

IMTS and JIMTOF 2018 Grand Challenge and QIF

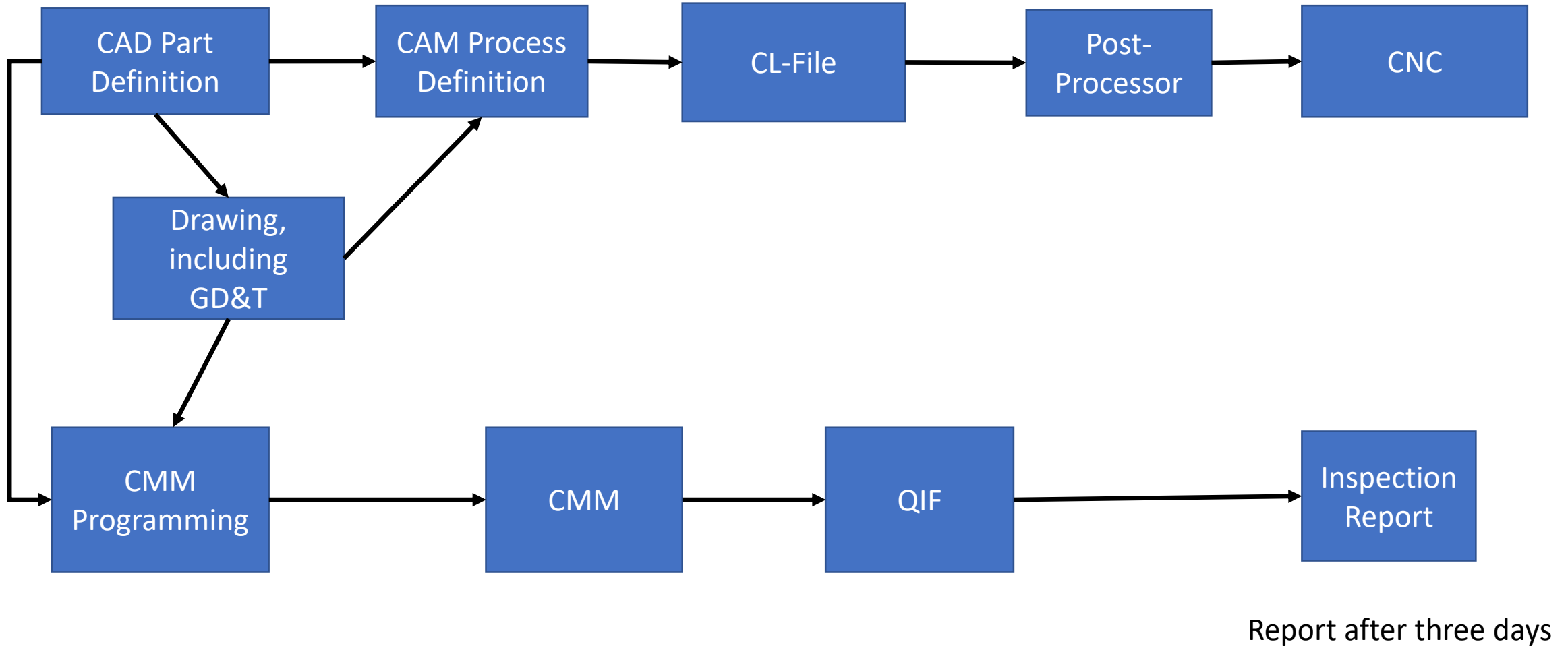
Dr. Martin Hardwick

Professor of Computer Science, RPI

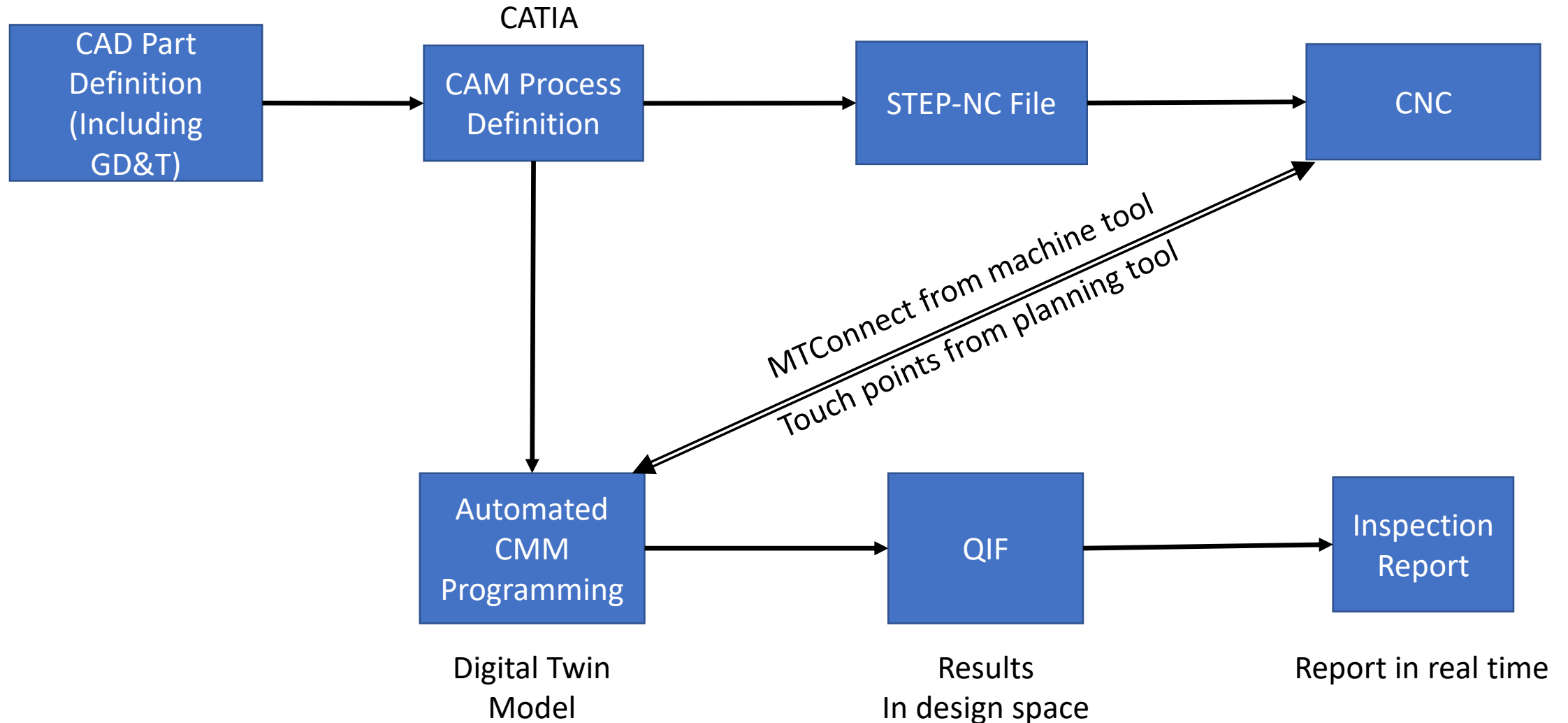
President STEP Tools, Inc.

