

# Inter-device Connectivity and Foundations of Industrial Internet



Cyber-physical  
Automation

William Sobel – MTConnect Chief Architect

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Conference · Workshop · Expo

Me

VIMANA | by System  
Insights

- Will Sobel
- System Insights – Predictive Analytics 4 Mfg
- Chief Strategy Officer
- MTConnect Chief Architect and Chair of TSC
- Done lots of stuff for many industries



# Agenda

- Inter-device connectivity
  - Demonstration of Part 3.1 Interfaces
- Industrial Internet
  - MTConnect as foundation of industrial internet



Inter-device connectivity using read-only communication  
Observation Communication Pattern

# MTCONNECT INTERFACES



# Interfaces

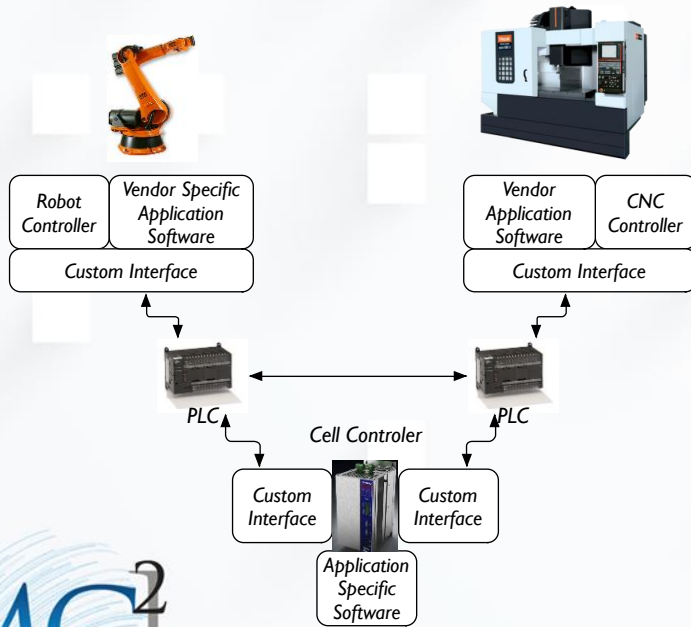


# Connectivity

Present - \$\$\$\$



MTConnect - \$



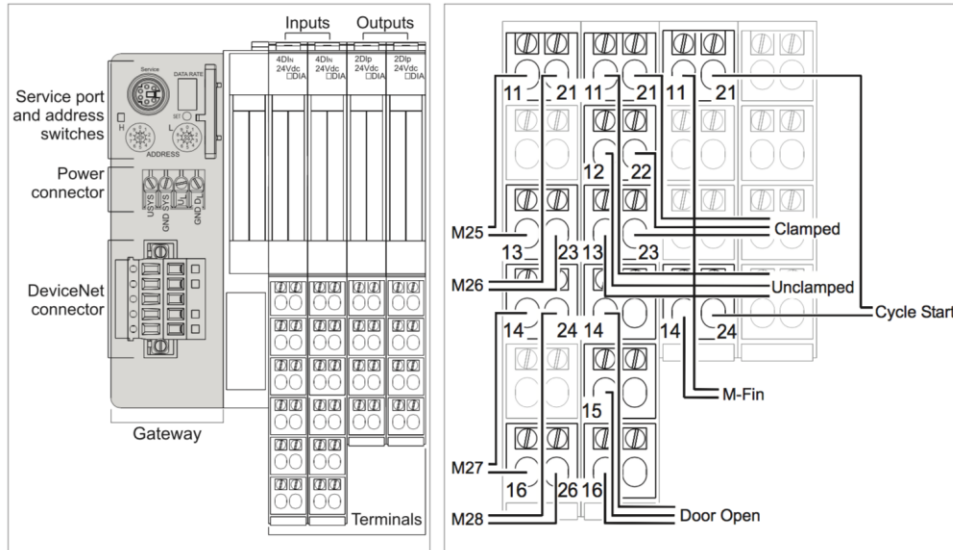
# Distributed Intelligence

**Present**

**MTConnect**



# Wires



*Robot Ready Module*

*Terminal Connections*



**Haas Robot Ready Option - 2014**



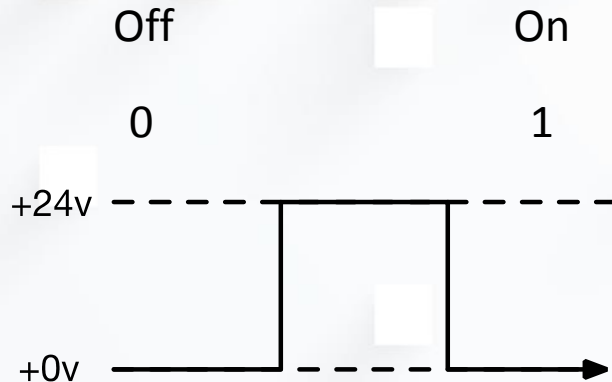


# Communications

Present

MTConnect

States



```
<PartArchetype assetId="X11255678" timestamp="2004-10-05T12:00:00Z"
revisionId="7">
```

