CalibrationDate

3919 Date upon which the sensor unit was last calibrated to the sensor element.
- 3920 • CalibrationInitials

3921 The initials of the person verifying the validity of the calibration data.
- 3922 • name

3923 name of the specific *sensing element*.
- 3924 • NextCalibrationDate

3925 Date upon which the sensor element is next scheduled to be calibrated with the
3926 sensor unit.
- 3927 • number

3928 unique identifier that will only refer to a specific *sensing element*.

3929 8.6 SolidModel

3930 This section provides semantic information for the SolidModel entity.

3931 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

3932 Note: See *Example 9* for the XML representation of the same example.

3933 8.6.1 SolidModel

3934 references to a file with the three-dimensional geometry of the Component or Compo-
 3935 sition.

3936 The geometry **MAY** have a transformation and a scale to position the Component with
 3937 respect to the other Components. A geometry file can contain a set of assembled items, in
 3938 this case, the SolidModel references the id of the assembly model file and the specific
 3939 item within that file.

3940 The SolidModel **MAY** provide a translation, rotation, and scale to correctly place it
 3941 relative to the other geometries in the machine. If the Component can move and has
 3942 a Motion Configuration, the SolidModel will move when the Component or
 3943 Composition moves.

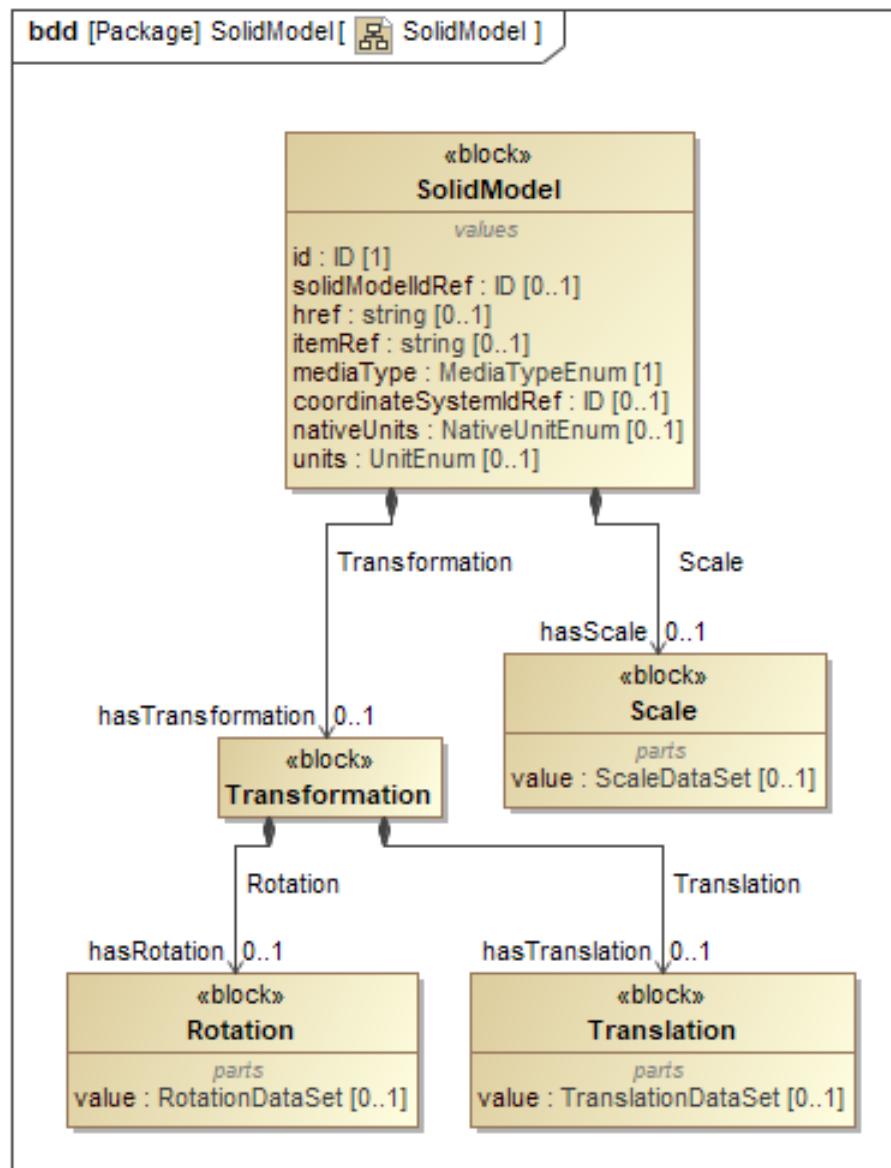
3944 Either an href or a modelIdRef and an itemRef **MUST** be specified.

3945 8.6.1.1 Value Properties of SolidModel

3946 *Table 109* lists the Value Properties of SolidModel.

Value Property name	Value Property type	Multiplicity
id	ID	1
solidModelIdRef	ID	0..1
href	string	0..1
itemRef	string	0..1
mediaType	MediaTypeEnum	1
coordinateSystemIdRef	ID	0..1
nativeUnits	NativeUnitEnum	0..1
units	UnitEnum	0..1

Table 109: Value Properties of SolidModel

**Figure 19:** SolidModel

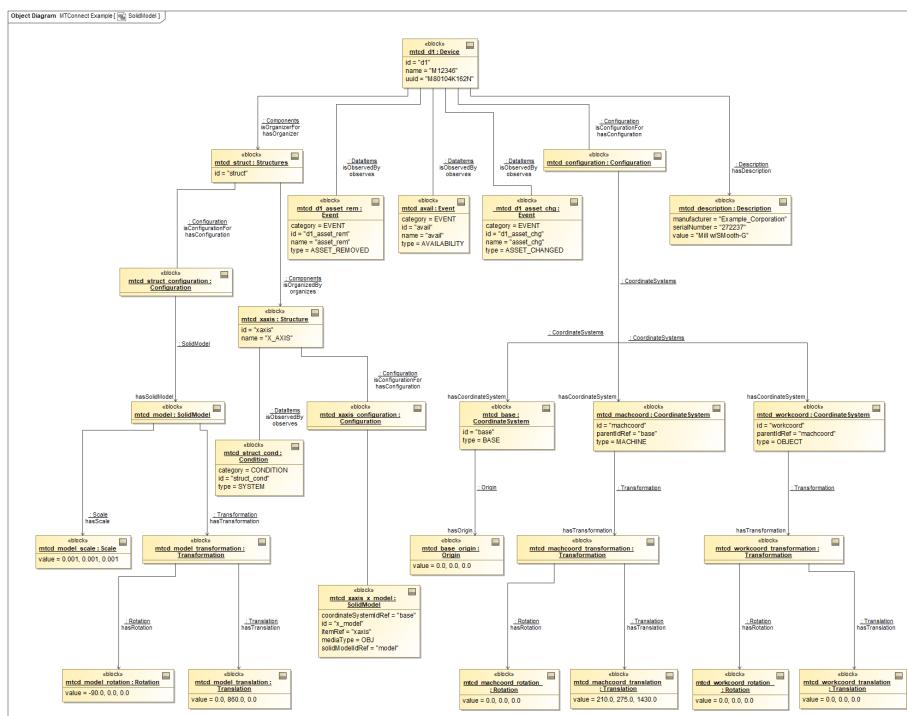


Figure 20: SolidModel Example

3947 Descriptions for Value Properties of SolidModel:

- 3948 • `id`
- 3949 unique identifier for this element.
- 3950 • `solidModelIdRef`
- 3951 associated model file if an item reference is used.
- 3952 • `href`
- 3953 Uniform Resource Locator (URL) giving the location of the SolidModel.
- 3954 If not present, the model referenced in the `solidModelIdRef` is used.
- 3955 `href` is of type `xlink:href` from the W3C XLink specification.
- 3956 • `itemRef`
- 3957 reference to the item within the model within the related geometry. A `solidModelIdRef` **MUST** be given.