Convener ISO WG15 Digital Manufacturing

Traditional Inspection Data Flow



Grand Challenge Inspection Data Flow

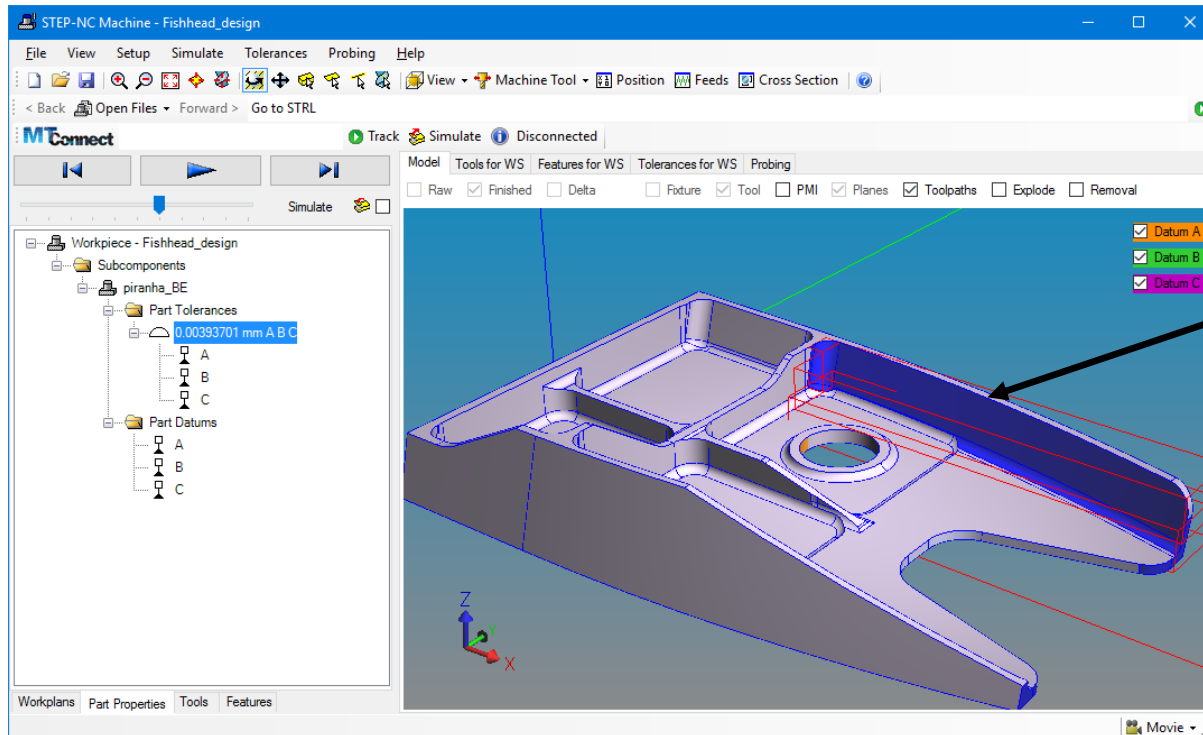


The Grand Challenge and QIF

- QIF reports on the quality of a measured part.
 - How well the tolerances have been met
 - Using coordinates measured from the part surface
- Most measurements are made on a CMM but making measurements on the CNC has two advantages
 - Reduces time and costs by not requiring a CMM setup and programming
 - Enables on machine corrections before the machining is finished
- But in order to measure on the CNC we need a coordinate space
 - Machine tools operate in their own coordinate space
 - Designers and planners need the measurements in design or planning space

Design Space

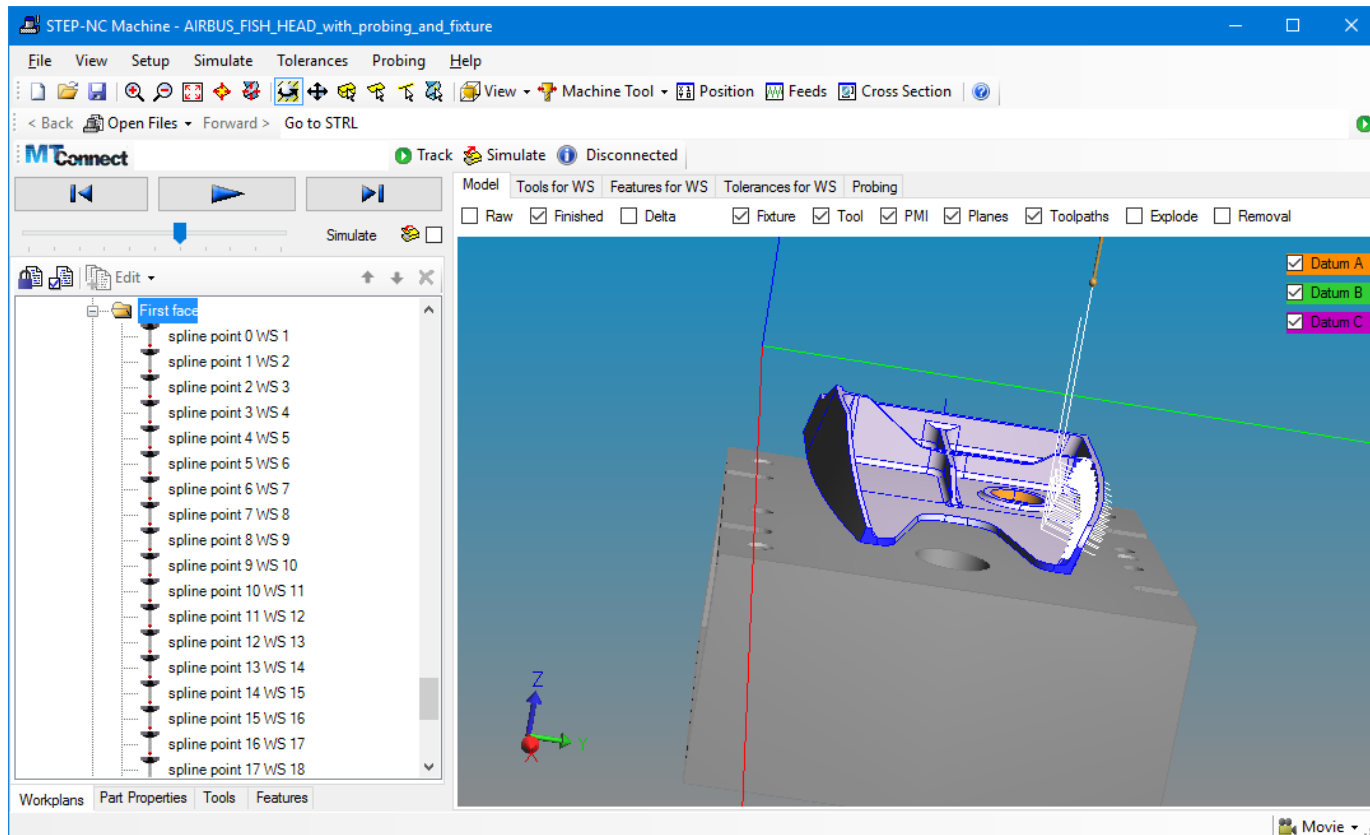
- This is the coordinate system defined by the designer of the part
- He or she is the customer and the tolerances required by the customer must be met.



