



# **MTConnect<sup>®</sup> Standard**

## **Part 5.0 – Interface Interaction Model**

### **Version 2.5.0**

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## 1 1 Purpose of This Document

2 This document, *MTConnect Standard: Part 5.0 - Interface Interaction Model* of the MT-  
3 Connect Standard, defines a structured data model used to organize information required  
4 to coordinate inter-operations between pieces of equipment.

5 This data model is based on an *interaction model* that defines the exchange of information  
6 between pieces of equipment and is organized in the MTConnect Standard by Inter-  
7 faces.

8 *Interfaces* is modeled as an extension to the *Device Information Model* and *Observa-*  
9 *tion Information Model*. *Interfaces* leverages similar rules and terminology as those  
10 used to describe a component in the *Device Information Model*. *Interfaces* also uses  
11 similar methods for reporting data to those used in the *MTConnectStreams Response Doc-*  
12 *ument*.

13 As defined in *MTConnect Standard: Part 2.0 - Device Information Model*, *Interfaces*  
14 *organizes* the *Interface* types (see Figure 3). Each individual *Interface* contains  
15 data associated with the corresponding *interface*.

16 Note: See *MTConnect Standard: Part 2.0 - Device Information Model* and  
17 *MTConnect Standard: Part 3.0 - Observation Information Model* of the MT-  
18 Connect Standard for information on how *Interfaces* is structured in the  
19 *response documents* which are returned from an *agent* in response to a *probe*  
20 *request*, *sample request*, or *current request*.



## 21 2 Terminology and Conventions

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

### 24 2.1 MTConnect References

- 25 [MTConnect Part 1.0] *MTConnect Standard Part 1.0 - Fundamentals*. Version 2.0.
- 26 [MTConnect Part 2.0] *MTConnect Standard: Part 2.0 - Device Information Model*. Ver-  
27 sion 2.0.
- 28 [MTConnect Part 3.0] *MTConnect Standard: Part 3.0 - Observation Information Model*.  
29 Version 2.0.
- 30 [MTConnect Part 5.0] *MTConnect Standard: Part 5.0 - Interface Interaction Model*. Ver-  
31 sion 2.0.

32

### 33 3 Interface Interaction Model

34 In many manufacturing processes, multiple pieces of equipment must work together to  
 35 perform a task. The traditional method for coordinating the activities between individual  
 36 pieces of equipment is to connect them using a series of wires to communicate equipment  
 37 states and demands for action. These interactions use simple binary ON/OFF signals to  
 38 accomplished their intention.

39 In the MTConnect Standard, *interfaces* provides a means to replace this traditional method  
 40 for interconnecting pieces of equipment with a structured *interaction model* that provides  
 41 a rich set of information used to coordinate the actions between pieces of equipment. Im-  
 42 plementers may utilize the information provided by this data model to (1) realize the inter-  
 43 action between pieces of equipment and (2) to extend the functionality of the equipment  
 44 to improve the overall performance of the manufacturing process.

45 The *interaction model* used to implement *interfaces* provides a lightweight and efficient  
 46 protocol, simplifies failure recovery scenarios, and defines a structure for implementing a  
 47 Plug-And-Play relationship between pieces of equipment. By standardizing the informa-  
 48 tion exchange using this higher-level semantic information model, an implementer may  
 49 more readily replace a piece of equipment in a manufacturing system with any other piece  
 50 of equipment capable of providing similar *interaction model* functions.

51 Two primary functions are required to implement the *interaction model* for an *interfaces*  
 52 and manage the flow of information between pieces of equipment. Each piece of equip-  
 53 ment needs to have the following:

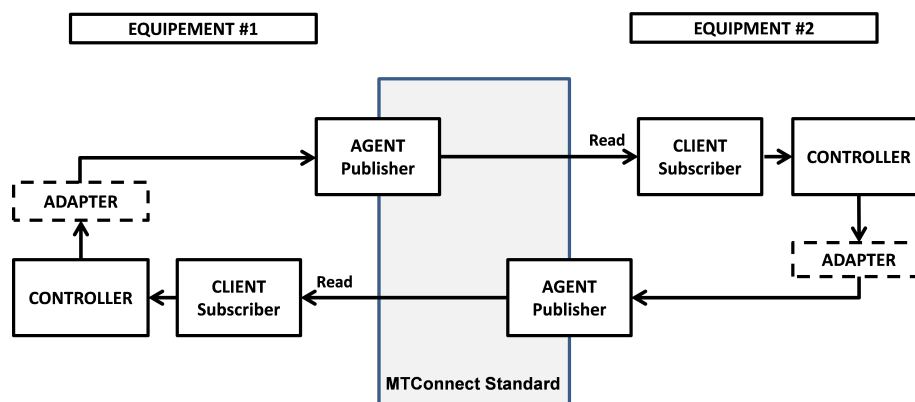
- 54 • An *agent* which provides:
- 55 • The data required to implement the *interaction model*.
- 56 • Any other data from a piece of equipment needed to implement the *interface* – op-  
 57 erating states of the equipment, position information, execution modes, process in-  
 58 formation, etc.
- 59 • A client software application that enables the piece of equipment to acquire and  
 60 interpret information from another piece of equipment.

#### 61 3.1 Interfaces Architecture

62 MTConnect Standard is based on a communications method that provides no direct way  
 63 for one piece of equipment to change the state of or cause an action to occur in another

64 piece of equipment. The *interaction model* used to implement *interfaces* is based on a  
 65 *publish and subscribe* type of communications as described in *MTConnect Standard Part*  
 66 *1.0 - Fundamentals* and utilizes a *request* and *response* information exchange mechanism.  
 67 For *interfaces*, pieces of equipment must perform both the publish (*agent*) and subscribe  
 68 (*client*) functions.

69 Note: The current definition of *interfaces* addresses the interaction between  
 70 two pieces of equipment. Future releases of the MTConnect Standard may  
 71 address the interaction between multiple (more than two) pieces of equipment.



**Figure 1:** Data Flow Architecture for Interfaces

72 Note: The data flow architecture illustrated in Figure 1 was historically re-  
 73 ferred to in the MTConnect Standard as a read-read concept.

74 In the implementation of the *interaction model* for *interfaces*, two pieces of equipment  
 75 can exchange information in the following manner. One piece of equipment indicates a  
 76 *request* for service by publishing a type of *request* using a data item provided through  
 77 an *agent* as defined in *Section 4.3 - DataItem Types for Interface*. The client associated  
 78 with the second piece of equipment, which is subscribing to data from the first machine,  
 79 detects and interprets that *request*. If the second machine chooses to take any action to  
 80 fulfill this *request*, it can indicate its acceptance by publishing a *response* using a data  
 81 item provided through its *agent*. The client on the first piece of equipment continues to  
 82 monitor information from the second piece of equipment until it detects an indication that  
 83 the *response* to the *request* has been completed or has failed.

84 An example of this type of interaction between pieces of equipment can be represented  
 85 by a machine tool that wants the material to be loaded by a robot. In this example, the  
 86 machine tool is the *requester*, and the robot is the *responder*. On the other hand, if the  
 87 robot wants the machine tool to open a door, the robot becomes the *requester* and the  
 88 machine tool the *responder*.

## 89 3.2 Request and Response Information Exchange

90 The `DataItem` elements defined by the *interaction model* each have a `REQUEST` and  
 91 `RESPONSE` subtype. These subtypes identify if the data item represents a *request* or a  
 92 *response*. Using these data items, a piece of equipment changes the state of its *request* or  
 93 *response* to indicate information that can be read by the other piece of equipment. To aid  
 94 in understanding how the *interaction model* functions, one can view this *interaction model*  
 95 as a simple state machine.