3959 Note: Item defined in ASME Y14.100 - A nonspecific term used to
 3960 denote any unit or product, including materials, parts, assemblies, equipment,
 3961 accessories, and computer software.

- 3962 • `mediaType`
- 3963 format of the referenced document.
- 3964 MediaTypeEnum Enumeration:

- 3965 – `3DS`
- 3966 Autodesk file format.
- 3967 – `ACIS`
- 3968 Dassault file format.
- 3969 – `COLLADA`
- 3970 ISO 17506.
- 3971 – `GDML`
- 3972 Geometry Description Markup Language.
- 3973 – `IGES`
- 3974 Initial Graphics Exchange Specification.
- 3975 – `OBJ`
- 3976 Wavefront OBJ file format.

3977 - STEP
 3978 ISO 10303 STEP AP203 or AP242 format.

3979 - STL
 3980 STereoLithography file format.

3981 - X_T
 3982 Parasolid XT Siemens data interchange format.

3983 • coordinateSystemIdRef
 3984 reference to the coordinate system for this SolidModel.

3985 • nativeUnits
 3986 same as nativeUnits. See *Section 6.1.1 - DataItem*.
 3987 The value of nativeUnits **MUST** be one of the NativeUnitEnum enumera-
 3988 tion.

3989 • units
 3990 same as units. See *Section 6.1.1 - DataItem*.
 3991 The value of units **MUST** be one of the UnitEnum enumeration.

3992 8.6.1.2 Part Properties of SolidModel

3993 *Table 110* lists the Part Properties of SolidModel.

Part Property name	Multiplicity
Transformation	0..1
Scale	0..1

Table 110: Part Properties of SolidModel

3994 Descriptions for Part Properties of SolidModel:

3995 • Transformation
 3996 process of transforming to the origin position of the coordinate system from a parent
 3997 coordinate system using Translation and Rotation.
 3998 See *Section 8.2.3 - Transformation*.

3999 • **Scale**
 4000 either a single multiplier applied to all three dimensions or a three space multiplier
 4001 given in the X, Y, and Z dimensions in the coordinate system used for the `SolidModel`.
 4002
 4003 See *Section 8.6.2 - Scale*.

4004 8.6.2 Scale

4005 either a single multiplier applied to all three dimensions or a three space multiplier given
 4006 in the X, Y, and Z dimensions in the coordinate system used for the `SolidModel`.

4007 8.6.2.1 Part Properties of Scale

4008 *Table 111* lists the Part Properties of `Scale`.

Part Property name	Multiplicity
<code>value</code>	0..1

Table 111: Part Properties of Scale

4009 Descriptions for Part Properties of `Scale`:

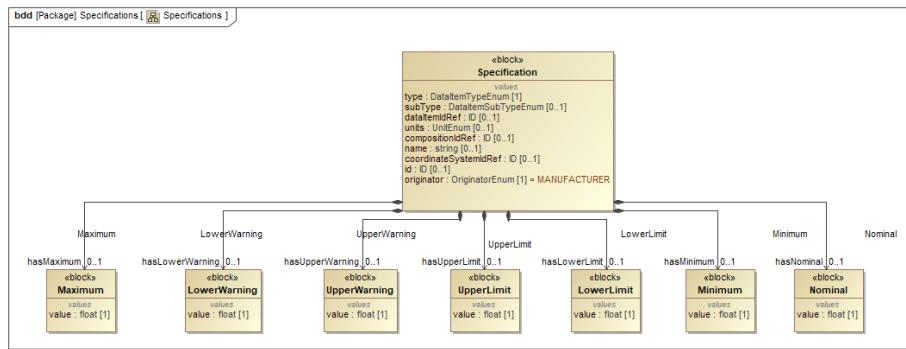
4010 • `ScaleDataSet`
 4011 multiplier for X axis.

4012 8.7 Specifications

4013 This section provides semantic information for the `Specification` entity.

4014 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

4015 Note: See *Example 10* for the XML representation of the same example.

**Figure 21:** Specifications

4016 8.7.1 Specification

4017 design characteristics for a piece of equipment.

4018 8.7.1.1 Value Properties of Specification

4019 *Table 112* lists the Value Properties of Specification.

Value Property name	Value Property type	Multiplicity
type	DataItemTypeEnum	1
subType	DataItemSubTypeEnum	0..1
dataItemIdRef	ID	0..1
units	UnitEnum	0..1
compositionIdRef	ID	0..1
name	string	0..1
coordinateSystemRef	ID	0..1
id	ID	0..1
originator	OriginatorEnum	1