...

```
<ProcessStep stepId="40">
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```
<Description>FINISH FWD</Description>
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```
<Targets>
```

```
<TargetDevice>SL-75</TargetDevice>
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```
</Targets>
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```
<ControlPrograms>
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</ControlPrograms>
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<TargetExecutionTime>1036</TargetExecutionTime>
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<TargetSetupTime>600</TargetSetupTime>
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```
<CuttingTools>
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<CuttingToolSetup sequence="1">
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</CuttingToolSetup>
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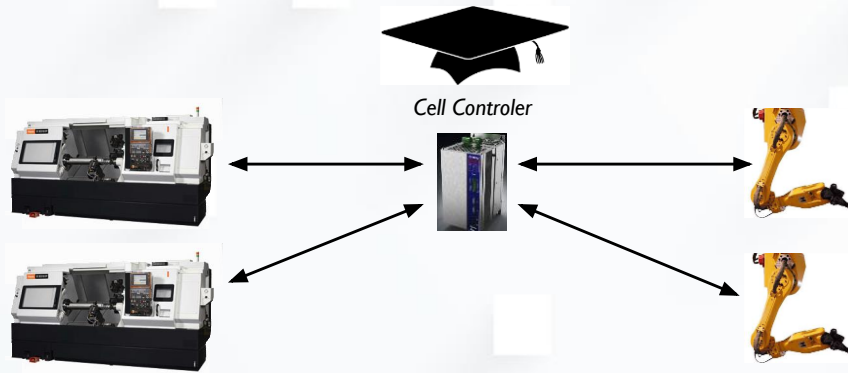
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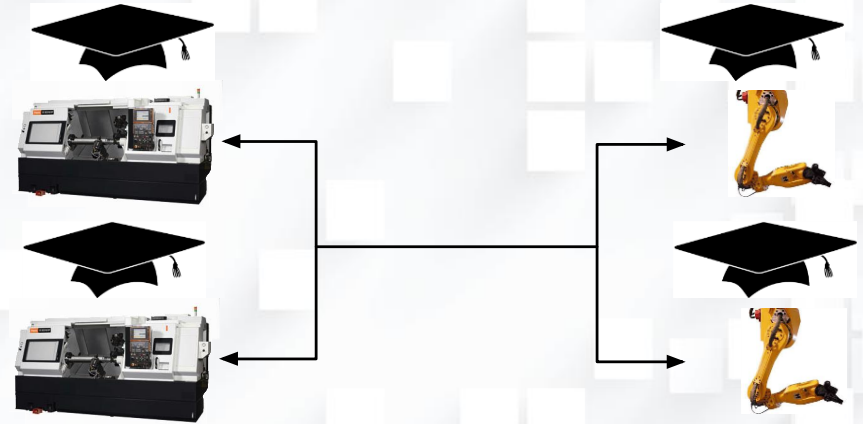
```
</CuttingToolSetup>
```

# Complexity

**Traditional**



**Distributed**



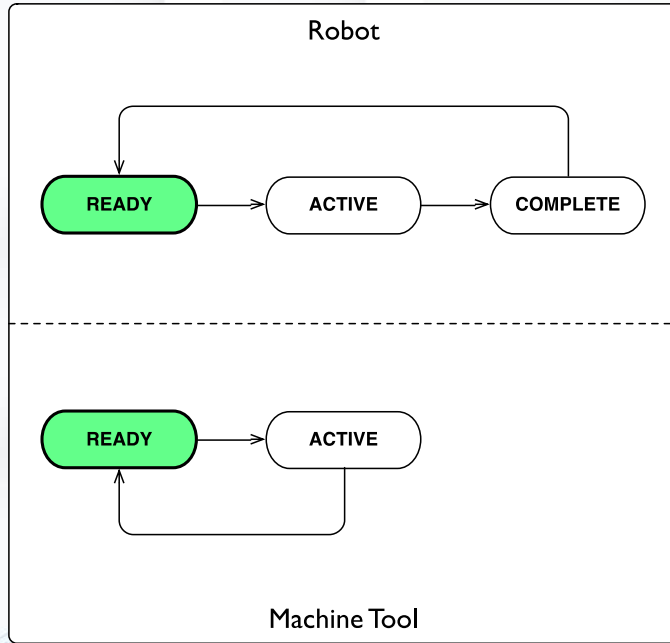
