Digital Twin Manufacturing Framework

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Overview

- Why do we need a framework?
- What might be in the framework
- Early testing
- Proposal

Digital Twin Machining

DMDII
a UI LABS Collaboration

"Mind the Gap"14-02-02

http://fishhead.steptools.com:8080/

- Real time twinning from MTConnect
  - 1Hz trace the plan data
  - 250Hz model the run data
- Open stack
  - STEP in Node.js
  - View in Three.js
  - UI in React.js
- JavaScript programming
  - Responsive
  - Adaptive
  - Closed Loop

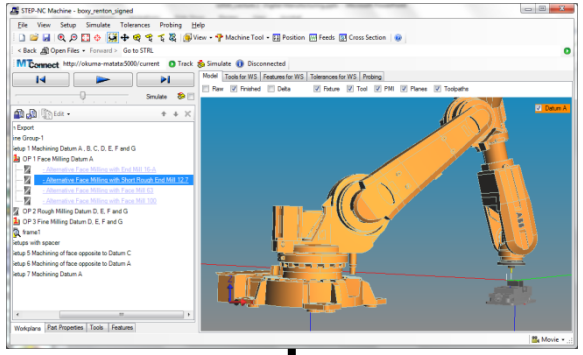
Goals

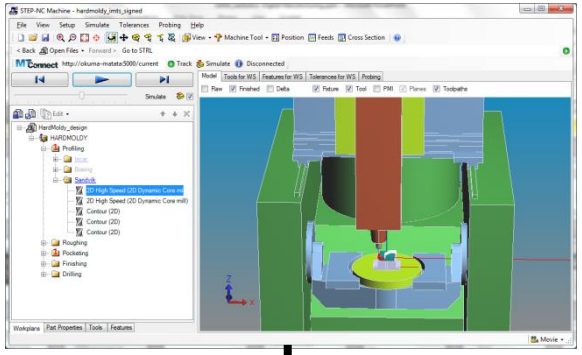
- Enable the twins to be as accurate as possible
- Enable the twins to be as large (complex) as possible
- Enable twinning on many kinds of machines
- Enable twinning for many kinds of processes
- Enable twinning using many different underlying systems

- Simplify the design and operation of manufacturing cells
- Share work between machines on the shop floor

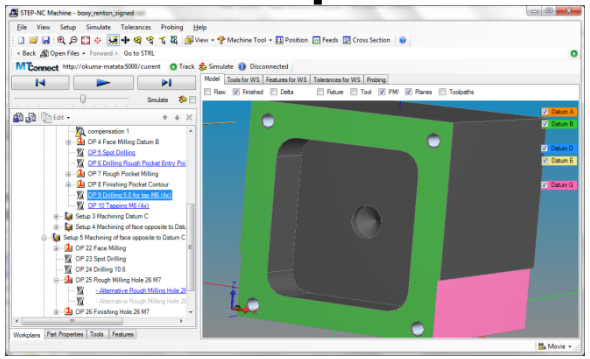
Digital Twin Manufacturing Framework

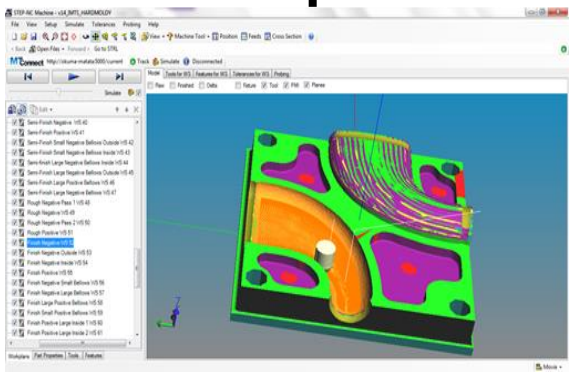
- Digital control
- Digital Planning
- Digital Metrology

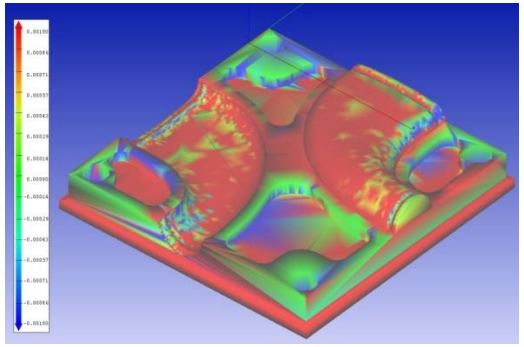




Communication about a shared manufacturing task (+15% efficiency)



