Technology for on-machine measurement using the Digital Thread

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DMDII Project O3 – Operate, Orchestrate, and Originate – 14-06-05

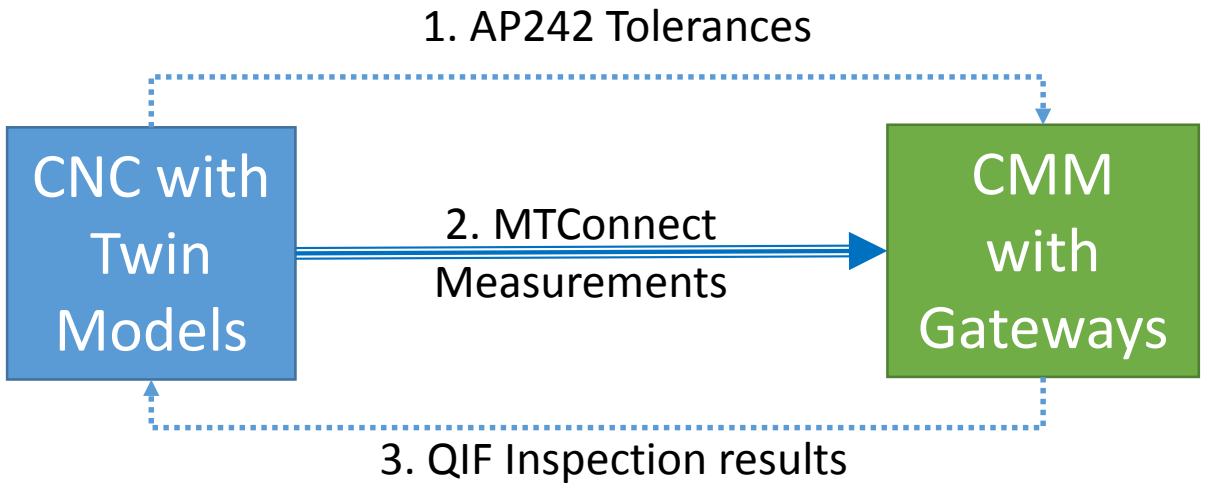
Why the Digital Thread

- The digital thread *increases productivity* by delivering model data to the shop floor
  - More flexibility to make last minute optimizations
  - More automated detection and correction of anomalies and errors
  - More efficient communication between systems using standards
  - Visual traceability and compliance to LOTAR requirements
  - **Automated measurement with minimal operator intervention**

Technology Demonstration

- http://www.steptools.com/demos/mtc/

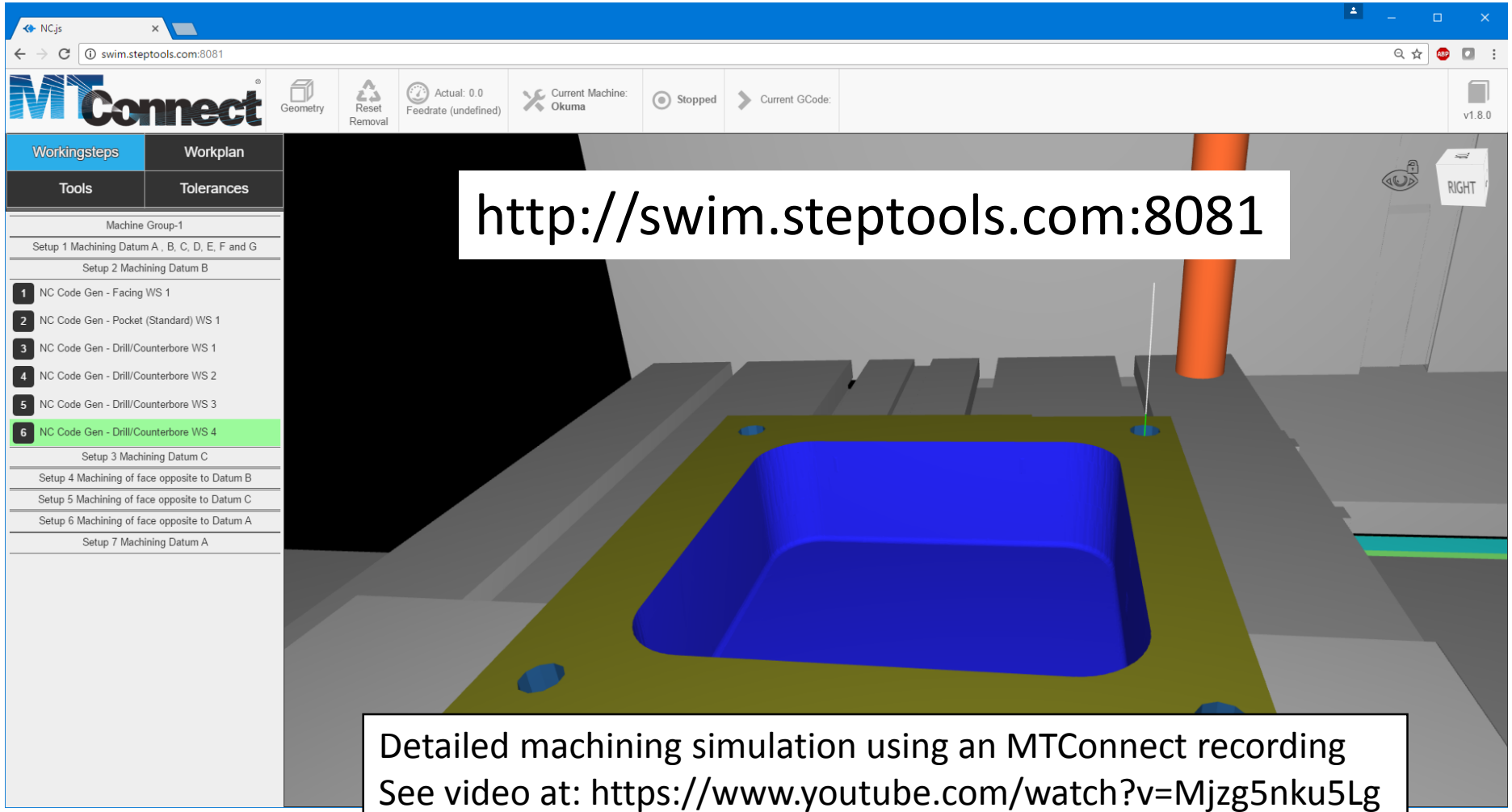
More accurate
More timely
More automated



