

IMTS and JIMTOF 2018 Challenge

Dr. Martin Hardwick

Professor of Computer Science, RPI

President STEP Tools, Inc.

Convener ISO WG15 Digital Manufacturing

Base Goals

1. Digital Twin machining in multiple booths
 - Read STEP-NC process for fishhead
 - Transmit machining status to large screen TV's using MTConnect
2. Demonstrate digital twin framework
 - Stop the machining
 - Transfer to another booth
3. Digital Twin measurement to validate results meet AP242 tolerances
 - In process measurement at the CNC
 - Final measurement on a CMM
 - Feedback to the digital twin using QIF

Digital Twin Machining



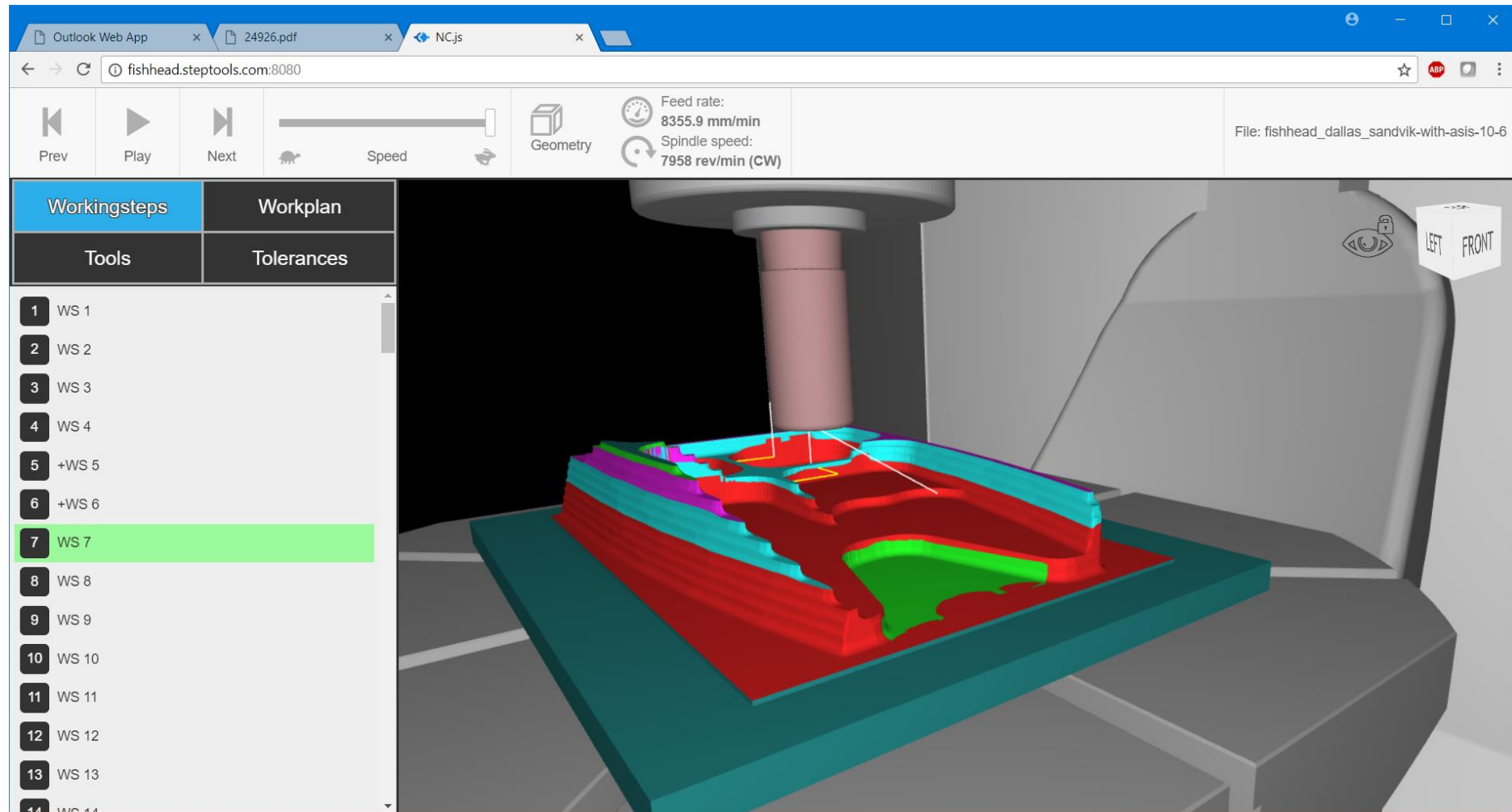
“Mind the Gap” 14-02-02



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

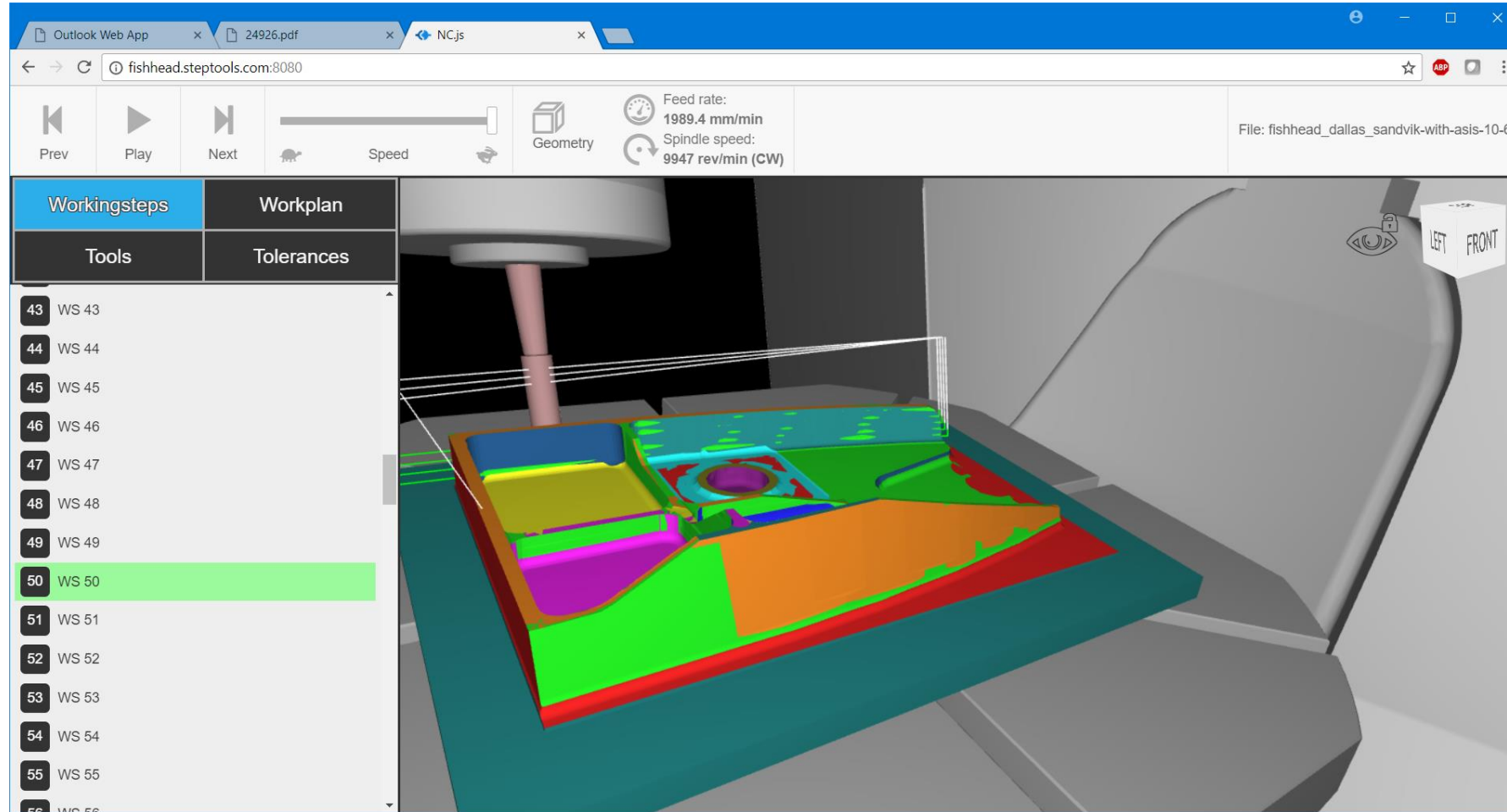
- Real time twinning from MTConnect
 - 1Hz trace the plan data
 - 250Hz model the run data
- Phone and large screen TV display
 - STEP in Node.js
 - View in Three.js
 - UI in React.js

