Enabling Learning for Manufacturing Machines

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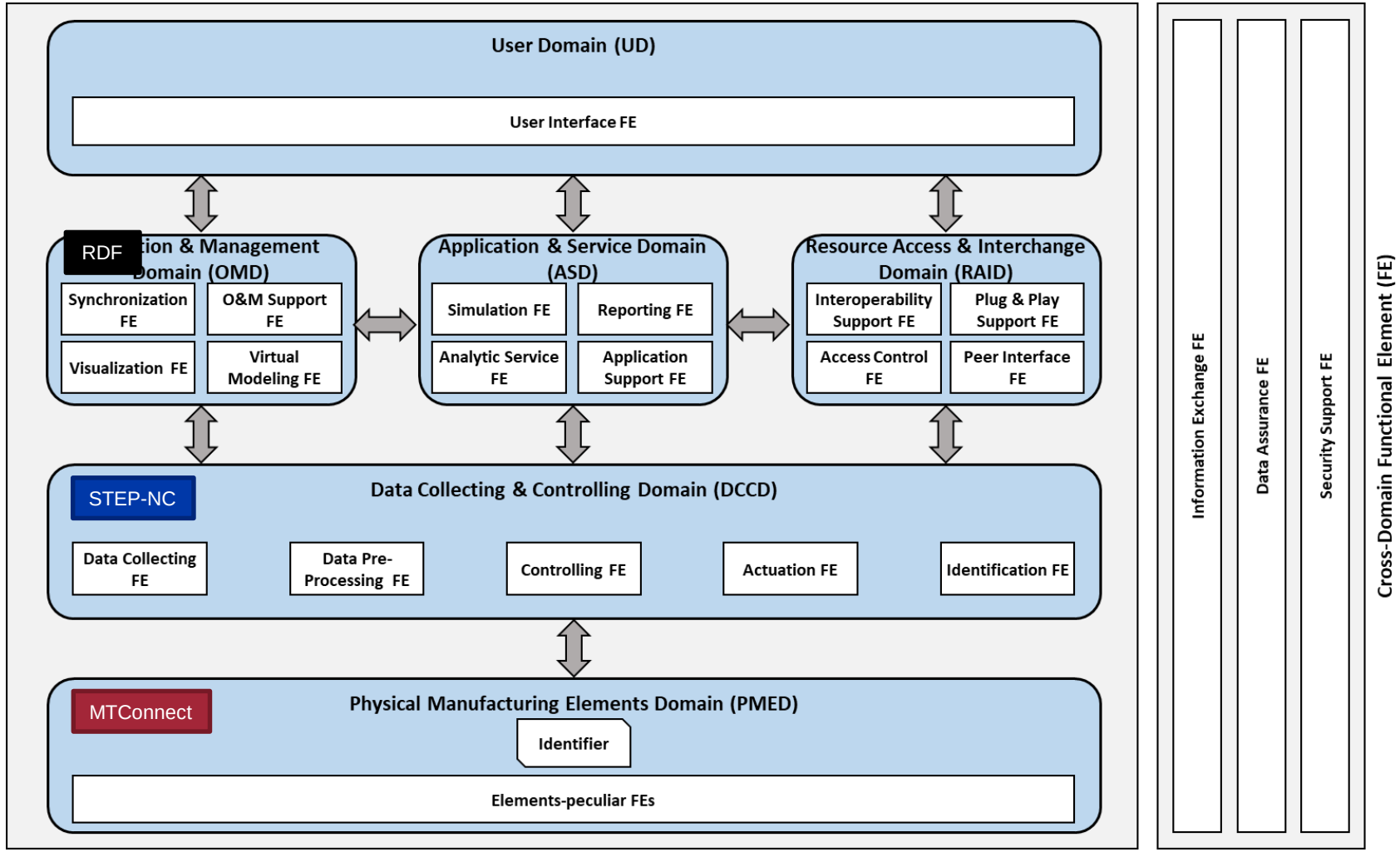
Introduction