More flexible
More timely
More automated

1. Tolerances that need to be measured
2. The measurements as they are made
3. The result of evaluating the measurements

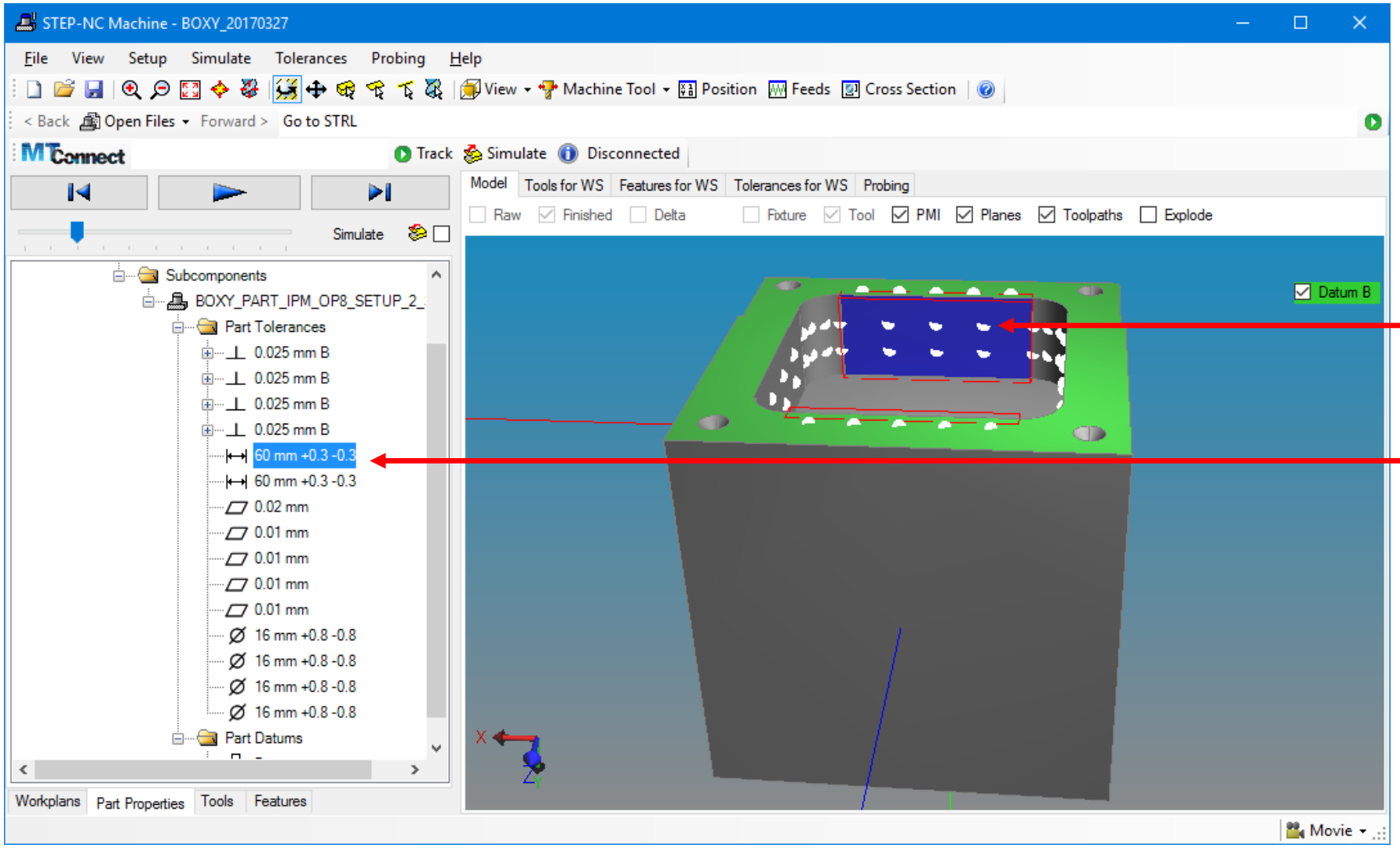
Virtual model of a part machined in Mukilteo



Detailed machining simulation using an MTConnect recording
See video at: https://www.youtube.com/watch?v=Mjzg5nku5Lg

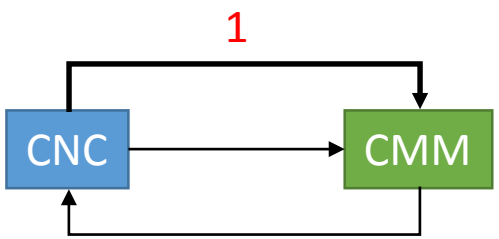
Are the features in tolerance?