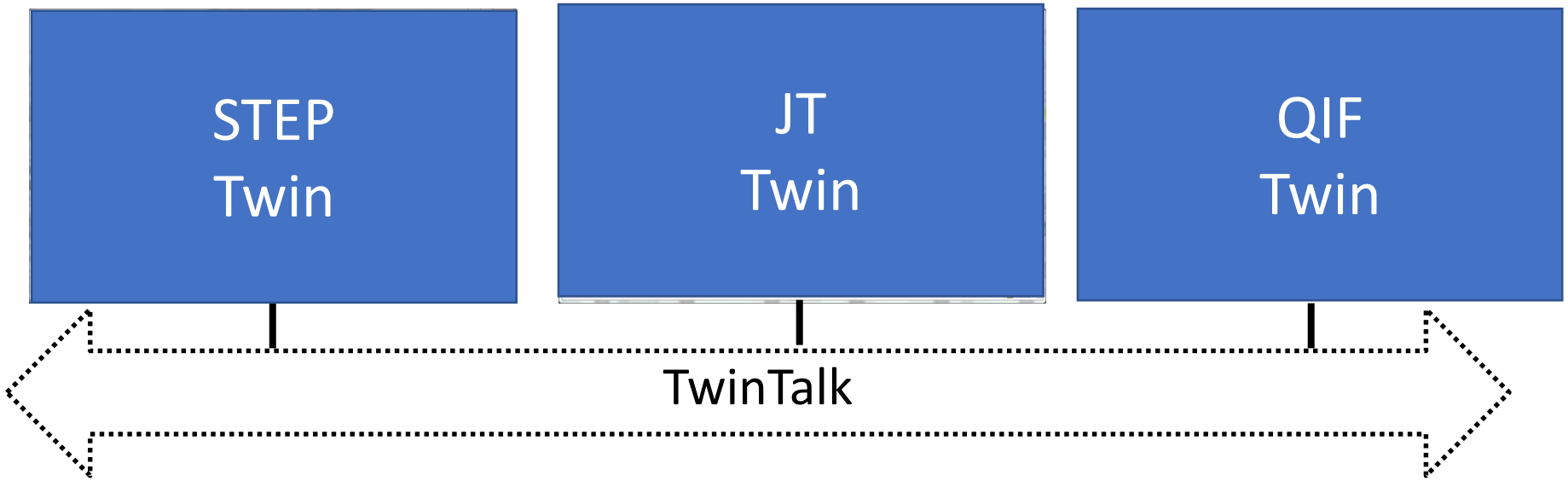




- Digital Assembly
- Digital Monitoring
- Digital Inspection

Semantic modeling of the manufacturing task

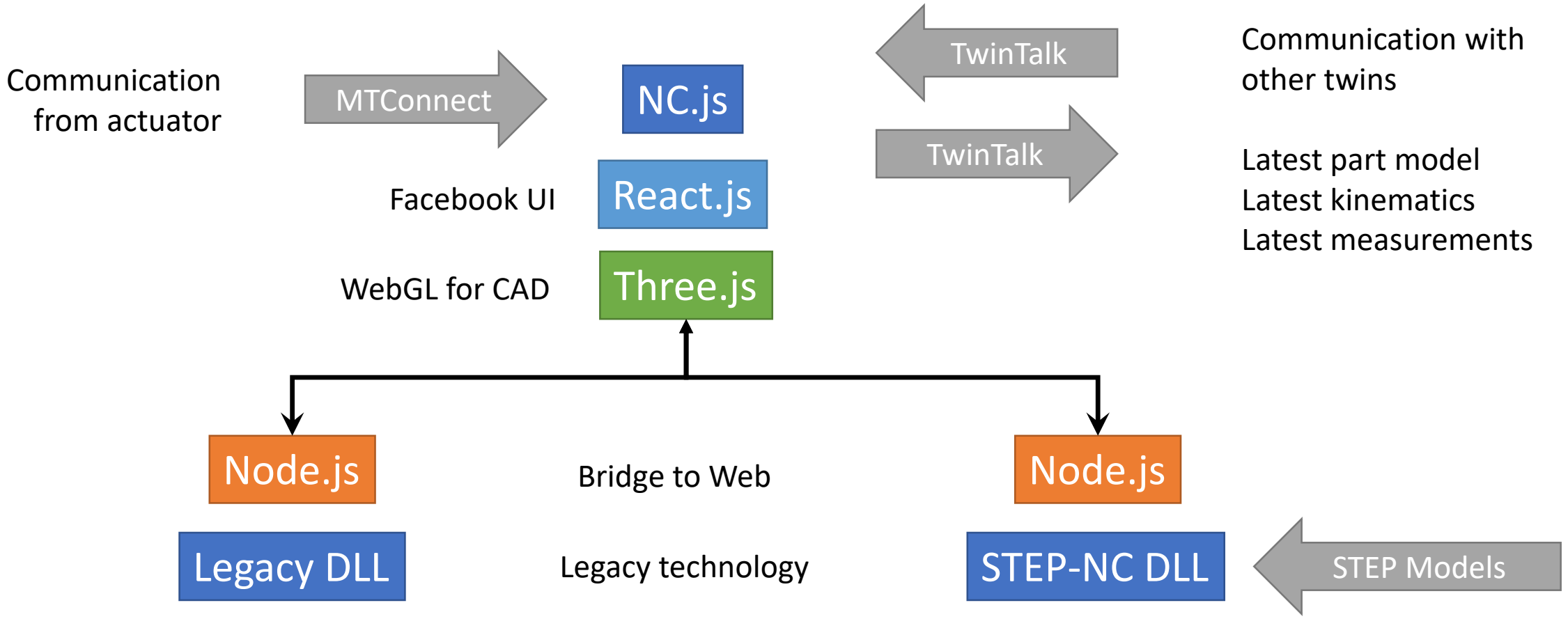
Digital Twin Manufacturing Framework



Twin Talk is

- Streaming language on top of publication and subscription protocols
- Each stream talks about changes made by its system
  - Here is the new value for a closed shell (during machining)
  - Here is the new position for these kinematics (during setup)
  - Here is the new as-measured tolerance (during measurement)

