Demonstration of Three ISO 23247 Digital Twin Use Cases

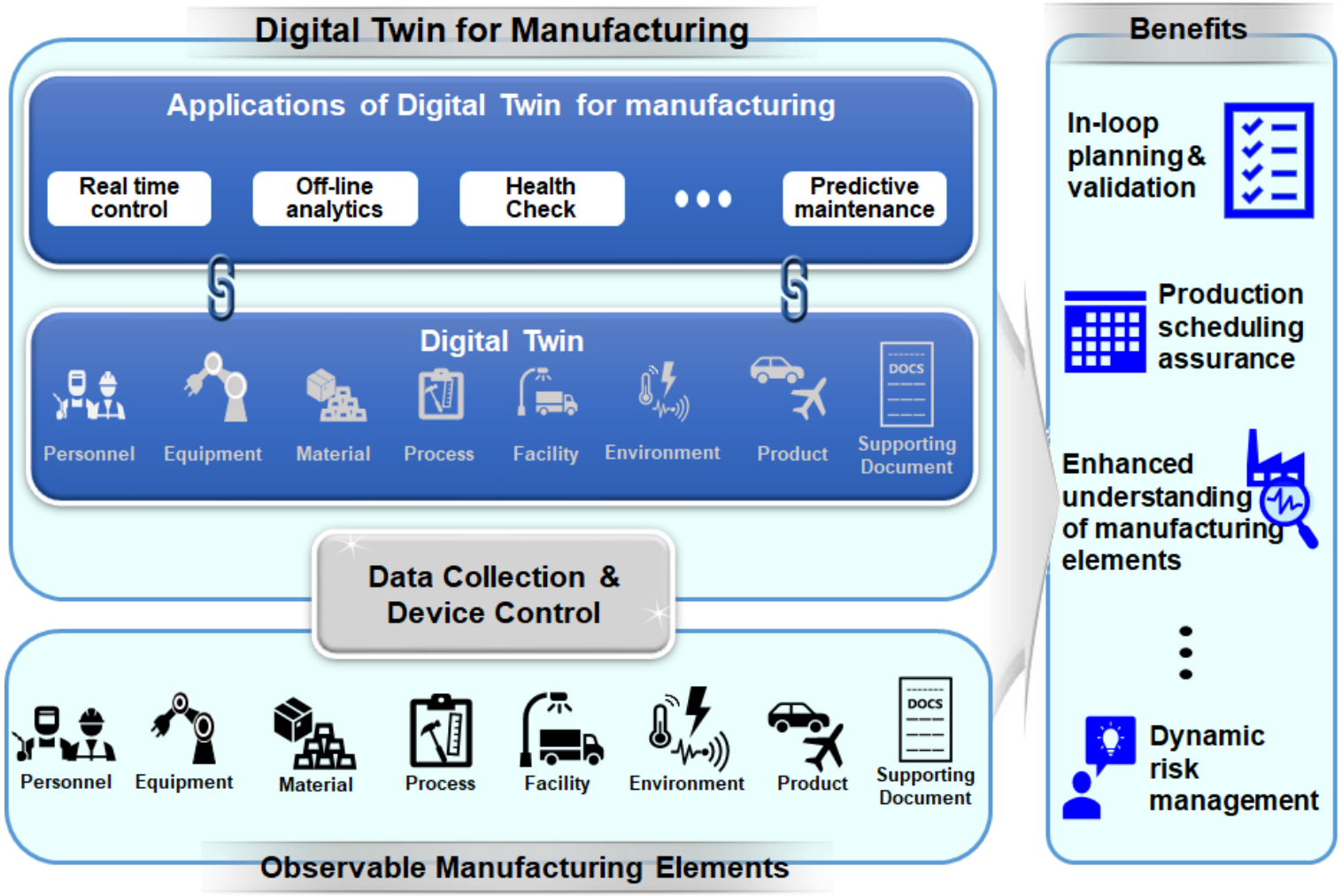
WG15

October 27, 2020

Who are we – ISO TC184/SC4 WG15

- ISO – International Standards Organization
  - Geneva, Switzerland
- Technical Committee 184 – Industrial automation standards
  - Chair – Patrick Lamboley, AFNOR, France
- Subcommittee 4 – Industrial Data
  - Chair – Kenny Swope, Boeing, USA
- Working Group 15 – Digital Manufacturing
  - Convenor – Martin Hardwick, STEP Tools, Inc., USA
  - Boeing, Lockheed Martin, Raytheon, NIST, Sandvik, Iscar, Mitutoyo, DMSC (QIF), MTConnect Institute, KTH Sweden, ETRI Korea, UW BARC

Digital Twin framework for manufacturing

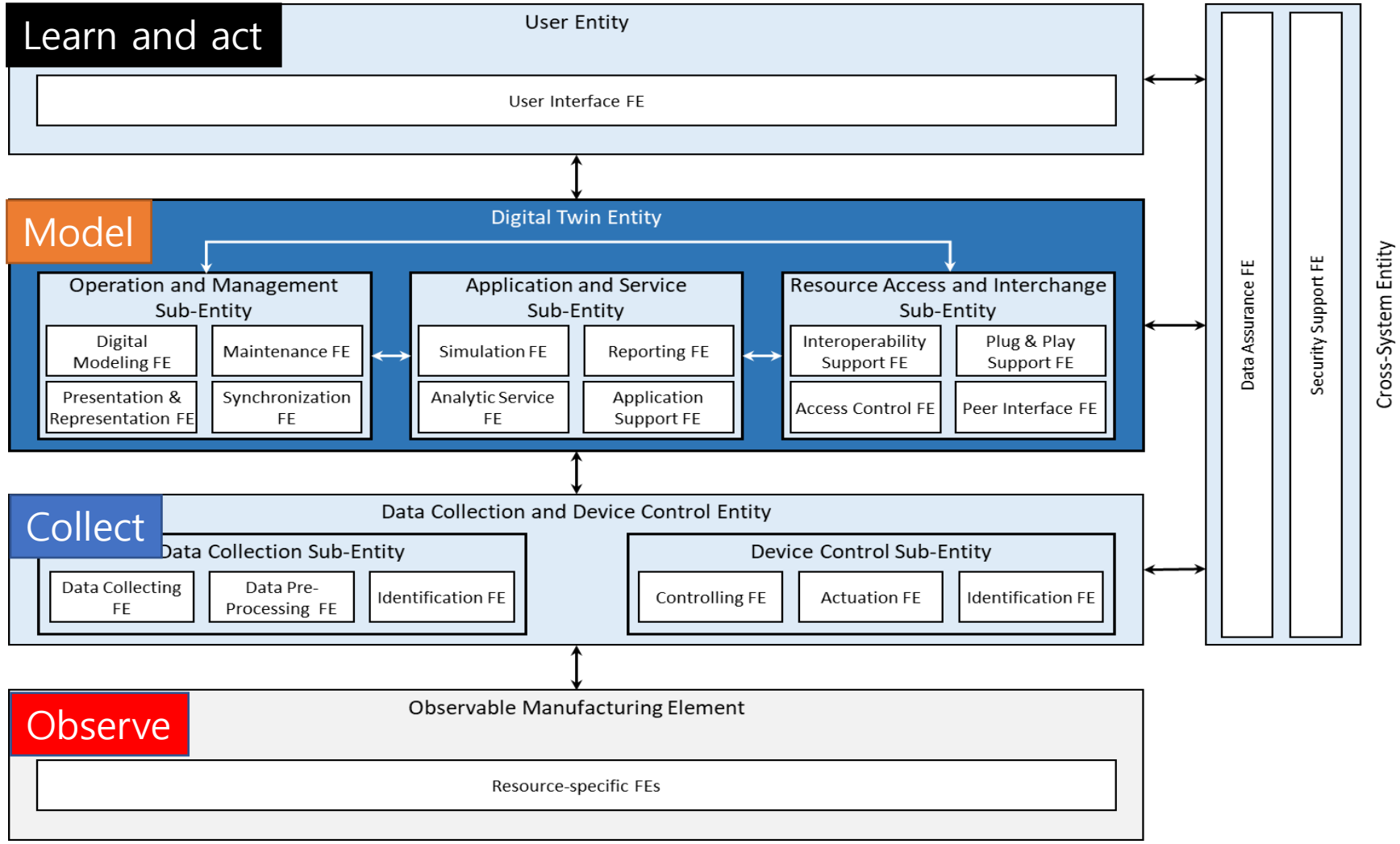


"Twin"