# Interfaces

- Chuck
- Door
- Material Handler
- Bar Feeder



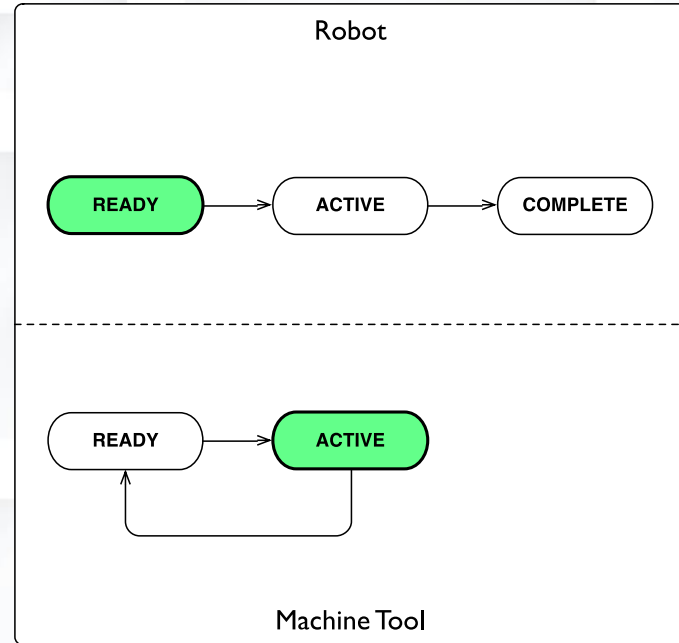
# Initial States

Response



Request

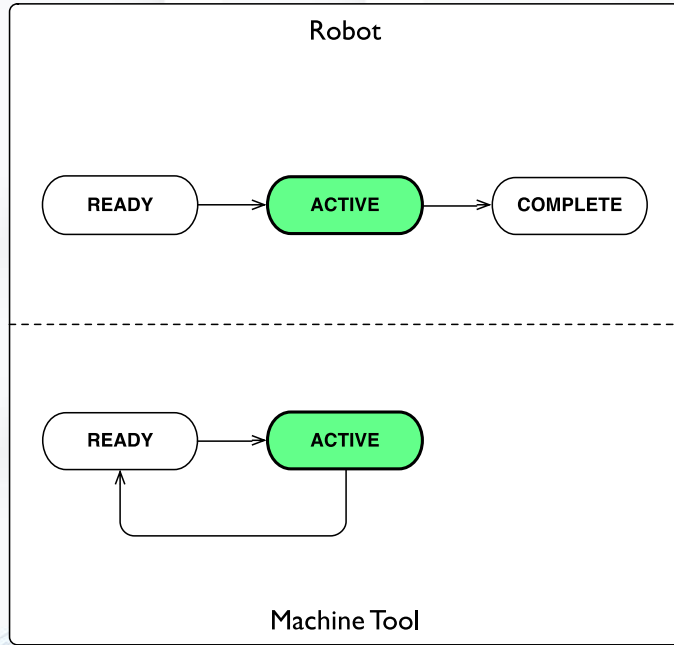
Response



Request

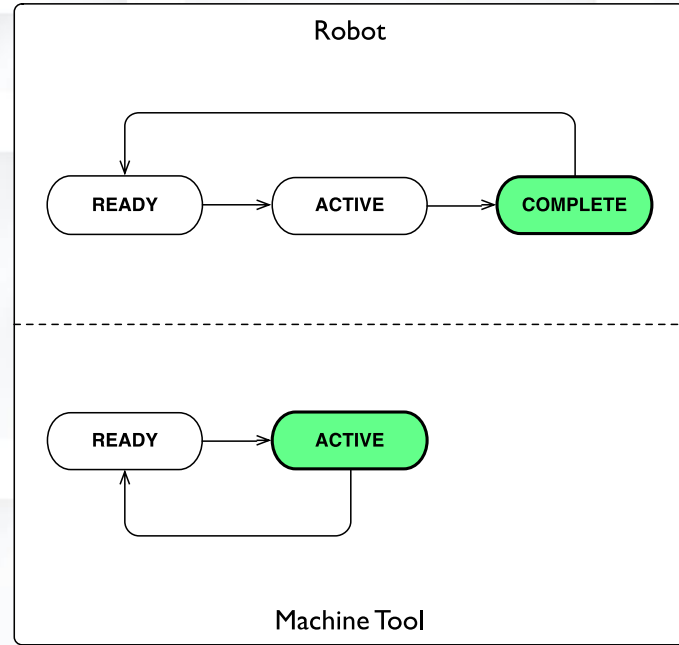
# Completing Task

Response



Request

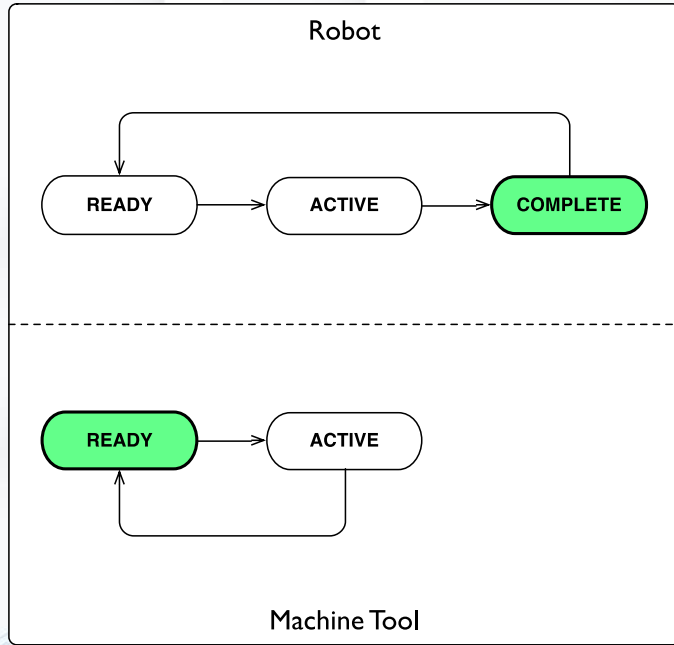
Response



Request

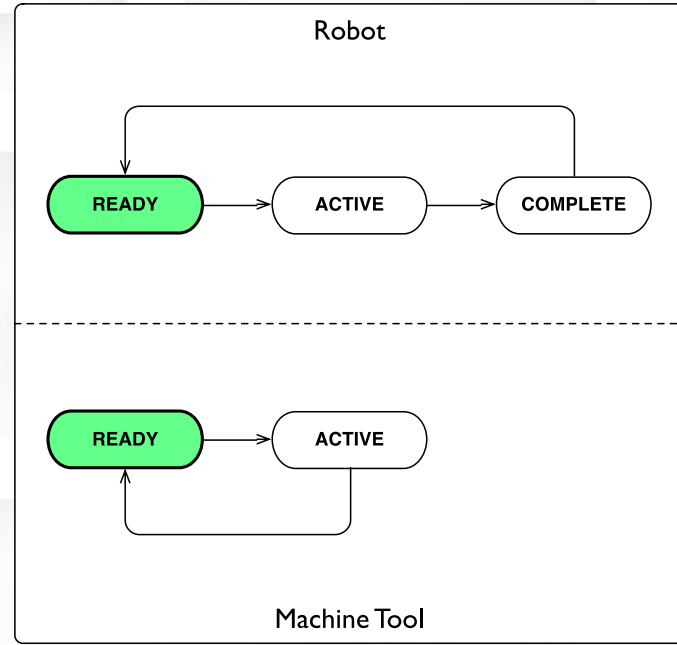
# Back to Ready

Response



Request

Response

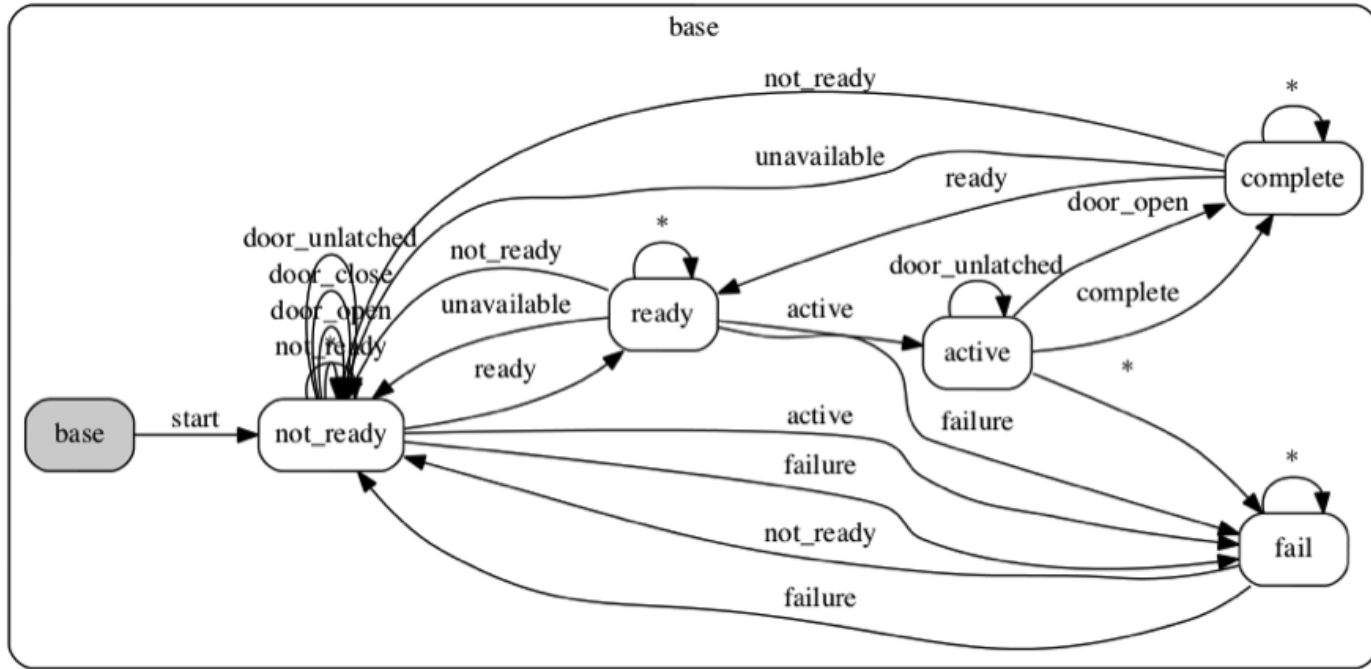


Request

# DEMONSTRATION

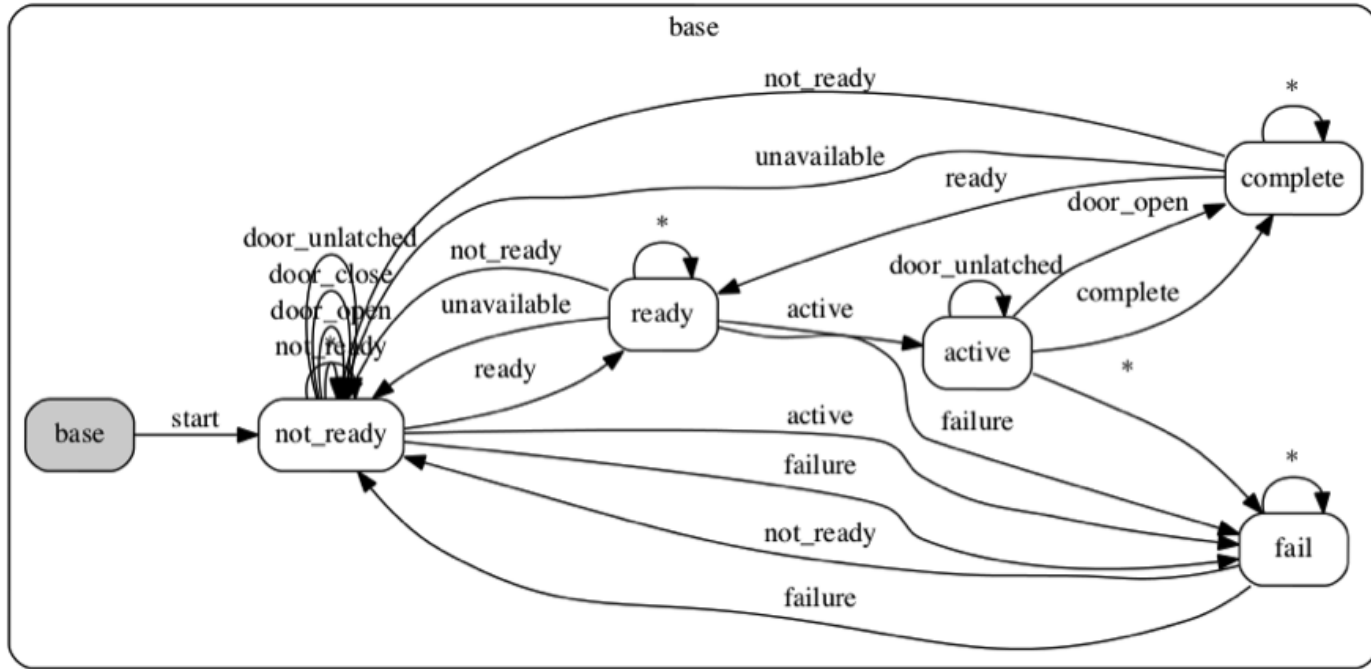


# Door States





# Door States



# Success

## Load

Given cnc MaterialLoad should be Active  
When robot MaterialInterface MaterialLoad becomes Active  
Then material load state should be processing  
And cnc DoorState should be Open  
And cnc Rotary ChuckState becomes Open  
And cnc ChuckState should be Open  
Then machine state should be loading  
When robot ChuckInterface Close becomes Active  
Then cnc CloseChuck should be Active  
Then after 1.2 seconds cnc CloseChuck should be Complete  
And cnc ChuckState should be Closed  
When robot DoorInterface Close becomes Ready  
