Preparation for
October demonstration
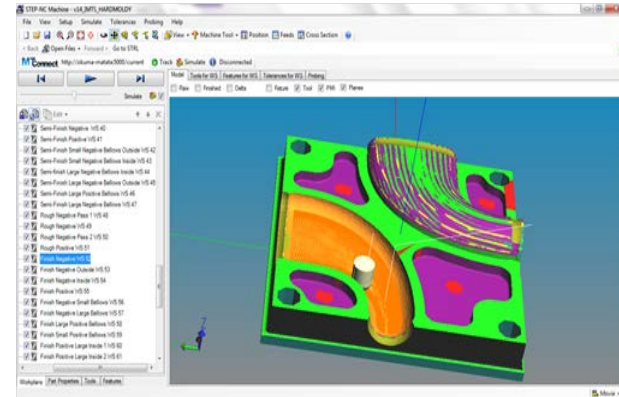# to Boeing, ISO and MTConnect

STEP Tools, Inc.
http://www.steptools.com
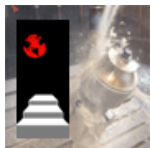
Martin Hardwick
Professor of Computer Science, RPI
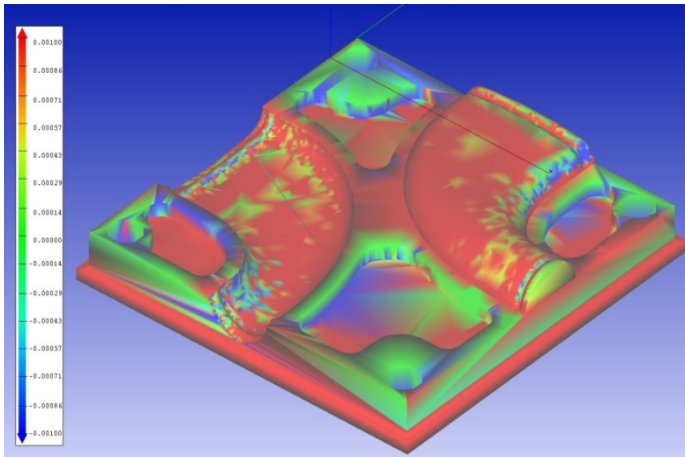President STEP Tools, Inc.

Machining and Measurement
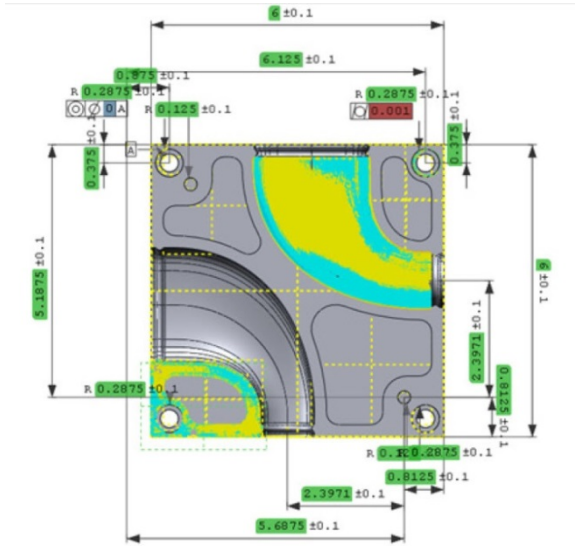
Part with GD&T