Architecture proposal

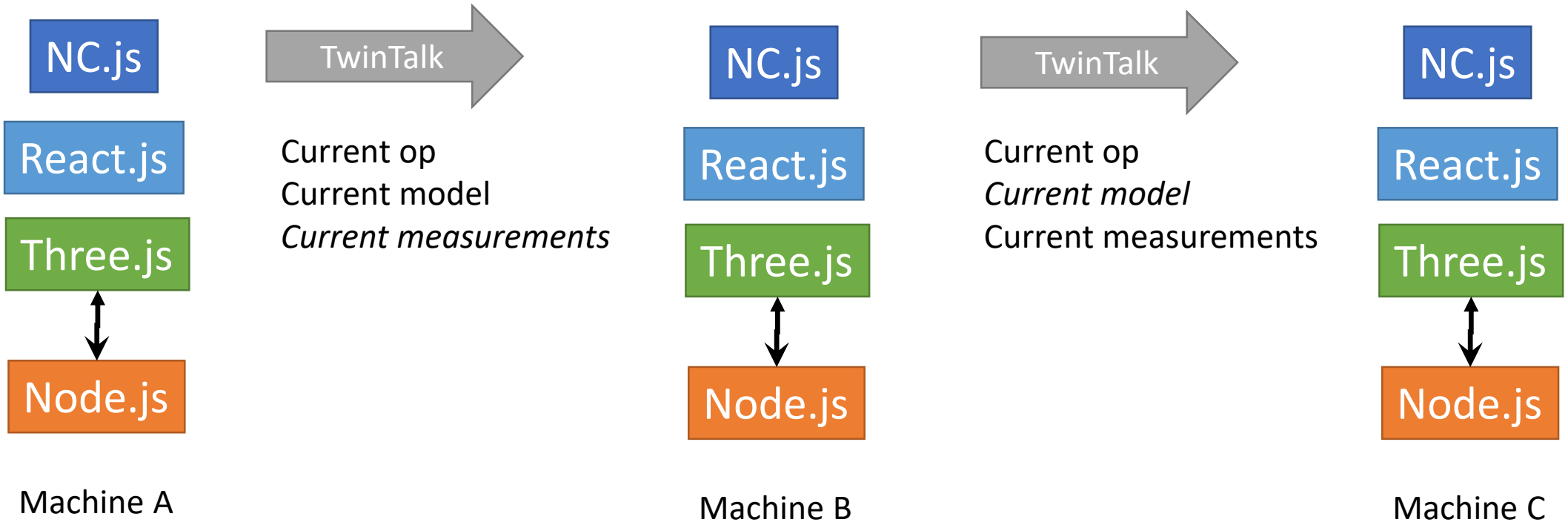


Choices include QIF, STEP, JT or direct interfaces to legacy systems

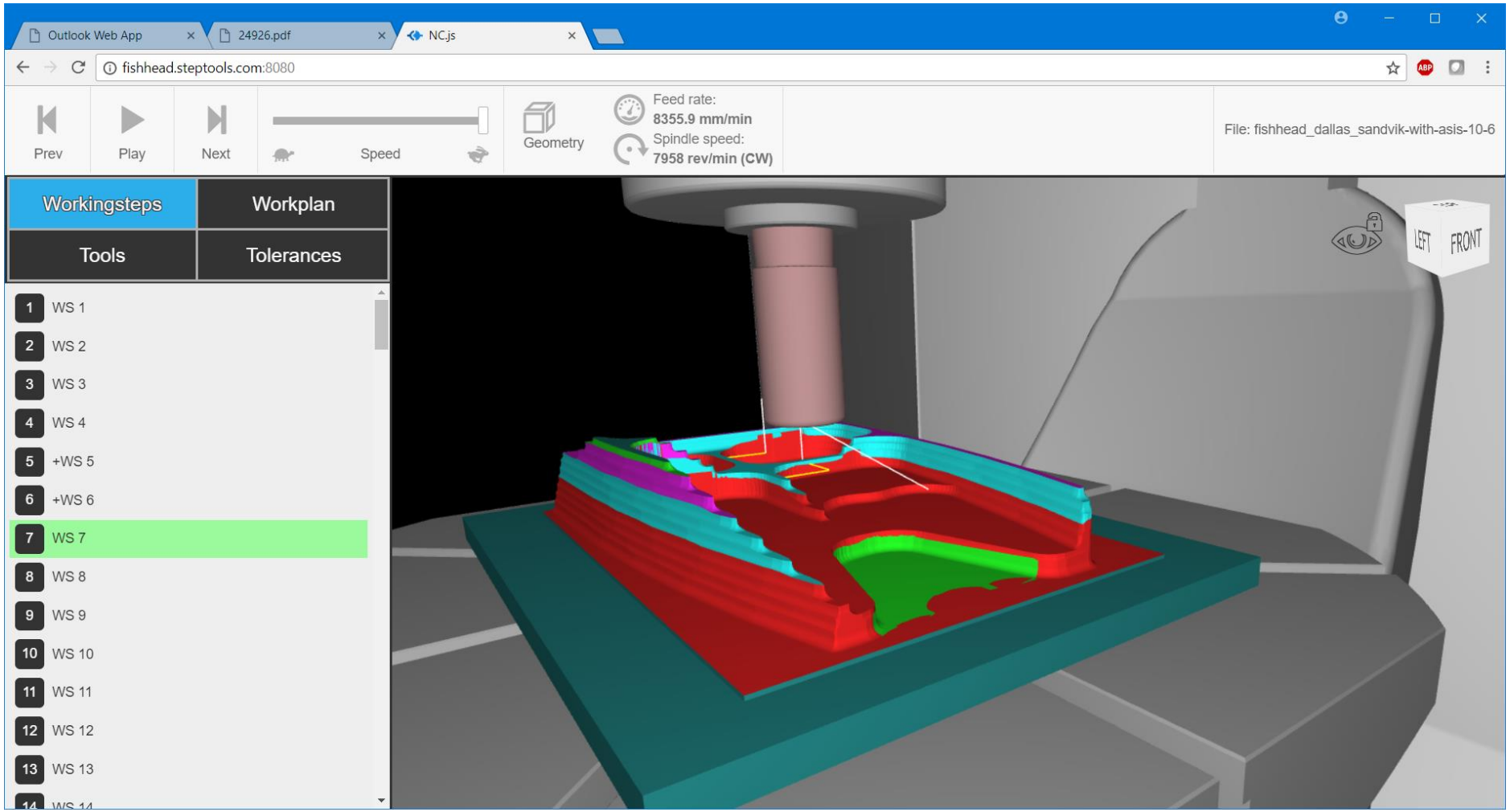
https://github.com/steptools/NC.js/blob/master/docs/index.md

IMTS / JIMTOF 2018 demonstration

- Stop work on one machine, continue work on next
  - Take on-machine measurements (optional)
  - Take CMM measurements (optional)