Table 112: Value Properties of Specification

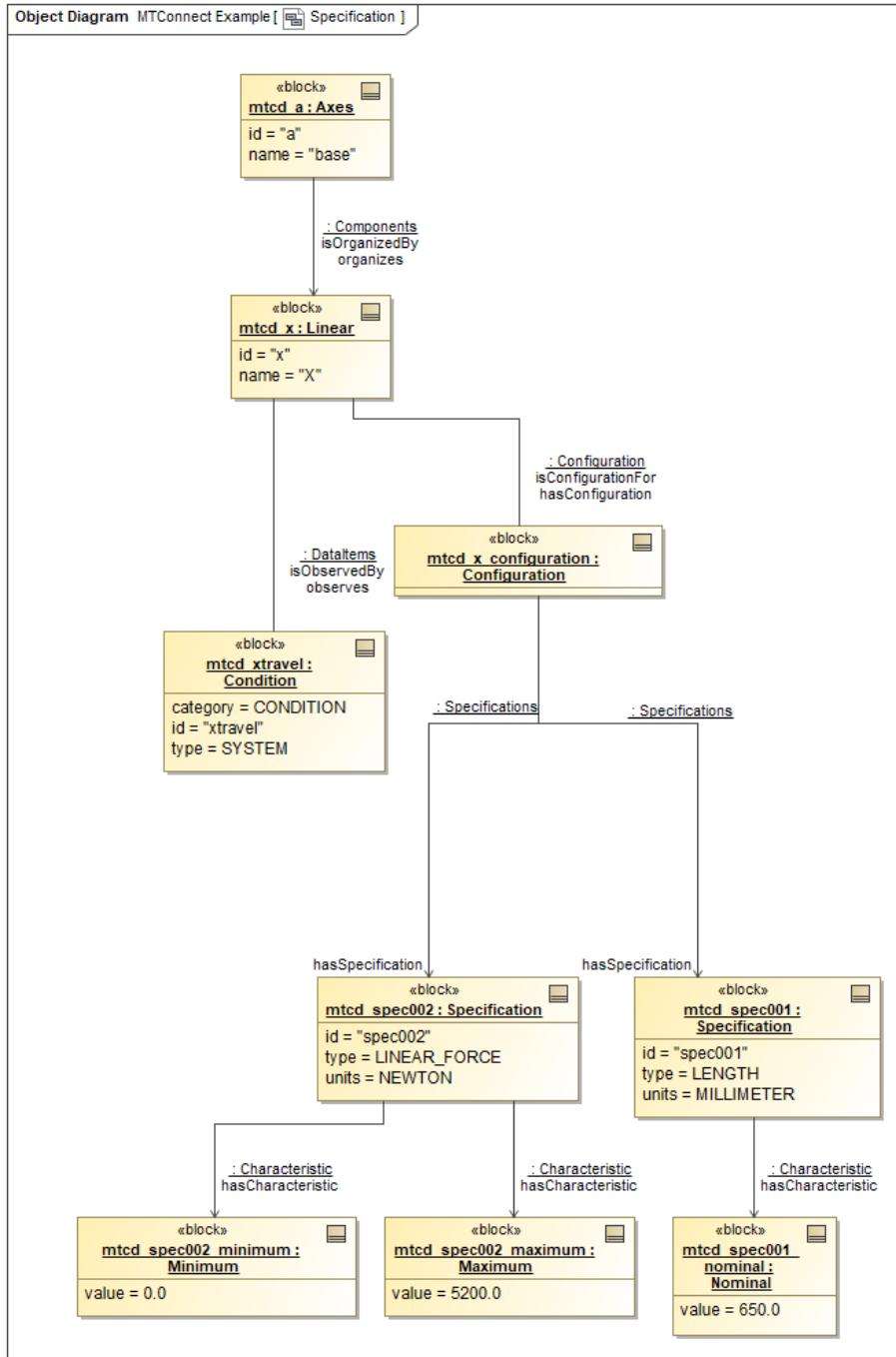


Figure 22: Specification Example

4020 Descriptions for Value Properties of Specification:

4021 • type

4022 same as type. See *Section 6.5 - DataItem Types*.

4023 The value of type **MUST** be one of the DataItemTypeEnum enumeration.

4024 • subType

4025 same as subType. See *Section 6.1.1 - DataItem*.

4026 The value of subType **MUST** be one of the DataItemSubTypeEnum enumeration.

4028 • dataItemIdRef

4029 reference to the id associated with this entity.

4030 • units

4031 same as units. See *Section 6.1.1 - DataItem*.

4032 The value of units **MUST** be one of the UnitEnum enumeration.

4033 • compositionIdRef

4034 reference to the id associated with this entity.

4035 • name

4036 name provides additional meaning and differentiates between Specification entities.

4038 • coordinateSystemIdRef

4039 references the CoordinateSystem for geometric Specification elements.

4040 • id

4041 unique identifier for this Specification.

4042 • originator

4043 reference to the creator of the Specification.

4044 OriginatorEnum Enumeration:

4045 – MANUFACTURER

4046 manufacturer of a piece of equipment or Component.

4047 – USER

4048 owner or implementer of a piece of equipment or Component.

4049 **8.7.1.2 Part Properties of Specification**4050 *Table 113* lists the Part Properties of Specification.

Part Property name	Multiplicity
Maximum	0..1
UpperLimit	0..1
LowerWarning	0..1
LowerLimit	0..1
UpperWarning	0..1
Nominal	0..1
Minimum	0..1

Table 113: Part Properties of Specification

4051 Descriptions for Part Properties of Specification:

4052 • Maximum

4053 numeric upper constraint.

4054 • UpperLimit

4055 upper conformance boundary for a variable.

4056 Note: immediate concern or action may be required.

4057 • LowerWarning

4058 lower boundary indicating increased concern and supervision may be required.

4059 • LowerLimit

4060 lower conformance boundary for a variable.

4061 Note: immediate concern or action may be required.

4062 • UpperWarning

4063 upper boundary indicating increased concern and supervision may be required.

4064 • Nominal

4065 numeric target or expected value.

4066 • Minimum

4067 numeric lower constraint.

4068 8.7.2 ProcessSpecification

4069 Specification that provides information used to assess the conformance of a variable
 4070 to process requirements.

4071 8.7.2.1 Part Properties of ProcessSpecification

4072 *Table 114* lists the Part Properties of ProcessSpecification.

Part Property name	Multiplicity
SpecificationLimits	0..1
ControlLimits	0..1
AlarmLimits	0..1

Table 114: Part Properties of ProcessSpecification

4073 Descriptions for Part Properties of ProcessSpecification:

4074 • SpecificationLimits
 4075 set of limits that define a range of values designating acceptable performance for a
 4076 variable.

4077 See *Section 8.7.5 - SpecificationLimits*.

4078 • ControlLimits
 4079 set of limits that is used to indicate whether a process variable is stable and in control.

4080 See *Section 8.7.3 - ControlLimits*.

4081 • AlarmLimits
 4082 set of limits that is used to trigger warning or alarm indicators.

4083 See *Section 8.7.4 - AlarmLimits*.

4084 8.7.3 ControlLimits

4085 set of limits that is used to indicate whether a process variable is stable and in control.

4086 8.7.3.1 Part Properties of ControlLimits

4087 *Table 115* lists the Part Properties of ControlLimits.

Part Property name	Multiplicity
UpperLimit	0..1
UpperWarning	0..1
LowerWarning	0..1
Nominal	0..1
LowerLimit	0..1

Table 115: Part Properties of ControlLimits

4088 Descriptions for Part Properties of ControlLimits:

4089 • UpperLimit
 4090 upper conformance boundary for a variable.
 4091 Note: immediate concern or action may be required.
 4092 • UpperWarning
 4093 upper boundary indicating increased concern and supervision may be required.
 4094 • LowerWarning
 4095 lower boundary indicating increased concern and supervision may be required.
 4096 • Nominal
 4097 numeric target or expected value.
 4098 • LowerLimit
 4099 lower conformance boundary for a variable.
 4100 Note: immediate concern or action may be required.

4101 8.7.4 AlarmLimits

4102 set of limits that is used to trigger warning or alarm indicators.

4103 8.7.4.1 Part Properties of AlarmLimits

4104 *Table 116* lists the Part Properties of AlarmLimits.

Part Property name	Multiplicity
UpperLimit	0..1
UpperWarning	0..1
LowerLimit	0..1
LowerWarning	0..1

Table 116: Part Properties of AlarmLimits

4105 Descriptions for Part Properties of AlarmLimits:

4106 • UpperLimit

4107 upper conformance boundary for a variable.

4108 Note: immediate concern or action may be required.

4109 • UpperWarning

4110 upper boundary indicating increased concern and supervision may be required.

4111 • LowerLimit

4112 lower conformance boundary for a variable.

4113 Note: immediate concern or action may be required.

4114 • LowerWarning

4115 lower boundary indicating increased concern and supervision may be required.

4116 8.7.5 SpecificationLimits

4117 set of limits that define a range of values designating acceptable performance for a variable.

4118 8.7.5.1 Part Properties of SpecificationLimits

4119 *Table 117* lists the Part Properties of SpecificationLimits.

Part Property name	Multiplicity
UpperLimit	0..1
Nominal	0..1
LowerLimit	0..1

Table 117: Part Properties of SpecificationLimits

4120 Descriptions for Part Properties of SpecificationLimits:

4121 • UpperLimit

4122 upper conformance boundary for a variable.

4123 Note: immediate concern or action may be required.

4124 • Nominal

4125 numeric target or expected value.

4126 • LowerLimit

4127 lower conformance boundary for a variable.

4128 Note: immediate concern or action may be required.

4129 8.7.6 UpperWarning

4130 upper boundary indicating increased concern and supervision may be required.

4131 The value of UpperWarning **MUST** be float.

4132 8.7.7 UpperLimit

4133 upper conformance boundary for a variable.