Real time mesh generation

Virtual metrology

Actual metrology

Goals

- Show the value of the STEP-NC AP238 standard
- As an enabler for real time machining simulation in the cloud or on the CNC
  - Reducing tool wear by > 15%
  - Automating error detection
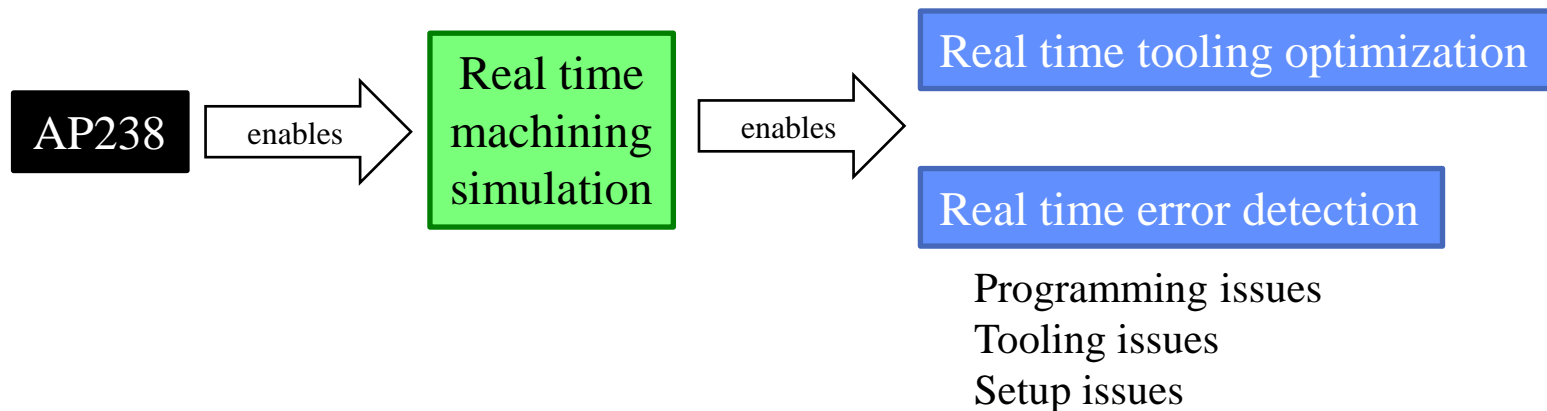
AP238 → enables → Real time machining simulation → enables →

Real time tooling optimization

Real time error detection

Programming issues
Tooling issues
Setup issues

Machining Simulation in the cloud

OP 29 Rough Pocket Milling [Z-] End Mill 16-A

Volume removal in the cloud
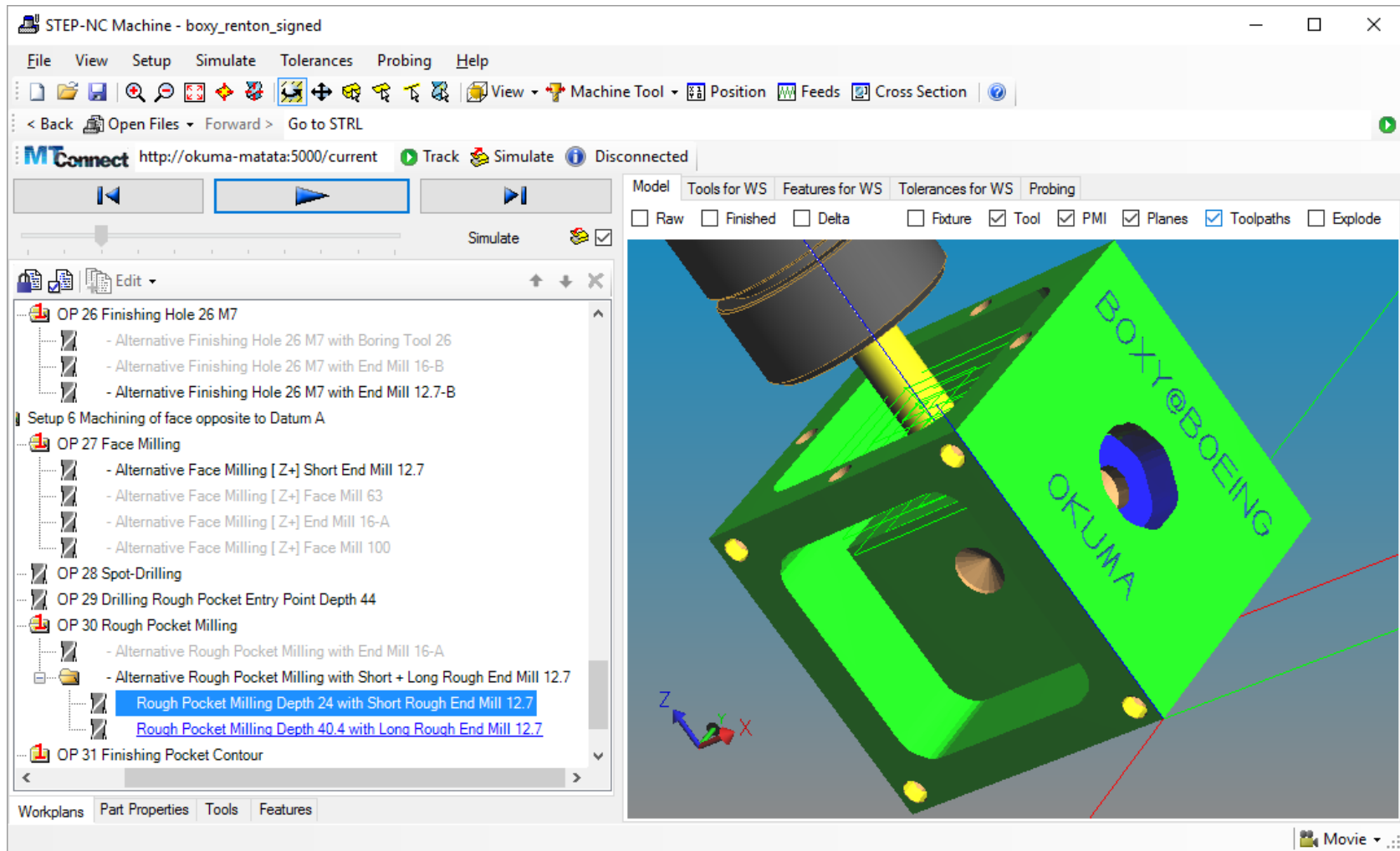
Demonstration Activities