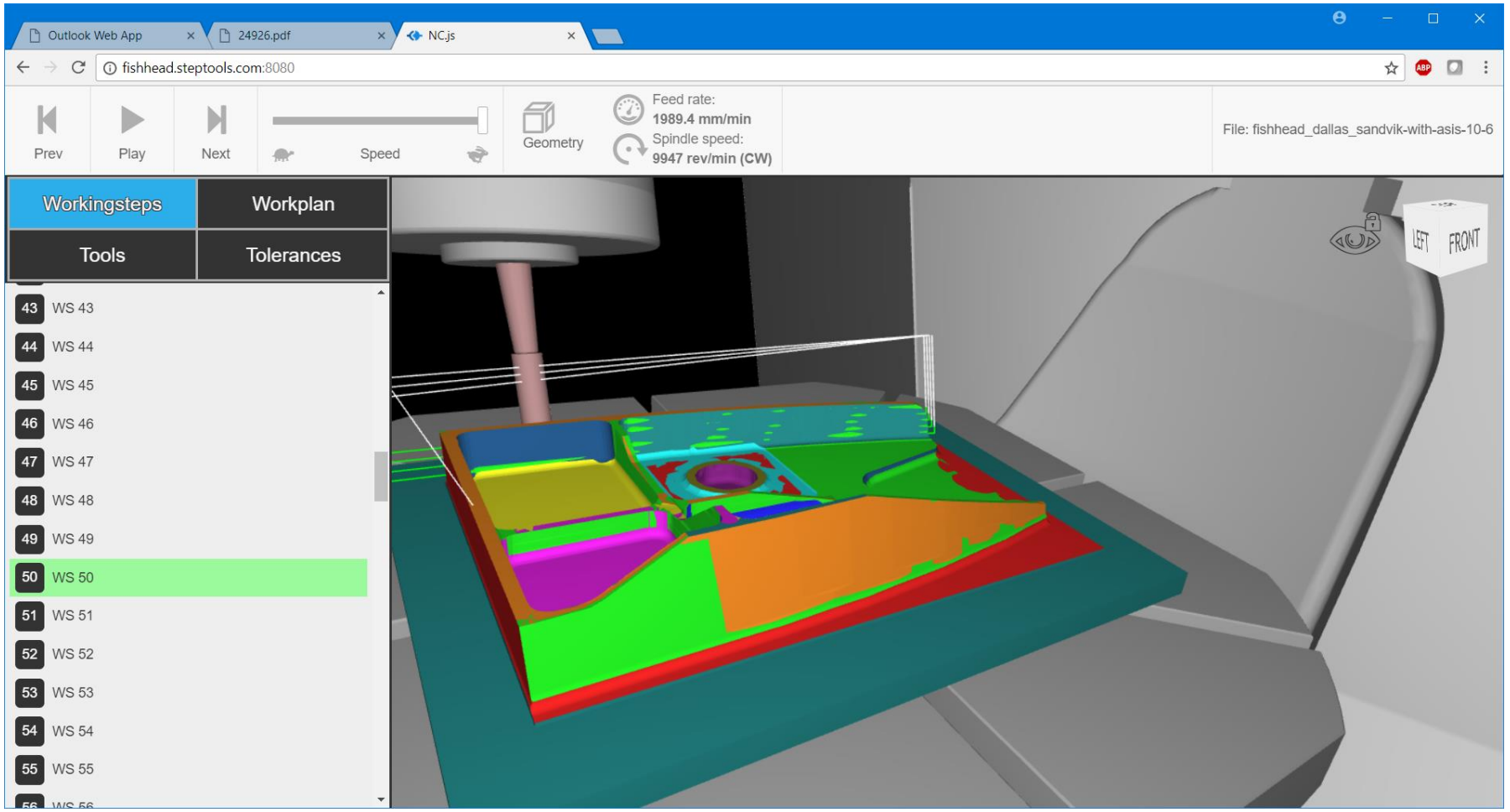


Fishhead (aerospace test part) at Operation 7



http://fishhead.steptools.com:8080/

Fishhead at Operation 50



http://fishhead.steptools.com:8080/

Digital Thread Demonstration, July 19 2017

STEP is good for product modeling and long term archiving
MTConnect is good for monitoring machining results
QIF is good for quality reporting

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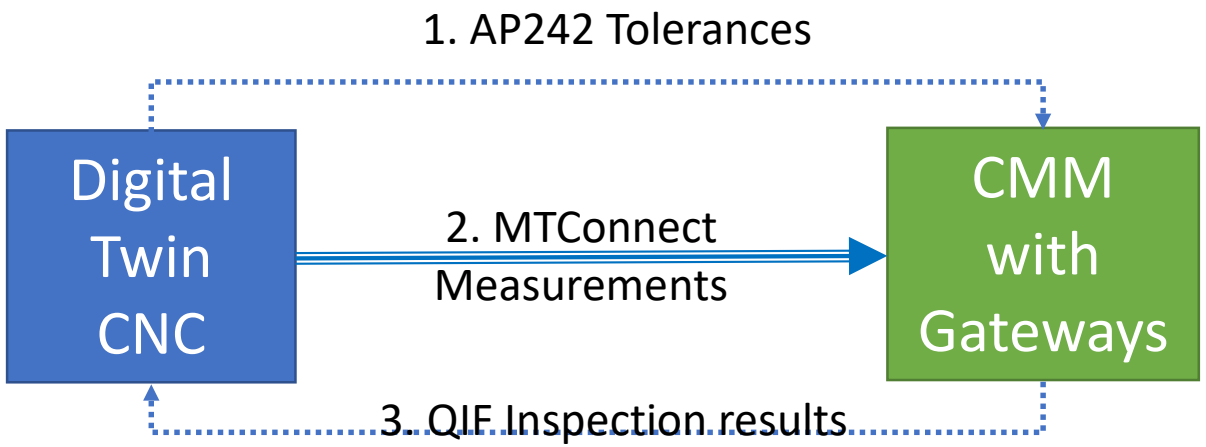
"O3" 14-06-05

Traditional CNC with Digital Twin for real time modeling



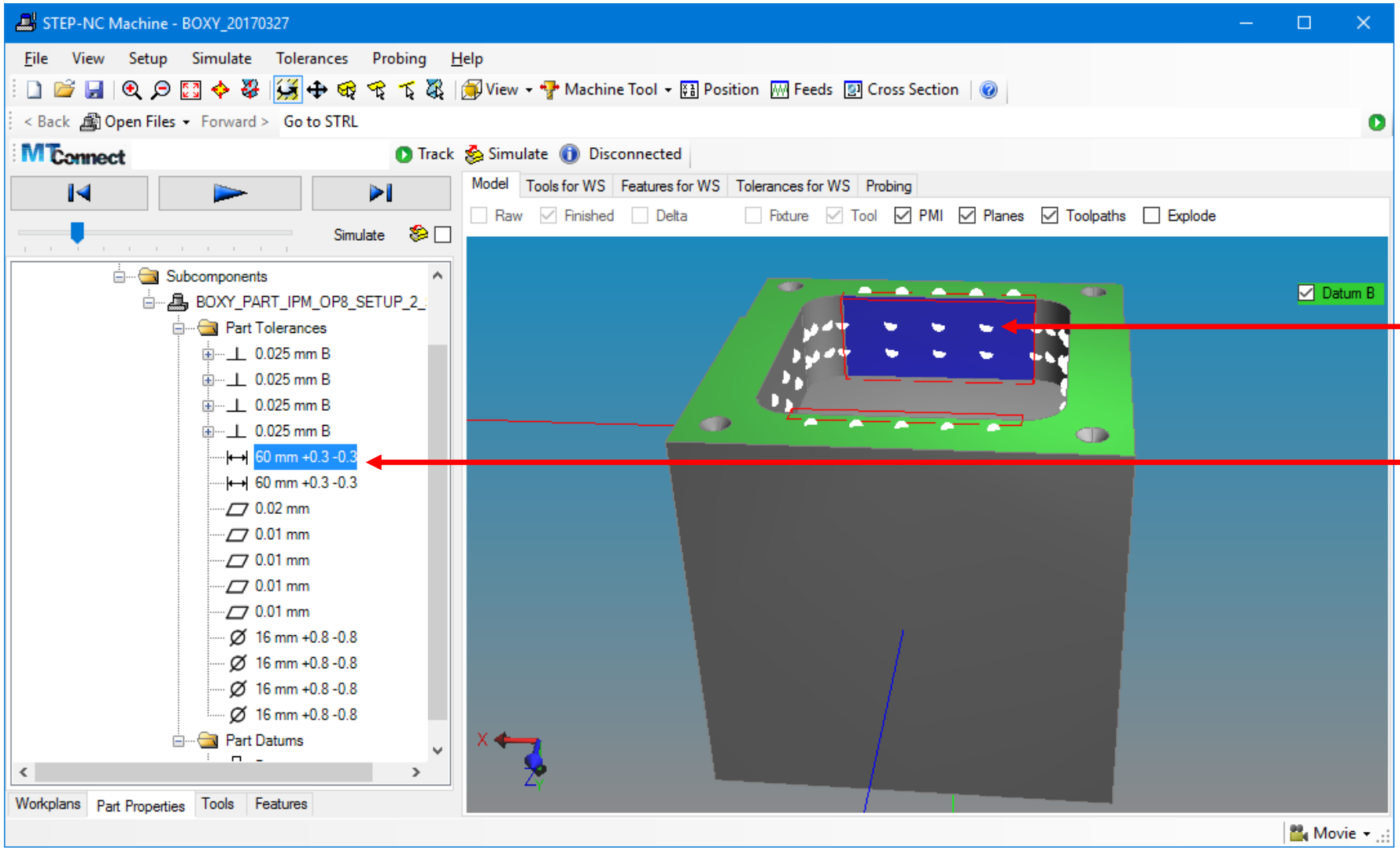
Traditional CMM with gateways for STEP, MTConnect, and QIF