4134 Note: immediate concern or action may be required.

4135 The value of UpperLimit **MUST** be float.

4136 8.7.8 Maximum

4137 numeric upper constraint.

4138 The value of Maximum **MUST** be float.

4139 8.7.9 LowerLimit

4140 lower conformance boundary for a variable.

4141 Note: immediate concern or action may be required.

4142 The value of LowerLimit **MUST** be float.

4143 8.7.10 LowerWarning

4144 lower boundary indicating increased concern and supervision may be required.

4145 The value of LowerWarning **MUST** be float.

4146 8.7.11 Minimum

4147 numeric lower constraint.

4148 The value of Minimum **MUST** be float.

4149 8.7.12 Nominal

4150 numeric target or expected value.

4151 The value of Nominal **MUST** be float.

4152 8.8 ImageFiles

4153 This section provides semantic information for the ImageFile entity.

4154 8.8.1 ImageFile

4155 reference to a file containing an image of the Component.

4156 8.8.1.1 Value Properties of ImageFile

4157 *Table 118* lists the Value Properties of ImageFile.

Value Property name	Value Property type	Multiplicity
id	ID	1
href	string	1
mediaType	string	1
name	string	0..1

Table 118: Value Properties of ImageFile

4158 Descriptions for Value Properties of ImageFile:

4159 • id

4160 unique identifier of the image file.

4161 • href

4162 URL giving the location of the image file.

4163 • mediaType

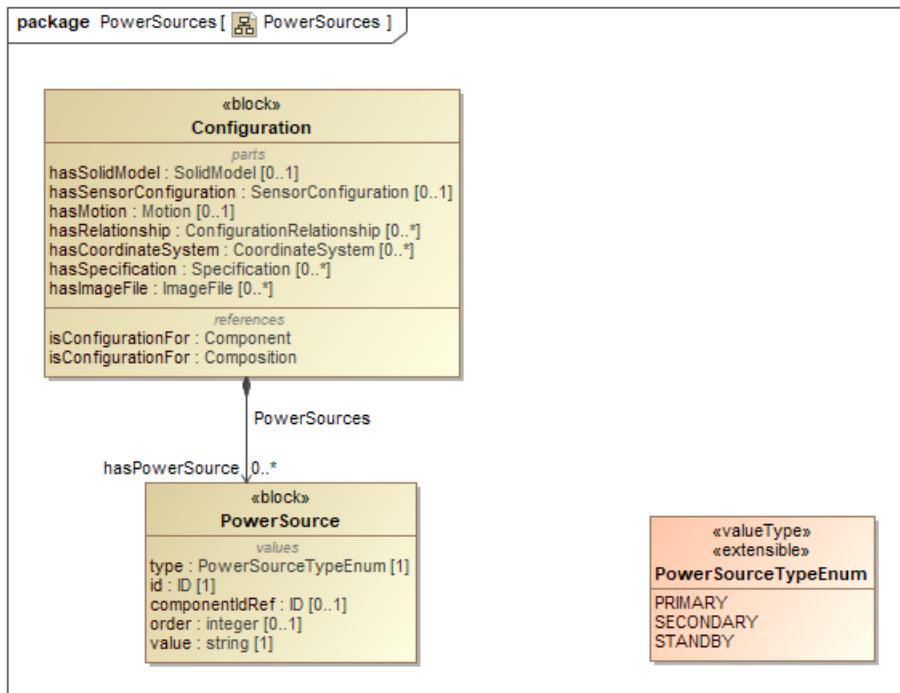
4164 mime type of the image file.

4165 • name

4166 description of the image file.

4167 8.9 PowerSources

4168 This section provides semantic information for the PowerSource entity.

**Figure 23:** PowerSources

4169 8.9.1 PowerSource

4170 potential energy sources for the Component.

4171 The value of `PowerSource` **MUST** be `string`.

4172 8.9.1.1 Value Properties of PowerSource

4173 *Table 119* lists the Value Properties of `PowerSource`.

Value Property name	Value Property type	Multiplicity
<code>type</code>	<code>PowerSourceTypeEnum</code>	1
<code>id</code>	<code>ID</code>	1
<code>componentIdRef</code>	<code>ID</code>	0..1
<code>order</code>	<code>integer</code>	0..1

Table 119: Value Properties of PowerSource

4174 Descriptions for Value Properties of `PowerSource`:

4175 • type
4176 type of the power source.
4177 <<extensible>> PowerSourceTypeEnum Enumeration:
4178 - PRIMARY
4179 main or principle.
4180 - SECONDARY
4181 alternate or not primary.
4182 - STANDBY
4183 held near at hand and ready for use and is uninterruptible.
4184 • id
4185 unique identifier for the power source.
4186 • componentIdRef
4187 reference to the Component providing observations about the power source.
4188 • order
4189 optional precedence for a given power source.

4190 9 Profile

4191 MTConnect Profile is a *profile* that extends the Systems Modeling Language (SysML) metamodel for the MTConnect domain using additional data types and *stereotypes*.

4193 9.1 DataTypes

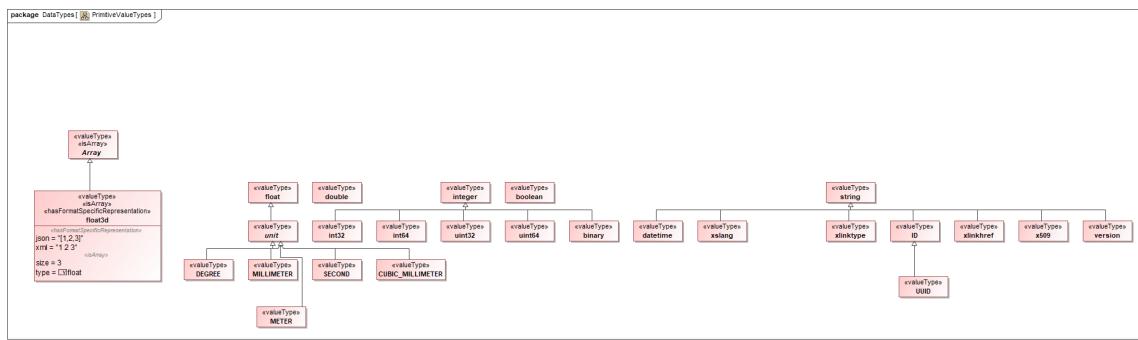


Figure 24: DataTypes

4194 9.1.1 boolean

4195 primitive type.

4196 9.1.2 ID

4197 string that represents an identifier (ID).

4198 9.1.3 string

4199 primitive type.

4200 9.1.4 float

4201 primitive type.

4202 9.1.5 `datetime`

4203 string that represents timestamp in ISO 8601 format.

4204 9.1.6 `integer`

4205 primitive type.

4206 9.1.7 `xlinktype`

4207 string that represents the type of an XLink element. See <https://www.w3.org/TR/xlink11/>.

4209 9.1.8 `xslang`

4210 string that represents a language tag. See <http://www.ietf.org/rfc/rfc4646.txt>.

4212 9.1.9 `SECOND`

4213 float that represents time in seconds.

4214 9.1.10 `xlinkhref`

4215 string that represents the locator attribute of an XLink element. See <https://www.w3.org/TR/xlink11/>.

4217 9.1.11 `x509`

4218 string that represents an x509 data block. *Ref ISO/IEC 9594-8:2020.*

4219 9.1.12 int32

4220 32-bit integer.

4221 9.1.13 int64

4222 64-bit integer.

4223 9.1.14 version

4224 series of three numeric values, separated by a decimal point, representing a *major*, *minor*,
4225 and *patch* number of the MTConnect Standard.