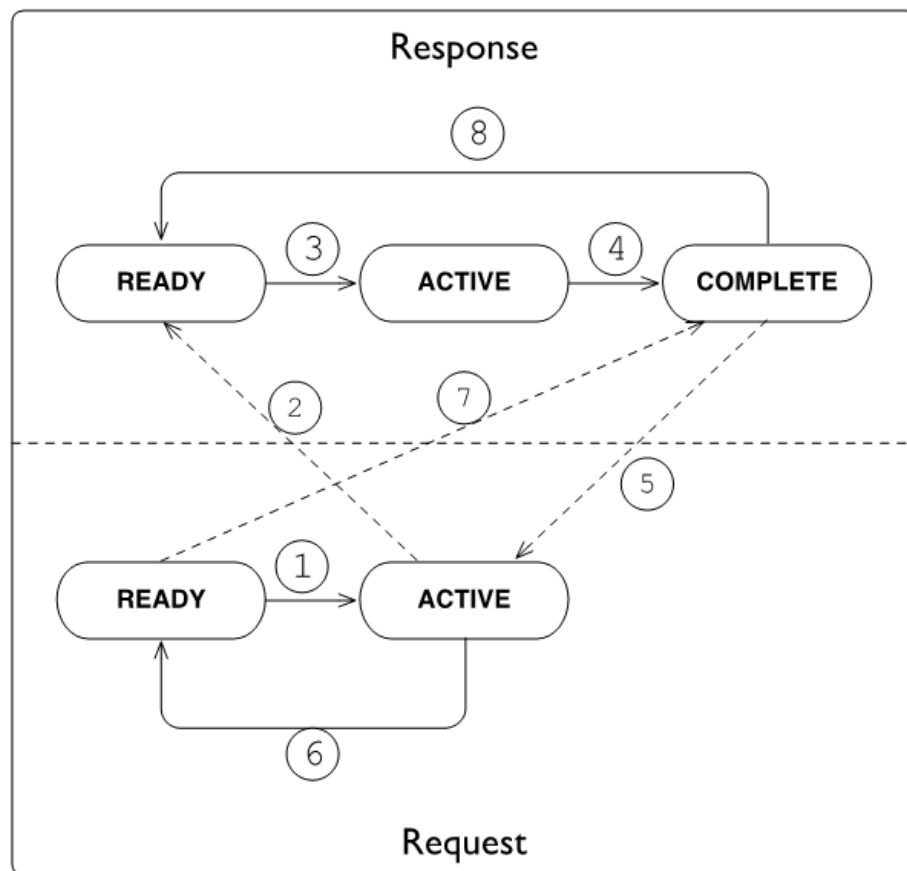
96 The interaction between two pieces of equipment can be described as follows. When the  
 97 *requester* wants an activity to be performed, it transitions its *request* state from a `READY`  
 98 state to an `ACTIVE` state. In turn, when the client on the *responder* reads this information  
 99 and interprets the *request*, the *responder* announces that it is performing the requested  
 100 task by changing its response state to `ACTIVE`. When the action is finished, the *responder*  
 101 changes its response state to `COMPLETE`. This pattern of *request* and *response* provides  
 102 the basis for the coordination of actions between pieces of equipment. These actions are  
 103 implemented using `EVENT` category data items. (See *Section 4.3 - DataItem Types for*  
 104 *Interface* for details on the `Event` type data items defined for *interfaces*.)

105       Note: The implementation details of how the *responder* piece of equipment  
 106       reacts to the *request* and then completes the requested task are up to the im-  
 107       plementer.

108 The initial condition of both the *request* and *response* states on both pieces of equipment  
 109 is `READY`. The dotted lines indicate the on-going communications that occur to monitor  
 110 the progress of the interactions between the pieces of equipment.

111 The interaction between the pieces of equipment as illustrated in Figure 2 progresses  
 112 through the sequence listed below.

- 113       • The *request* transitions from `READY` to `ACTIVE` signaling that a service is needed.
- 114       • The *response* detects the transition of the *request*.
- 115       • The *response* transitions from `READY` to `ACTIVE` indicating that it is performing  
 116       the action.
- 117       • Once the action has been performed, the *response* transitions to `COMPLETE`.
- 118       • The *request* detects the action is `COMPLETE`.
- 119       • The *request* transitions back to `READY` acknowledging that the service has been  
 120       performed.



**Figure 2: Request and Response Overview**

- 121 • The *response* detects the *request* has returned to **READY**.
- 122 • In recognition of this acknowledgement, the *response* transitions back to **READY**.
- 123 After the final action has been completed, both pieces of equipment are back in the **READY**
- 124 state indicating that they are able to perform another action.

### 125 3.3 Interface

- 126 abstract `Component` that coordinates actions and activities between pieces of equipment.

### 127 3.3.1 Commonly Observed DataItem Types for Interface

128 *Table 1* lists the Commonly Observed DataItem Types for Interface.

Commonly Observed DataItem Types	Multiplicity
InterfaceState	1

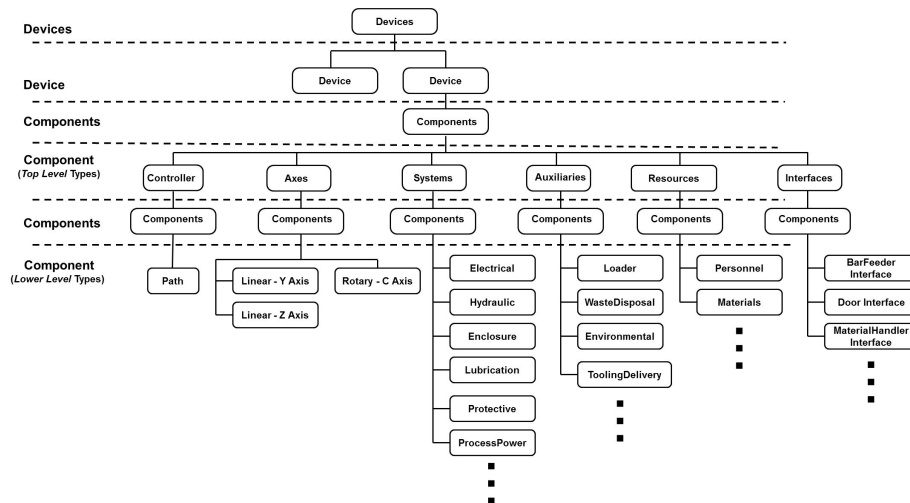
**Table 1:** Commonly Observed DataItem Types for Interface

## 129 4 Interfaces for Device and Observation Information Mod- 130 els

131 The *interaction model* for implementing *interfaces* is defined in the MTConnect Standard  
132 as an extension to the *Device Information Model* and *Observation Information Model*.

133 A piece of equipment **MAY** support multiple different *interfaces*. Each piece of equipment  
134 supporting *interfaces* **MUST** model the information associated with each *interface* as an  
135 Interface component. Interface is an abstract Component and is realized by  
136 Interface component types.

137 The Figure 3 illustrates where an Interface is modeled in the *Device Information*  
138 *Model* for a piece of equipment.



**Figure 3:** Interfaces in Entity Hierarchy

### 139 4.1 Interface Types

140 The abstract `Interface` is realized by the following types listed in this section.

141 In order to implement the *interaction model* for *interfaces*, each piece of equipment asso-  
142 ciated with an *interface* **MUST** provide the corresponding `Interface` type. A piece of  
143 equipment **MAY** support any number of unique *interfaces*.

#### 144 **4.1.1 BarFeederInterface**

145 Interface that coordinates the operations between a bar feeder and another piece of  
146 equipment.

147 Bar feeder is a piece of equipment that pushes bar stock (i.e., long pieces of material of  
148 various shapes) into an associated piece of equipment – most typically a lathe or turning  
149 center.

#### 150 **4.1.2 ChuckInterface**

151 Interface that coordinates the operations between two pieces of equipment, one of  
152 which controls the operation of a chuck.

153 The piece of equipment that is controlling the chuck **MUST** provide the data item Chuck-  
154 State as part of the set of information provided.

#### 155 **4.1.3 DoorInterface**

156 Interface that coordinates the operations between two pieces of equipment, one of  
157 which controls the operation of a door.

158 The piece of equipment that is controlling the door **MUST** provide data item DoorState  
159 as part of the set of information provided.