Fishhead (aerospace test) at Workingstep 7



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

Fishhead at Workingstep 50



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

QIF results on STEP twin

The screenshot displays a web browser window at swim.steptools.com:8080. The interface includes a control bar with 'Prev', 'Play', and 'Next' buttons, a speed slider, and a 'Geometry' button. The main area shows a 3D simulation of a CNC machine with a tool bit positioned over a workpiece. A 'RIGHT' view indicator is visible. On the left, a 'Tolerances' panel lists various QIF results for the current workpiece:

Symbol	Feature	Tolerance	Status
⊥	Perpendicularity Tolerance	- 0.025mm	Pass (Green)
⊥	Perpendicularity Tolerance	- 0.025mm	Pass (Green)
⊥	Perpendicularity Tolerance	- 0.025mm	Fail (Red)
⊥	Perpendicularity Tolerance	- 0.025mm	Pass (Green)
	Linear Distance Dimension	- 60mm ± 0.3mm	Pass (Green)
	Linear Distance Dimension	- 60mm ± 0.3mm	Pass (Green)
□	Flatness Tolerance	- 0.02mm	Pass (Green)
□	Flatness Tolerance	- 0.01mm	Pass (Green)
□	Flatness Tolerance	- 0.01mm	Pass (Green)
□	Flatness Tolerance	- 0.01mm	Fail (Red)
□	Flatness Tolerance	- 0.01mm	Pass (Green)
∅	Diameter Size Dimension	- 12.7mm ± 0.3mm	Pass (Green)
∅	Diameter Size Dimension	- 16mm ± 0.8mm	Pass (Green)
∅	Diameter Size Dimension	- 16mm ± 0.8mm	Pass (Green)
∅	Diameter Size Dimension	- 16mm ± 0.8mm	Fail (Red)
∅	Diameter Size Dimension	- 16mm ± 0.8mm	Pass (Green)

At the bottom of the tolerance list, there are five feature markers labeled A, B, D, and E, each with a corresponding eye icon for visibility control.

Invited Participants

- Makino
- Okuma
- Hyundai
- DMG Mori
- Mazak?
- Limits
 - 4 machine vendors
 - 1 cutter vendor
- Supporters
 - Mitutoyo
 - Renishaw
 - DMSC/QIF
 - Dassault?
 - Autodesk?
 - NIST
 - Boeing
 - OMAC
 - ISO WG15 Digital Manufacturing
 - Sandvik
 - STEP Tools
 - AMT/MTConnect?

Sales pitch for the machine tool vendors

- Visit to Boeing to see a digital twin demonstration and STEP-NC Machining in production
- Write-up on what we are trying to do
 - Who we are
 - What we expect from each participant
 - What are the benefits
 - How we will publicize
- Ask them to participate in showing
 - Work movement with MTConnect at low resolution [1Hz] or high resolution [40Hz] for digital twinning
 - Fishhead to be machined from start to finish in each performance
 - Choice of which vendor performs which operation to be selected randomly at the start of each performance
 - Each performance ends at Mitutoyo for measurement with QIF results shown on the digital twin
- Vendors encouraged to show the advantages of the Digital Twin with applications to show
 - Automated setup
 - On machine Inspection
 - Tracking
 - Optimization
 - Cost estimation
 - Digital manufacturing framework
 - Other ideas