- **Who am I**
  - **Dr. Martin Hardwick**
  - **Convener of ISO Digital Manufacturing working group**
  - **www.steptools.com, info@steptools.com**
- **What standards are we developing / assisting**
  - **Digital Twin manufacturing framework - ISO 23247**
  - **STEP-NC integrated model for machine control – ISO 10303-238**
  - **QIF Quality Information Framework – ISO 23952**
- **What do I want to talk about**
  - **Using digital twins for machine learning**

Digital Twin manufacturing framework – ISO 23247

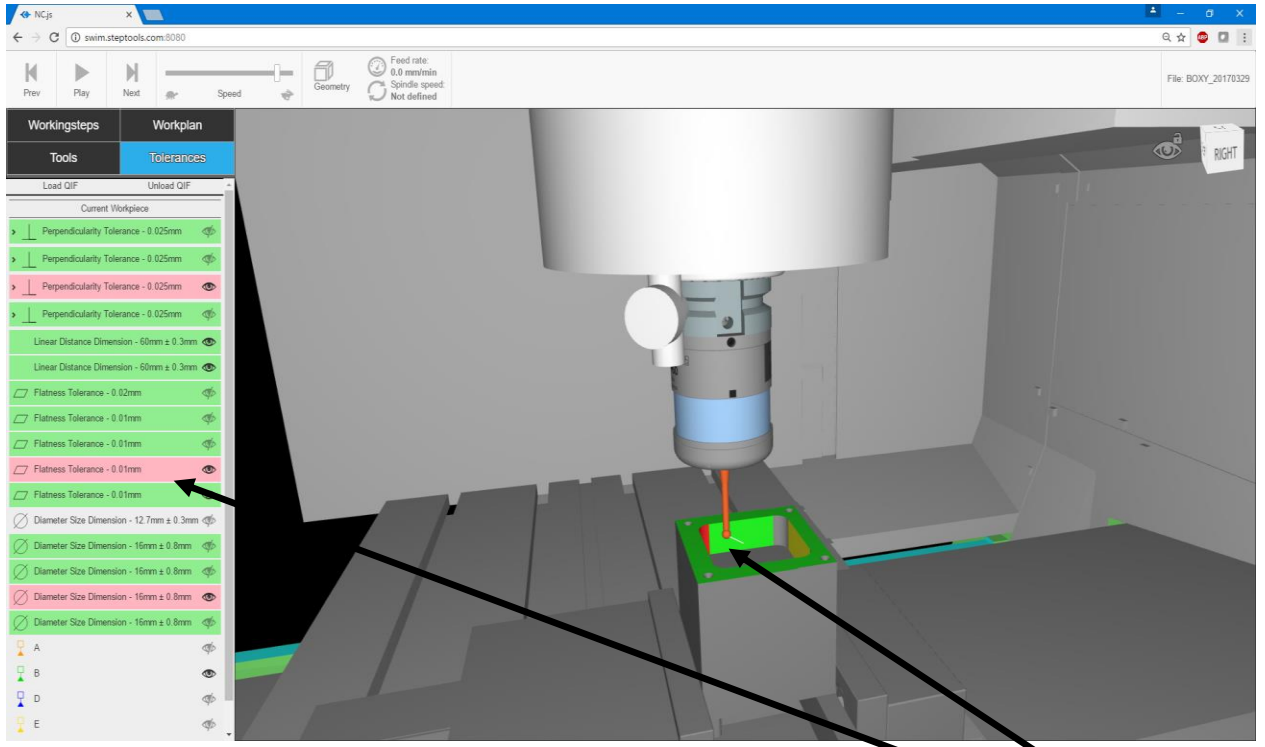


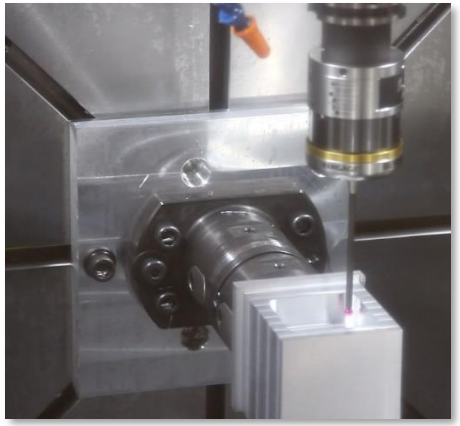
ISO 23247 layered on the IoT architecture ISO 30141

CD ballot passed on September 4

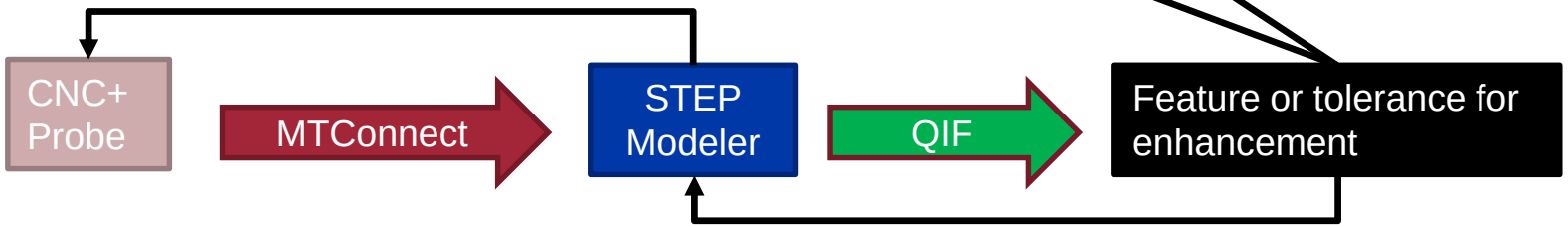
RDF, STEP and MTConnect are example technologies for each level