1. Tolerances and probe points in AP242

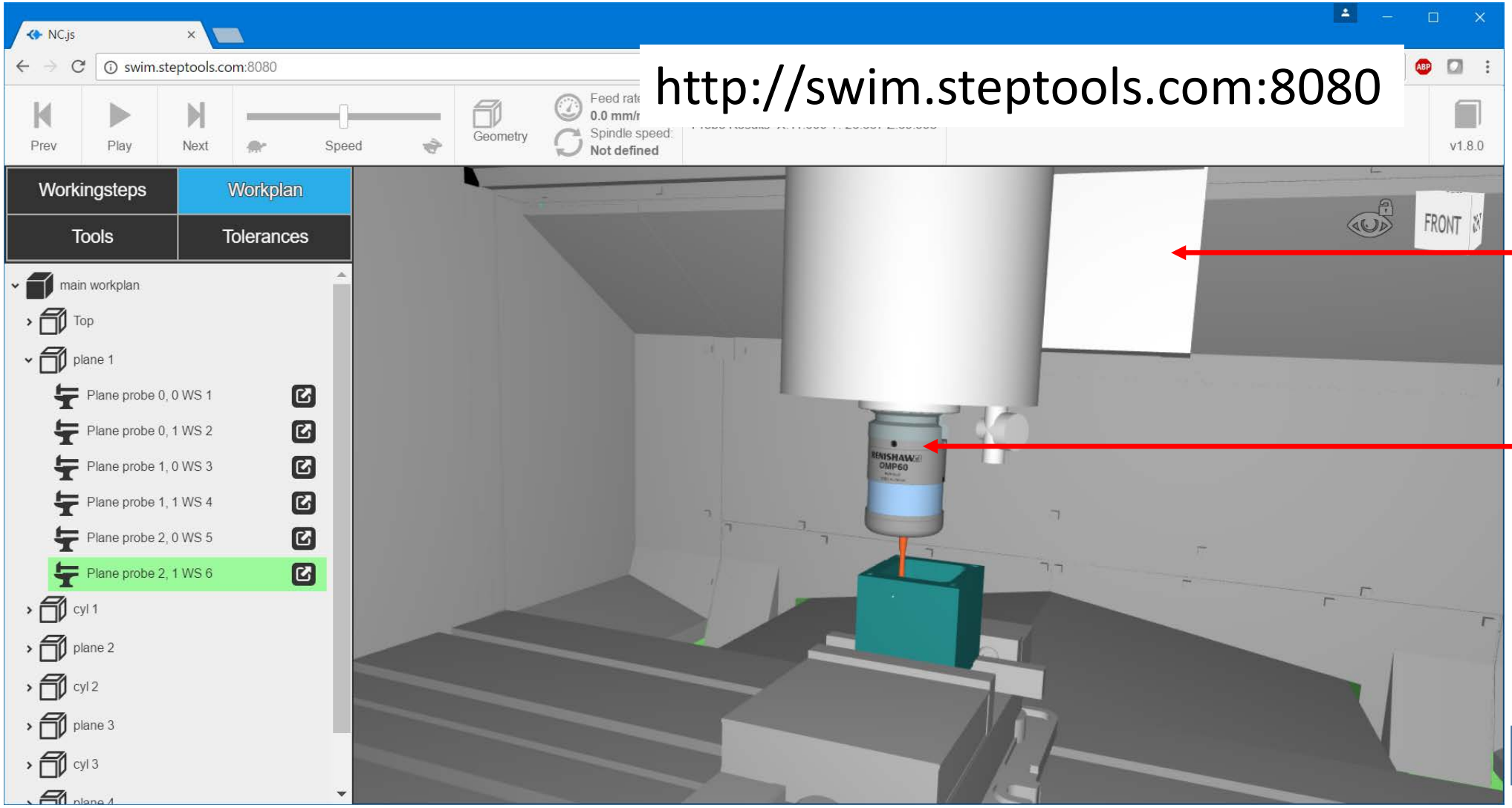


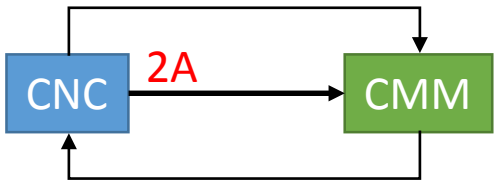
Measurement point

Semantic Tolerance



2A. Measurement points on the CNC





2B. 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
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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
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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
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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
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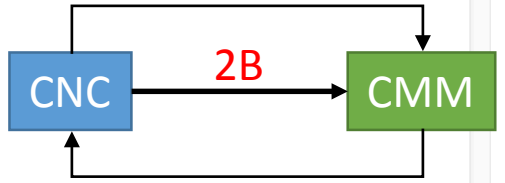
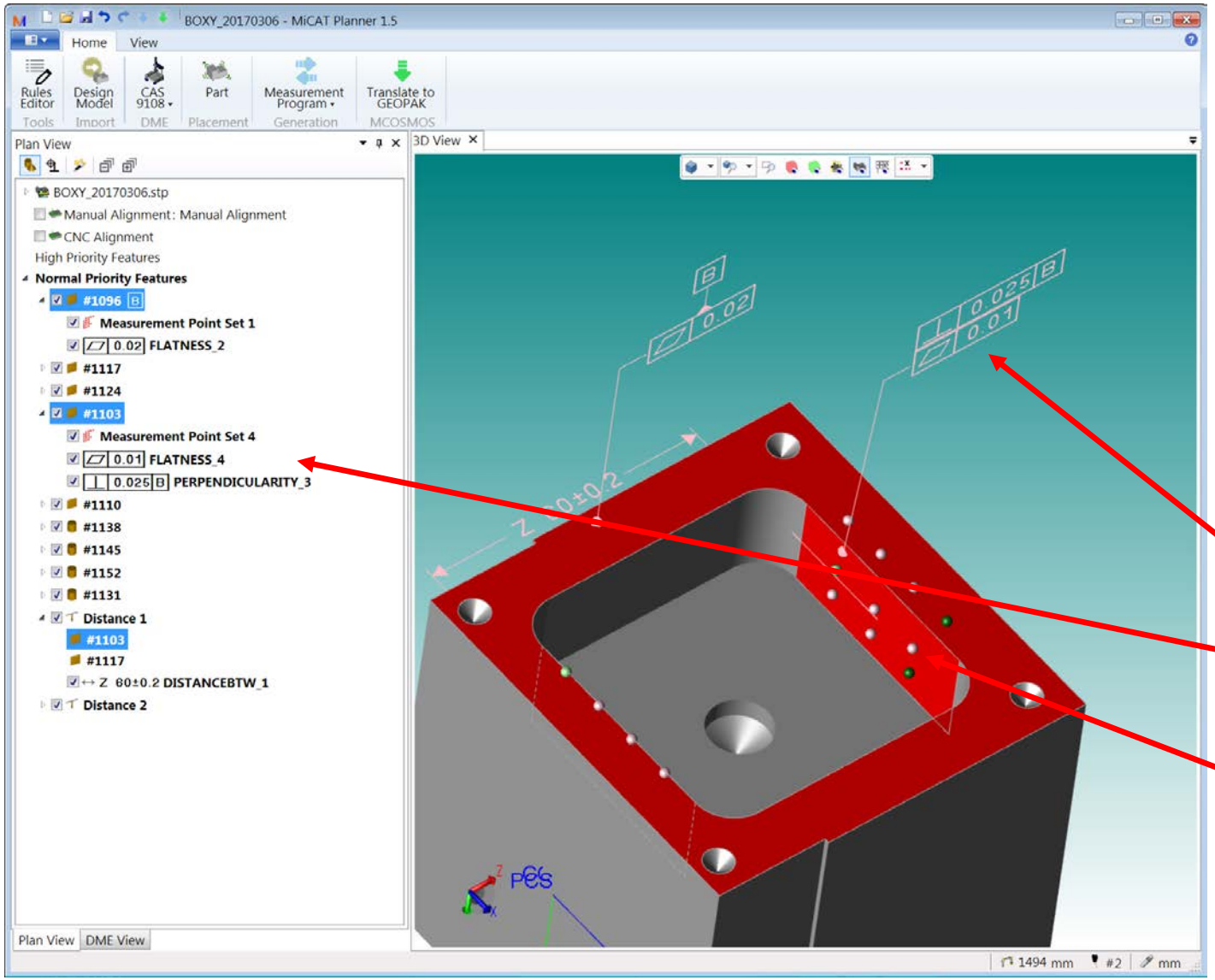
Linear : X