Surface tolerance on a critical design feature

Planning space

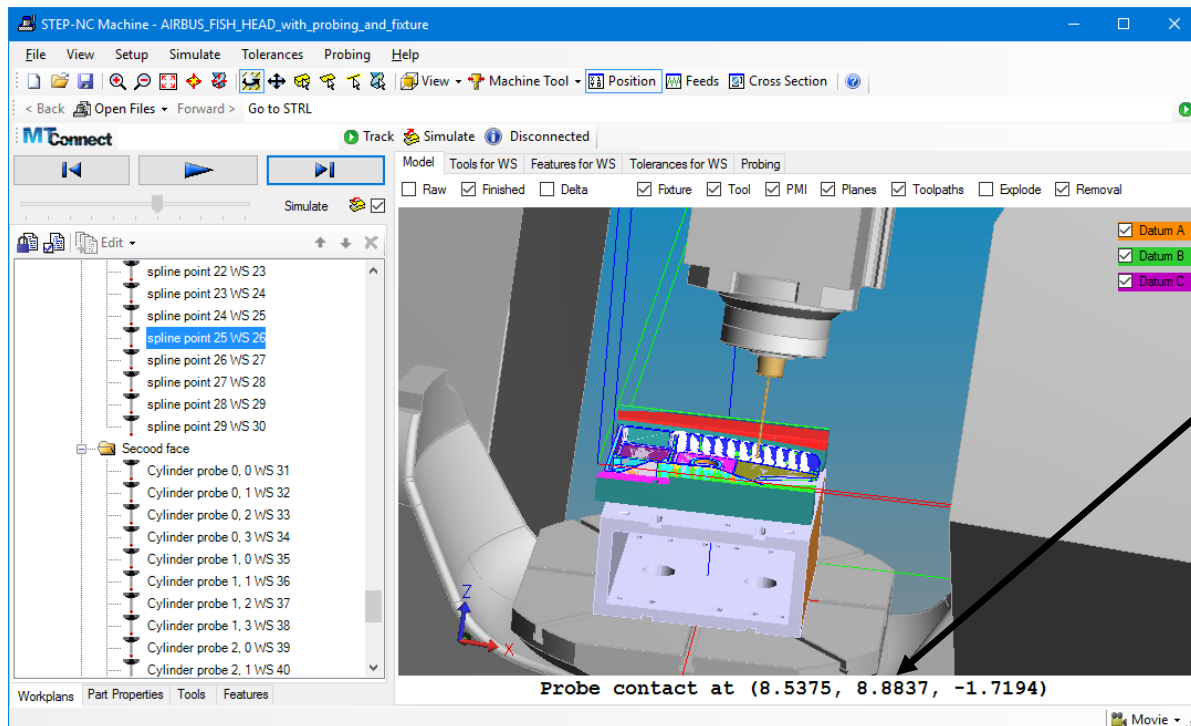
- This is the coordinate space defined for the manufacturing solution
- Part is placed on a fixture in a virtual machine
 - For a multi-setup solution the part may be rotated to give better access to a feature
 - For a measured solution touch points may be planned in advance



Part on fixture
Clamps holding part not shown
As planned touch points shown

Machining space

- The CNC program executes in machine space
 - Post processor makes the coordinates
 - Operator sets offsets for actual position of part and actual length of tools