Aft room

Plan ——**AP238**——┐
                   │
Video ——————————→ ┌─────────────────────┐   **AP242**   Stage
                  │ Machining simulator │ ———————————→   Model
Workpiece offsets ——**MTConnect 1.4**——→ │   │
                  └─────────────────────┘

Tool dimensions ——**MTConnect 1.3**——

Current or
previous ——**MTConnect 1.2**——
Results

Point / Facet
Cloud   Basement room

                                    │ **STL**
                                    ↓
Stage   **AP242**   ┌──────────────────┐   **QIF**   Measured
Model ———————————→   │   Measurement   │ ————————→   Results
                       │   machine   │
                       └──────────────────┘
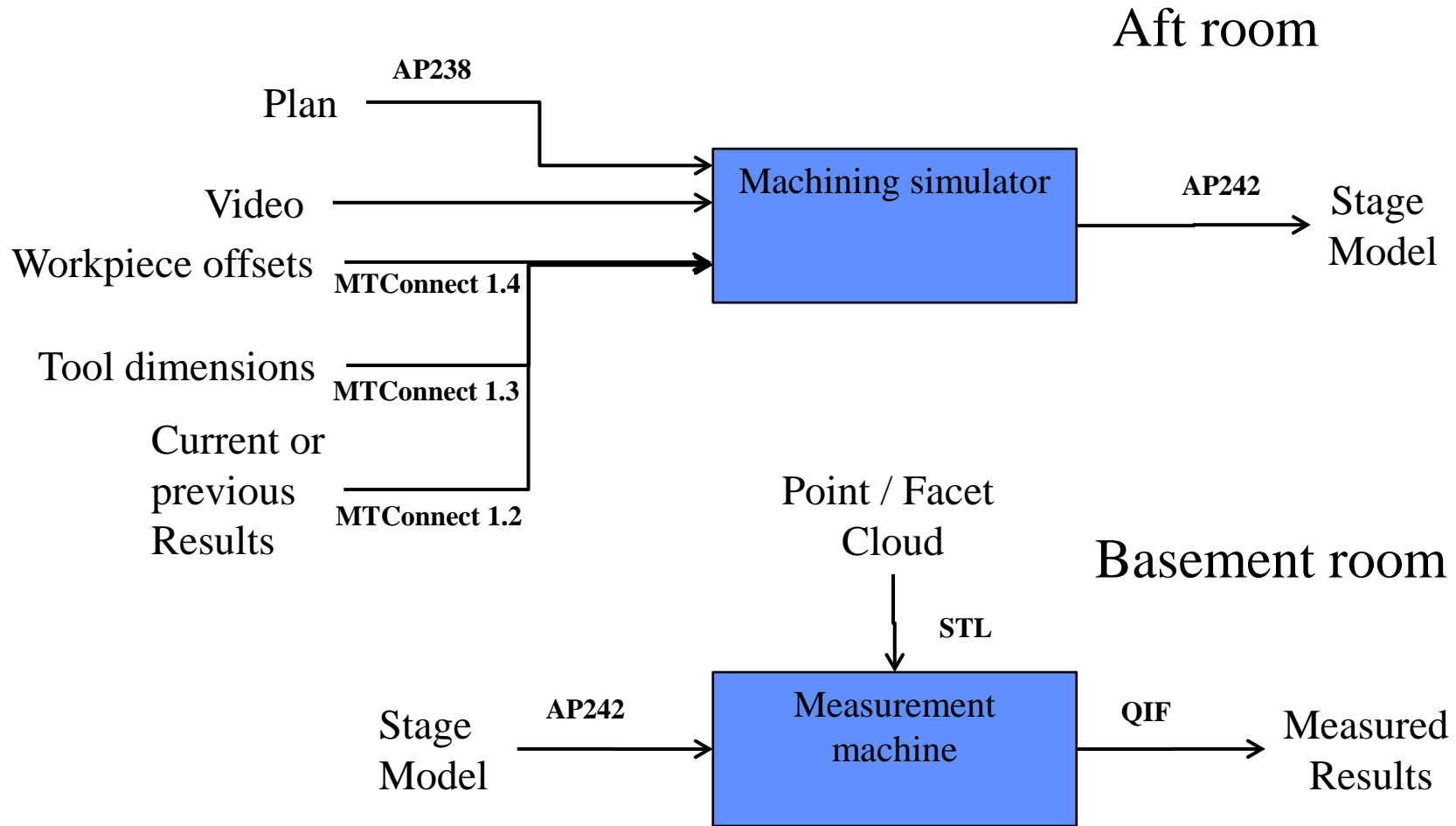
Actual measurement uses stage model with GD&T
Virtual measurement uses stage model with generated mesh and GD&T