#### 160 **4.1.4 MaterialHandlerInterface**

161 Interface that coordinates the operations between a piece of equipment and another  
162 associated piece of equipment used to automatically handle various types of materials or  
163 services associated with the original piece of equipment.

164 A material handler is a piece of equipment capable of providing any one, or more, of a  
165 variety of support services for another piece of equipment or a process like:

- 166 • Loading/unloading material or tooling
- 167 • Part inspection



- 168     • Testing
- 169     • Cleaning

170 A robot is a common example of a material handler.

## 171 4.2 Data for Interface

172 Each *interface* **MUST** provide the data associated with the specific *interface* to implement  
 173 the *interaction model* and any additional data that may be needed by another piece of  
 174 equipment to understand the operating states and conditions of the first piece of equipment  
 175 as it applies to the *interface*.

176 Details on data items specific to the *interaction model* for each type of *interface* are pro-  
 177 vided in *Section 4.3 - DataItem Types for Interface*.

178 An implementer may choose any other data available from a piece of equipment to describe  
 179 the operating states and other information needed to support an *interface*.

### 180 4.2.1 References for Interface

181 Some of the data items needed to support a specific *interface* may already be defined  
 182 elsewhere in the *MTConnectDevices Response Document* for a piece of equipment. How-  
 183 ever, the implementer may not be able to directly associate this data with the *interface*  
 184 since the MTConnect Standard does not permit multiple occurrences of a piece of data to  
 185 be configured in an *MTConnectDevices Response Document*. *References* provides a  
 186 mechanism for associating information defined elsewhere in the *information model* for a  
 187 piece of equipment with a specific *interface*.

188 *References* *organizes* *Reference* elements.

189 *Reference* is a pointer to information that is associated with another entity defined  
 190 elsewhere for a piece of equipment.

191 *References* is an economical syntax for providing interface specific information with-  
 192 out directly duplicating the occurrence of the data. It provides a mechanism to include all  
 193 necessary information required for interaction and deterministic information flow between  
 194 pieces of equipment.

195 For more information on the `References` model, see *MTConnect Standard: Part 2.0 -*  
 196 *Device Information Model*.

## 197 4.3 DataItem Types for Interface

198 Each `Interface` contains data items which are used to communicate information re-  
 199 quired to execute the *interface*. When these data items are read by another piece of equip-  
 200 ment, that piece of equipment can then determine the actions that it may take based upon  
 201 that data.

202 `InterfaceState` is a data item specifically defined for *interfaces*. It defines the op-  
 203 erational state of the *interface*. This is an indicator identifying whether the *interface* is  
 204 functioning or not. See *Section 4.3.4 - InterfaceState* for complete semantic details.

205 Some data items **MAY** be directly associated with the `Interface` element and others  
 206 will be organized by a `References` element. It is up to an implementer to determine  
 207 which additional data items are required for a particular *interface*.

### 208 4.3.1 Specific Data Items for the Interaction Model for Interface

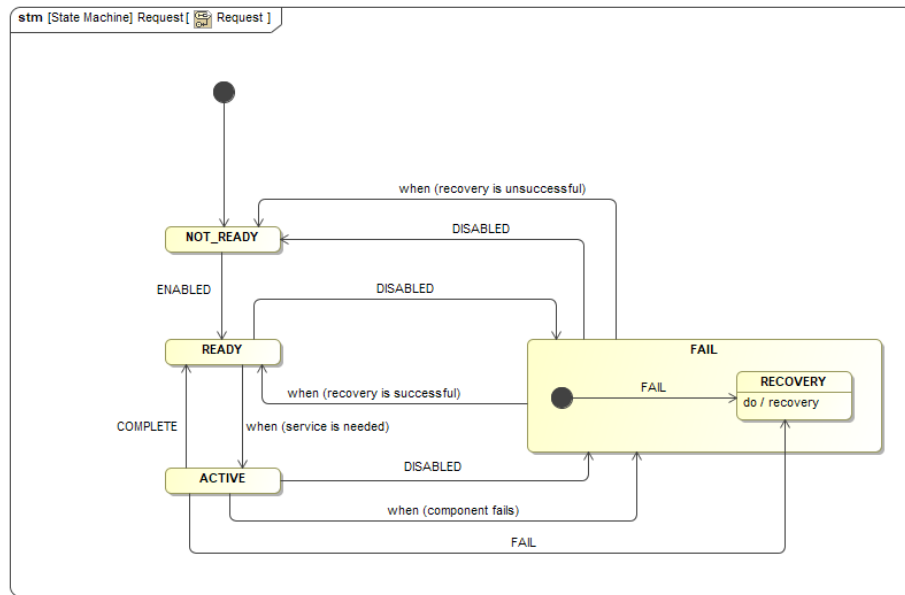
209 A special set of data items have been defined to be used in conjunction with `Interface`.  
 210 They provide information from a piece of equipment to *request* a service to be performed  
 211 by another associated piece of equipment; and for the associated piece of equipment to  
 212 indicate its progress in performing its *response* to the *request* for service. .

213 Many of the data items describing the services associated with an *interface* are paired to  
 214 describe two distinct actions – one to *request* an action to be performed and a second to  
 215 reverse the action or to return to an original state. For example, a `DoorInterface` will  
 216 have two actions `OpenDoor` and `CloseDoor`. An example of an implementation of this  
 217 would be a robot that indicates to a machine that it would like to have a door opened so  
 218 that the robot could extract a part from the machine and then asks the machine to close  
 219 that door once the part has been removed.

220 When these data items are used to describe a service associated with an *interface*, they  
 221 **MUST** have one of the following two `subType` elements: `REQUEST` or `RESPONSE`.  
 222 These **MUST** be specified to define whether the piece of equipment is functioning as the  
 223 *requester* or *responder* for the service to be performed. The *requester* **MUST** specify the  
 224 `REQUEST` `subType` for the data item and the *responder* **MUST** specify a corresponding  
 225 `RESPONSE` `subType` for the data item to enable the coordination between the two pieces  
 226 of equipment.

227 These data items and their associated `subType` provide the basic structure for implement-  
 228 ing the *interaction model* for an *interface* and are defined in the following sections.

229 Figure 4 and Figure 5 show possible state transitions for a *request* and *response* respec-  
 230 tively. The state machine diagrams provide the permissible values of the observations for  
 231 the `DataItem` types listed in this section.



**Figure 4:** Request State Machine

## 232 4.3.2 CloseChuck

233 A `subType` **MUST** always be specified.

### 234 4.3.2.1 Subtypes of CloseChuck

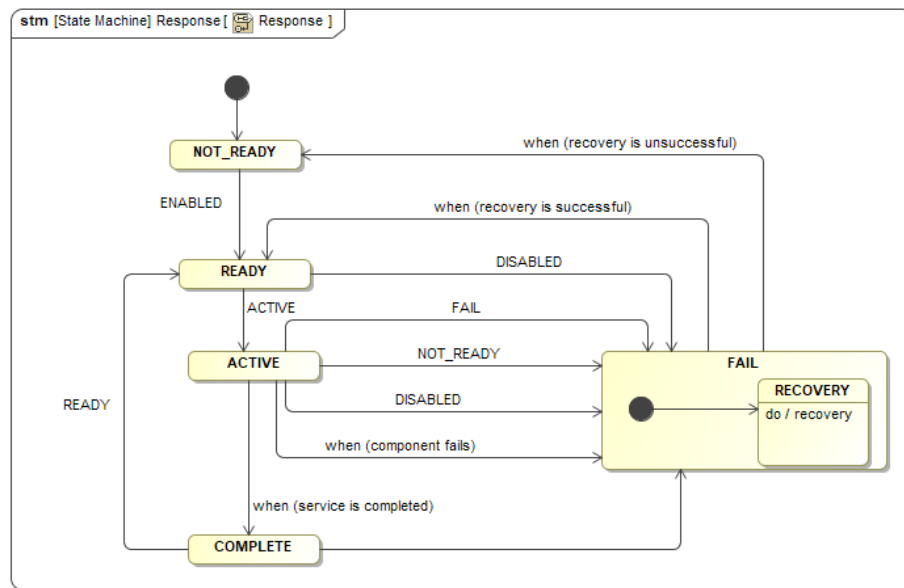
- 235 • REQUEST

236 operating state of the *request* to close a chunk.