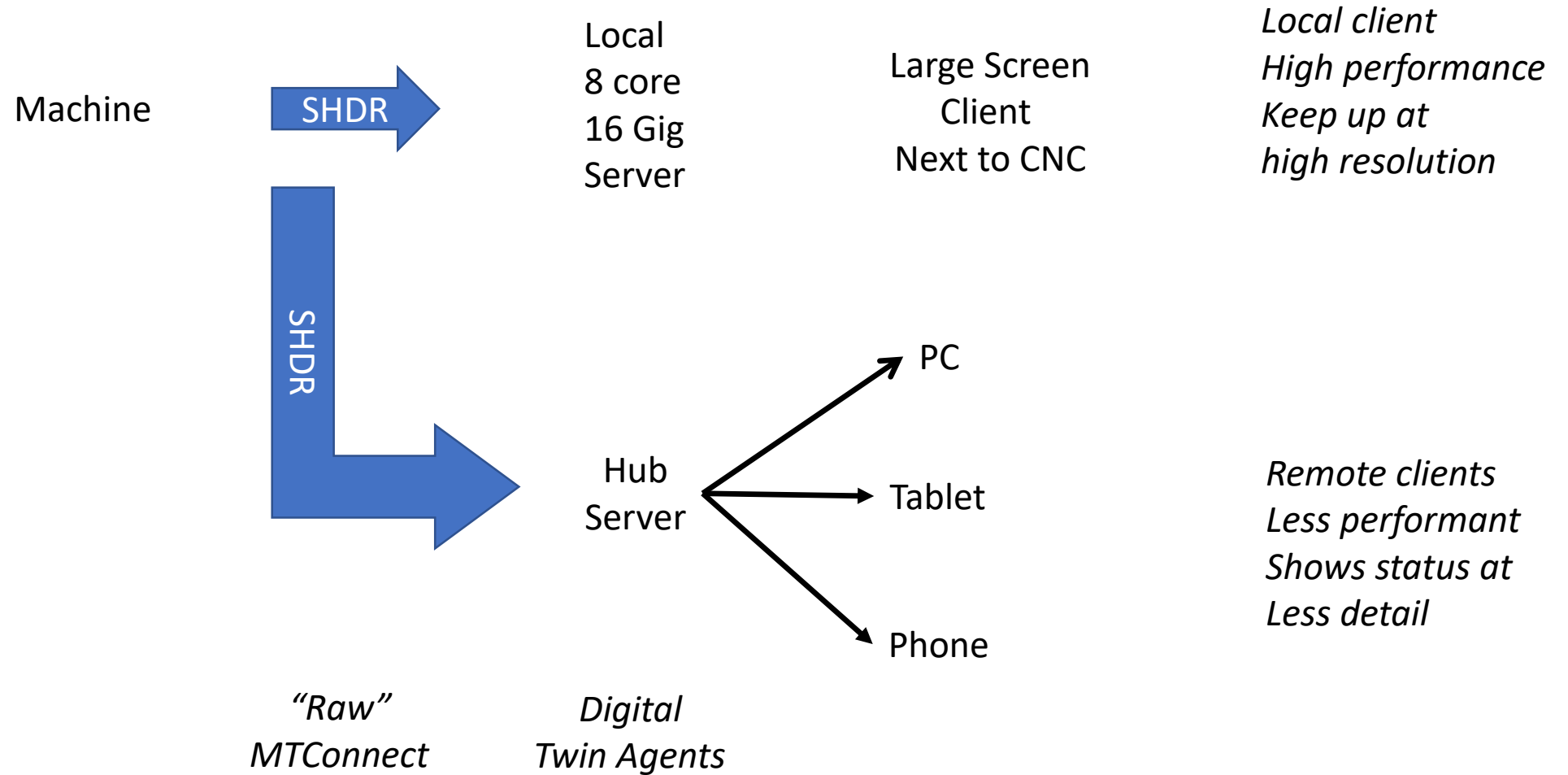
Grand Challenge preparation schedule

- Clean up fishhead data / model – Nov 30th?
 - Mitutoyo tolerances – Nov 30th
 - Boeing defined fixturing – Nov 30th
 - Boeing defined reference points – Nov 30th
 - Boeing defined ws names – Nov 30th
 - Boeing to divide into rough1, rough2, semi-finish, and finish
- Complete extract of AP238 from CATIA – Dec 31st
- **Finalize write-up – Jan 31st**
- Confirm support/funding – Feb 1st
- Visits to Boeing to see STEP-NC production machining, and machining of the fishhead test part
 - Visit 1 – Feb 15 (DMG?)
 - Visit 2 – Feb 28 (Makino confirmed)
 - Visit 3 – March 15
 - Visit 4 – March 31
- Finalization of commitments May 1st
 - After this you may be able to join but we may not be able to help you
- Completion of detailed planning of the show logistics July 1st