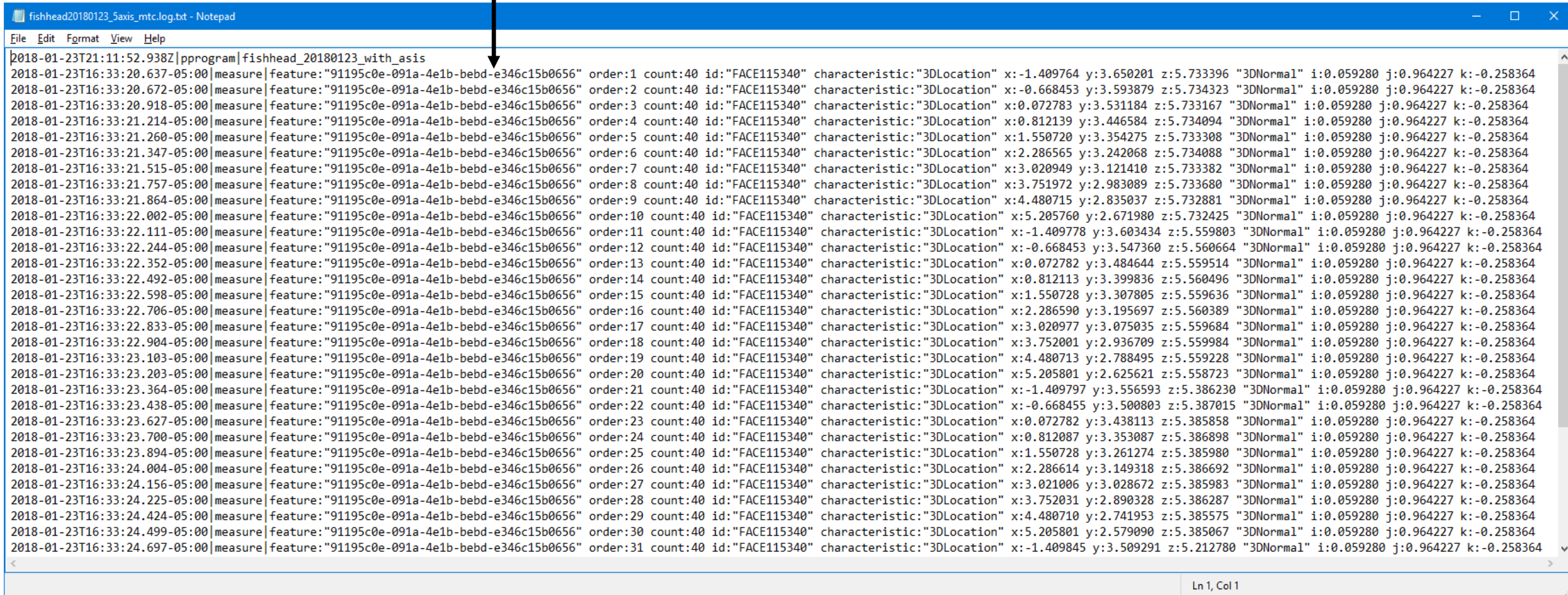
QIF and the Grand Challenge

- Results should be reported in design space
 - So the designer gets the data he or she wants, without regard to setup and machine configuration.
- New resources should be defined in planning space
 - To verify that new touch points are able to measure a surface
 - Planning space will be defined/managed by CNC NC program definitions, assisted by automated CMM measurement tools
- Measurements will take place in machine space
 - Touch points must be converted from machine space to design space
 - Digital twin supports all three options (design, planning and machine)

MTConnect results in planning space

QPID / UUID of face being measured

Locations and normals of contact points



```
fishhead20180123_5axis_mtc.log.txt - Notepad
File Edit Format View Help
2018-01-23T21:11:52.938Z|pprogram|fishhead_20180123_with_asis
2018-01-23T16:33:20.637-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:1 count:40 id:"FACE115340" characteristic:"3DLocation" x:-1.409764 y:3.650201 z:5.733396 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:20.672-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:2 count:40 id:"FACE115340" characteristic:"3DLocation" x:-0.668453 y:3.593879 z:5.734323 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:20.918-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:3 count:40 id:"FACE115340" characteristic:"3DLocation" x:0.072783 y:3.531184 z:5.733167 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:21.214-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:4 count:40 id:"FACE115340" characteristic:"3DLocation" x:0.812139 y:3.446584 z:5.734094 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:21.260-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:5 count:40 id:"FACE115340" characteristic:"3DLocation" x:1.550720 y:3.354275 z:5.733308 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:21.347-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:6 count:40 id:"FACE115340" characteristic:"3DLocation" x:2.286565 y:3.242068 z:5.734088 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:21.515-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:7 count:40 id:"FACE115340" characteristic:"3DLocation" x:3.020949 y:3.121410 z:5.733382 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:21.757-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:8 count:40 id:"FACE115340" characteristic:"3DLocation" x:3.751972 y:2.983089 z:5.733680 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:21.864-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:9 count:40 id:"FACE115340" characteristic:"3DLocation" x:4.480715 y:2.835037 z:5.732881 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:22.002-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:10 count:40 id:"FACE115340" characteristic:"3DLocation" x:5.205760 y:2.671980 z:5.732425 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:22.111-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:11 count:40 id:"FACE115340" characteristic:"3DLocation" x:-1.409778 y:3.603434 z:5.559803 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:22.244-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:12 count:40 id:"FACE115340" characteristic:"3DLocation" x:-0.668453 y:3.547360 z:5.560664 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:22.352-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:13 count:40 id:"FACE115340" characteristic:"3DLocation" x:0.072782 y:3.484644 z:5.559514 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:22.492-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:14 count:40 