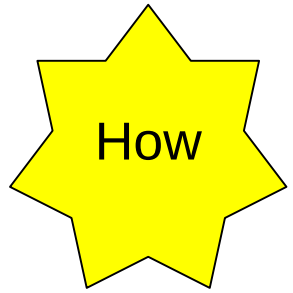
Example 1 – on machine measurement





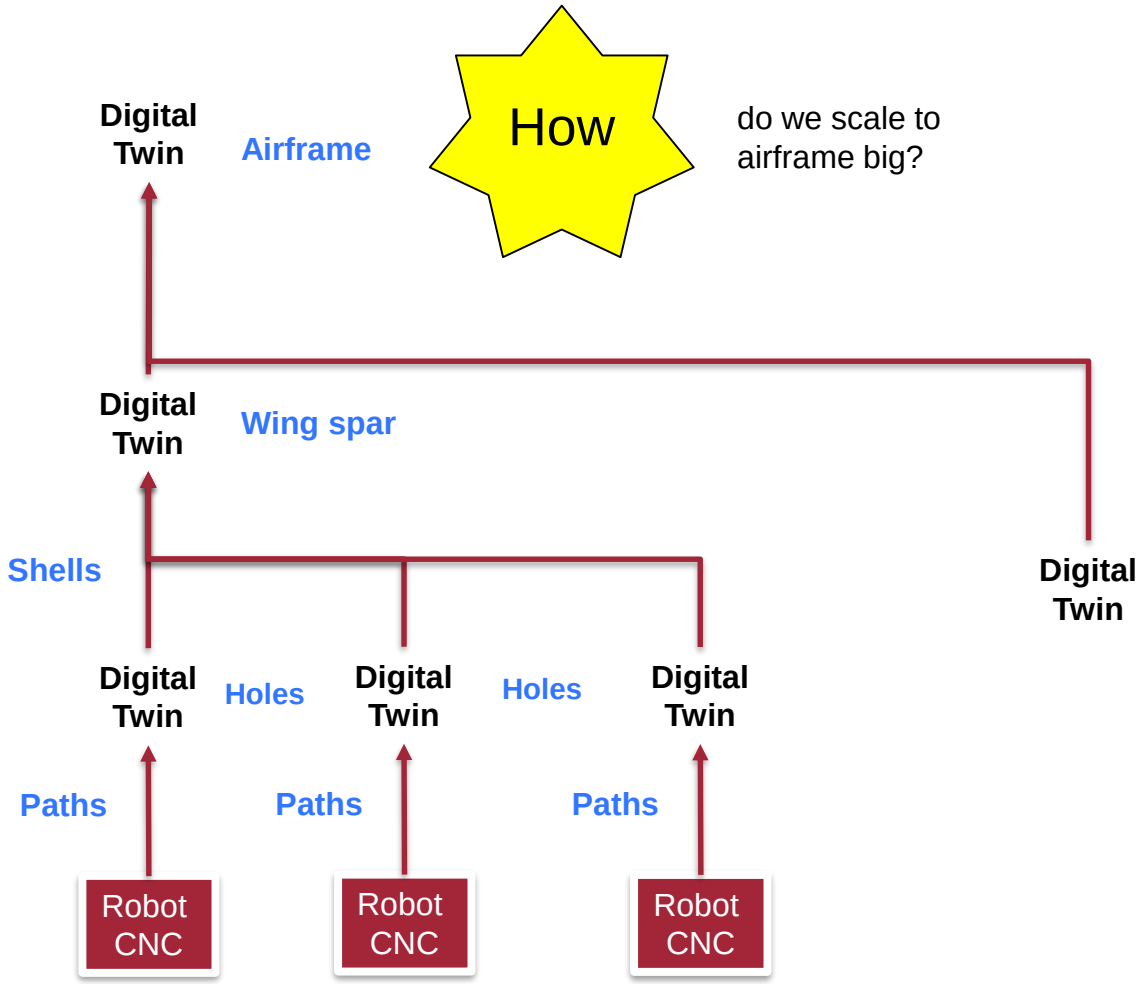
https://www.mmsonline.com/articles/machining-demonstration-shows-the-digital-twin-concept-in-action



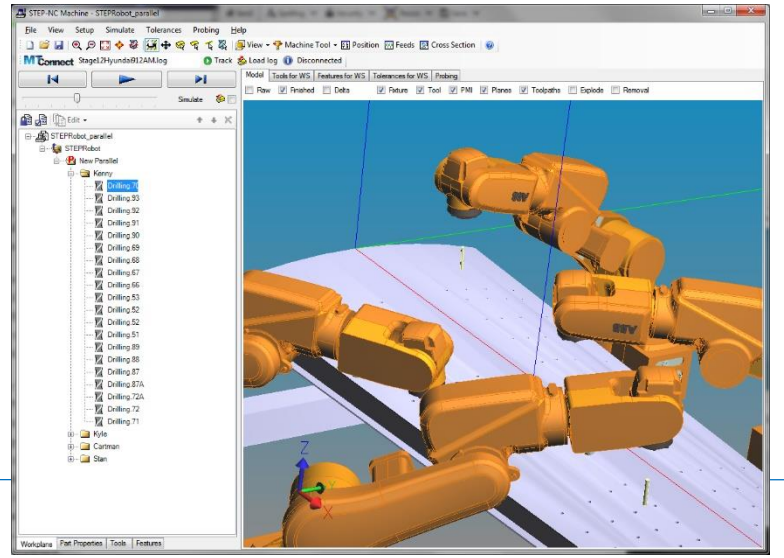


do we learn to make corrections?