"Framework"

"Manufacturing"

ISO 23247 Digital Twin framework for manufacturing

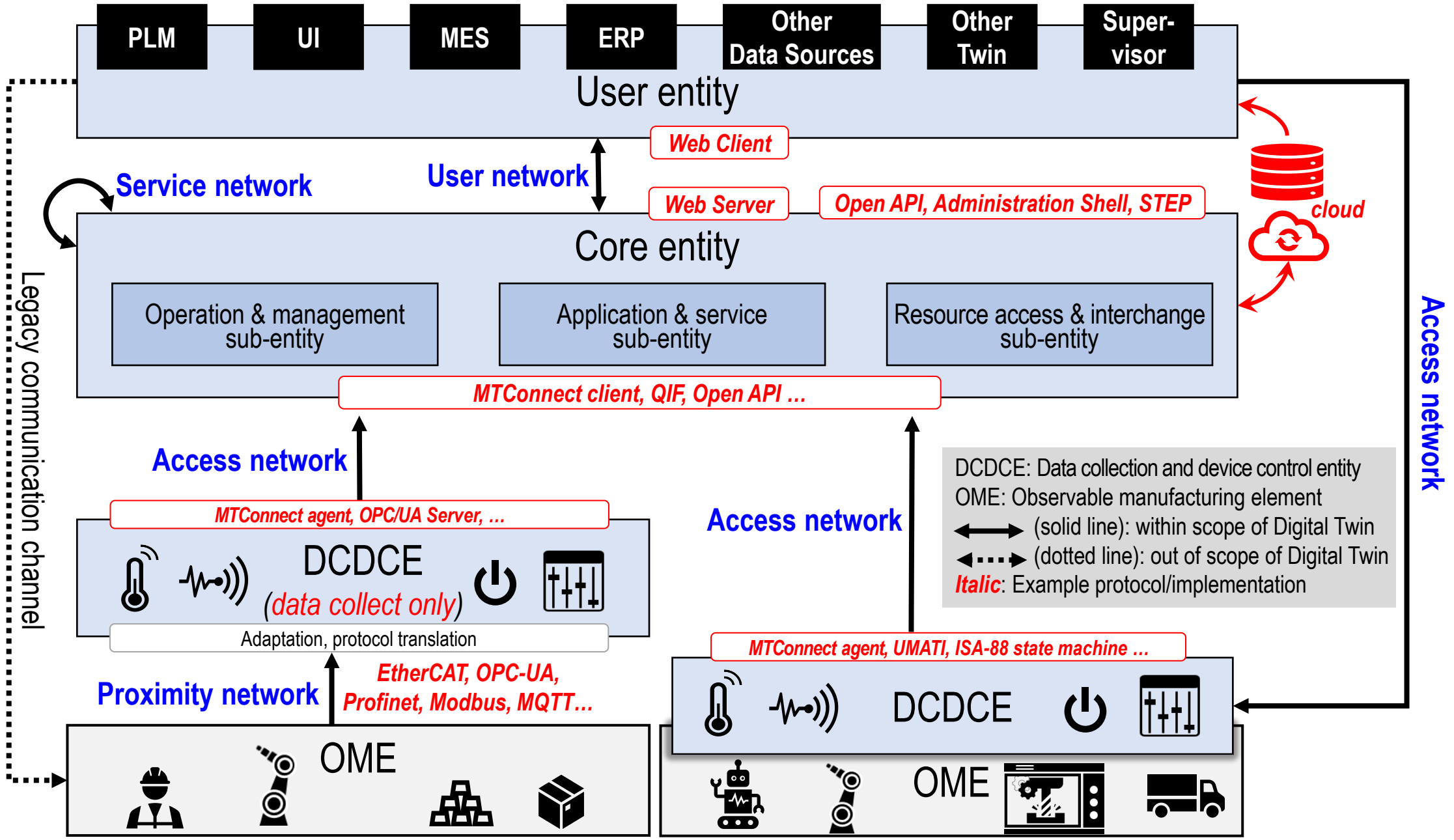


FE = Functional Element

ISO 23247 is layered on the IoT architecture ISO 30141

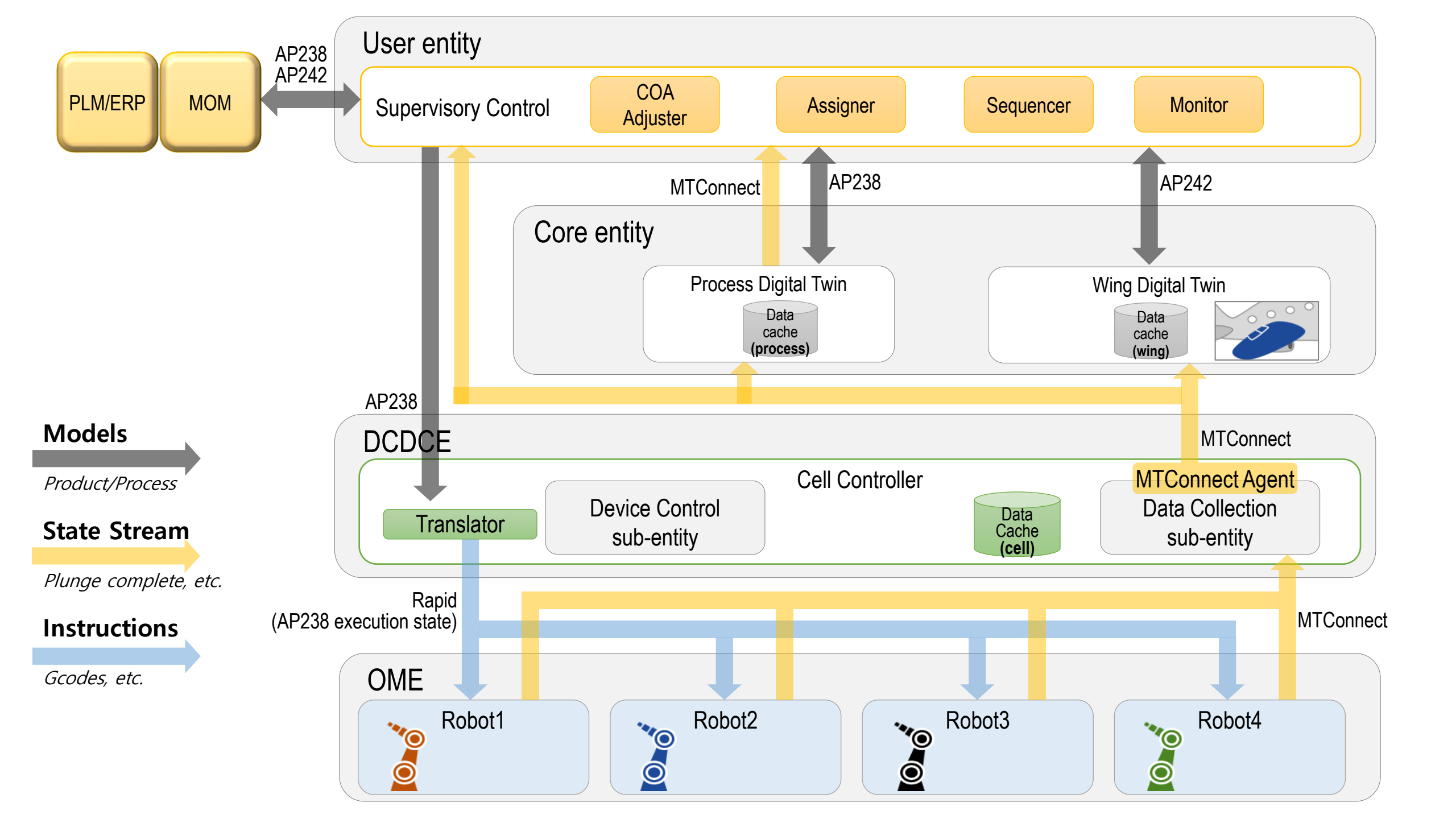
DIS ballot ended on October 19

Options


PLM
UI
MES
ERP
Other Data Sources
Other Twin
Super-visor
User entity
Web Client
User network
Service network
Web Server
Open API, Administration Shell, STEP
cloud
Core entity
Operation & management sub-entity
Application & service sub-entity
Resource access & interchange sub-entity
MTConnect client, QIF, Open API ...
Access network
Legacy communication channel
Access network
MTConnect agent, OPC/UA Server, ...
DCDCE
(data collect only)
Adaptation, protocol translation
Proximity network
EtherCAT, OPC-UA, Profinet, Modbus, MQTT...
OME
MTConnect agent, UMATI, ISA-88 state machine ...
DCDCE
OME
Access network
DCDCE: Data collection and device control entity
OME: Observable manufacturing element
(solid line): within scope of Digital Twin
(dotted line): out of scope of Digital Twin
Italic: Example protocol/implementation