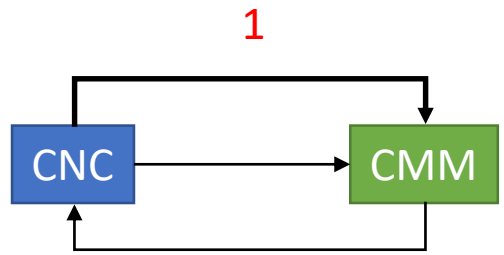
https://youtu.be/Mjzg5nku5Lg

Build Here if you meet the tolerances

https://youtu.be/n_syXtpyxgM

1. Tolerances and probe points in STEP





PMI validation point

Semantic Dimension

2. Measurement points in MTConnect agent

swim.steptools.com:5000/current

2017-02-20T18:41:49.443571Z	Unavailable		system	Msystem	49	

Path : path

Samples

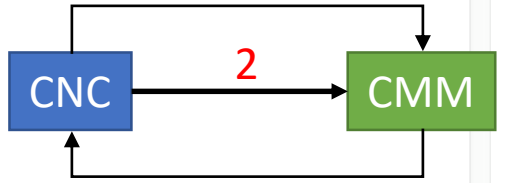
Timestamp	Type	Sub Type	Name	Id	Sequence	Value
2017-02-20T18:41:49.443571Z	AccumulatedTime	x:CUTTING_TIME	p1CuttingTime	Mp1CuttingTime	27	UNAVAILABLE
2017-02-20T18:41:49.443571Z	PathFeedrate	ACTUAL	p1Fact	Mp1Fact	28	UNAVAILABLE
2017-02-20T18:41:49.443571Z	PathFeedrate	PROGRAMMED	p1Fcmd	Mp1Fcmd	29	UNAVAILABLE
2017-02-20T18:41:49.443571Z	PathPosition		p1LPathPos	Mp1LPathPos	30	UNAVAILABLE
2017-02-20T18:41:49.443571Z	AccumulatedTime	x:OPERATING_TIME	p1OperatingTime	Mp1OperatingTime	34	UNAVAILABLE
2017-02-20T18:41:49.443571Z	AccumulatedTime	x:RUNNING_TIME	p1RunningTime	Mp1RunningTime	35	UNAVAILABLE
2017-02-20T18:41:49.443571Z	AccumulatedTime	x:SPINDLE_RUN_TIME	p1SpindleRunTime	Mp1SpindleRunTime	36	UNAVAILABLE
2017-02-20T18:41:49.443571Z	AccumulatedTime	x:TOTAL_CUTTING_TIME	p1TotalCuttingTime	Mp1TotalCuttingTime	38	UNAVAILABLE
2017-02-20T18:41:49.443571Z	AccumulatedTime	x:TOTAL_OPERATING_TIME	p1TotalOperatingTime	Mp1TotalOperatingTime	39	UNAVAILABLE
2017-02-20T18:41:49.443571Z	AccumulatedTime	x:TOTAL_RUNNING_TIME	p1TotalRunningTime	Mp1TotalRunningTime	40	UNAVAILABLE
2017-02-20T18:41:49.443571Z	AccumulatedTime	x:TOTAL_SPINDLE_RUN_TIME	p1TotalSpindleRunTime	Mp1TotalSpindleRunTime	41	UNAVAILABLE

Events

Timestamp	Type	Sub Type	Name	Id	Sequence	Value
2017-02-20T18:41:49.443571Z	e:BlockNumber		p1BlockNumber	Mp1BlockNumber	24	UNAVAILABLE
2017-02-20T18:41:49.443571Z	e:Variables	x:COMMON	p1CommonVariable	Mp1CommonVariable	25	UNAVAILABLE
2017-02-20T18:41:49.443571Z	ToolNumber		p1CurrentTool	Mp1CurrentTool	26	UNAVAILABLE
2017-02-20T18:41:49.443571Z	e:Macman	x:PANEL_HISTORY	p1MacManPanelHistory	Mp1MacManPanelHistory	31	UNAVAILABLE
2017-02-20T18:41:49.443571Z	e:OutputSignal	x:DRY_RUN	p1MachineOperationPanelOutputDryRun	Mp1MachineOperationPanelOutputDryRun	32	UNAVAILABLE
2017-02-20T18:41:49.443571Z	e:OutputSignal	x:MACHINE_LOCK	p1MachineOperationPanelOutputMachineLock	Mp1MachineOperationPanelOutputMachineLock	33	UNAVAILABLE
2017-02-20T18:41:49.443571Z	ToolAssetId		p1ToolAssetId	Mp1ToolAssetId	37	UNAVAILABLE
2017-02-20T18:41:49.443571Z	Block		p1block	Mp1block	42	UNAVAILABLE
2017-02-20T18:41:49.443571Z	Line		p1line	Mp1line	43	UNAVAILABLE
2017-02-20T18:41:49.443571Z	PathFeedrateOverride	PROGRAMMED	pFovr	MpFovr	44	UNAVAILABLE
2017-02-20T18:41:49.443571Z	Execution		pexecution	Mpexecution	45	UNAVAILABLE
2017-02-20T18:41:49.443571Z	ControllerMode		pmode	Mpmode	46	UNAVAILABLE
2017-02-20T18:41:49.443571Z	PartCount		ppartcount	Mppartcount	47	UNAVAILABLE
2017-02-21T18:54:35.271Z	Program		pprogram	Mpprogram	346	BOXY_PART_IPM_OP8_20170216
2017-02-21T14:00:32.526-05:00	Measurement		measure	p1_85	365	feature:"9ffd7cbf-25bd-4be9-ab37-90b7ee855c69" order:1 count:6 id:"FACE27463" characteristic:"3DLocation" x:-11.000000 y:-33.333333 z:10.002639