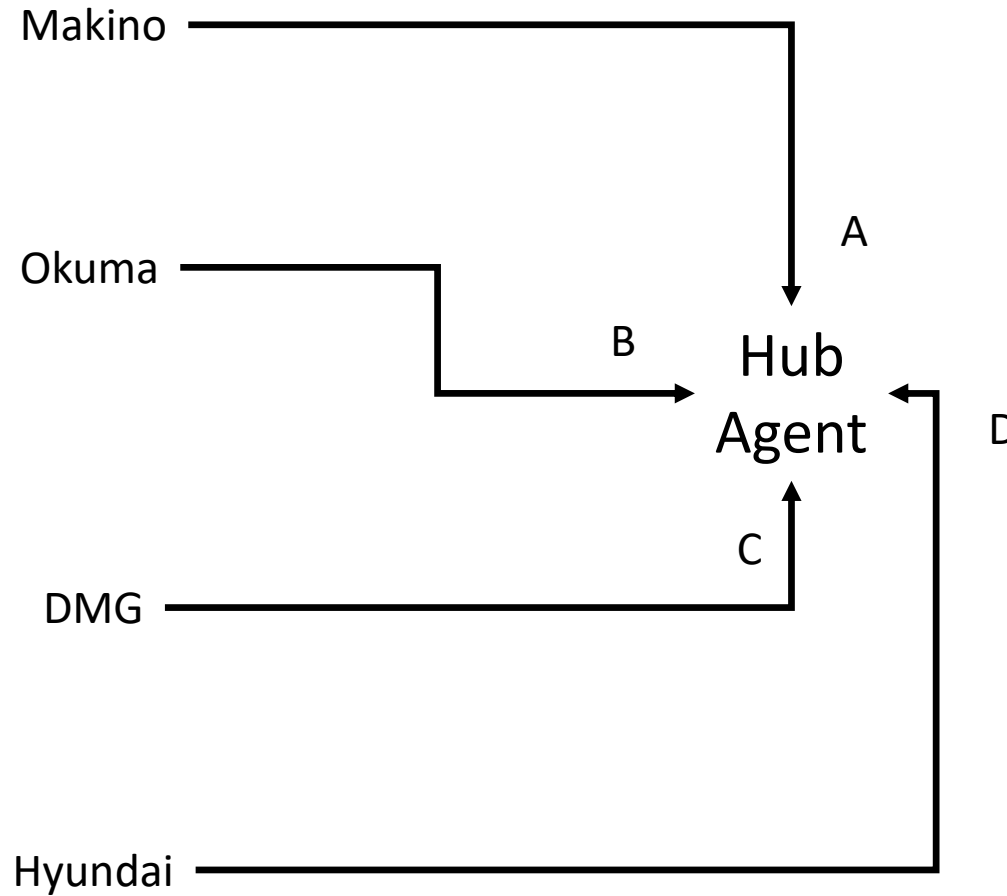
Sandvik hosting of digital twin hub

- Sandvik suppliers cutters under its standard terms for a show
- Sandvik shares models of its tools
- Machine vendor shares model of its machine
- High speed internet delivers MTConnect in real time
- Digital twin can be seen in vendor booth and at the twin hub
- Story board – November 30th
- Write-up – December 31st
- Agreement on minimal functionality – Jan 31st

Machine Twinning



Hub Twinning



Hub agent listens to each socket (one per CNC)

When a CNC starts streaming
Load the right machine model
Continue twin from the last CNC

Contents of the write-up

- Vision statement
- What will happen
- How to participate
- Check-list of requirements for participating
- How supporters can help

IMTS and JIMTOF Audience takeaway's

- Digital twin manufacturing is inter-operable
- Digital twin manufacturing is measurable
- Digital twin manufacturing is transparent and open

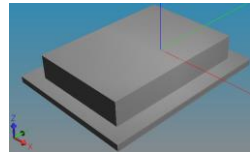
- Digital twin manufacturing enables many new savings
 - See the vendor demos

- Digital twin manufacturing is the future
 - Integration of devices into machining centers
 - Enabler for machine learning and autonomous operation