id:"FACE115340" characteristic:"3DLocation" x:0.812113 y:3.399836 z:5.560496 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:22.598-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:15 count:40 id:"FACE115340" characteristic:"3DLocation" x:1.550728 y:3.307805 z:5.559636 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:22.706-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:16 count:40 id:"FACE115340" characteristic:"3DLocation" x:2.286590 y:3.195697 z:5.560389 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:22.833-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:17 count:40 id:"FACE115340" characteristic:"3DLocation" x:3.020977 y:3.075035 z:5.559684 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:22.904-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:18 count:40 id:"FACE115340" characteristic:"3DLocation" x:3.752001 y:2.936709 z:5.559984 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:23.103-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:19 count:40 id:"FACE115340" characteristic:"3DLocation" x:4.480713 y:2.788495 z:5.559228 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:23.203-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:20 count:40 id:"FACE115340" characteristic:"3DLocation" x:5.205801 y:2.625621 z:5.558723 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:23.364-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:21 count:40 id:"FACE115340" characteristic:"3DLocation" x:-1.409797 y:3.556593 z:5.386230 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:23.438-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:22 count:40 id:"FACE115340" characteristic:"3DLocation" x:-0.668455 y:3.500803 z:5.387015 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:23.627-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:23 count:40 id:"FACE115340" characteristic:"3DLocation" x:0.072782 y:3.438113 z:5.385858 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:23.700-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:24 count:40 id:"FACE115340" characteristic:"3DLocation" x:0.812087 y:3.353087 z:5.386898 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:23.894-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:25 count:40 id:"FACE115340" characteristic:"3DLocation" x:1.550728 y:3.261274 z:5.385980 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:24.004-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:26 count:40 id:"FACE115340" characteristic:"3DLocation" x:2.286614 y:3.149318 z:5.386692 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:24.156-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:27 count:40 id:"FACE115340" characteristic:"3DLocation" x:3.021006 y:3.028672 z:5.385983 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:24.225-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:28 count:40 id:"FACE115340" characteristic:"3DLocation" x:3.752031 y:2.890328 z:5.386287 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:24.424-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:29 count:40 id:"FACE115340" characteristic:"3DLocation" x:4.480710 y:2.741953 z:5.385575 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:24.499-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:30 count:40 id:"FACE115340" characteristic:"3DLocation" x:5.205801 y:2.579090 z:5.385067 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
2018-01-23T16:33:24.697-05:00|measure|feature:"91195c0e-091a-4e1b-bebd-e346c15b0656" order:31 count:40 id:"FACE115340" characteristic:"3DLocation" x:-1.409845 y:3.509291 z:5.212780 "3DNormal" i:0.059280 j:0.964227 k:-0.258364
Ln 1, Col 1
```