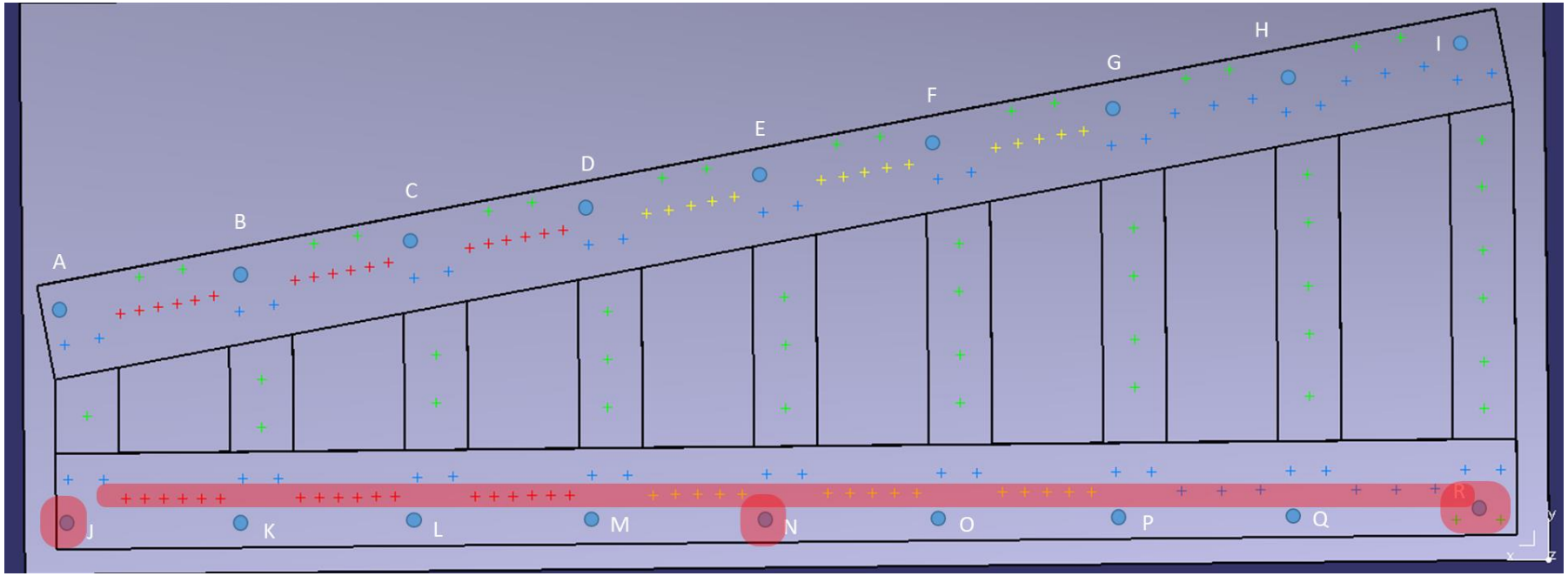
Use Case 1 – flexible schedule for robot drill & fill

- Manual -> Automatic
- Massive monolithic machines -> Robot cells
- Static processes -> dynamic processes
- Non-Optimized -> Optimized

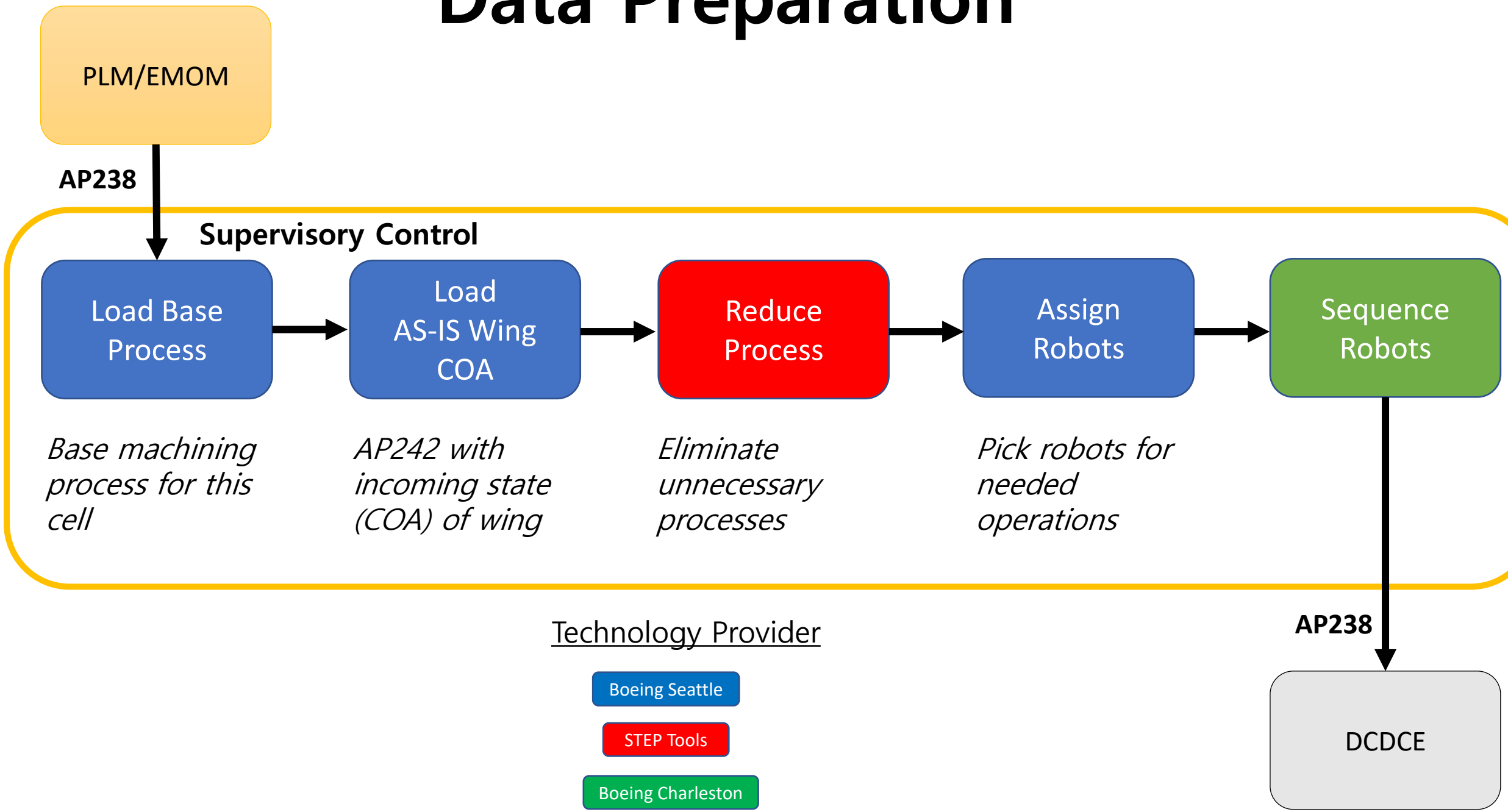

PLM/ERP
MOM
AP238
AP242
User entity
Supervisory Control
COA Adjuster
Assigner
Sequencer
Monitor
MTConnect
AP238
AP242
Core entity
Process Digital Twin
Data cache (process)
Wing Digital Twin
Data cache (wing)
AP238
DCDCE
MTConnect
Cell Controller
MTConnect Agent
Translator
Device Control sub-entity
Data Cache (cell)
Data Collection sub-entity
Rapid
(AP238 execution state)
MTConnect
OME
Robot1
Robot2
Robot3
Robot4
Models
Product/Process
State Stream
Plunge complete, etc.
Instructions
Gcodes, etc.