4226 9.1.15 uint32

4227 32-bit unsigned integer.

4228 9.1.16 uint64

4229 64-bit unsigned integer.

4230 9.1.17 binary

4231 base-2 numeral system or binary numeral system represented by two digits: “0” and “1”.

4232 9.1.18 double

4233 primitive type.

4234 9.1.19 Array

4235 array.

4236 9.1.20 <>hasFormatSpecificRepresentation>>float3d

4237 array of size 3 and datatype float.

4238 9.1.21 UUID

4239 Universally Unique IDentifier. *Ref IETF:RFC-4122*

4240 9.1.22 METER

4241 float that represents measurement in meter.

4242 9.2 Stereotypes

4243 9.2.1 organizer

4244 element that *organizes* other elements of a type.

4245 9.2.2 deprecated

4246 element that has been deprecated.

4247 9.2.3 extensible

4248 enumeration that can be extended.

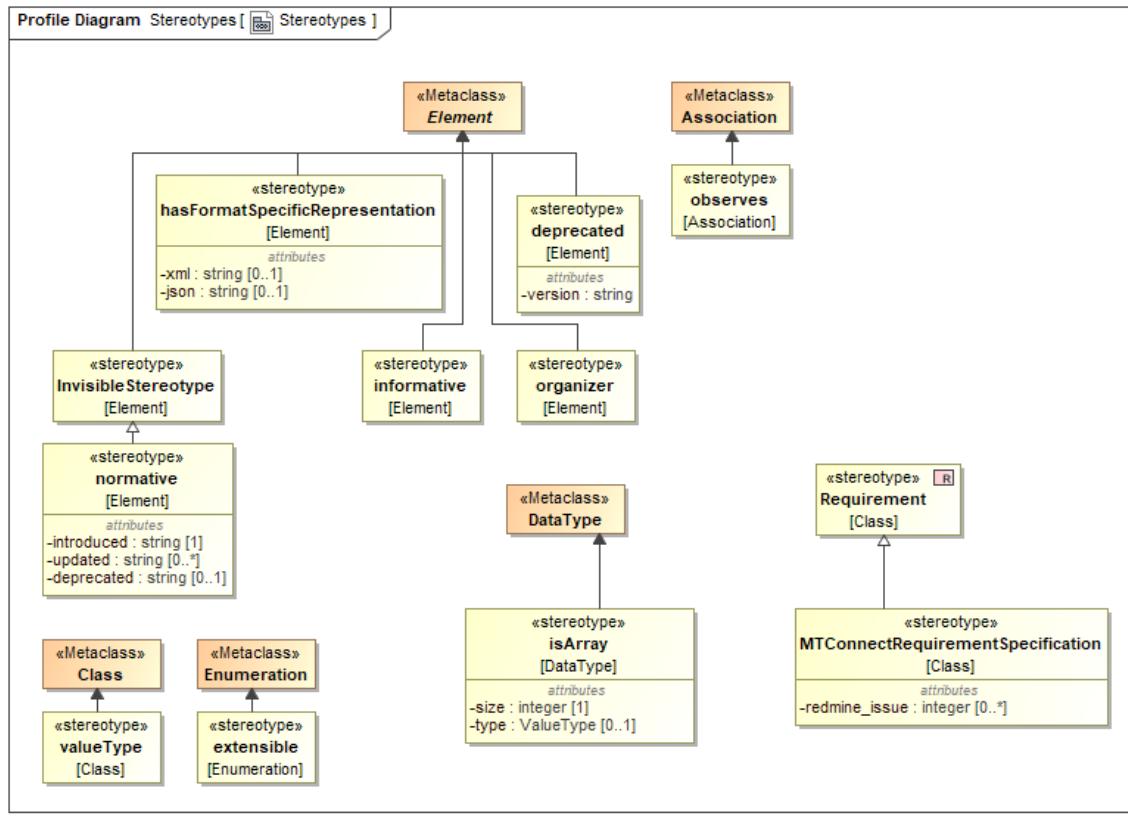


Figure 25: Stereotypes

4249 9.2.4 informative

4250 element that is descriptive and non-normative.

4251 9.2.5 normative

4252 element that has been added to the standard.

4253 9.2.6 observes

4254 association in which a *Component* makes *Observations* about an observable *DataItem*.

4255 **9.2.7 satisfiedBy**

4256 **9.2.8 hasFormatSpecificRepresentation**

4257 element that has format specific representation that might be different from the element's
4258 SysML representation.

4259 **9.2.9 valueType**

4260 extends Class to be used as a SysML <<ValueType>>.

4261 **9.2.10 isArray**

4262 datatype that is an array.

4263 **9.2.11 MTConnectRequirementSpecification**

4264 MTConnect Requirement.

4265 Appendices

4266 A Bibliography

4267 Engineering Industries Association. EIA Standard - EIA-274-D, Interchangeable Variable, 4268 Block Data Format for Positioning, Contouring, and Contouring/Positioning Numerically 4269 Controlled Machines. Washington, D.C. 1979.

4270 ISO TC 184/SC4/WG3 N1089. ISO/DIS 10303-238: Industrial automation systems and 4271 integration Product data representation and exchange Part 238: Application Protocols: Ap- 4272 plication interpreted model for computerized numerical controllers. Geneva, Switzerland, 4273 2004.

4274 International Organization for Standardization. ISO 14649: Industrial automation sys- 4275 tems and integration – Physical device control – Data model for computerized numerical 4276 controllers – Part 10: General process data. Geneva, Switzerland, 2004.

4277 International Organization for Standardization. ISO 14649: Industrial automation sys- 4278 tems and integration – Physical device control – Data model for computerized numerical 4279 controllers – Part 11: Process data for milling. Geneva, Switzerland, 2000.

4280 International Organization for Standardization. ISO 6983/1 – Numerical Control of ma- 4281 chines – Program format and definition of address words – Part 1: Data format for posi- 4282 tioning, line and contouring control systems. Geneva, Switzerland, 1982.

4283 Electronic Industries Association. ANSI/EIA-494-B-1992, 32 Bit Binary CL (BCL) and 4284 7 Bit ASCII CL (ACL) Exchange Input Format for Numerically Controlled Machines. 4285 Washington, D.C. 1992.

4286 National Aerospace Standard. Uniform Cutting Tests - NAS Series: Metal Cutting Equip- 4287 ment Specifications. Washington, D.C. 1969.

4288 International Organization for Standardization. ISO 10303-11: 1994, Industrial automa- 4289 tion systems and integration Product data representation and exchange Part 11: Descrip- 4290 tion methods: The EXPRESS language reference manual. Geneva, Switzerland, 1994.

4291 International Organization for Standardization. ISO 10303-21: 1996, Industrial automa- 4292 tion systems and integration – Product data representation and exchange – Part 21: Imple- 4293 mentation methods: Clear text encoding of the exchange structure. Geneva, Switzerland, 4294 1996.

4295 H.L. Horton, F.D. Jones, and E. Oberg. Machinery's Handbook. Industrial Press, Inc.

4296 New York, 1984.

4297 International Organization for Standardization. ISO 841-2001: Industrial automation sys-
4298 tems and integration - Numerical control of machines - Coordinate systems and motion
4299 nomenclature. Geneva, Switzerland, 2001.

4300 ASME B5.57: Methods for Performance Evaluation of Computer Numerically Controlled
4301 Lathes and Turning Centers, 1998.