And robot DoorInterface Close becomes Active  
Then cnc CloseDoor should be Active  
Then after 1.2 seconds cnc CloseDoor should be Complete  
And cnc DoorState should be Closed  
When robot MaterialInterface MaterialLoad becomes Complete  
And robot MaterialInterface MaterialLoad becomes Ready  
Then machine state should be cycle\_start  
And cnc MaterialLoad should be Not\_Ready  
And robot MaterialInterface MaterialLoad becomes Ready

## Unload

Scenario: Cnc asks Robot to Unload Material  
Given machine state should be unloading  
When robot MaterialInterface MaterialUnload becomes Active  
  
Then material unload state should be processing  
When robot DoorInterface Open becomes Active  
  
Then cnc OpenDoor should be Active  
And cnc DoorState should be Unlatched  
And after 1.2 seconds cnc OpenDoor should be Complete  
And cnc DoorState should be Open  
When robot ChuckInterface Open becomes Active  
  
Then cnc OpenChuck should be Active  
And cnc ChuckState should be Unlatched  
And after 1.2 seconds cnc OpenDoor should be Complete  
And cnc ChuckState should be Open  
When robot MaterialInterface MaterialUnload becomes Complete  
  
Then cnc MaterialUnload should be Not\_Ready  
And cnc MaterialLoad should be Active  
And machine state should be loading

# Failure

## Chuck Failure

**Given robot MaterialHandlerInterface  
MaterialLoad becomes Active  
Then material load state should be  
processing**

**When robot ChuckInterface Close becomes  
Active**

**Then cnc CloseChuck should be Active  
And cnc Rotary ChuckState becomes Unlatched**

**When cnc ChuckInterface Close becomes  
Failure**

**Then close chuck state should be fail  
And cnc CloseChuck should be Fail  
And cnc ChuckState should be Unlatched  
And cnc should have fault  
And machine state should be fault  
And cnc fault should have code  
"Cnc::CloseChuck"**

## Out of Material

**Given robot MaterialInterface MaterialLoad becomes  
Active  
Then material load state should be processing  
When robot faults Device FILL\_LEVEL with  
"No Material"  
And robot MaterialInterface MaterialLoad becomes  
Fail**

**Then cnc MaterialLoad should be Fail  
And machine state should be loading  
And material load state should be fail  
When robot MaterialInterface MaterialLoad becomes  
Not\_Ready**