Large Aerospace Structures

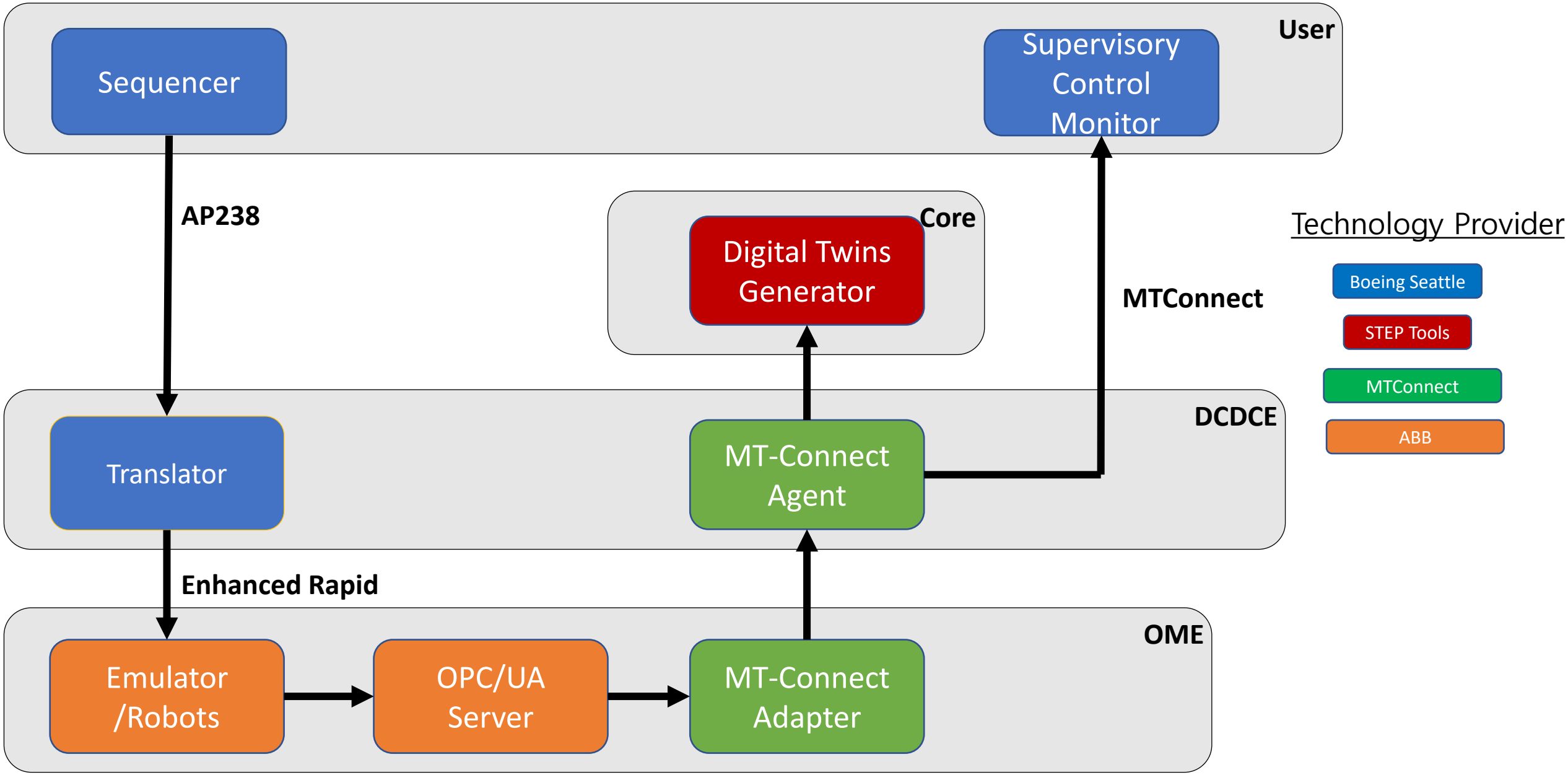
- 1000s of holes and fasteners
  - "Condition of Assembly (COA)" can vary
    - Holes drilled already (prior work)
    - Holes not to be drilled (missing bracket)
- "One-Up-Assembly (OUA)" requirements mean the process sequence has constraints
- Any variations/exceptions must be tracked for validation and subsequent work (becomes new COA)