237 `RequestStateEnum` Enumeration:

- 238 – ACTIVE

239 *requester* has initiated a *request* for a service and the service has not yet been  
 240 completed by the *responder*.



**Figure 5: Response State Machine**

- 241       – FAIL
- 242        *requester* has detected a failure condition.
- 243       – NOT\_READY
- 244        *requester* is not ready to make a *request*.
- 245       – READY
- 246        *requester* is prepared to make a *request*, but no *request* for service is required.
- 247       • RESPONSE
- 248        operating state of the *response* to a *request* to close a chunk.
- 249        ResponseStateEnum Enumeration:
- 250        – ACTIVE
- 251        *responder* has detected and accepted a *request* for a service and is in the process
- 252        of performing the service, but the service has not yet been completed.
- 253        – COMPLETE
- 254        *responder* has completed the actions required to perform the service.
- 255        – FAIL
- 256        *responder* has detected a failure condition.
- 257        – NOT\_READY
- 258        *responder* is not ready to perform a service.

259           – READY  
 260            *responder* is prepared to react to a *request*, but no *request* for service has been  
 261           detected.

### 262 4.3.3 CloseDoor

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

#### 264 4.3.3.1 Subtypes of CloseDoor

265       • REQUEST  
 266       operating state of the *request* to close a door.  
 267       The value of CloseDoor **MUST** be one of the RequestStateEnum enumera-  
 268       tion.

269       • RESPONSE  
 270       operating state of the *response* to a *request* to close a door.  
 271       The value of CloseDoor **MUST** be one of the ResponseStateEnum enumer-  
 272       ation.

### 273 4.3.4 InterfaceState

274 When the InterfaceState is DISABLED, the state of all data items that are specific  
 275 for the *interaction model* associated with that Interface **MUST** be set to NOT\_READY.

276 InterfaceStateEnum Enumeration:

277       • DISABLED  
 278       Interface is currently not operational.  
 279       • ENABLED  
 280       Interface is currently operational and performing as expected.

## 281 4.3.5 MaterialChange

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

### 283 4.3.5.1 Subtypes of MaterialChange

#### 284 • REQUEST

285 operating state of the *request* to change the type of material or product being loaded  
286 or fed to a piece of equipment.

287 The value of MaterialChange **MUST** be one of the RequestStateEnum  
288 enumeration.

#### 289 • RESPONSE

290 operating state of the *response* to a *request* to change the type of material or product  
291 being loaded or fed to a piece of equipment.

292 The value of MaterialChange **MUST** be one of the ResponseStateEnum  
293 enumeration.

## 294 4.3.6 MaterialFeed

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

### 296 4.3.6.1 Subtypes of MaterialFeed

#### 297 • REQUEST

298 operating state of the *request* to advance material or feed product to a piece of equip-  
299 ment from a continuous or bulk source.

300 The value of MaterialFeed **MUST** be one of the RequestStateEnum enu-  
301 meration.

#### 302 • RESPONSE

303 operating state of the *response* to a *request* to advance material or feed product to a  
304 piece of equipment from a continuous or bulk source.

305 The value of MaterialFeed **MUST** be one of the ResponseStateEnum enu-  
306 meration.

### 307 4.3.7 MaterialLoad

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

#### 309 4.3.7.1 Subtypes of MaterialLoad

- 310 • REQUEST
- 311 operating state of the *request* to load a piece of material or product.
- 312 The value of MaterialLoad **MUST** be one of the RequestStateEnum enu-
- 313 meration.
- 314 • RESPONSE
- 315 operating state of the *response* to a *request* to load a piece of material or product.
- 316 The value of MaterialLoad **MUST** be one of the ResponseStateEnum enu-
- 317 meration.

### 318 4.3.8 MaterialRetract

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

#### 320 4.3.8.1 Subtypes of MaterialRetract

- 321 • REQUEST
- 322 operating state of the *request* to remove or retract material or product.
- 323 The value of MaterialRetract **MUST** be one of the RequestStateEnum
- 324 enumeration.
- 325 • RESPONSE
- 326 operating state of the *response* to a *request* to remove or retract material or product.
- 327 The value of MaterialRetract **MUST** be one of the ResponseStateEnum
- 328 enumeration.

### 329 4.3.9 MaterialUnload

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

### 331 4.3.9.1 Subtypes of MaterialUnload

- 332     • REQUEST
- 333         operating state of the *request* to unload a piece of material or product.
- 334         The value of MaterialUnload **MUST** be one of the RequestStateEnum
- 335         enumeration.
- 336     • RESPONSE
- 337         operating state of the *response* to a *request* to unload a piece of material or product.
- 338         The value of MaterialUnload **MUST** be one of the ResponseStateEnum
- 339         enumeration.

### 340 4.3.10 OpenChuck

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

#### 342 4.3.10.1 Subtypes of OpenChuck

- 343     • REQUEST
- 344         operating state of the *request* to open a chuck.
- 345         The value of OpenChuck **MUST** be one of the RequestStateEnum enumera-
- 346         tion.
- 347     • RESPONSE
- 348         operating state of the *response* to a *request* to open a chuck.
- 349         The value of OpenChuck **MUST** be one of the ResponseStateEnum enumer-
- 350         ation.

### 351 4.3.11 OpenDoor

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



### 353 4.3.11.1 Subtypes of OpenDoor

- 354 • REQUEST
- 355 operating state of the *request* to open a door.
- 356 The value of `OpenDoor` **MUST** be one of the `RequestStateEnum` enumera-
- 357 tion.
- 358 • RESPONSE
- 359 operating state of the *response* to a *request* to open a door.
- 360 The value of `OpenDoor` **MUST** be one of the `ResponseStateEnum` enumera-
- 361 tion.

### 362 4.3.12 PartChange

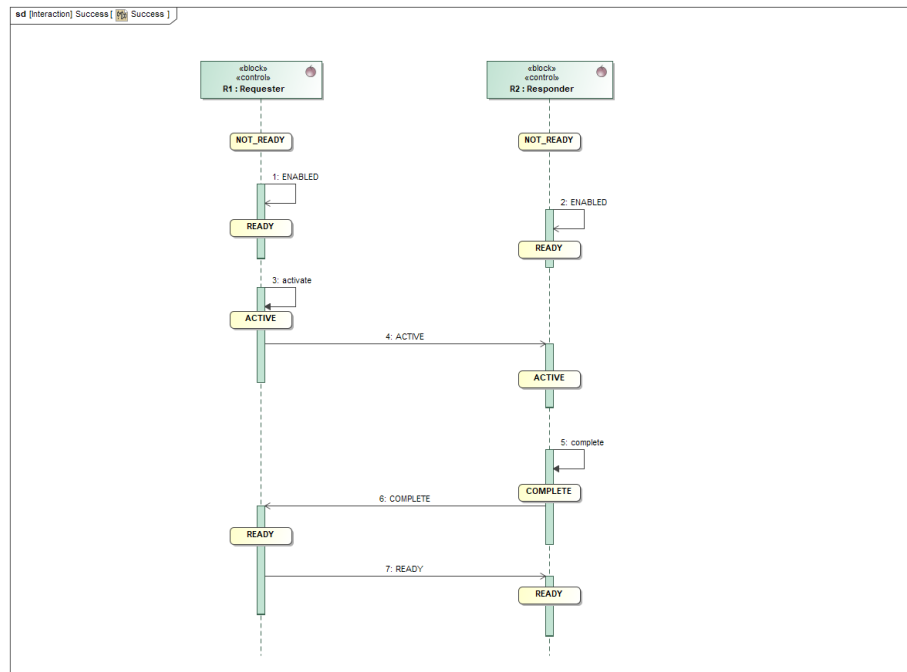
363 A `subType` **MUST** always be specified.