QIF Results in design space

```
<?xml version="1.0" encoding="UTF-8"?>
- <QIFDocument xsi:schemaLocation="http://qifstandards.org/xsd/qif3 ../QIFApplications/QIFDocument.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" versionQIF="3.0.0" idMax="6" xmlns="http://qifstandards.org/xsd/qif3">
- <Features>
- <FeatureDefinitions n="1">
- <PlaneFeatureDefinition id="1">
- </FeatureDefinitions>
- <FeatureNominals n="1">
- <PlaneFeatureNominal id="2">
- <Name>FACE46896</Name>
- <UUID>91195c0e-091a-4e1b-bebd-e346c15b0656</UUID>
- <FeatureDefinitionId>1</FeatureDefinitionId>
- </PlaneFeatureNominal>
- </FeatureNominals>
- <FeatureItems n="1">
- <PlaneFeatureItem id="3">
- <FeatureNominalId>2</FeatureNominalId>
- <FeatureName>P1001</FeatureName>
- <DeterminationMode>
- <Checked>
- <CheckDetails>
- <Measured/>
- </CheckDetails>
- </Checked>
- </DeterminationMode>
- </PlaneFeatureItem>
- </FeatureItems>
- </Features>
- <MeasurementsResults>
- <MeasurementResultsSet n="1">
- <MeasurementResults id="4">
- <ExternalFileReferences n="1">
- <ExternalFileReference>
- <URI>fishhead_20180123.stpnc</URI>
- <FileSpec>
- <CommonFileSpecEnum>stpnc</CommonFileSpecEnum>
- </FileSpec>
- <Description>fishhead probe</Description>
- </ExternalFileReference>
- </ExternalFileReferences>
- <MeasuredPointSets n="1">
- <MeasuredPointSet id="6" count="40">
- <Pts> 4.593544 3.904372 1.011544 5.334455 3.845348 1.013195 6.076552 3.793648 1.009093 6.816032 3.710292 1.009687 7.554638 3.618164 1.008852 8.290462 3.505800 1.009674 9.024817 3.384978 1.009013
9.755789 3.246411 1.009376 10.483557 3.093893 1.009774 11.206610 2.922817 1.011467 4.593544 3.857841 0.837888 5.334455 3.798817 0.839539 6.076538 3.746977 0.835475 6.816032 3.663761 0.836031
7.554638 3.571633 0.835196 8.290460 3.459259 0.836021 9.024815 3.338434 0.835360 9.755789 3.199880 0.835720 10.483585 3.798817 0.839539 6.076538 3.746977 0.835475 6.816032 3.663761 0.836031
5.334455 3.752286 0.665883 6.076524 3.700306 0.661856 6.816032 3.617230 0.662375 7.554638 3.525102 0.661540 8.290459 3.412718 0.662367 9.024813 3.291891 0.661707 9.755789 3.153349 0.662064
10.483613 3.001087 0.662393 11.206610 2.829755 0.664155 4.593544 3.764779 0.490576 5.334455 3.705755 0.492227 6.076511 3.653636 0.488238 6.816032 3.570699 0.488719 7.554638 3.478571 0.487884
8.290458 3.366185 0.488712 9.024810 3.245348 0.488055 9.755787 3.106809 0.488411 10.483625 2.954613 0.488722 11.206610 2.783224 0.490499 </Pts>
- <Normals> 0.059280 0.964227 -0.258364 0.077556 0.963016 -0.258039 0.095820 0.961481 -0.257628 0.114063 0.959622 -0.257130 0.132278 0.957438 -0.256545 0.150454 0.954931 -0.255873 0.168585 0.952101
-0.255115 0.186660 0.948949 -0.254270 0.204673 0.945478 -0.253340 0.222614 0.941687 -0.252324 0.059280 0.964227 -0.258364 0.077556 0.963016 -0.258039 0.095820 0.961481 -0.257628 0.114063 0.959622
-0.257130 0.132278 0.957438 -0.256545 0.150454 0.954931 -0.255873 0.168585 0.952101 -0.255115 0.186660 0.948949 -0.254270 0.204673 0.945478 -0.253340 0.222614 0.941687 -0.252324 0.059280 0.964227
-0.258364 0.077556 0.963016 -0.258039 0.095820 0.961481 -0.257628 0.114063 0.959622 -0.257130 0.132278 0.957438 -0.256545 0.150454 0.954931 -0.255873 0.168585 0.952101 -0.255115 0.186660 0.948949
-0.254270 0.204673 0.945478 -0.253340 0.222614 0.941687 -0.252324 0.059280 0.964227 -0.258364 0.077556 0.963016 -0.258039 0.095820 0.961481 -0.257628 0.114063 0.959622 -0.257130 0.132278 0.957438
-0.256545 0.150454 0.954931 -0.255873 0.168585 0.952101 -0.255115 0.186660 0.948949 -0.254270 0.204673 0.945478 -0.253340 0.222614 0.941687 -0.252324 </Normals>
- <Compensated>true</Compensated>
- <TimeStamps> 2018-01-25T16:22:15.68 2018-01-25T16:22:15.75 2018-01-25T16:22:15.82 2018-01-25T16:22:16.02 2018-01-25T16:22:16.46 2018-01-25T16:22:16.51 2018-01-25T16:22:16.65 2018-01-25T16:22:16.70
```