Data Preparation



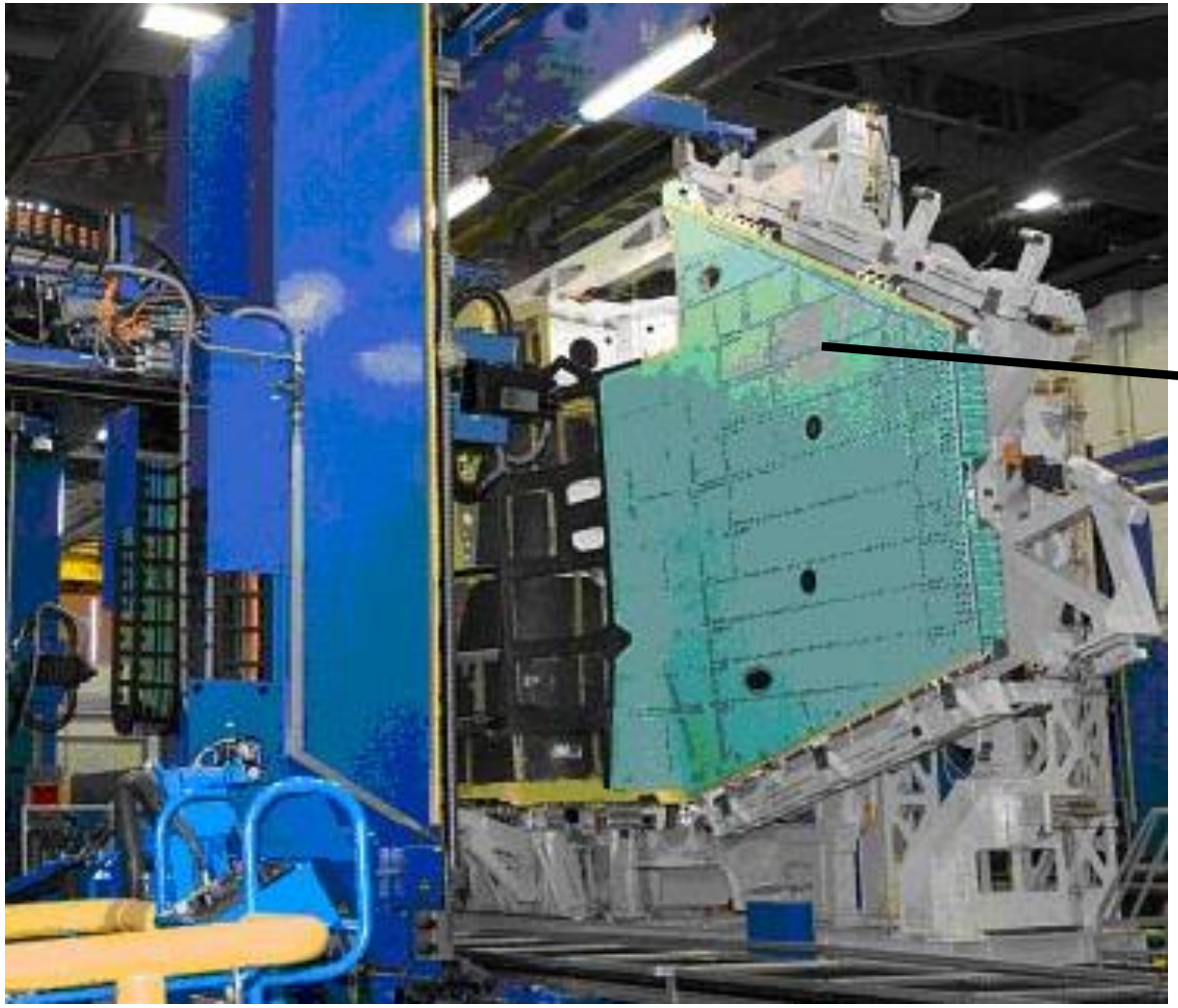
Execution

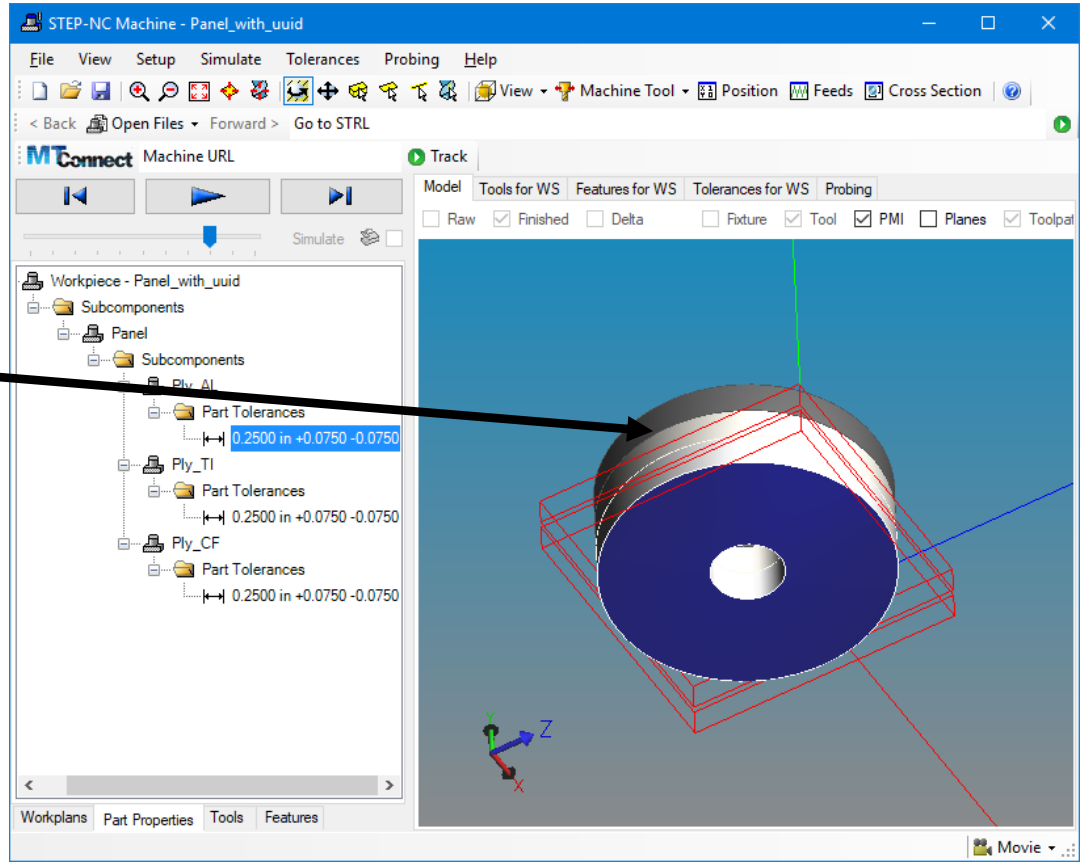

User
Sequencer
Supervisory Control Monitor
AP238
Core
Digital Twins Generator
MTConnect
Technology Provider
Boeing Seattle
STEP Tools
MTConnect
ABB
DCDCE
Translator
MT-Connect Agent
Enhanced Rapid
OME
Emulator /Robots
OPC/UA Server
MT-Connect Adapter

Benefits of 23247 Framework

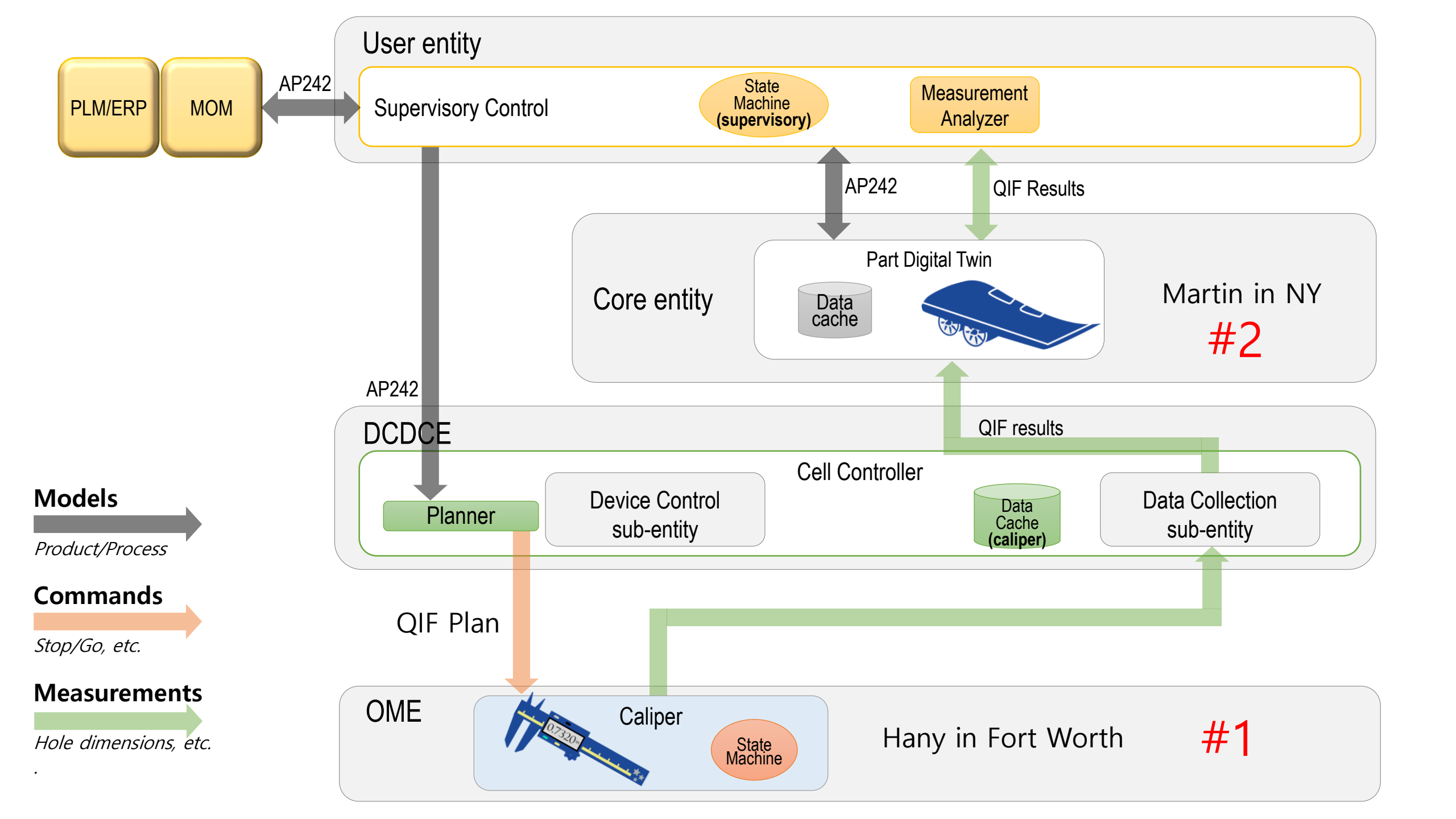
- Multiple applications on one infrastructures
  - Process reducer for COA (AP242/AP238)
  - Process division (AP238)
  - Process sequencer for robots (AP238)
  - Process monitor (MTConnect)
- Part Digital Twin (AP242)
  - Enables real time monitoring and analysis
  - Enables machine learning
- Process Digital Twin (AP238)
  - Enables modification
  - Enables validation