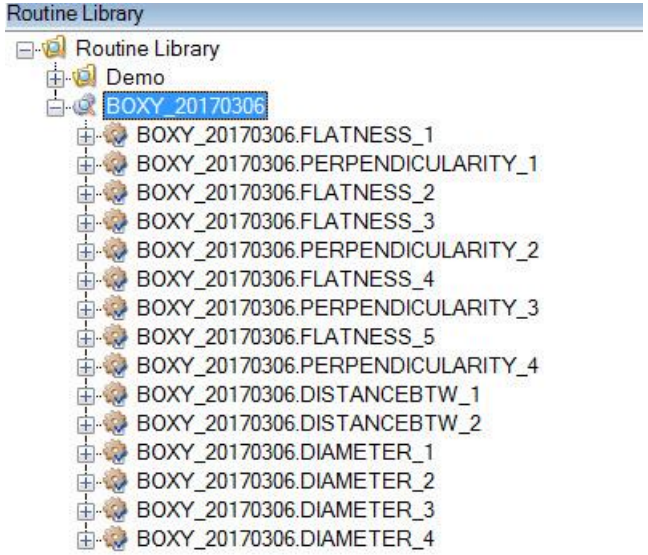
Linear : X

Samples

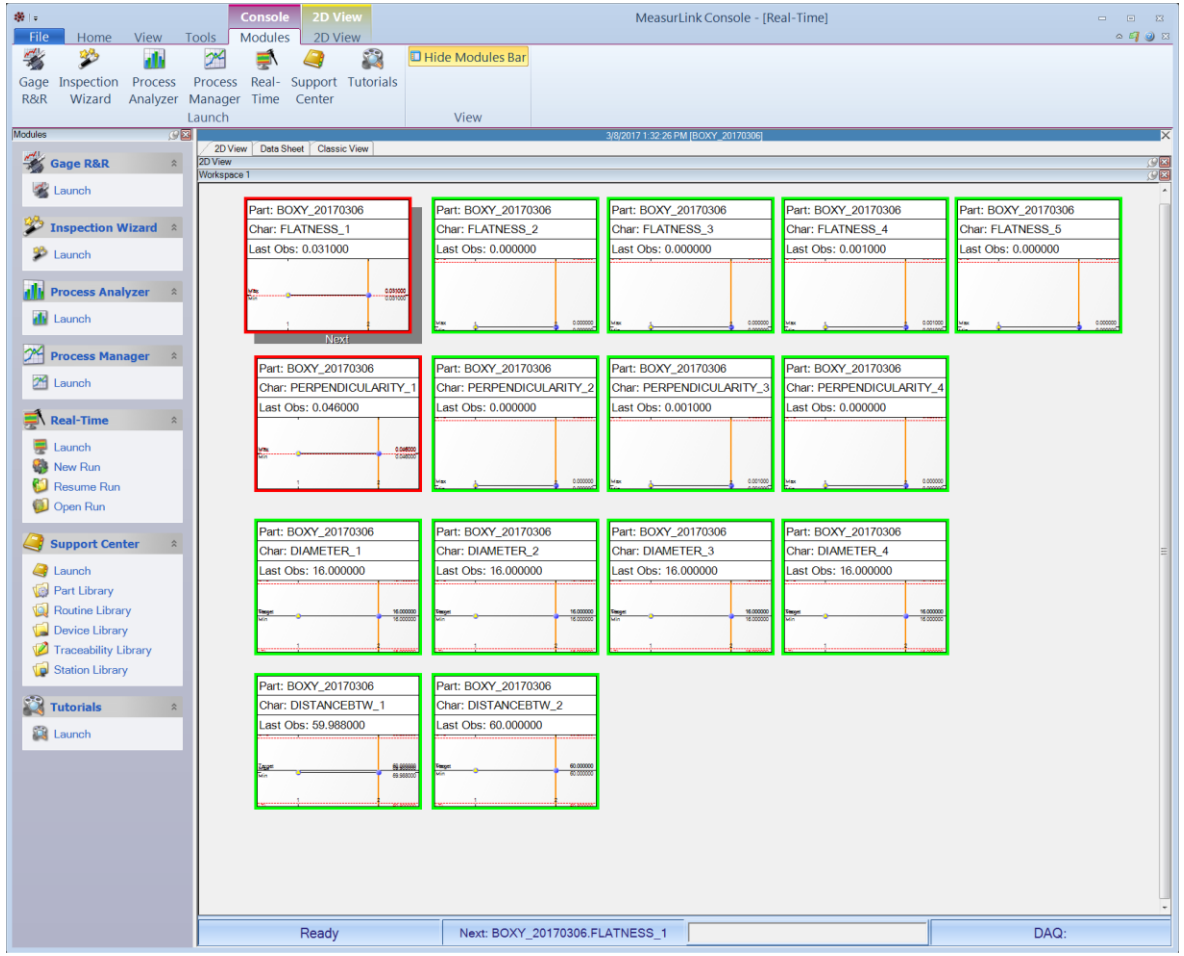


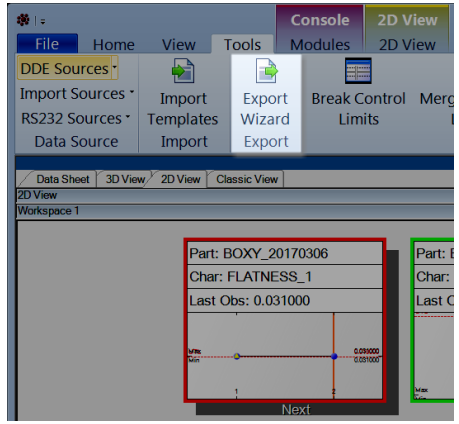
http://swim.steptools.com:5000/current

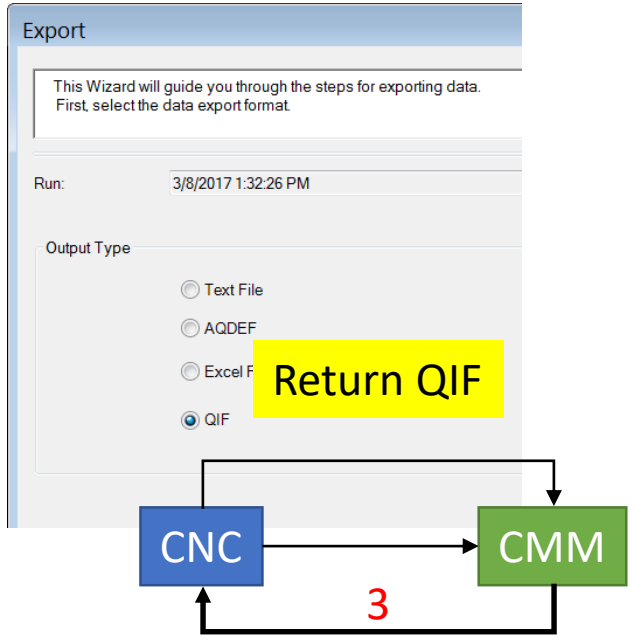