← QPID / UUID of face being measured

Locations and normals of contact points

Digital Twin Framework

STEP Data

QIF Data

```
STEP File Browser - BOXY_20170306.stp [page 1/1]
File View Navigate Help
FILE_SCHEMA (('AP242_MANAGED_MODEL_BASED_3D_ENGINEERING_MIM_LF { 1 0 1 0 }
ENDSEC;
ANCHOR;
<4210ed32-a599-43d1-9e84-96120d5ece42>=#983; /* perpendicularity_toler
<767be10a-4d9a-49d8-9fd5-205adcd7ad82>=#987; /* perpendicularity_toler
<459f7ee4-fced-4c3d-be7d-ca20f28e1855>=#991; /* perpendicularity_toler
<a584e6fc-b7cc-4904-b41e-81c97383b15f>=#995; /* perpendicularity_toler
<dc13594f-b8d5-4b23-bb38-ca86d96552e1>=#1094; /* datum_feature */
<9ce00c71-b207-4cb5-98fc-734ce92a60b0>=#1101; /* shape_aspect */
<9ffd7cbf-25bd-4be9-ab37-90b7ee855c69>=#1115; /* shape_aspect */
<754a586f-3593-4c1a-b0a9-a36f7c886540>=#1108; /* shape_aspect */
```

```
BOXY_20170306_Results.xml - Notepad
File Edit Format View Help
<CharacteristicNominalId>19</CharacteristicNominalId>
</FlatnessCharacteristicItem>
<PerpendicularityCharacteristicItem id="23">
  <Attributes n="1">
    <AttributeQPID name="QPID">
      <Value>4210ed32-a599-43d1-9e84-96120d5ece42</Value>
    </AttributeQPID>
  </Attributes>
  <Description>BOXY_20170306.PERPENDICULARITY_3</Description>
  <Name>PERPENDICULARITY_3</Name>
  <CharacteristicNominalId>22</CharacteristicNominalId>
</PerpendicularityCharacteristicItem>
<FlatnessCharacteristicItem id="26">
  <Attributes n="1">
    <AttributeQPID name="QPID">
      <Value>c3fe4af3-8e4a-4345-af0f-d6d62d0b5001</Value>
    </AttributeQPID>
  </Attributes>
```