#### 364 4.3.12.1 Subtypes of PartChange

- 365 • REQUEST
- 366 operating state of the *request* to change the part or product associated with a piece
- 367 of equipment to a different part or product.
- 368 The value of `PartChange` **MUST** be one of the `RequestStateEnum` enumer-
- 369 ation.
- 370 • RESPONSE
- 371 operating state of the *response* to a *request* to change the part or product associated
- 372 with a piece of equipment to a different part or product.
- 373 The value of `PartChange` **MUST** be one of the `ResponseStateEnum` enu-
- 374 meration.

## 375 5 Operation and Error Recovery

376 The *request and response* state model implemented for *interfaces* may also be represented  
 377 by a graphical model. The scenario in Figure 6 demonstrates the state transitions that occur  
 378 during a successful *request* for service and the resulting *response* to fulfill that service  
 379 *request*.



**Figure 6:** Success Scenario

### 380 5.1 Request and Response Failure Handling and Recovery

381 A significant feature of the *request and response interaction model* is the ability for ei-  
 382 ther piece of equipment to detect a failure associated with either the *request* or *response*  
 383 actions. When either a failure or unexpected action occurs, the *request* and the *response*  
 384 portion of the *interaction model* can announce a FAIL state upon detecting a problem. The  
 385 following are graphical models describing multiple scenarios where either the *requester*  
 386 or *responder* detects and reacts to a failure. In these examples, either the *requester* or  
 387 *responder* announces the detection of a failure by setting either the *request* or the *response*  
 388 state to FAIL.

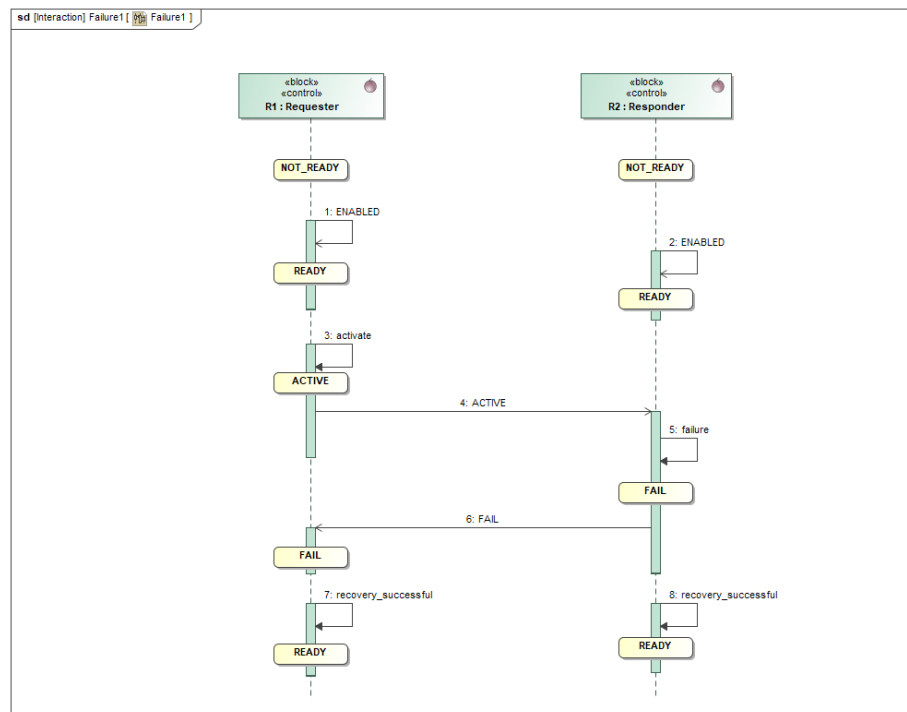
389 Once a failure is detected, the *interaction model* provides information from each piece of  
 390 equipment as they attempt to recover from a failure, reset all of their functions associated

391 with the *interface* to their original state, and return to normal operation.

392 The following sections are scenarios that describe how pieces of equipment may react to  
 393 different types of failures and how they indicate when they are again ready to request a  
 394 service or respond to a request for service after recovering from those failures:

### 395 5.1.1 Responder Fails Immediately

396 In this scenario, a failure is detected by the *responder* immediately after a *request* for  
 397 service has been initiated by the *requester*.



**Figure 7: Responder Fails Immediately**

398 In this case, the *request* transitions to ACTIVE and the *responder* immediately detects  
 399 a failure before it can transition the *response* state to ACTIVE. When this occurs, the  
 400 *responder* transitions the *response* state to FAIL.

401 After detecting that the *responder* has transitioned its state to FAIL, the *requester* **MUST**  
 402 change its state to FAIL.

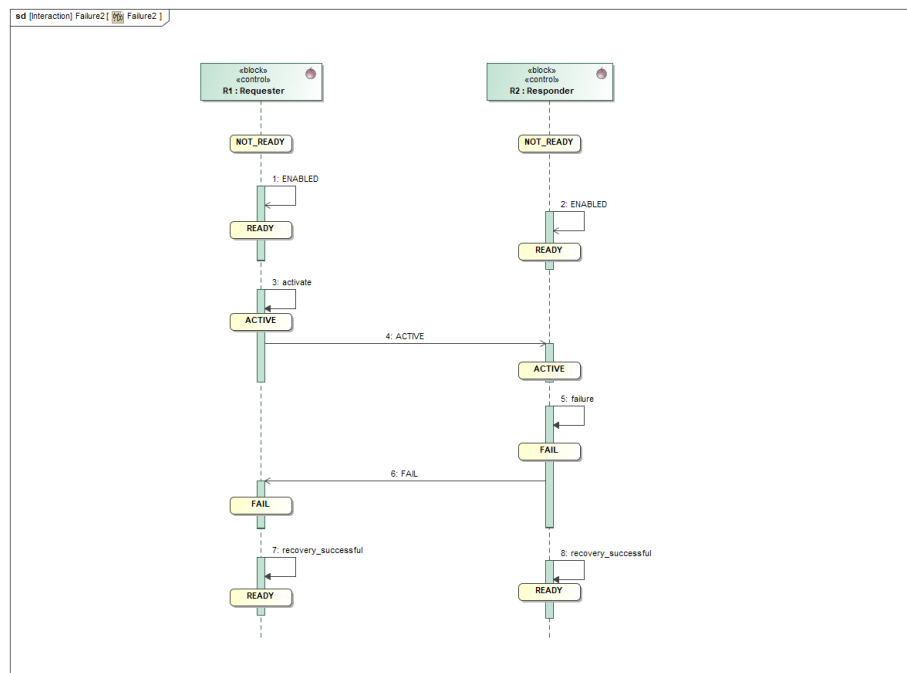
403 The *requester*, as part of clearing a failure, resets any partial actions that were initiated and  
 404 attempts to return to a condition where it is again ready to request a service. If the recovery

405 is successful, the *requester* changes its state from FAIL to READY. If for some reason  
 406 the *requester* cannot return to a condition where it is again ready to request a service, it  
 407 transitions its state from FAIL to NOT\_READY.

408 The *responder*, as part of clearing a failure, resets any partial actions that were initiated  
 409 and attempts to return to a condition where it is again ready to perform a service. If the  
 410 recovery is successful, the *responder* changes its *response* state from FAIL to READY. If  
 411 for some reason the *responder* is not again prepared to perform a service, it transitions its  
 412 state from FAIL to NOT\_READY.

## 413 5.1.2 Responder Fails While Providing a Service

414 This is the most common failure scenario. In this case, the *responder* will begin the actions  
 415 required to provide a service. During these actions, the *responder* detects a failure and  
 416 transitions its *response* state to FAIL.