Use Case 2 – weight reduction

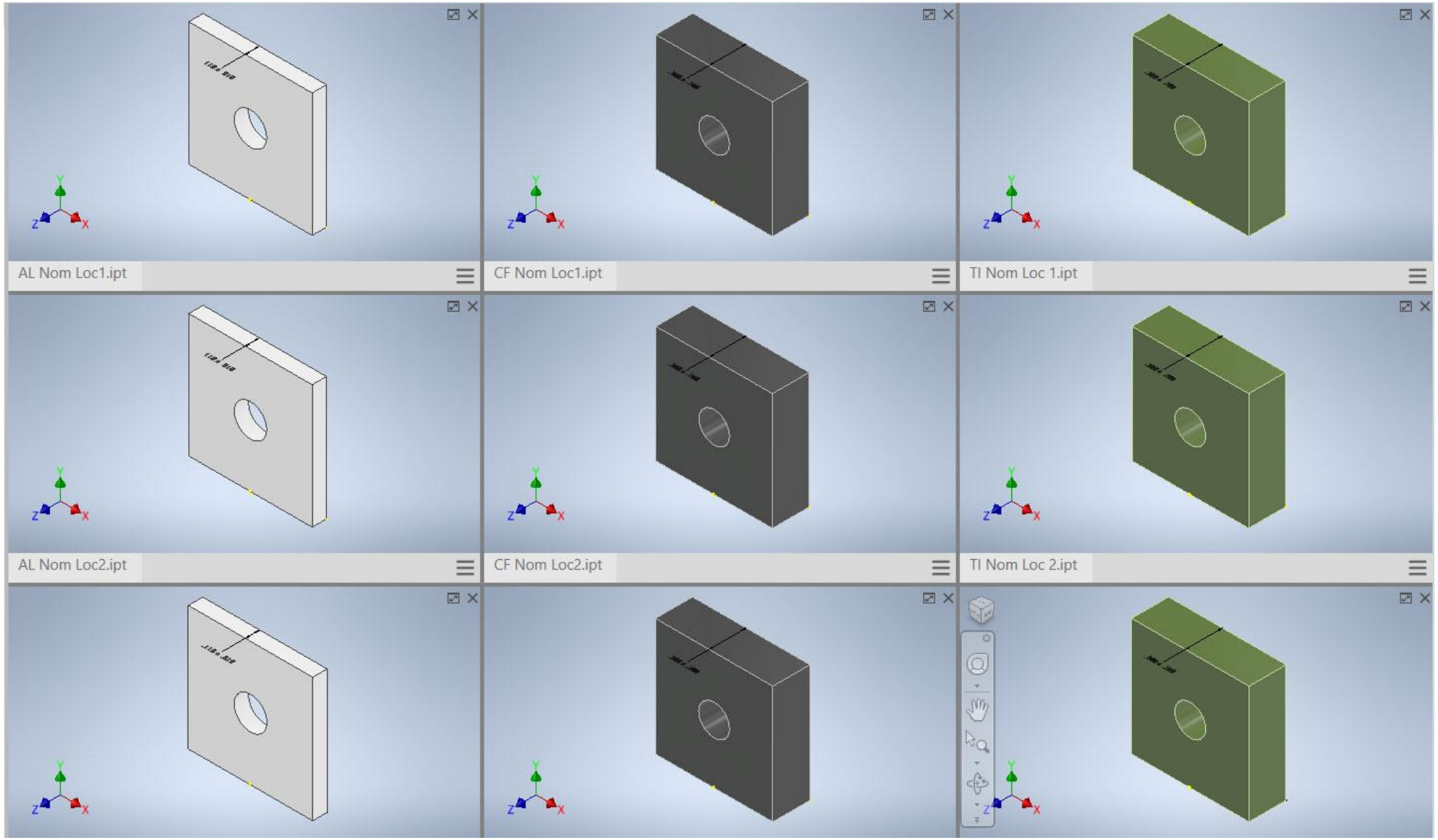




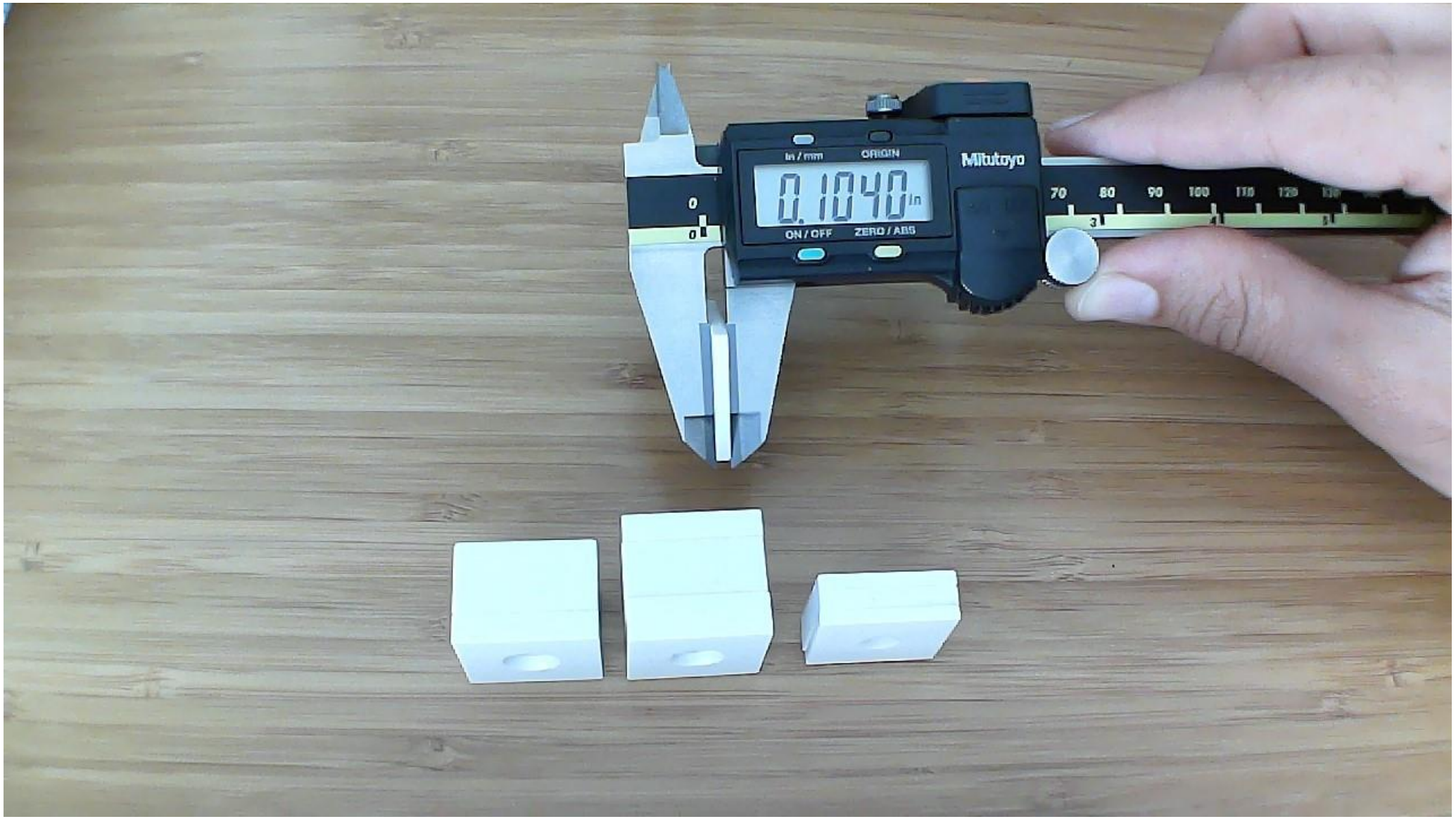
Exact match of fastener to hole depth can reduce weight by hundreds of lbs.