Samples

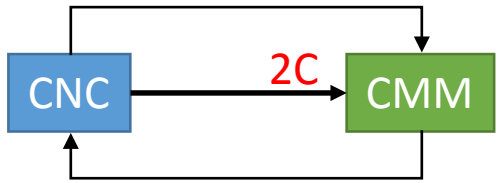


http://swim.steptools.com:5000/current

2C. Planner*: CMM evaluation of measurements



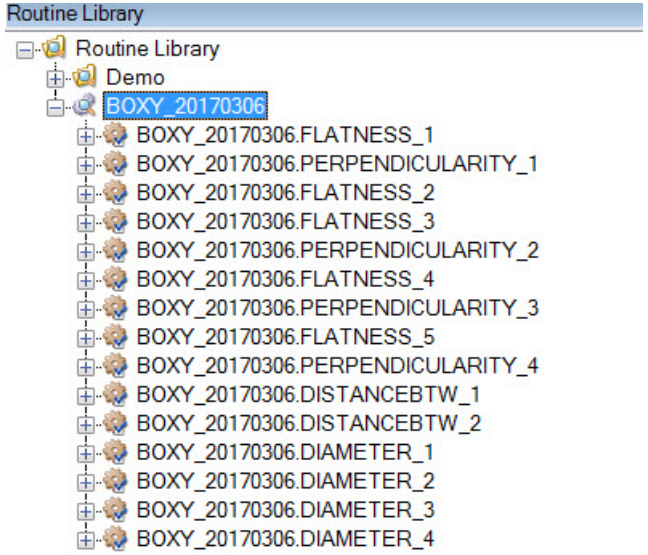
* MiCAT Planner 1.5 special version for DMDII O3 Investigation Only