**Figure 8:** Responder Fails While Providing a Service

417 When a *requester* detects a failure of a *responder*, it transitions its state from ACTIVE to  
 418 FAIL.

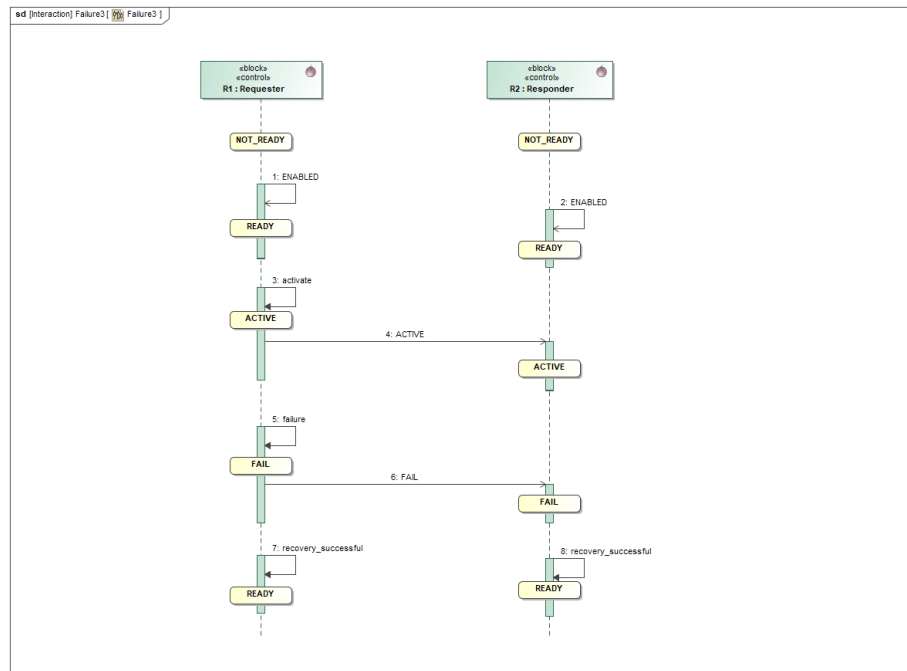
419 The *requester* resets any partial actions that were initiated and attempts to return to a  
 420 condition where it is again ready to request a service. If the recovery is successful, the

421 *requester* changes its state from `FAIL` to `READY` if the failure has been cleared and it is  
 422 again prepared to request another service. If for some reason the *requester* cannot return  
 423 to a condition where it is again ready to request a service, it transitions its state from `FAIL`  
 424 to `NOT_READY`.

425 The *responder*, as part of clearing a failure, resets any partial actions that were initiated  
 426 and attempts to return to a condition where it is again ready to perform a service. If the  
 427 recovery is successful, the *responder* changes its *response* state from `FAIL` to `READY` if  
 428 it is again prepared to perform a service. If for some reason the *responder* is not again  
 429 prepared to perform a service, it transitions its state from `FAIL` to `NOT_READY`.

### 430 5.1.3 Requester Failure During a Service Request

431 In this scenario, the *responder* will begin the actions required to provide a service. During  
 432 these actions, the *requester* detects a failure and transitions its *request* state to `FAIL`.



**Figure 9:** Requester Fails During a Service Request

433 When the *responder* detects that the *requester* has transitioned its *request* state to `FAIL`,  
 434 the *responder* also transitions its *response* state to `FAIL`.

435 The *requester*, as part of clearing a failure, resets any partial actions that were initiated and  
 436 attempts to return to a condition where it is again ready to request a service. If the recovery

437 is successful, the *requester* changes its state from FAIL to READY. If for some reason  
 438 the *requester* cannot return to a condition where it is again ready to request a service, it  
 439 transitions its state from FAIL to NOT\_READY.

440 The *responder*, as part of clearing a failure, resets any partial actions that were initiated  
 441 and attempts to return to a condition where it is again ready to perform a service. If the  
 442 recovery is successful, the *responder* changes its *response* state from FAIL to READY. If  
 443 for some reason the *responder* is not again prepared to perform a service, it transitions its  
 444 state from FAIL to NOT\_READY.

#### 445 **5.1.4 Requester Changes to an Unexpected State While Responder is** 446 **Providing a Service**

447 In some cases, a *requester* may transition to an unexpected state after it has initiated a  
 448 *request* for service.

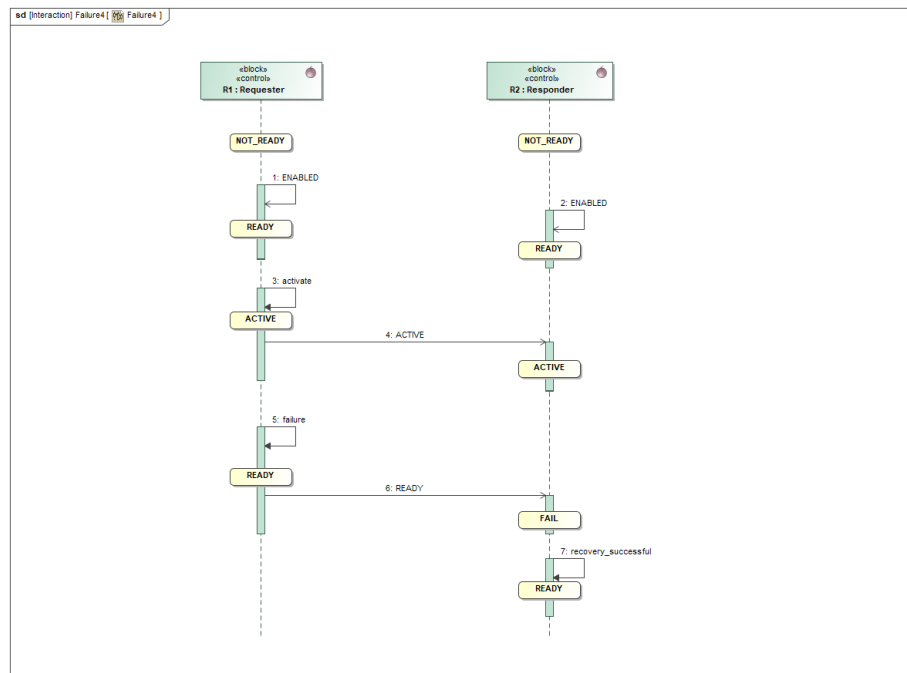
449 As demonstrated in Figure 10, the *requester* has initiated a *request* for service and its  
 450 *request* state has been changed to ACTIVE. The *responder* begins the actions required to  
 451 provide the service. During these actions, the *requester* transitions its *request* state back  
 452 to READY before the *responder* can complete its actions. This **SHOULD** be regarded as a  
 453 failure of the *requester*.

454 In this case, the *responder* reacts to this change of state of the *requester* in the same way  
 455 as though the *requester* had transitioned its *request* state to FAIL (i.e., the same as in  
 456 Scenario 3 above).

457 At this point, the *responder* then transitions its *response* state to FAIL.

458 The *responder* resets any partial actions that were initiated and attempts to return to its  
 459 original condition where it is again ready to perform a service. If the recovery is successful,  
 460 the *responder* changes its *response* state from FAIL to READY. If for some reason the  
 461 *responder* is not again prepared to perform a service, it transitions its state from FAIL to  
 462 NOT\_READY.

463 Note: The same scenario exists if the *requester* transitions its *request* state to  
 464 NOT\_READY. However, in this case, the *requester* then transitions its *request*  
 465 state to READY after it resets all of its functions back to a condition where it  
 466 is again prepared to make a *request* for service.