Example 2 – schedule team of robots

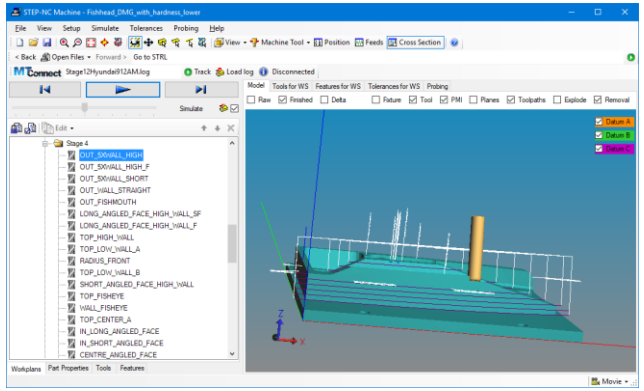


"Kill" Kenny

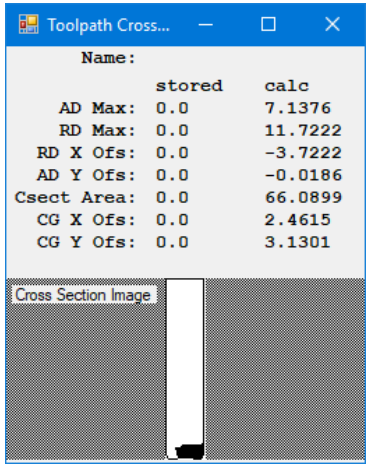


Drill and fill

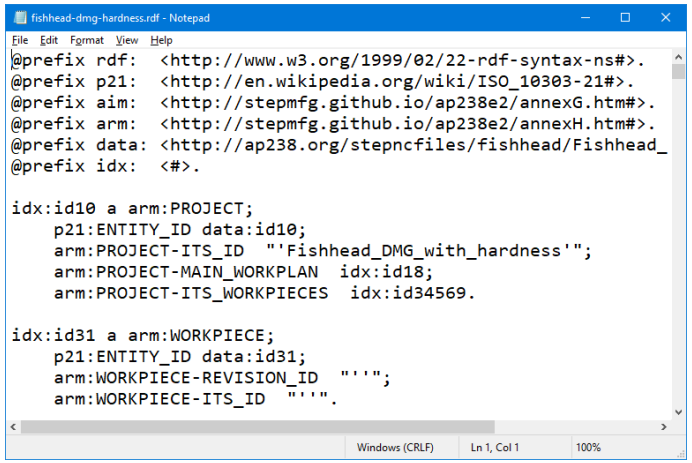
Example 3– learn how to maximize tool life



Change tool diameter



Compute tool engagement



Make linked data

Go / No Go

OMAC	ANSI	STEP Tools	ISO	USAF	IOF
Machining Context Macros →	MTConnect →	STEP Agent →	STEP-NC →	STEP2RDF →	RDF
Gcode operations	Stream machining results	Filter Results	Add model data	Convert to RDF resources	Analyze and learn

Other use cases

1. **Process optimization (deployed at Boeing)**
2. **On machine measurement (example 1)**
3. **Dynamic scheduling (example 2)**
4. **Tool life management (example 3)**
5. **Materials identification**
6. **Closed loop machining**
7. **CNC to CNC data exchange**
8. **CNC to CAM data exchange**
9. **CAM to CAM data exchange**
10. **CAM to CAD data exchange**

Machine Learning

RDF — Learning standard

STEP-NC — Modeling standard

MTConnect — Machining standard

Machine Manufacturing

ISO 23247

Concluding remarks

- **Fit between STEP and RDF is a good one**
  - **RDF is more powerful and flexible than EXPRESS**
  - **RDF has seamless interfaces to JSON-LD and Python**
  - **RDF is made practical by Turtle and SHACL**
- **Work described here is early**
  - **Intelligent GD&T is new to the public domain**
  - **Integration with BOF and Industry Ontology Foundry (IOF)**
- **Starting experiments with an industry team**
  - **ASM for materials experts**
  - **Boeing for manufacturing experts**
  - **USAF for ontology and machine learning experts**