Demonstration Facilities

MTConnect Simulation

- Aft room on first floor

- Up to 65 people

- Two feeds
  - MTConnect feed from Renton
  - Video feed from Renton

- Demonstration highlights
  - Real time simulation
  - Mesh cloud measurement
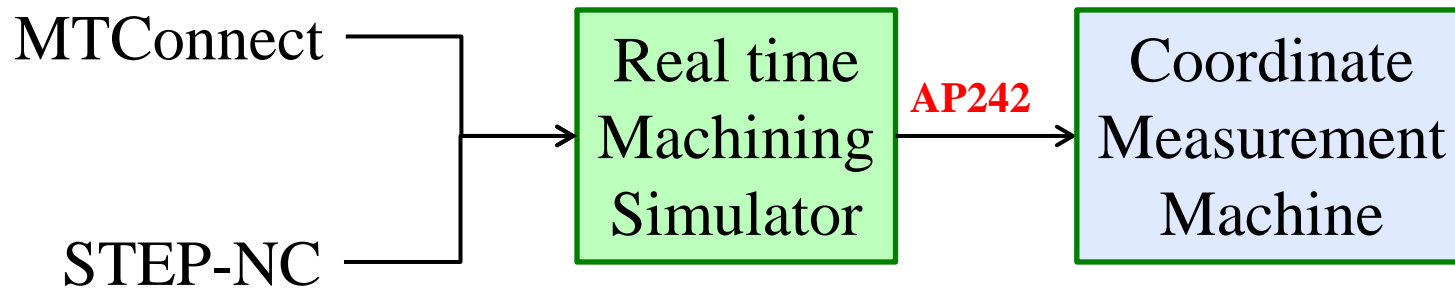 - Tooling optimization

AP242 Measurement

- Basement room

- Up to 50 people

- CMM machine
  - Part machined previously
  - Contact measurement

- Demonstration highlights
  - AP242 -> ACIS translation
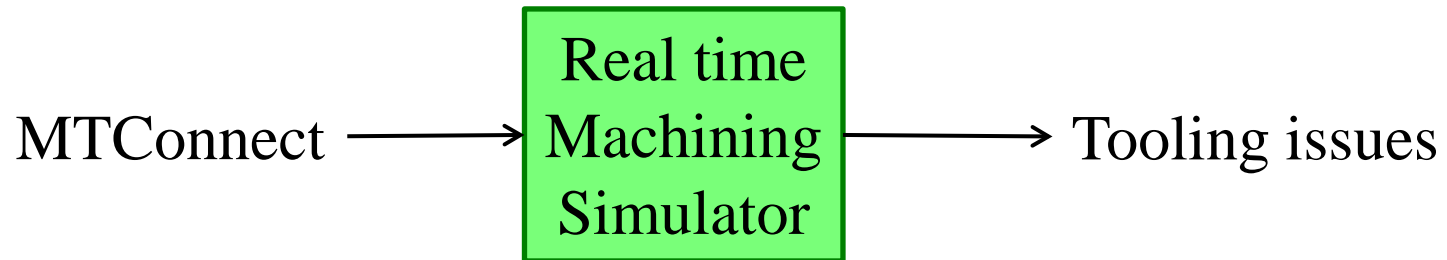 - Touch probe measurement
  - QIF results