User entity
PLM/ERP
MOM
AP242
Supervisory Control
State Machine (supervisory)
Measurement Analyzer
AP242
QIF Results
Core entity
Part Digital Twin
Data cache
Martin in NY
#2
AP242
DCDCE
QIF results
Cell Controller
Planner
Device Control sub-entity
Data Cache (caliper)
Data Collection sub-entity
Models
Product/Process
Commands
Stop/Go, etc.
QIF Plan
Measurements
Hole dimensions, etc.
OME
Caliper
State Machine
Hany in Fort Worth
#1

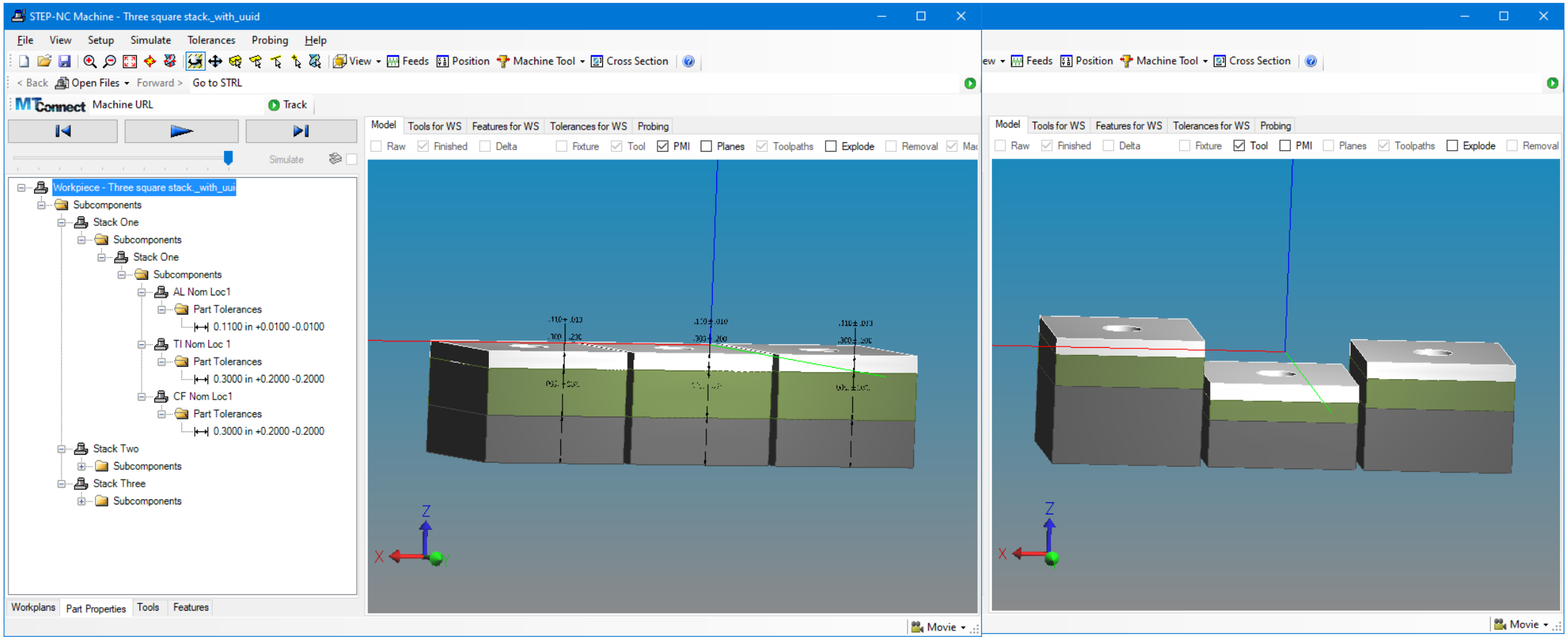
Measurement samples



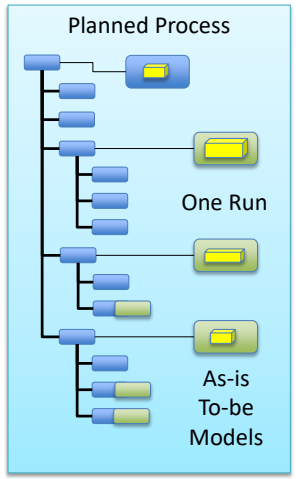
Digital Gage makes QIF Results



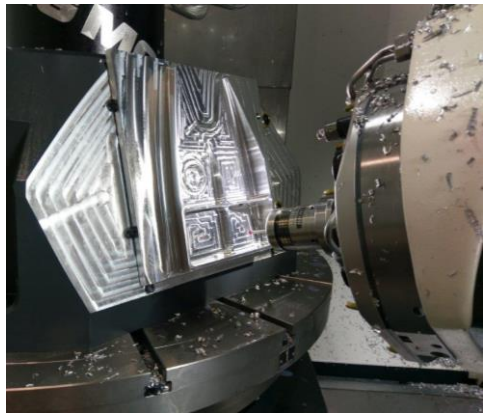
Three stacks before and after QIF Results applied