4302 ASME/ANSI B5.54: Methods for Performance Evaluation of Computer Numerically Con-
4303 trolled Machining Centers. 2005.

4304 OPC Foundation. OPC Unified Architecture Specification, Part 1: Concepts Version 1.00.
4305 July 28, 2006.

4306 IEEE STD 1451.0-2007, Standard for a Smart Transducer Interface for Sensors and Ac-
4307 tuators – Common Functions, Communication Protocols, and Transducer Electronic Data
4308 Sheet (TEDS) Formats, IEEE Instrumentation and Measurement Society, TC-9, The In-
4309 stitute of Electrical and Electronics Engineers, Inc., New York, N.Y. 10016, SH99684,
4310 October 5, 2007.

4311 IEEE STD 1451.4-1994, Standard for a Smart Transducer Interface for Sensors and Ac-
4312 tuators – Mixed-Mode Communication Protocols and Transducer Electronic Data Sheet
4313 (TEDS) Formats, IEEE Instrumentation and Measurement Society, TC-9, The Institute of
4314 Electrical and Electronics Engineers, Inc., New York, N.Y. 10016, SH95225, December
4315 15, 2004.

4316 **B XML Schema Diagrams**

4317 See XML schemas for the MTConnect standard here: <https://schemas.mtconnect.org/>.

4319 **B.1 Components Schema Diagrams**

4320 See **Components** element in MTConnectDevices schema.

4321 See **Description** element in MTConnectDevices schema.

4322 **B.2 DataItems Schema Diagrams**

4323 See **DataItems** element in MTConnectDevices schema.

4324 See **Source** element in MTConnectDevices schema.

4325 See **Constraints** element in MTConnectDevices schema.

4326 See **Filter** element in MTConnectDevices schema.

4327 See **Definition** element in MTConnectDevices schema.

4328 **B.3 References Schema Diagrams**

4329 See **References** element in MTConnectDevices schema.

4330 See **ComponentRef** element in MTConnectDevices schema.

4331 See **DataItemRef** element in MTConnectDevices schema.

4332 **B.4 Configuration Schema Diagrams**

4333 See **Configuration** element in MTConnectDevices schema.

4334 See **CoordinateSystem** element in MTConnectDevices schema.

4335 See Motion element in MTConnectDevices schema.

4336 See Relationships element in MTConnectDevices schema.

4337 See ComponentRelationship element in MTConnectDevices schema.

4338 See DeviceRelationship element in MTConnectDevices schema.

4339 See SensorConfiguration element in MTConnectDevices schema.

4340 See SolidModel element in MTConnectDevices schema.

4341 See Specifications element in MTConnectDevices schema.

4342 See ProcessSpecification element in MTConnectDevices schema.

4343 C XML Examples

4344 C.1 Device Entity Hierarchy Example

Example 3: Device Entity Hierarchy Example

```

4345 1 <Devices>
4346 2   <Device id="d1" name="M12346" uuid="M80104K162N">
4347 3     <Components>
4348 4       <Axes id="a" name="base">
4349 5         <Components>
4350 6           <Linear id="x" name="X"/>
4351 7           <Linear id="y" name="Y"/>
4352 8           <Linear id="z" name="Z"/>
4353 9           <Rotary id="ar" name="B"/>
4354 10          <Linear id="w" name="Z3" nativeName="W"/>
4355 11          <Rotary id="c" name="C"/>
4356 12        </Components>
4357 13      </Axes>
4358 14      <Controller id="cont" name="controller">
4359 15        <Components>
4360 16          <Path id="path1" name="path"/>
4361 17        </Components>
4362 18      </Controller>
4363 19      <Door id="door1" name="door"/>
4364 20      <Systems id="systems" name="systems">
4365 21        <Components>
4366 22          <WorkEnvelope id="wel" name="workenv">
4367 23            <Compositions>
4368 24              <Composition type="WORKPIECE" id="wp"/>

```

```

4369 25      <Composition type="TABLE" id="tbl"/>
4370 26      </Compositions>
4371 27      </WorkEnvelope>
4372 28      <Electric id="elec" name="electric"/>
4373 29      <Hydraulic id="hydraulic" name="hydraulic"/>
4374 30      <Coolant id="coolant" name="coolant"/>
4375 31      <Pneumatic id="pneumatic" name="pneumatic"/>
4376 32      <Lubrication id="lubrication" name="lubrication"/>
4377 33      </Components>
4378 34      </Systems>
4379 35      <Auxiliaries id="Aux" name="auxiliaries">
4380 36      <Components>
4381 37          <Environmental id="room" name="environmental"/>
4382 38      </Components>
4383 39      </Auxiliaries>
4384 40      <Resources id="resources" name="resources">
4385 41      <Components>
4386 42          <Personnel id="personnel" name="personnel"/>
4387 43          <Materials id="materials" name="materials">
4388 44          <Components>
4389 45              <Stock id="procstock" name="stock"/>
4390 46          </Components>
4391 47          <Materials/>
4392 48      </Components>
4393 49      </Resources>
4394 50      </Components>
4395 51      </Device>
4396 52  </Devices>

```

4397 C.2 Component Example

Example 4: Component Example

```

4398 1  <Devices>
4399 2      <Device id="d1" name="M12346" uuid="M80104K162N">
4400 3          <Description manufacturer="Example\textunderscore_Corporation"
4401 4              serialNumber="272237"> Mill w/SMooth-G
4402 5          </Description>
4403 6          <DataItems>
4404 7              <DataItem category="EVENT" id="avail" name="avail" type="AVAILABILITY"/>
4405 8              <DataItem category="EVENT" id="d1\textunderscore_asset\textunderscore_chg"
4406 9                  name="asset\textunderscore_chg" type="ASSET\textunderscore_CHANGED"/>
4407 10             <DataItem category="EVENT" id="d1\textunderscore_asset\textunderscore_rem"
4408 11                 name="asset\textunderscore_rem" type="ASSET\textunderscore_Removed"/>
4409 12         </DataItems>

```

```

4413 11      <Components>
4414 12        <Controller id="cont" name="controller">
4415 13          <DataItems>
4416 14            <DataItem category="EVENT" id="estop" name="estop" type="EMERGENCY\textunderscore_STOP"/>
4417 15            <DataItem category="CONDITION" id="logic\textunderscore_cond" type="LOGIC\textunderscore_PROGRAM"/>
4418 16            <DataItem category="CONDITION" id="cont\textunderscore_system" type="SYSTEM"/>
4419 17            <DataItem category="SAMPLE" id="cut\textunderscore_time" type="ACCUMULATED\textunderscore_TIME" units="SECOND"/>
4420 18        </DataItems>
4421 19        <Components>
4422 20          <Path id="path1" name="path">
4423 21            <DataItems>
4424 22              <DataItem category="EVENT" id="execution" name="execution" type="EXECUTION"/>
4425 23              <DataItem category="SAMPLE" id="cspeed" subType="ACTUAL" type="CUTTING\textunderscore_SPEED" units="MILLIMETER/SECOND"/>
4426 24              <DataItem category="CONDITION" id="path\textunderscore_system" type="SYSTEM"/>
4427 25              <DataItem category="EVENT" id="cvars" representation="DATA\textunderscore_SET" type="VARIABLE"/>
4428 26              <DataItem category="EVENT" id="woffset" representation="TABLE" type="WORK\textunderscore_OFFSET"/>
4429 27            </DataItems>
4430 28          </Path>
4431 29        </Components>
4432 30        </Controller>
4433 31      </Components>
4434 32      </Device>
4435 33  </Devices>

```

4446 C.3 Component with Compositions Example

4447 In XML, Composition types are represented differently than Component types. For
 4448 Component types, the element name is Pascal Case of the Component type name.
 4449 Whereas, the element name for all Composition types is Composition and the type
 4450 is defined by the type attribute of the element (see example below).