UUID's

UUID's

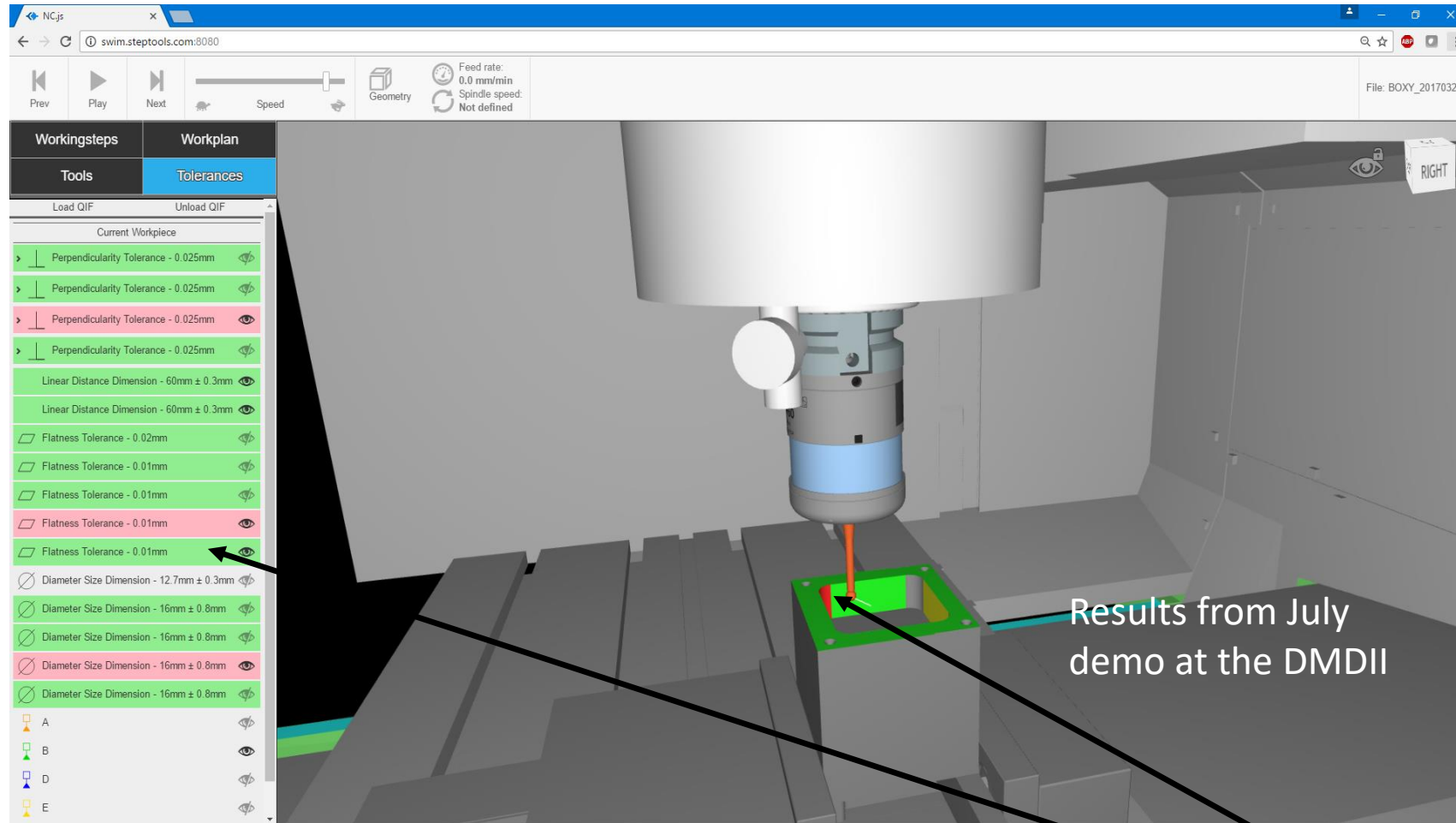
MTConnect Adapter Data

```
BOXY_20170306.log.txt - Notepad
File Edit Format View Help
2017-03-02T18:53:41.080Z|pprogram|BOXY_20170306
2017-03-02T13:53:49.104-05:00|measure|feature:"dc13594f-b8d5-4b23-bb38-ca86d96552e1" order:1 count:8 id:"FACE32373" characteristic:"3DLocation" x:-14.166667 y:-40.000000 z:9.166667
2017-03-02T13:53:50.306-05:00|measure|feature:"dc13594f-b8d5-4b23-bb38-ca86d96552e1" order:2 count:8 id:"FACE32373" characteristic:"3DLocation" x:-4.722222 y:-40.000000 z:9.166667
2017-03-02T13:53:51.507-05:00|measure|feature:"dc13594f-b8d5-4b23-bb38-ca86d96552e1" order:3 count:8 id:"FACE32373" characteristic:"3DLocation" x:4.722222 y:-40.000000 z:9.166667
2017-03-02T13:53:52.712-05:00|measure|feature:"dc13594f-b8d5-4b23-bb38-ca86d96552e1" order:4 count:8 id:"FACE32373" characteristic:"3DLocation" x:14.166667 y:-40.000000 z:9.166667
2017-03-02T13:53:53.913-05:00|measure|feature:"dc13594f-b8d5-4b23-bb38-ca86d96552e1" order:5 count:8 id:"FACE32373" characteristic:"3DLocation" x:-14.166667 y:-40.000000 z:73.333333
2017-03-02T13:53:55.117-05:00|measure|feature:"dc13594f-b8d5-4b23-bb38-ca86d96552e1" order:6 count:8 id:"FACE32373" characteristic:"3DLocation" x:-4.722222 y:-40.000002 z:73.333333
```


Digital Twin Measurement



"O3" 14-06-05



- Green good
- Red bad
- Yellow good and bad

Results from July demo at the DMDII

Tablet,
Phone or
Large Screen TV