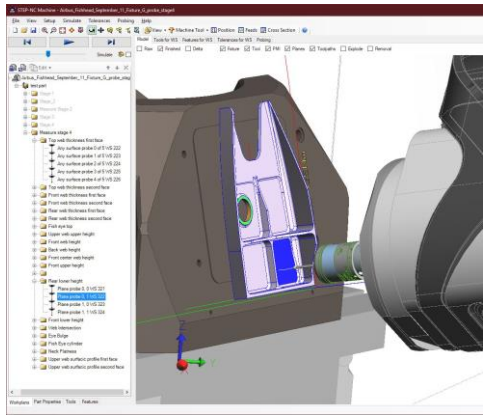
Use Case 3 – Process Optimization



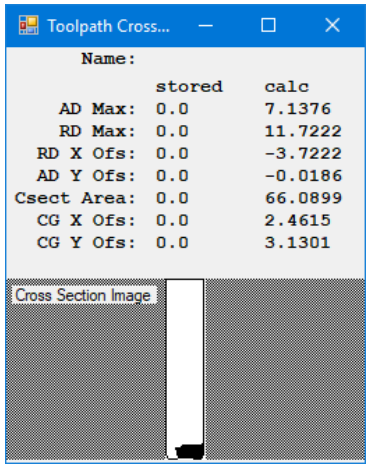
Plan & verify process



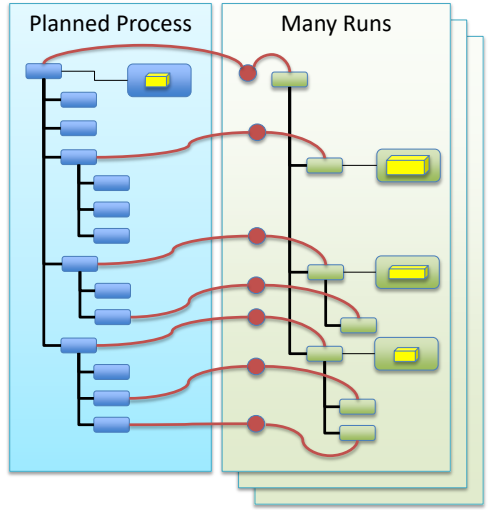
Machine parts



Monitor process execution



Compute tool engagement



Store linked data

ISO

STEP-NC

Planned models of product & process

KTH/OMAC

Machining Context Macros

Gcode execution

ANSI

MTConnect

Stream results

STEP Tools

STEP Agent

Apply Results

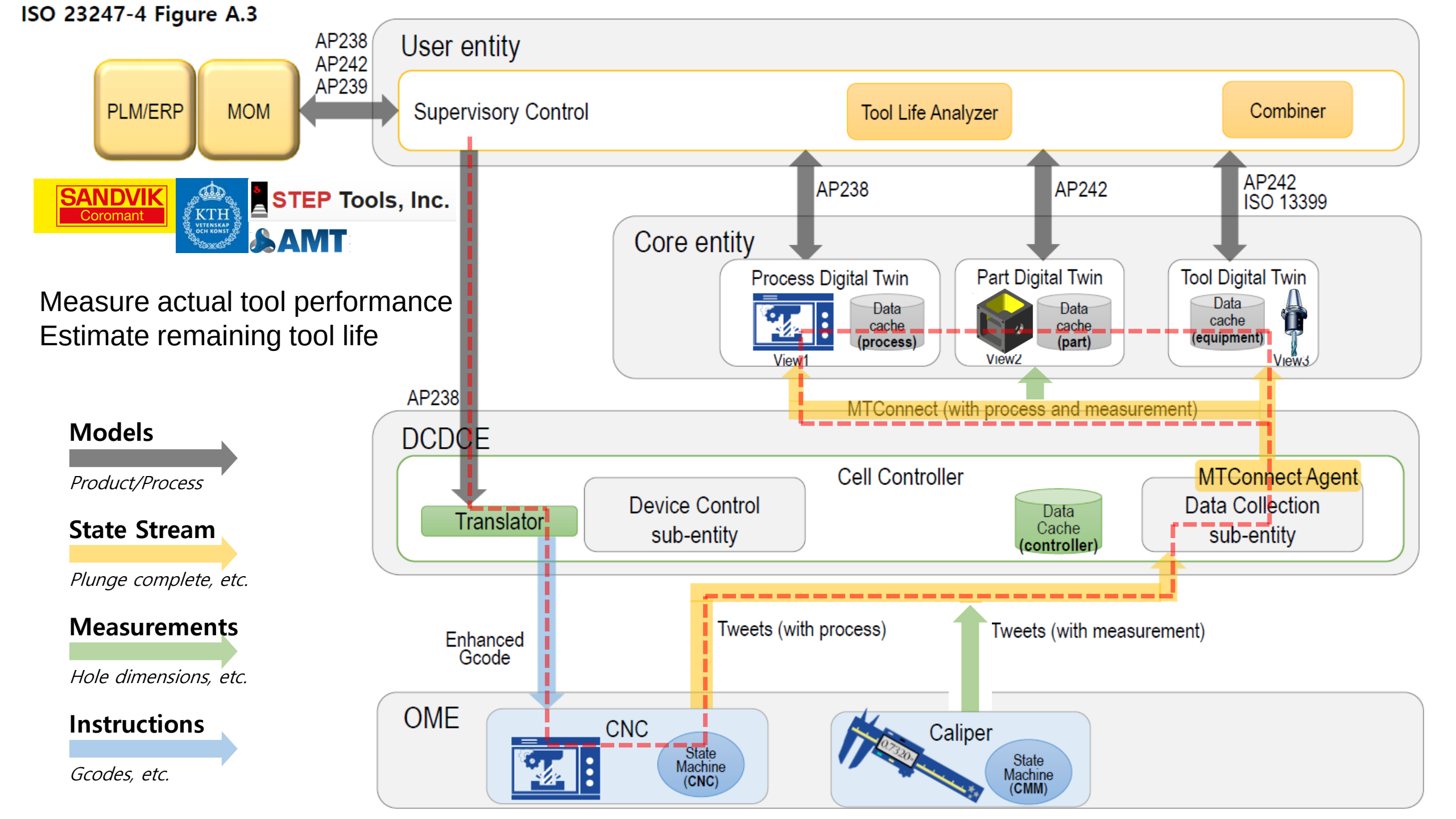
ISO

STEP-NC

Twinned models of product & process

Process cost reduced by 15%

ISO 23247-4 Figure A.3



Demo
– feedback from CNC to CAM via MTConnect

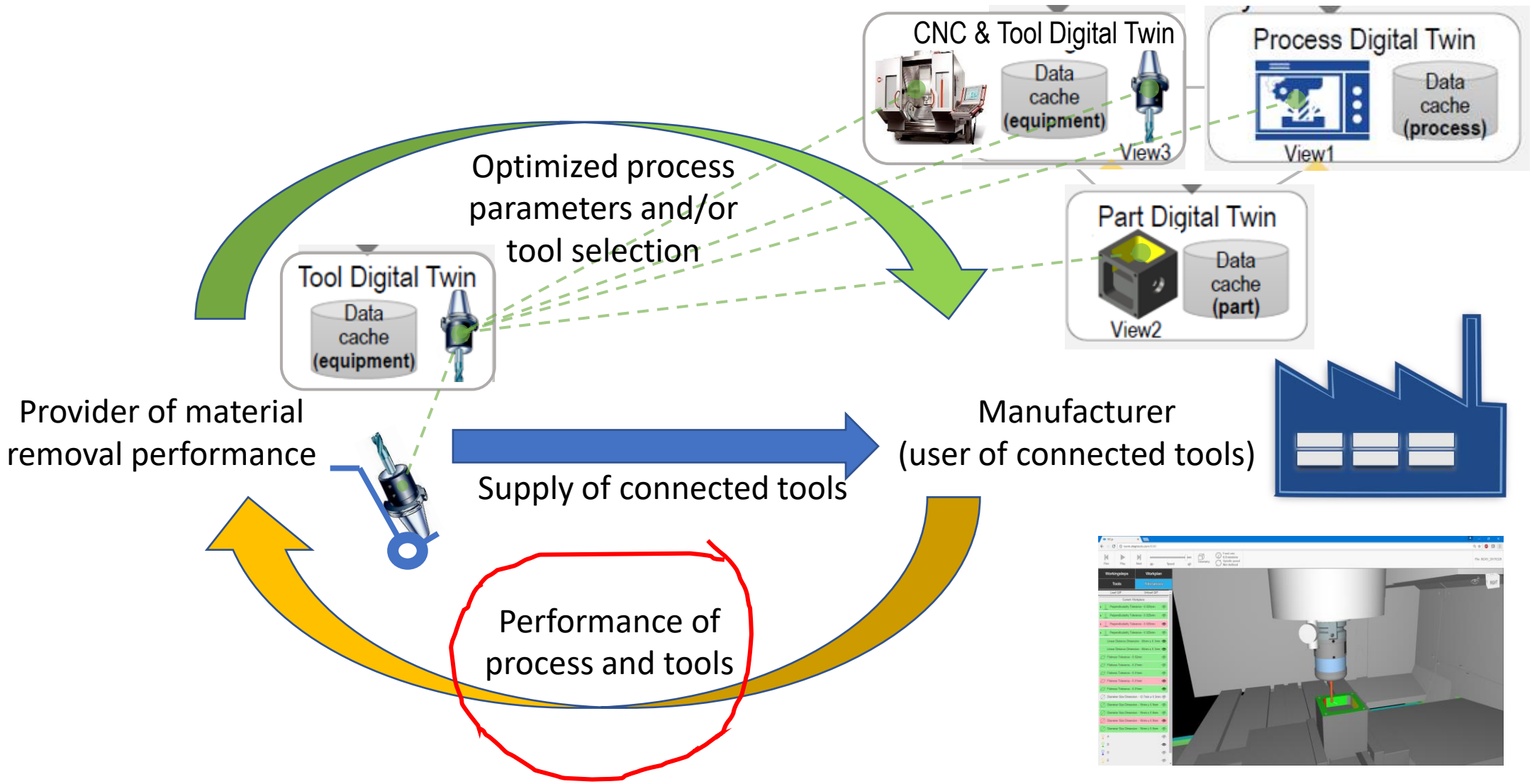
1. StepNC data set is post processed into StepNC enhanced G-code.

2. As CNC executes process, its MTConnect data stream is enhanced with StepNC process data:
   - Time stamped WorkingSteps (CAM operations) as executed
   - Actual part being machined
   - Actual tool being used

3. Digital Twins application has access to full MTConnect data stream in context of the planned StepNC process.
   - This use case uses feed override as example

4. Feature measurements relate to “as-planned” (by CAD/CAM) and “as-processed” (by CNC) are demonstrated in use case 2.
5. Twinned data can be analyzed, combined or stored for improved decision making and machine learning.

Material Removal Performance as a Service -a "new" business model



Concluding remarks

- ISO 23247 defines a framework divided into four layers
  - Observation, Collection, Modeling and Learning
  - Implemented by data protocols (guidance given in Part 3)
  - Connected by networking protocols (guidance given in Part 4)
- for digital twins of observable elements
  - Products and processes on the manufacturing shop floor
  - Synchronized with digital twins in software systems
  - So that applications can make savings by measuring