Tooling optimization
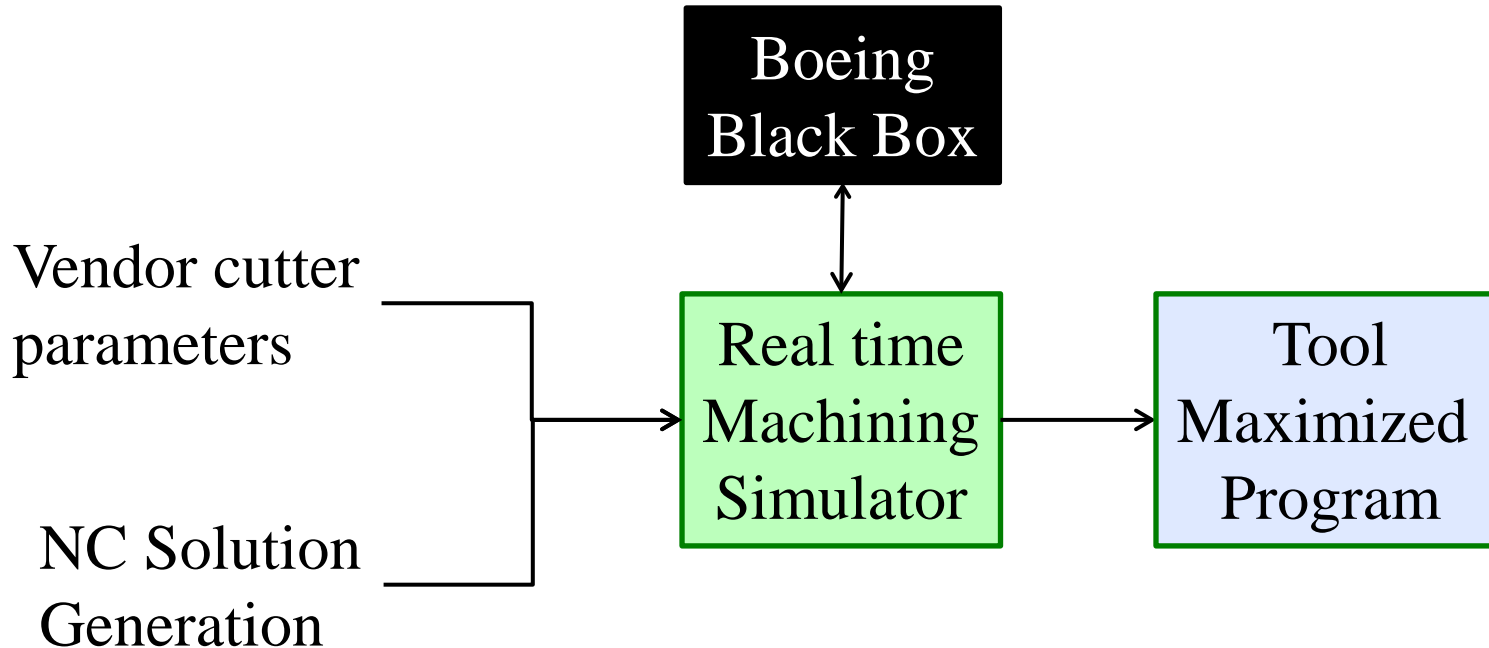
- Simulator computes cut cross section
- Vendor recommends chip thickness
- Black box optimizes feeds

Programming Issue detection

MTConnect ————┐
                 │ ——→ | Real time Machining Simulator | —**AP242**→ | Coordinate Measurement Machine |
STEP-NC ————┘

- Simulator computes / predicts feature dimensions
- CMM measurement service measures against nominal
  - Too much material (shows as blue in color map)
  - Too little material (shows as red in color map)