**Figure 10: Requester Makes Unexpected State Change**

## 467 5.1.5 Responder Changes to an Unexpected State While Providing a 468 Service

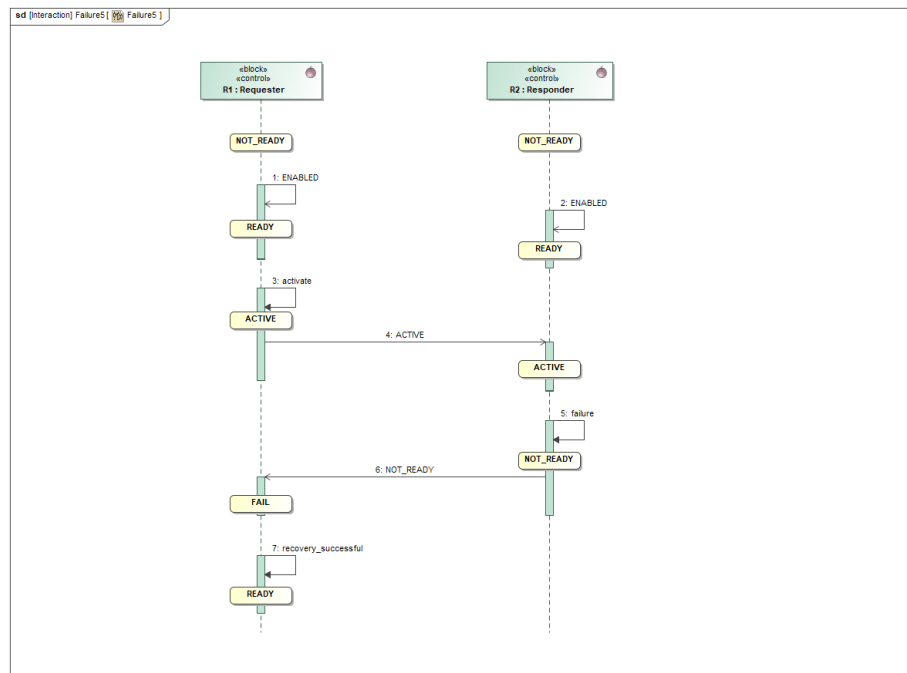
469 Similar to Scenario 5, a *responder* may transition to an unexpected state while providing  
470 a service.

471 As demonstrated in Figure 11, the *responder* is performing the actions to provide a service  
472 and the *response* state is ACTIVE. During these actions, the *responder* transitions its state  
473 to NOT\_READY before completing its actions. This should be regarded as a failure of the  
474 *responder*.

475 Upon detecting an unexpected state change of the *responder*, the *requester* transitions its  
476 state to FAIL.

477 The *requester* resets any partial actions that were initiated and attempts to return to a  
478 condition where it is again ready to request a service. If the recovery is successful, the  
479 *requester* changes its state from FAIL to READY. If for some reason the *requester* cannot  
480 return to a condition where it is again ready to request a service, it transitions its state from  
481 FAIL to NOT\_READY.

482 Since the *responder* has failed to an invalid state, the condition of the *responder* is un-



**Figure 11: Responder Makes Unexpected State Change**

known. Where possible, the *responder* should try to reset to an initial state.

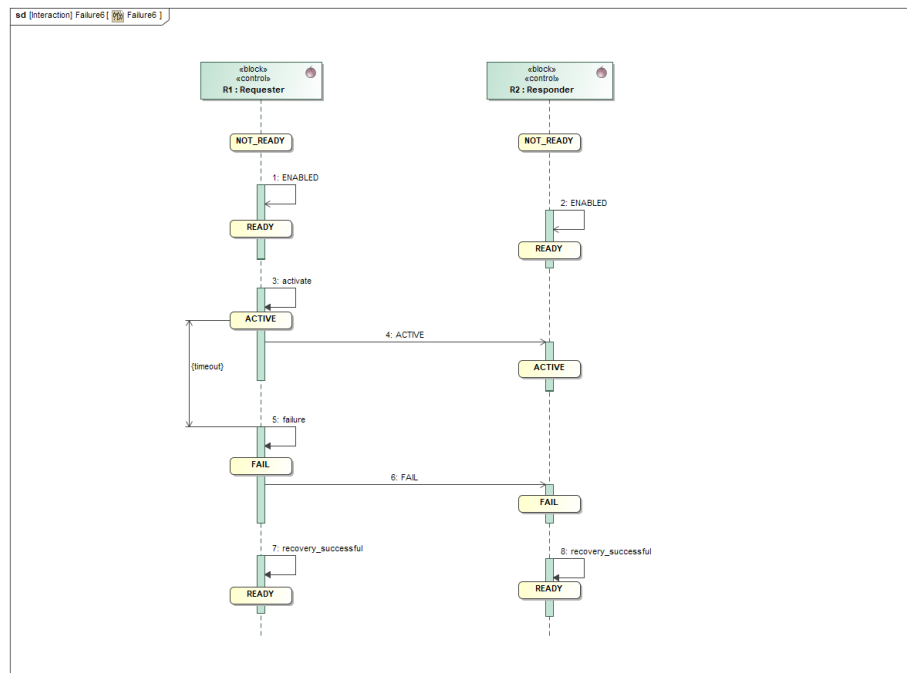
The *responder*, as part of clearing the cause for the change to the unexpected state, should attempt to reset any partial actions that were initiated and then return to a condition where it is again ready to perform a service. If the recovery is successful, the *responder* changes its *response* state from the unexpected state to `READY`. If for some reason the *responder* is not again prepared to perform a service, it maintains its state as `NOT_READY`.

### 5.1.6 Responder or Requester Become UNAVAILABLE or Experience a Loss of Communication

In this scenario, a failure occurs in the communications connection between the *responder* and *requester*. This failure may result from the `InterfaceState` from either piece of equipment returning a value of `UNAVAILABLE` or one of the pieces of equipment does not provide a heartbeat within the desired amount of time (See *MTConnect Standard Part 1.0 - Fundamentals* for details on heartbeat).

When one of these situations occurs, each piece of equipment assumes that there has been a failure of the other piece of equipment.



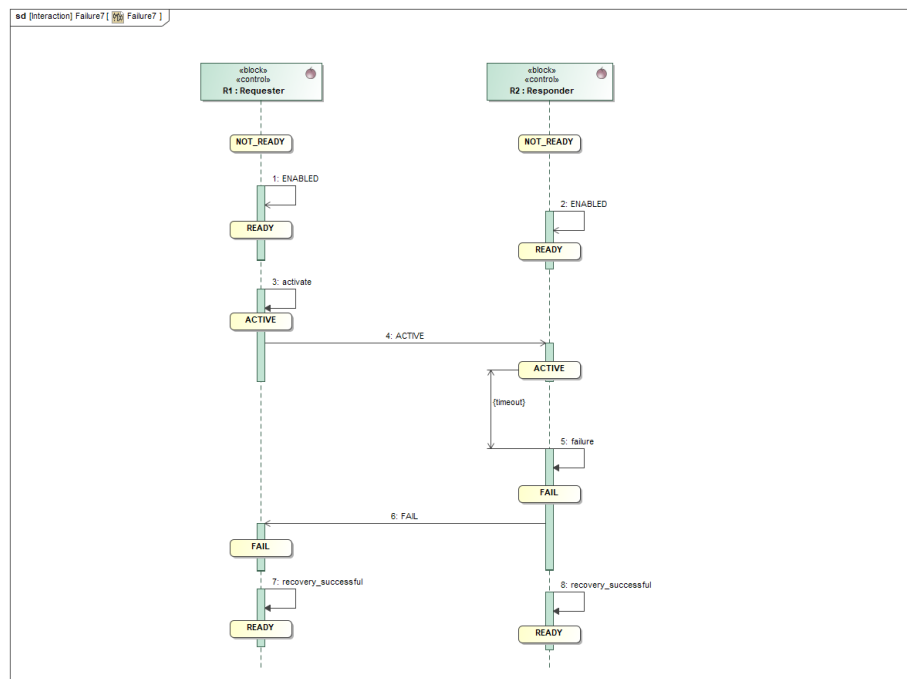


**Figure 12: Requester - Responder Communication Failure 1**

508 When normal communications are re-established, neither piece of equipment should as-  
 509 sume that the *request* and *response* state of the other piece of equipment remains valid.  
 510 Both pieces of equipment should set their state to **FAIL**.

501 The *requester*, as part of clearing its **FAIL** state, resets any partial actions that were ini-  
 502 tiated and attempts to return to a condition where it is again ready to request a service.  
 503 If the recovery is successful, the *requester* changes its state from **FAIL** to **READY**. If for  
 504 some reason the *requester* cannot return to a condition where it is again ready to request a  
 505 service, it transitions its state from **FAIL** to **NOT\_READY**.