3. MeasurLink* evaluates measurements



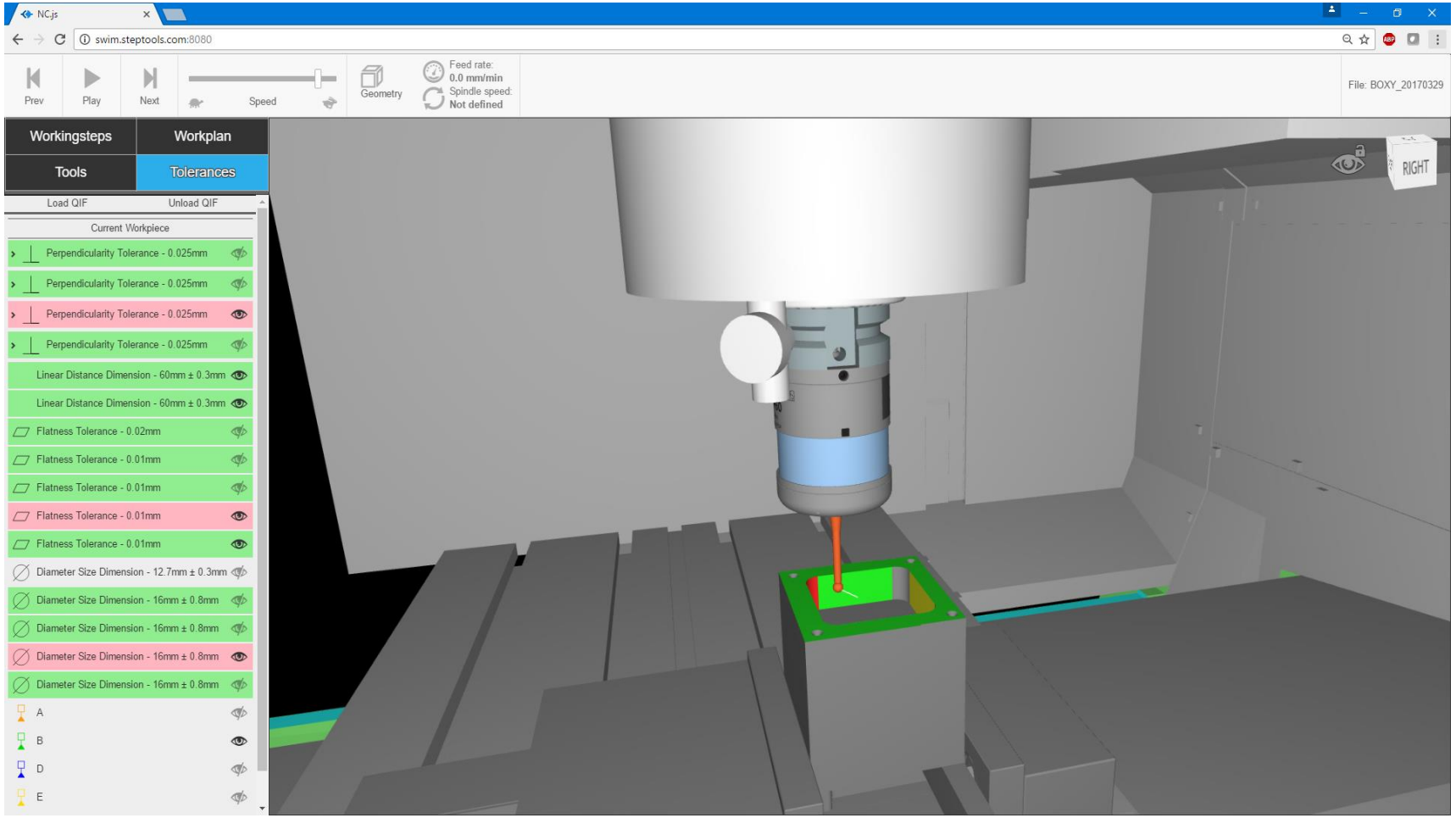
* MeasurLink v8.2.1 (released Dec 2016) and newer







QIF Results shown on Digital Twin



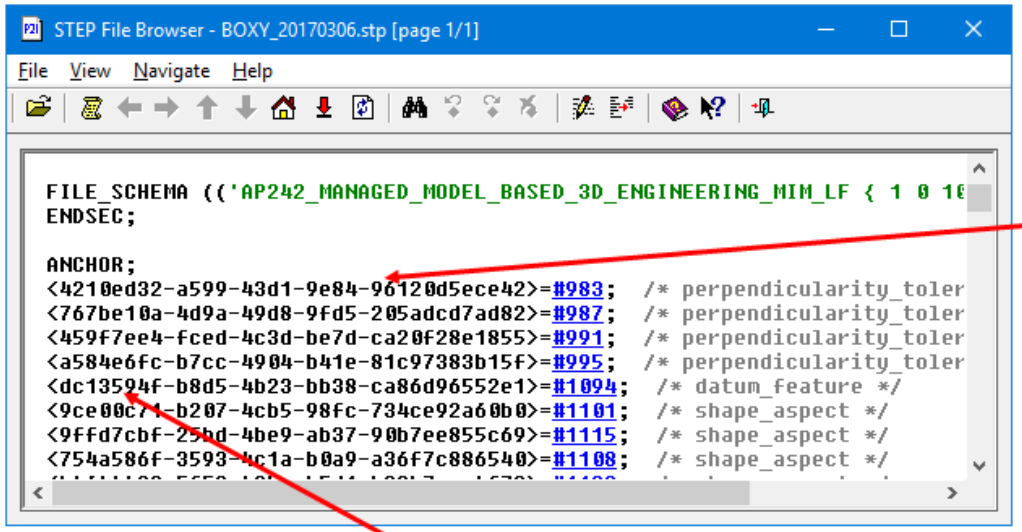
- Green good
- Red bad
- Yellow good and bad