Example 5: Component with Compositions Example

```

4451 1  <WorkEnvelope id="wel" name="workenv">
4452 2    <DataItems>
4453 3      <DataItem category="CONDITION" id="hardware1" name="hardware1" type="HARDWARE"/>
4454 4    </DataItems>

```

```

4456 5   <Compositions>
4457 6     <Composition type="WORKPIECE" id="wp"/>
4458 7     <Composition type="TABLE" id="tbl"/>
4459 8   </Compositions>
4460 9 </WorkEnvelope>

```

4461 C.4 CoordinateSystem Example

Example 6: CoordinateSystem Example

```

4462 1 <Devices>
4463 2   <Device id="d1" name="M12346" uuid="M80104K162N">
4464 3     <Description manufacturer="Example\textunderscore_Corporation"
4465 4       serialNumber="272237"> Mill w/Smooth-G
4466 5     </Description>
4467 6     <DataItems>
4468 7       <DataItem id="avail" type="AVAILABILITY" category="EVENT"/>
4469 8       <DataItem category="EVENT" id="d1\textunderscore_asset\
4470 9         textunderscore_chg" name="asset\textunderscore_chg" type=""
4471 10      ASSET\textunderscore_CHANGED"/>
4472 11       <DataItem category="EVENT" id="d1\textunderscore_asset\
4473 12         textunderscore_rem" name="asset\textunderscore_rem" type=""
4474 13         ASSET\textunderscore_Removed"/>
4475 14     </DataItems>
4476 15   <Configuration>
4477 16     <CoordinateSystems>
4478 17       <CoordinateSystem id="base" type="BASE">
4479 18         <Origin>0 0 0</Origin>
4480 19       </CoordinateSystem>
4481 20       <CoordinateSystem id="machcoord" type="MACHINE" parentIdRef=
4482 21         "base">
4483 22         <Transformation>
4484 23           <Translation>210 275 1430</Translation>
4485 24           <Rotation>0 0 0</Rotation>
4486 25         </Transformation>
4487 26       </CoordinateSystem>
4488 27       <CoordinateSystem id="workcoord" type="OBJECT" parentIdRef=
4489 28         "machcoord">
4490 29         <Transformation>
4491 30           <Translation>0 0 0</Translation>
4492 31           <Rotation>0 0 0</Rotation>
4493 32         </Transformation>
4494 33       </CoordinateSystem>
4495 34     </CoordinateSystems>
4496 35   </Configuration>
4497 36   </Device>
4498 37 </Devices>

```

4499 C.5 Motion Example

Example 7: Motion Example

```

4500 1 <Devices>
4501 2   <Device id="d1" name="M12346" uuid="M80104K162N">
4502 3     <Description manufacturer="Example\textunderscore_Corporation"
4503 4       serialNumber="272237" Mill w/SMooth-G
4504 5     </Description>
4505 6     <DataItems>
4506 7       <DataItem id="avail" type="AVAILABILITY" category="EVENT"/>
4507 8       <DataItem category="EVENT" id="d1\textunderscore_asset\
4508 9         textunderscore_chg" name="asset\textunderscore_chg" type="ASSET\textunderscore_CHANGED"/>
4509 10      <DataItem category="EVENT" id="d1\textunderscore_asset\
4510 11        textunderscore_rem" name="asset\textunderscore_rem" type="ASSET\textunderscore_Removed"/>
4511 12     </DataItems>
4512 13   <Configuration>
4513 14     <CoordinateSystems>
4514 15       <CoordinateSystem id="base" type="BASE">
4515 16         <Origin>0 0 0</Origin>
4516 17       </CoordinateSystem>
4517 18       <CoordinateSystem id="machcoord" type="MACHINE" parentIdRef=
4518 19         "base">
4519 20         <Transformation>
4520 21           <Translation>210 275 1430</Translation>
4521 22           <Rotation>0 0 0</Rotation>
4522 23         </Transformation>
4523 24       </CoordinateSystem>
4524 25       <CoordinateSystem id="workcoord" type="OBJECT" parentIdRef=
4525 26         "machcoord">
4526 27         <Transformation>
4527 28           <Translation>0 0 0</Translation>
4528 29           <Rotation>0 0 0</Rotation>
4529 30         </Transformation>
4530 31       </CoordinateSystem>
4531 32     </CoordinateSystems>
4532 33   </Configuration>
4533 34   <Components>
4534 35     <Axes id="a" name="base">
4535 36       <Components>
4536 37         <Linear id="x" name="X">
4537 38           <Configuration>
4538 39             <Motion id="xmotion" coordinateSystemIdRef="machcoord"
4539 40               type="PRISMATIC" actuation="DIRECT">
4540 41               <Transformation>
4541 42                 <Translaton>300 915 590</Translaton>
4542 43                 <Rotation>0 0 0</Rotation>
4543 44               </Transformation>
4544 45             <Axis>1.0 0 0</Axis>
4545 46

```

```

4547 41          </Motion>
4548 42          </Configuration>
4549 43      </Linear>
4550 44      <DataItems>
4551 45          <DataItem id="xtravel" type="SYSTEM" category="CONDITION"
4552 46      ">
4553 46          </DataItems>
4554 47      </Components>
4555 48          </Axes>
4556 49      </Components>
4557 50      </Device>
4558 51  </Devices>

```

4559 C.6 Relationship Example

Example 8: Relationship Example

```

4560 1  <Components>
4561 2      <Axes id="a" name="base">
4562 3          <Components>
4563 4              <Linear id="x" name="X">
4564 5                  <Configuration>
4565 6                      <Relationships>
4566 7                          <ComponentRelationship id="xpar" type="PARENT" idRef="
4567  we1"/>
4568 8                  </Relationships>
4569 9          </Configuration>
4570 10         </Linear>
4571 11         <DataItems>
4572 12             <DataItem id="xtravel" type="SYSTEM" category="CONDITION">
4573 13         </DataItems>
4574 14     </Components>
4575 15 </Axes>
4576 16 <Systems id="systems" name="systems">
4577 17     <Components>
4578 18         <WorkEnvelope id="we1" name="workenv">
4579 19             <Compositions>
4580 20                 <Composition type="WORKPIECE" id="wp"/>
4581 21                 <Composition type="TABLE" id="tbl"/>
4582 22             </Compositions>
4583 23             <DataItems>
4584 24                 <DataItem id="we1cond" type="SYSTEM" category="CONDITION">
4585 25                 </DataItems>
4586 26             </WorkEnvelope>
4587 27     </Components>
4588 28 </Systems>
4589 29 </Components>