506 The *responder*, as part of clearing its **FAIL** state, resets any partial actions that were initi-  
 507 ated and attempts to return to a condition where it is again ready to perform a service. If  
 508 the recovery is successful, the *responder* changes its *response* state from **FAIL** to **READY**.  
 509 If for some reason the *responder* is not again prepared to perform a service, it transitions  
 510 its state from **FAIL** to **NOT\_READY**.



**Figure 13:** Requester - Responder Communication Failure 2

## 511 6 Profile

512 MTConnect Profile is a *profile* that extends the Systems Modeling Language (SysML)  
 513 metamodel for the MTConnect domain using additional data types and *stereotypes*.

### 514 6.1 DataTypes

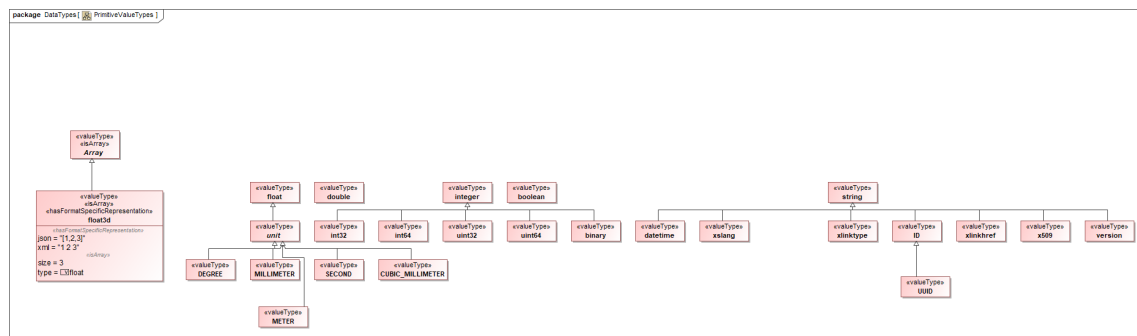


Figure 14: DataTypes

#### 515 6.1.1 boolean

516 primitive type.

#### 517 6.1.2 ID

518 string that represents an identifier (ID).

#### 519 6.1.3 string

520 primitive type.

#### 521 6.1.4 float

522 primitive type.

**523 6.1.5 datetime**

524 string that represents timestamp in ISO 8601 format.

**525 6.1.6 integer**

526 primitive type.

**527 6.1.7 xlinktype**

528 string that represents the type of an XLink element. See [https://www.w3.org/TR/](https://www.w3.org/TR/xlink11/)  
529 [xlink11/](https://www.w3.org/TR/xlink11/).

**530 6.1.8 xslang**

531 string that represents a language tag. See [http://www.ietf.org/rfc/rfc4646.](http://www.ietf.org/rfc/rfc4646.txt)  
532 [txt](http://www.ietf.org/rfc/rfc4646.txt).

**533 6.1.9 SECOND**

534 float that represents time in seconds.

**535 6.1.10 xlinkhref**

536 string that represents the locator attribute of an XLink element. See [https://www.w3.](https://www.w3.org/TR/xlink11/)  
537 [org/TR/xlink11/](https://www.w3.org/TR/xlink11/).

**538 6.1.11 x509**

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

**540 6.1.12 int32**

541 32-bit integer.

**542 6.1.13 int64**

543 64-bit integer.

**544 6.1.14 version**

545 series of three numeric values, separated by a decimal point, representing a *major*, *minor*,  
546 and *patch* number of the MTConnect Standard.

**547 6.1.15 uint32**

548 32-bit unsigned integer.

**549 6.1.16 uint64**

550 64-bit unsigned integer.

**551 6.1.17 binary**

552 base-2 numeral system or binary numeral system represented by two digits: “0” and “1”.

**553 6.1.18 double**

554 primitive type.

555 **6.1.19 Array**

556 array.

557 **6.1.20 <<hasFormatSpecificRepresentation>>float3d**

558 array of size 3 and datatype float.

559 **6.1.21 UUID**

560 Universally Unique Identifier. *Ref IETF:RFC-4122*

561 **6.1.22 METER**

562 float that represents measurement in meter.

563 **6.2 Stereotypes**

564 **6.2.1 organizer**

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

566 **6.2.2 deprecated**

567 element that has been deprecated.

568 **6.2.3 extensible**

569 enumeration that can be extended.

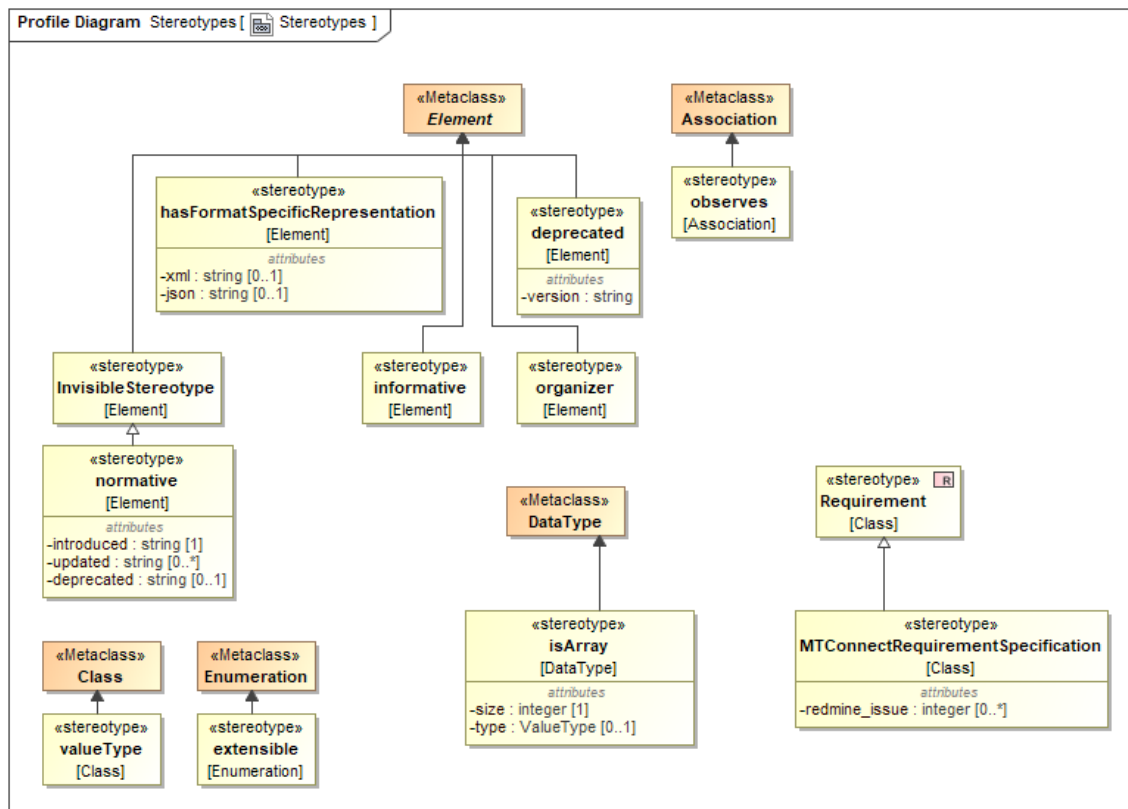


Figure 15: Stereotypes

## 570 6.2.4 informative

571 element that is descriptive and non-normative.

## 572 6.2.5 normative

573 element that has been added to the standard.

## 574 6.2.6 observes

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

576 **6.2.7 satisfiedBy**

577 **6.2.8 hasFormatSpecificRepresentation**

578 element that has format specific representation that might be different from the element's  
579 SysML representation.

580 **6.2.9 valueType**

581 extends `Class` to be used as a SysML `<<ValueType>>`.

582 **6.2.10 isArray**

583 datatype that is an array.

584 **6.2.11 MTConnectRequirementSpecification**

585 MTConnect Requirement.



## 586 Appendices

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