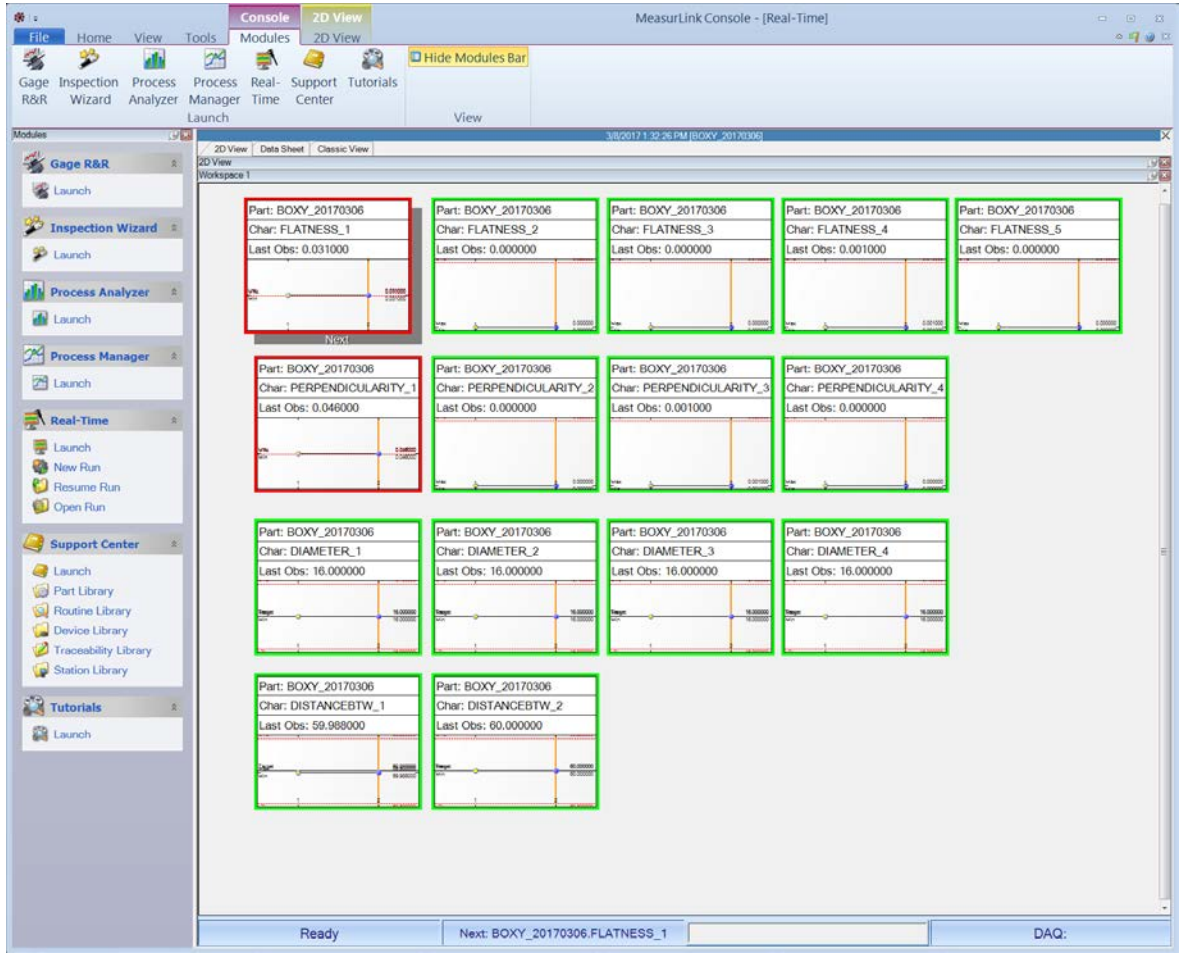


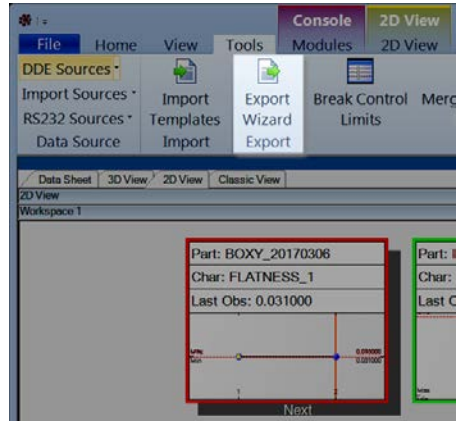
Semantic Tolerance

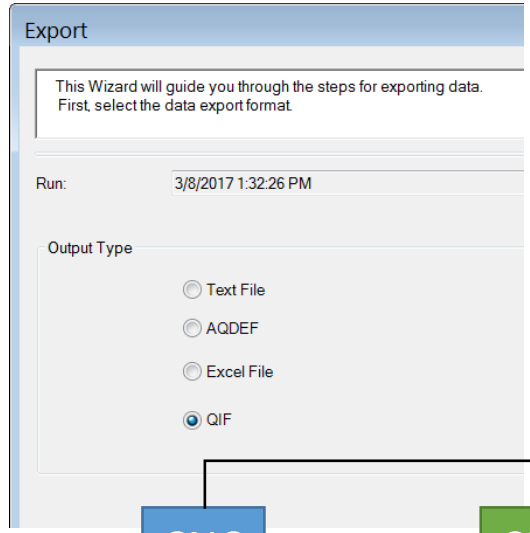
Measurement point

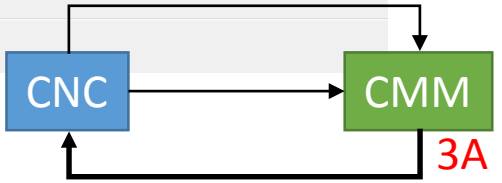