```

4590 **C.7 SolidModel Example****Example 9:** SolidModel Example

```

4591 1 <Devices>
4592 2   <Device id="d1" name="M12346" uuid="M80104K162N">
4593 3     <Description manufacturer="Example\textunderscore_Corporation"
4594 4       serialNumber="272237" Mill w/SMooth-G
4595 5     </Description>
4596 6     <DataItems>
4597 7       <DataItem id="avail" type="AVAILABILITY" category="EVENT"/>
4598 8       <DataItem category="EVENT" id="d1\textunderscore_asset\
4599 9         textunderscore_chg" name="asset\textunderscore_chg" type=""
4600 10      ASSET\textunderscore_CHANGED"/>
4601 11      <DataItem category="EVENT" id="d1\textunderscore_asset\
4602 12        textunderscore_rem" name="asset\textunderscore_rem" type=""
4603 13        ASSET\textunderscore_Removed"/>
4604 14     </DataItems>
4605 15     <Configuration>
4606 16       <CoordinateSystems>
4607 17         <CoordinateSystem id="base" type="BASE">
4608 18           <Origin>0 0 0</Origin>
4609 19         </CoordinateSystem>
4610 20         <CoordinateSystem id="machcoord" type="MACHINE" parentIdRef=
4611 21           "base">
4612 22           <Transformation>
4613 23             <Translation>210 275 1430</Translation>
4614 24             <Rotation>0 0 0</Rotation>
4615 25           </Transformation>
4616 26         </CoordinateSystem>
4617 27         <CoordinateSystem id="workcoord" type="OBJECT" parentIdRef=""
4618 28           machcoord">
4619 29           <Transformation>
4620 30             <Translation>0 0 0</Translation>
4621 31             <Rotation>0 0 0</Rotation>
4622 32           </Transformation>
4623 33         </CoordinateSystem>
4624 34       </CoordinateSystems>
4625 35     </Configuration>
4626 36     <Components>
4627 37       <Structures id="struct">
4628 38         <Configuration>
4629 39           <SolidModel id="model" mediaType="OBJ" href="/objs/mazak.
4630 40             obj" coordinateSystemIdRef="base">
4631 41               <Transformation>
4632 42                 <Translation>0 860 0</Translation>
4633 43                 <Rotation>-90 0 0</Rotation>
4634 44               </Transformation>
4635 45               <Scale>0.001 0.001 0.001</Scale>
4636 46             </SolidModel>
4637 47           </Configuration>

```

```

4638 41      <Components>
4639 42          <Structure id="xaxis" name="X\textunderscore_AXIS">
4640 43              <Configuration>
4641 44                  <SolidModel id="x\textunderscore_model" mediaType="OBJ"
4642 " itemRef="xaxis" solidModelIdRef="model" coordinateSystemIdRef="
4643 base"/>
4644 45          </Configuration>
4645 46          <DataItems>
4646 47              <DataItem type="SYSTEM" category="CONDITION" id="
4647 struct\textunderscore_cond"/>
4648 48          </DataItems>
4649 49          </Structure>
4650 50      </Components>
4651 51      </Structures>
4652 52  </Components>
4653 53  </Device>
4654 54 </Devices>

```

4655 C.8 Specification Example

Example 10: Specification Example

```

4656 1  <Components>
4657 2      <Axes id="a" name="base">
4658 3          <Components>
4659 4              <Linear id="x" name="X">
4660 5                  <Configuration>
4661 6                      <Specifications>
4662 7                          <Specification id="spec001" type="LENGTH" units="
4663 MILLIMETER">
4664 8                              <Nominal>650</Nominal>
4665 9                          </Specification>
4666 10                     <Specification id="spec002" type="LINEAR\textunderscore_
4667 FORCE" units="NEWTON">
4668 11                         <Maximum>5200</Maximum>
4669 12                         <Minimum>0</Minimum>
4670 13                     </Specification>
4671 14                 </Specifications>
4672 15             </Configuration>
4673 16             <DataItems>
4674 17                 <DataItem id="xtravel" type="SYSTEM" category="CONDITION">
4675 18                     </DataItems>
4676 19             </Linear>
4677 20         </Components>
4678 21     </Axes>
4679 22 </Components>

```

4680 **C.9 Example of sensing element provided as data item associated with**
 4681 **a Component**

Example 11: Example of sensing element provided as data item associated with a Component

```
4682 1 <Components>
4683 2   <Axes id="a" name="base"
4684 3     <Components>
4685 4       <Rotary id="c" name="C">
4686 5         <DataItems>
4687 6           <DataItem type="TEMPERATURE" id="servotemp4"
4688 7             category="SAMPLE" nativeUnits="CELSIUS"
4689 8             compositionId="Bmotor" units="CELSIUS"/>
4690 9         </DataItems>
4691 10       </Rotary>
4692 11     </Components>
4693 12   </Axes>
4694 13 </Components>
```

4695 **C.10 Example of Sensor for rotary axis**

Example 12: Example of Sensor for rotary axis

```
4696 1 <Components>
4697 2   <Axes id="a" name="base"
4698 3     <Components>
4699 4       <Rotary id="ar" name="B">
4700 5         <Components>
4701 6           <Sensor id="spdlm" name="Spindlemonitor">
4702 7             <DataItems>
4703 8               <DataItem type="DISPLACEMENT" id="cvib"
4704 9                 category="SAMPLE" name="Svib"
4705 10                units="MILLIMETER"/>
4706 11             </DataItems>
4707 12           </Sensor >
4708 13         <Components>
4709 14       </Rotary>
4710 15     </Components>
4711 16   </Axes>
4712 17 </Components>
```

4713 **C.11 Example of sensor unit with sensing element**

Example 13: Example of sensor unit with sensing element

```

4714 1  <Axes id="a" name="base"
4715 2    <Components>
4716 3      <Sensor id="sens1" name="Sensorunit">
4717 4        <DataItems>
4718 5          <DataItem type="TEMPERATURE" id="sentemp"
4719 6            category="SAMPLE" name="Sensortemp"
4720 7            units="CELSIUS"/>
4721 8        </DataItems>
4722 9      </Sensor >
4723 10     <Linear id="x" name="X">
4724 11       <DataItems>
4725 12         <DataItem type="DISPLACEMENT" id="xvib"
4726 13           category="SAMPLE" name="xvib"
4727 14           units="MILLIMETER">
4728 15             <Source componentId="sens1"/>
4729 16         </DataItem>
4730 17       </DataItems>
4731 18     </Rotary>
4732 19     <Linear id="y" name="Y">
4733 20       <DataItems>
4734 21         <DataItem type="DISPLACEMENT" id="yvib"
4735 22           category="SAMPLE" name="yvib"
4736 23           units="MILLIMETER">
4737 24             <Source componentId="sens1"/>
4738 25         </DataItem>
4739 26       </DataItems>
4740 27     </Linear>
4741 28   <Components>
4742 29 </Axes>

```

4743 C.12 Example of configuration data for Sensor**Example 14:** Example of configuration data for Sensor

```

4744 1  <Sensor id="sensor" name="sensor">
4745 2    <Configuration>
4746 3      <SensorConfiguration>
4747 4        <FirmwareVersion>2.02</FirmwareVersion>
4748 5        <CalibrationDate>2010-05-16</CalibrationDate>
4749 6        <NextCalibrationDate>2010-05-16</NextCalibrationDate>
4750 7        <CalibrationInitials>WS</CalibrationInitials>
4751 8      <Channels>
4752 9        <Channel number="1" name="A/D:1">
4753 10          <Description>A/D With Thermister</Description>
4754 11        </Channel>
4755 12      </Channels>
4756 13    </SensorConfiguration>

```

```
4757 14  </Configuration>
4758 15  <DataItems>
4759 16  <DataItem category="CONDITION" id="sensorc"
4760 17  name="sensorc" type="SYSTEM" />
4761 18  <DataItem category="SAMPLE" id="senv" name="sensorc"
4762 19  type="VOLTAGE\textunderscore_DC" units="VOLT" subType="ACTUAL"
4763 20  />
4764 20  </DataItems>
4765 21  </Sensor>
```