Digital Twin Machining Demonstration 2018

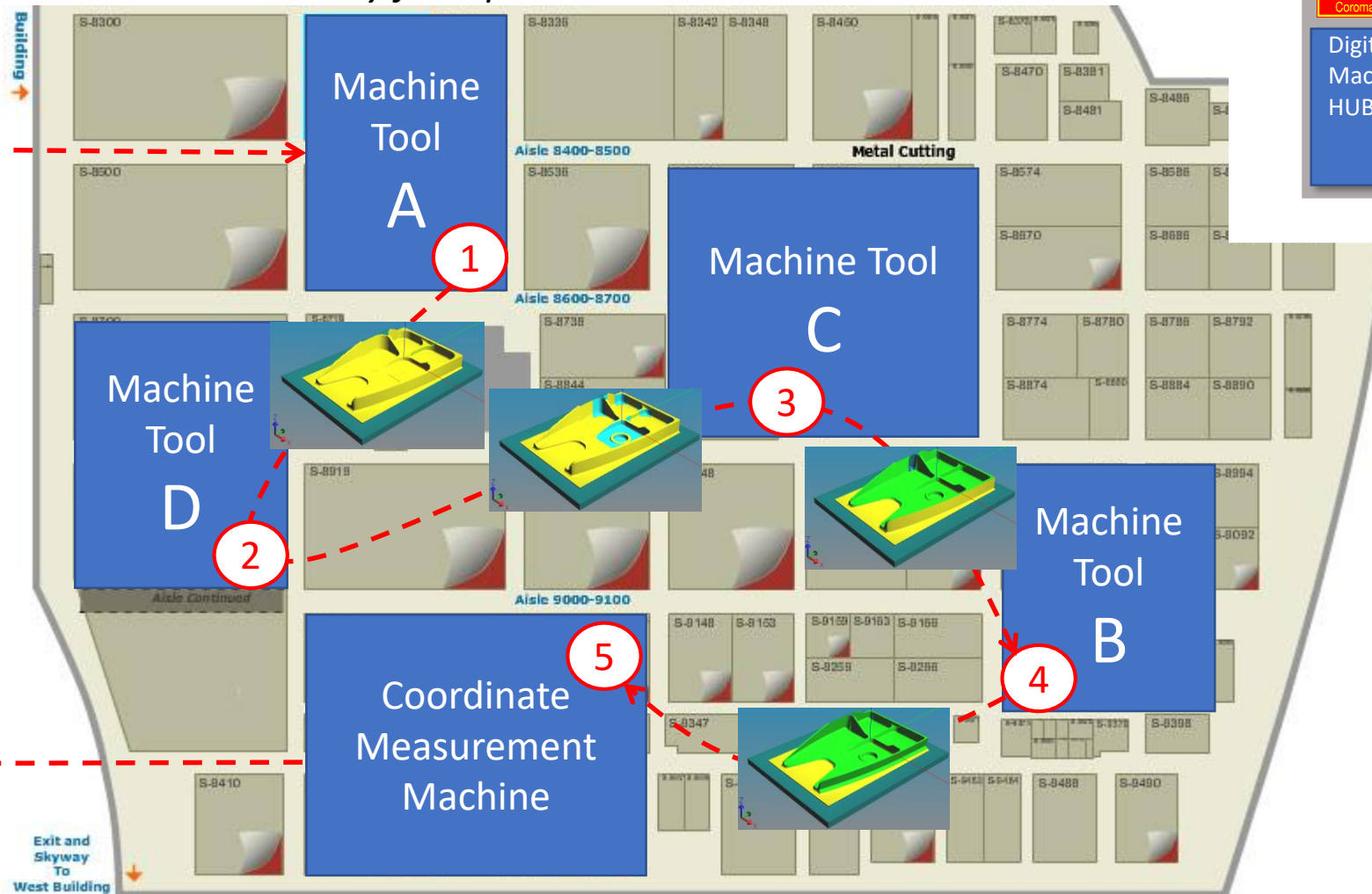
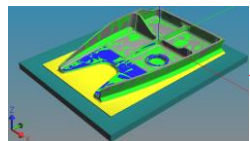
"Factory floor plan" at machine tool show

- ✓ Plan process



- ✓ Send workpiece through factory

- ✓ Receive finished part



Action items from Nov 15 call

- Meet deadlines for data preparation – on track for first drafts on Thursday, Nov 30th
 - David O and Larry
- Determine response rate of MTConnect on Boeing Gantry with FANUC control – also Thursday
 - Sid
- Visit Boeing in January to prepare demonstration - TBD
 - Martin
- Investigate inclusion of Sandvik and Renishaw in vendor visits - TBD
 - Discussion with vendors
- Investigate expanding role of QIF in the demonstrations by working with DMSC – call on Monday
 - John and Martin
- Sell idea of hosting the digital twin hub to Sandvik – see new slide
 - Bengt
- Investigate use of robot for transport - TBD
 - Larry

Action items from Nov 29 call

- Participate in-process measurement call on Monday
- Think about how to tag the part with an RFID
- Complete the first draft data preparation
- Contact Russ Waddell of AMT to promote the demo
 - Tom Hedberg
- Contact Renishaw to see if they can support in-process measurement for the demonstration with the new MTConnect
 - John Horst
- Get one year Boeing badge for STEP Tools
 - Sid Venkatesh