**Then machine state should be idle  
And cnc MaterialLoad should be Ready  
When robot clears Device FILL\_LEVEL  
And robot MaterialInterface MaterialLoad becomes  
Ready**

**Then machine state should be loading  
And cnc MaterialLoad should be Active**



# Next Steps



Foundation of Manufacturing Technology Information Model and  
Communications

# INDUSTRIAL INTERNET



# Types of Standards

## Communications

- Ethernet/IP, ProfiNET/BUS
- Modbus
- Bacnet
- OPC/UA
- MQTT
- OpenDDS

## Information Models

- STEP-NC/AP-238
- ISO 13399 (Tooling)
- MIMOSA
- ISA-95/B2MML
- PLC Open
- QIF/DMIS/I++

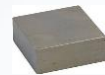
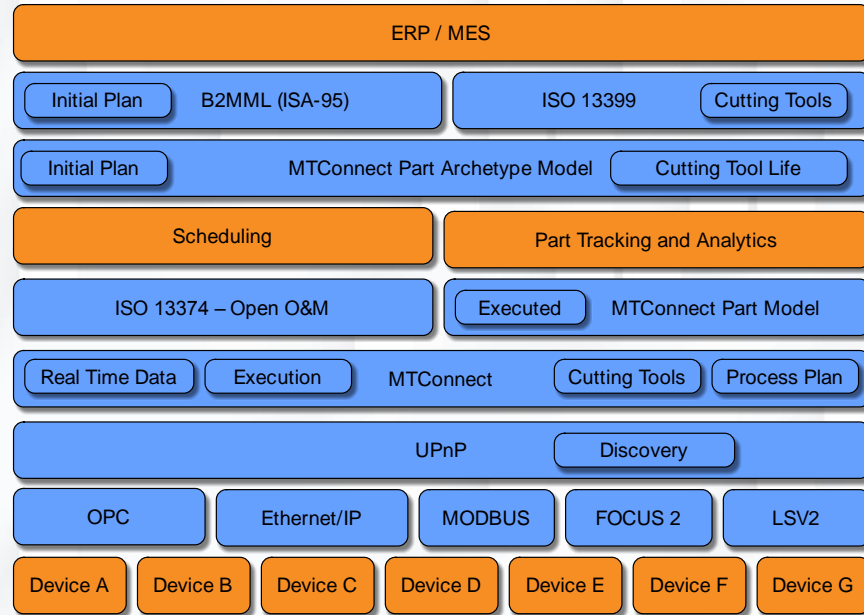


# What MTConnect Provides

- Pub/Sub Protocol with Event History
- Store and Forward
- High Performance with Push
- Asset (doc) Storage w/ Information Models
- Two Tier Architecture for Security and Safety



# Layers of Standards



Cradle to Gate





# Collaborate & Appropriate

- Primary Focus: Information Model
- Never Invent If *Reasonable* Alternative Exists
- Find Standards to Provide Dependent services
- Harmonize
- Collaborate – example: OPC/UA



# Security - CASSaVa



## Communication

- Connection/Firewall
- On the Wire

## Safety

- Human in the Loop

## Access

- Authentication
- Authorization
  - Read
  - Write

## Storage

- In Memory
- At Rest
- Derived

## Verification

- Validity
- Provenance
- Authenticity



# MTConnect Domain Security

- Agent Authentication – Use existing standards
- Access attached to Components, Data Items, and Assets
- Use the information model and “types”
- Example: PathPosition has more security risk than ControllerMode and Execution



# Future Services

- Next Generation Products and Services
- Outcome based economies
- Economies of Scale
- Digital Thread and Distributed Manufacturing



# Outcome Economies

Tools



Holes



# Grand Challenges

- Art to Part
- Design for Manufacturing and Engineering Close Loop
- Dynamic Process Optimization
- Sustainability
- Full Automation – Systems of Systems...



# Next Steps

- Complete MTConnect Technical Roadmap
- Harmonize with other standards groups
- Disseminate Benefits of Interoperability
- Create new Markets, Opportunities, and Capabilities





# QUESTIONS

Thank you...

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