3A. MeasurLink* generating QIF Results





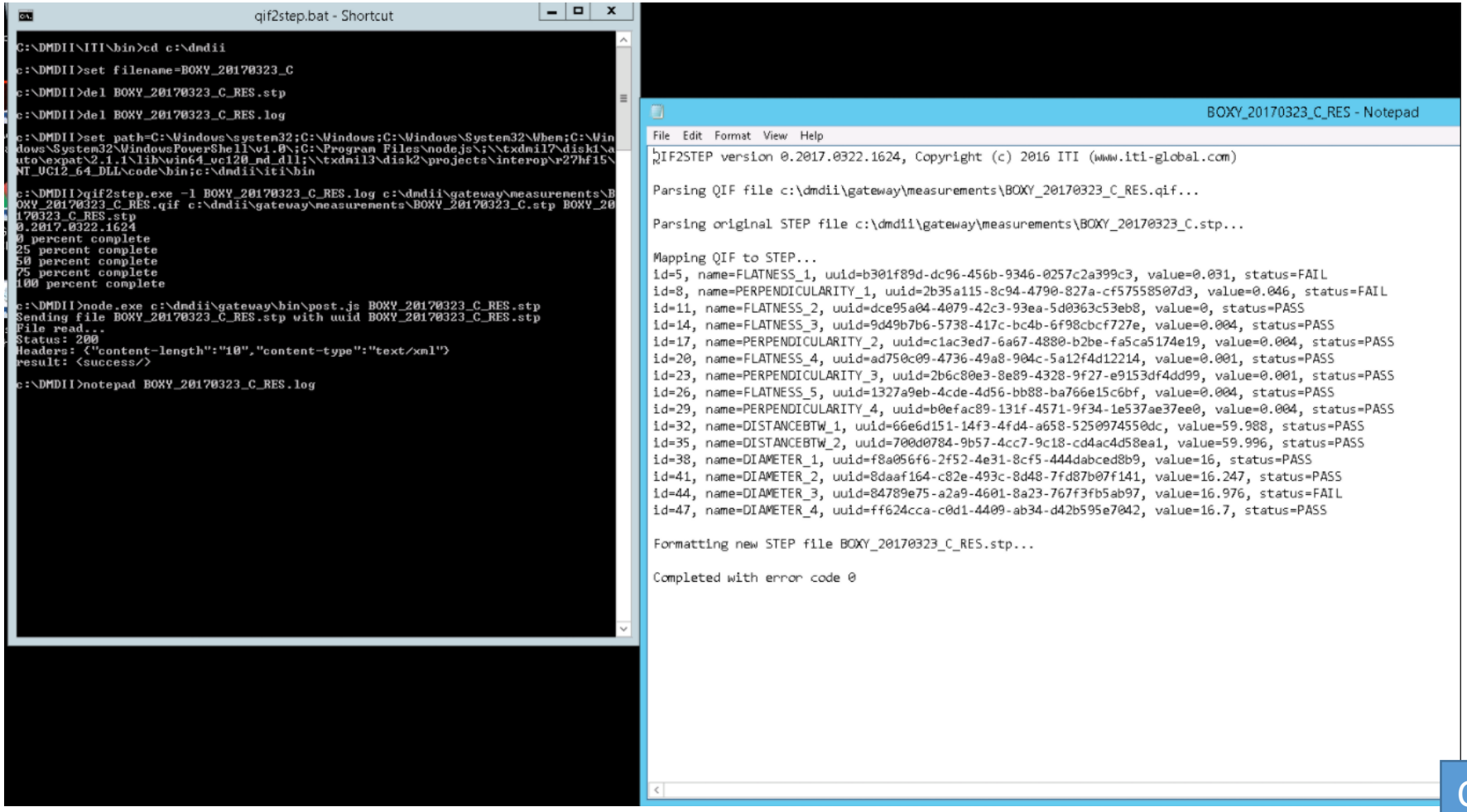




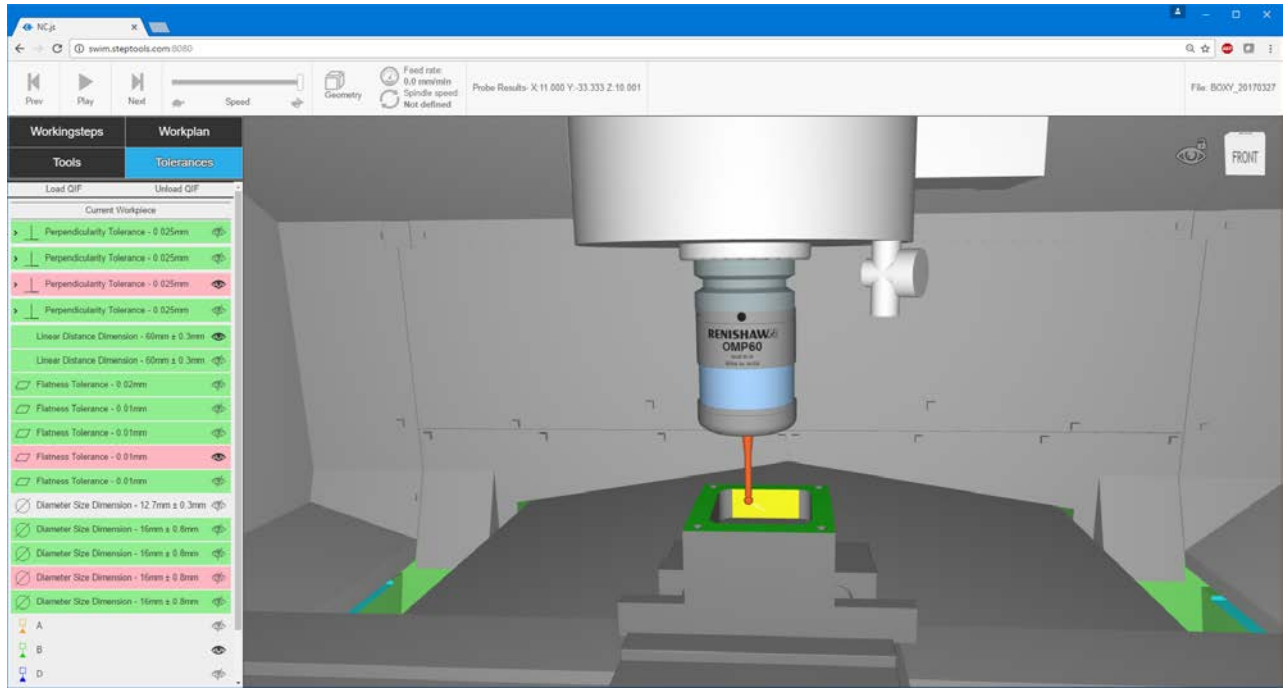


* MeasurLink v8.2.1 (released Dec 2016) and newer

3B. ITI adds QIF Results to AP242