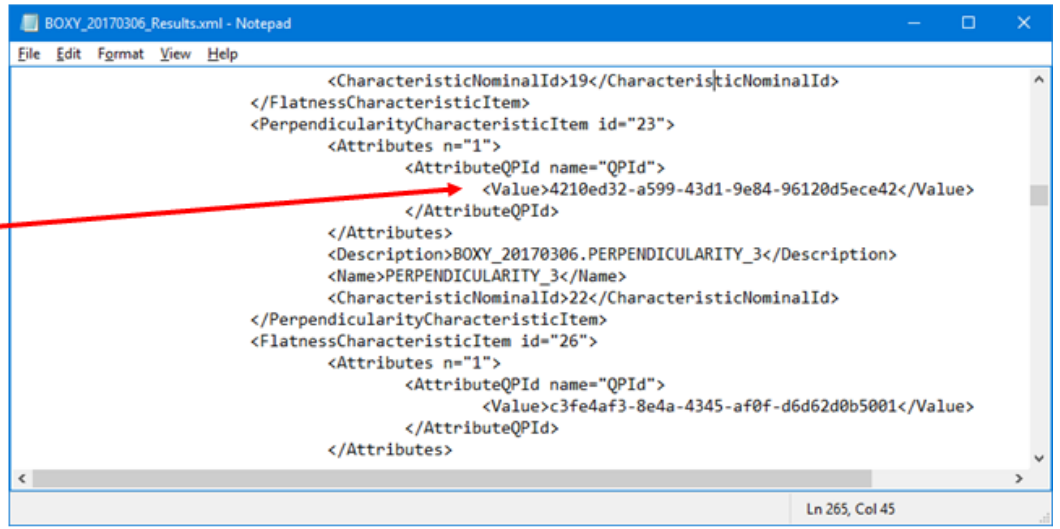
Tablet,
Phone or
Large Screen TV

Relating tolerances to measurements

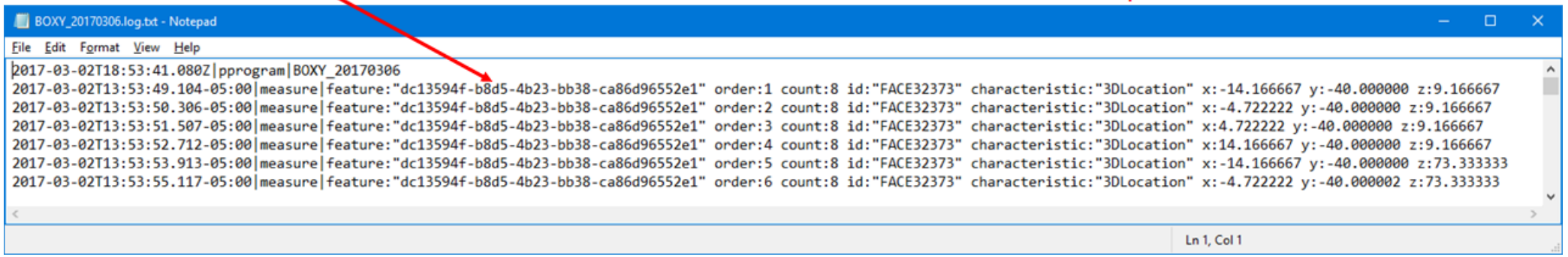
STEP Data

QIF Data





MTConnect Adapter Data

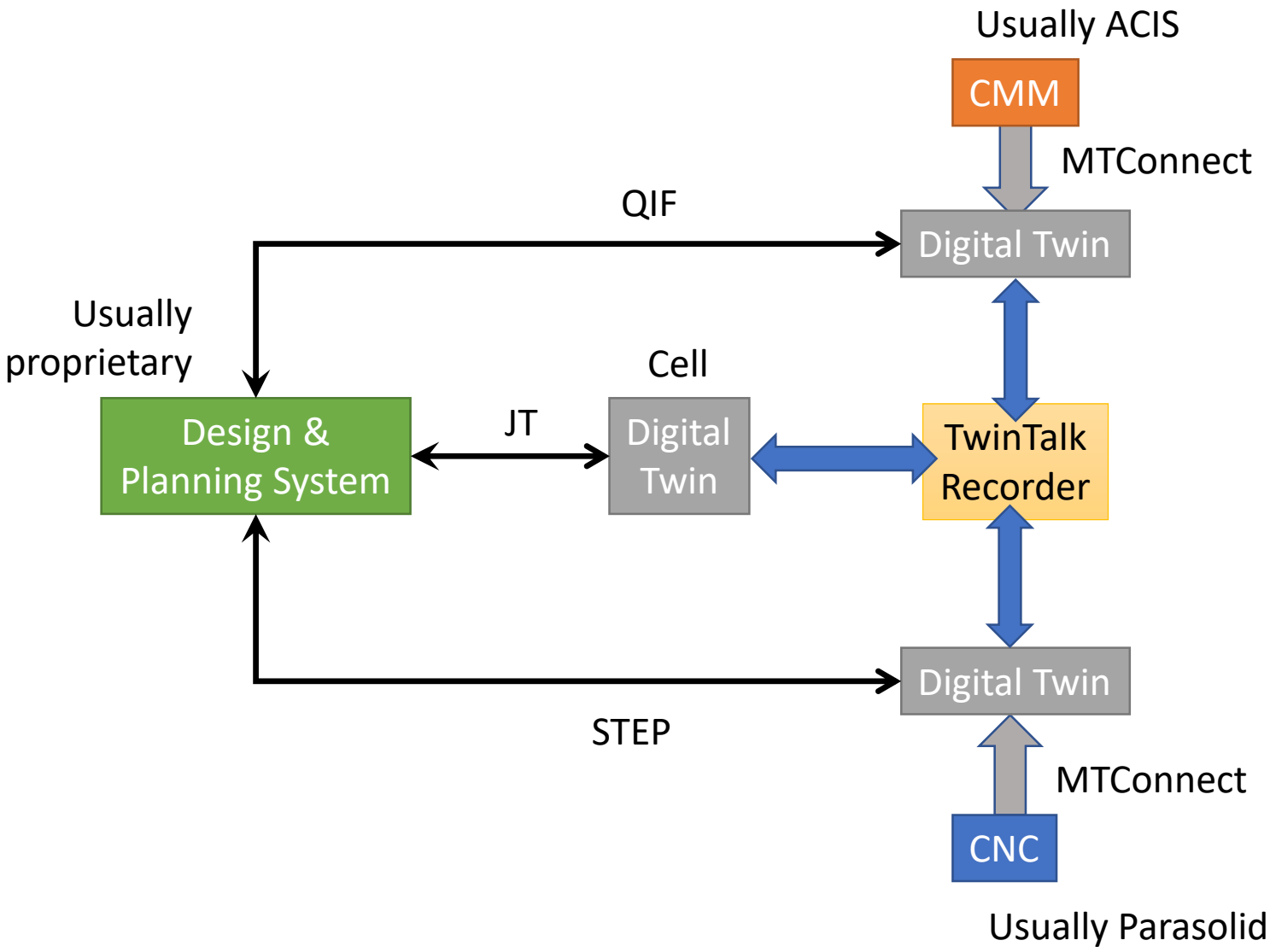


UUID’s supported by all three standards

Framework Proposal

- QIF becomes ISO 10304
  - Multiple parts starting with a DIS for QIF results
- MTConnect used as a model for a new Part 28
  - Enable systems to talk about changes made to a shared model
  - <Action> <time-stamp><sequence><new value>
  - Action might be assign, update, insert, delete
  - Value might be a model, a placement or a measurement result
- Digital Twin Manufacturing Framework specifies
  - Shareable object types: shell, placement, tolerance, ….
  - Allowed representations: STEP, QIF, …..

Strawman testbed



- CNC TwinTalk
  - Latest part shape
  - Latest kinematic coordinates
- CMM TwinTalk
  - Latest tolerances
  - Latest touch points
- Cell TwinTalk
  - Latest operation
  - Latest part dimensions