3C. QIF Results back to CNC

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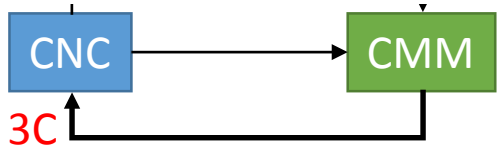
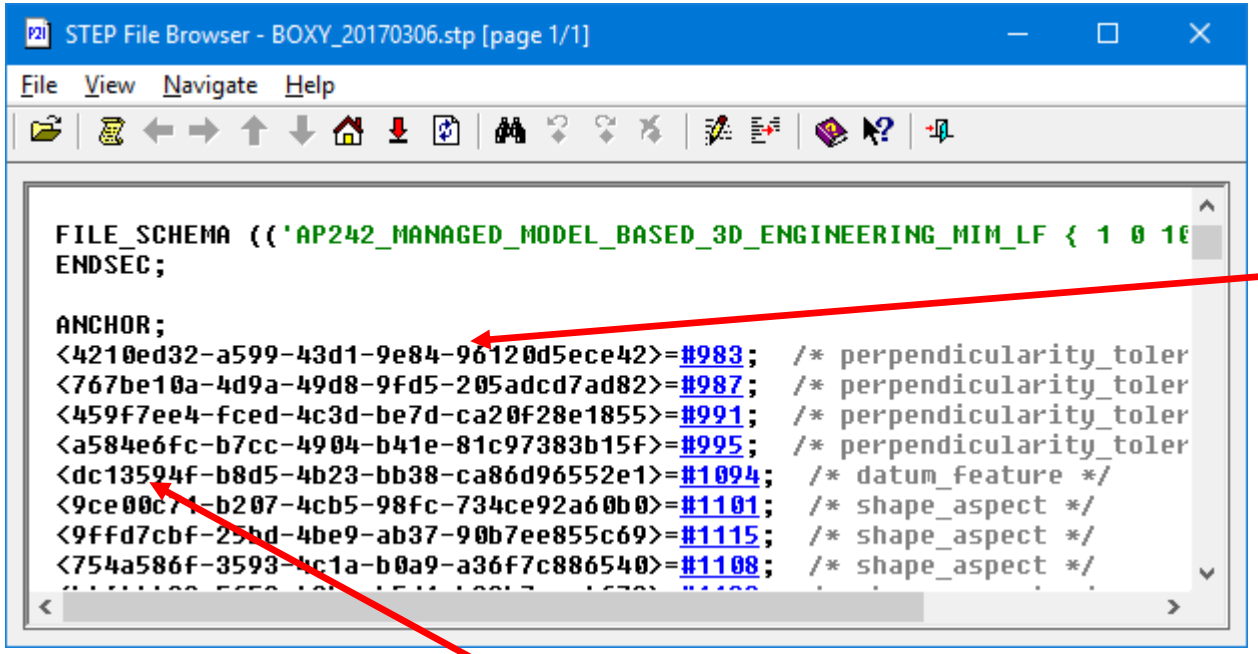
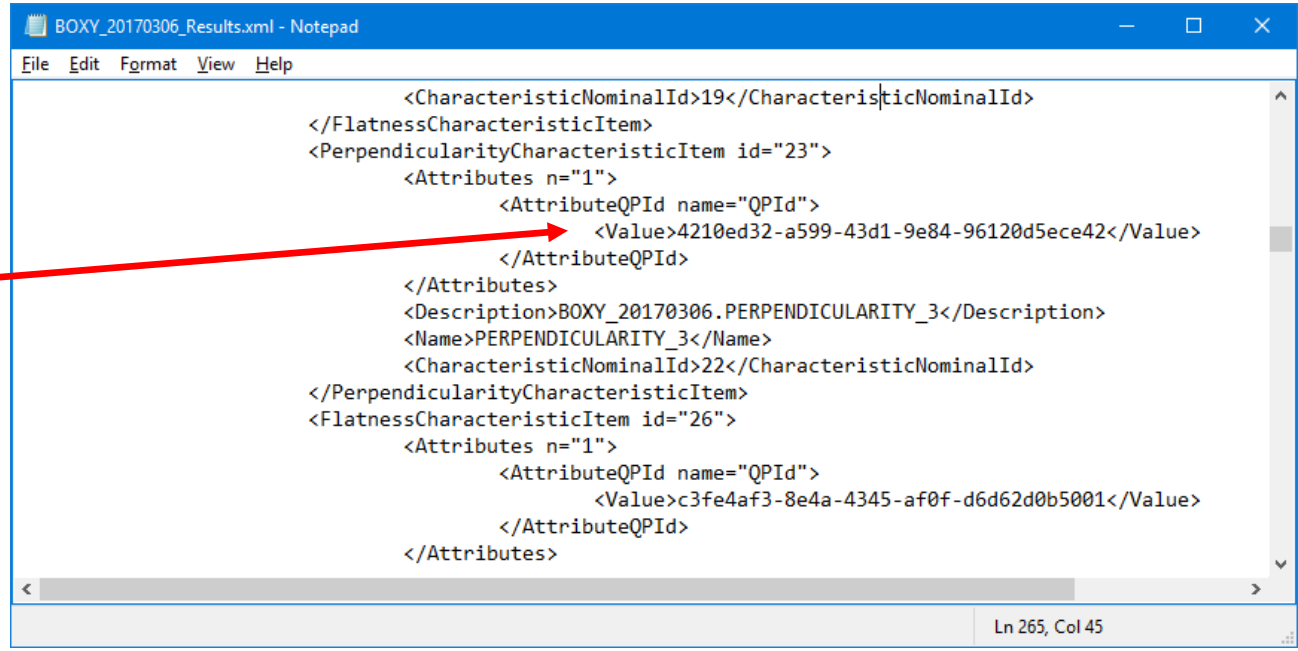


Internal: UUID's that relate all the data

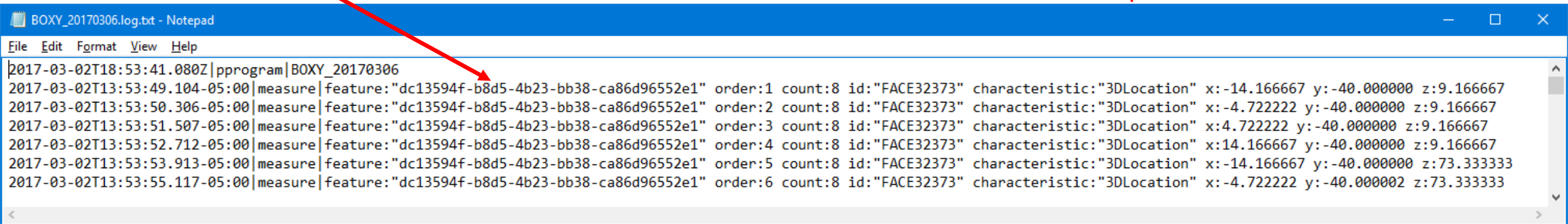
STEP Data

QIF Data



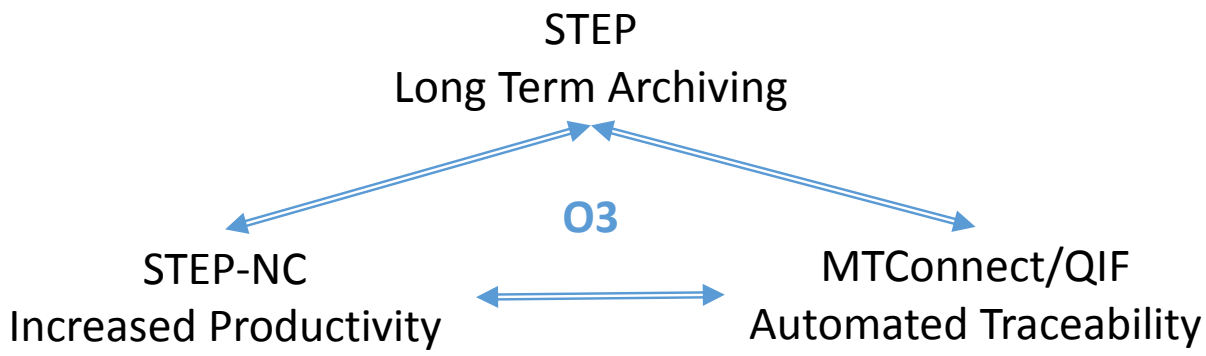


MTConnect Adapter Data



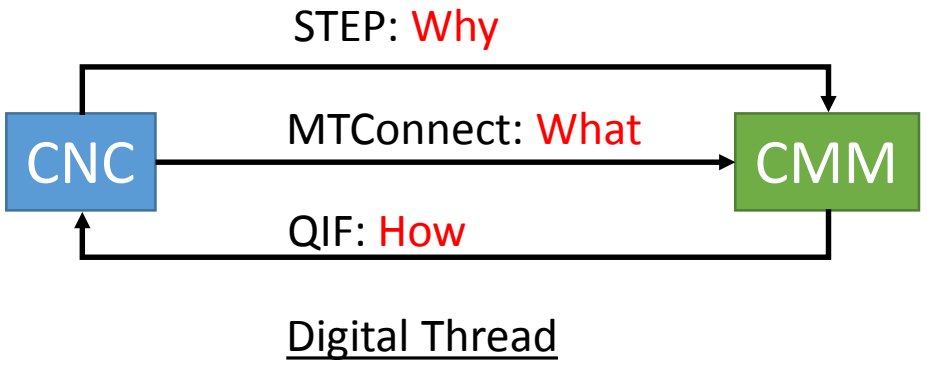
Result - Increased Productivity

- Feedback between suppliers and OEM's
  - Automated detection and correction of anomalies
  - Automated adjustments to meet the tolerances
- Integration of CNC and CMM functions
  - Single setup
  - On demand measurement
- Enabling tooling optimization
  - Feed speed optimization
  - Adaptive programming
  - 15% more efficient manufacturing



Summary

- We automated measurement using semantic tolerances
  - Requirements sent using STEP
  - Measurements streamed using MTConnect
  - Results returned using QIF
- We used the CNC as a CMM
  - One setup
  - On-demand or as-planned
  - Same CMM algorithms



What next?

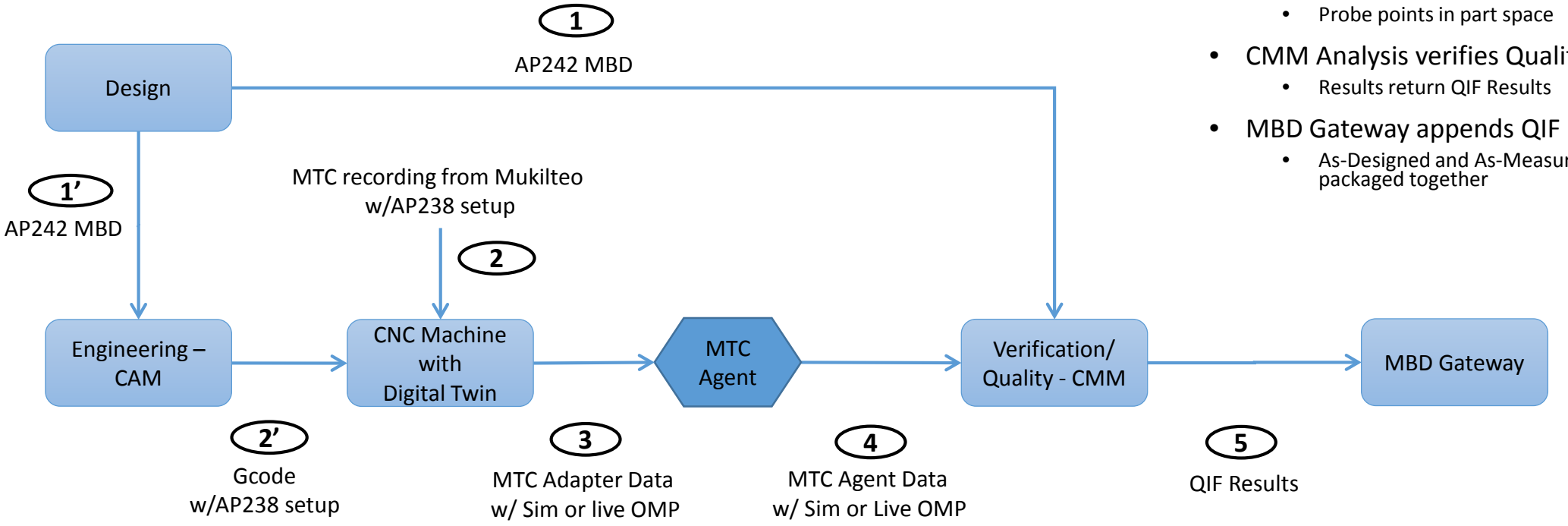
- Live machining at DMDII on May 23rd
  - Machining using a 5-axis Hyundai with Siemens 840D
  - Touch probing using Renishaw macros
  - Tolerance evaluation on a Mitutoyo Metrology server
  - Interoperability testing on a DMG and Okuma
- Pilot production in aerospace in the Fall
  - Demonstration planned for Korea ISO meeting

Backup

Standards used in the thread

	STEP AP242	STEP AP238	MTConnect	QIF
Normal source	CAD systems	CAM systems	CNC systems	CMM systems
Role in thread	Define design tolerances and nominal touch probe points	Translate as-measured touch probe points into part space	Communicate measured points from CNC to CMM	Communicate tolerance quality back to CNC

All the process steps



- Design to CAM/CMM
  - via AP242 MBD
- CAM to CNC Machine with Digital Twin
  - Playback via MTConnect and AP238 for setup
- OMP streams through MTC to CMM
  - Probe points in part space
- CMM Analysis verifies Quality
  - Results return QIF Results
- MBD Gateway appends QIF Results to AP242
  - As-Designed and As-Measured PMI (Characteristics) packaged together

1' 2' Performed at Mukilteo (see https://www.youtube.com/watch?v=Mjzg5nku5Lg)

1 2 3 4 5 Performed live <u>today</u> with a virtual CNC in NY and a virtual CMM in Chicago