Tooling Issue detection

```
                   ┌─────────────┐
                   │ Real time   │
MTConnect  ──────→ │ Machining   │ ──────→ Tooling issues
                   │ Simulator   │
                   └─────────────┘
```

- Tool dimensions issues
  - Too much "stick out" causes a collision
  - Cutting edge insufficient for engagement
  - Insufficient tool life to complete operation

Setup Issue detection

MTConnect ⟶

Video
& audio ⟶

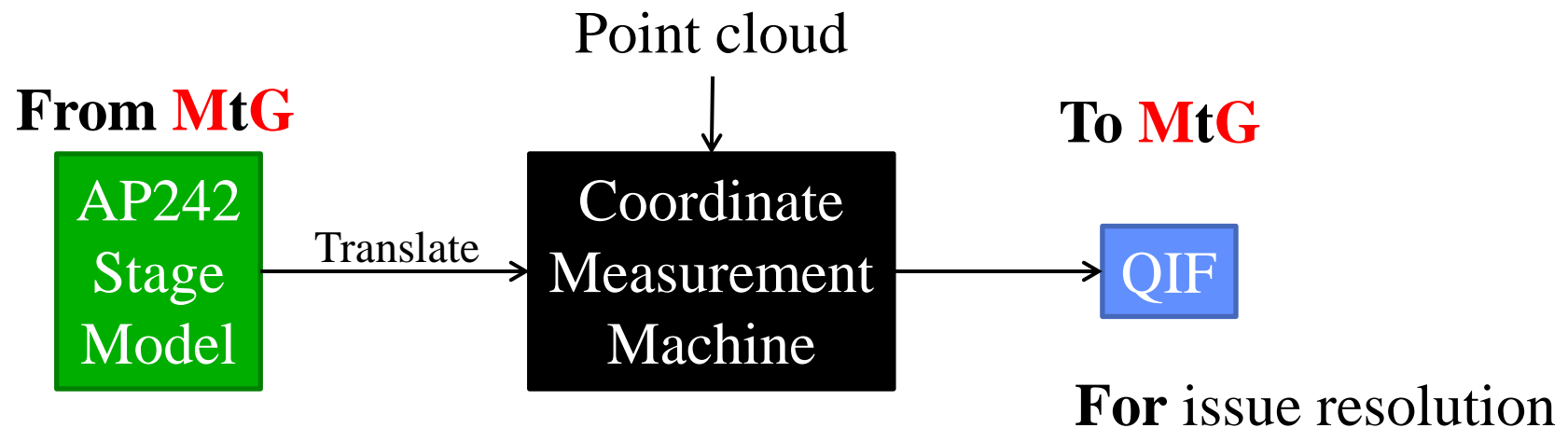[Real time Machining Simulator] ⟶ Setup issues
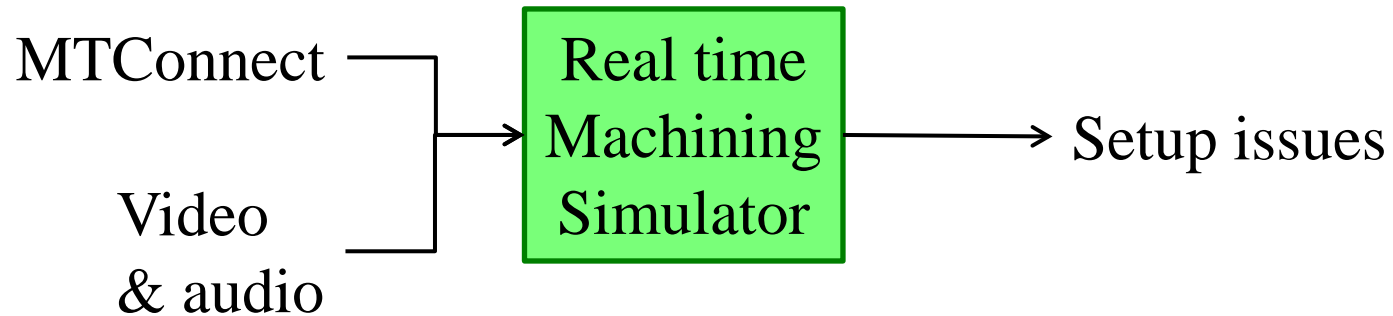
- Sound does not correspond to machining simulation
  - Starts too early, or too late
  - Does not increase or decrease as depth changes
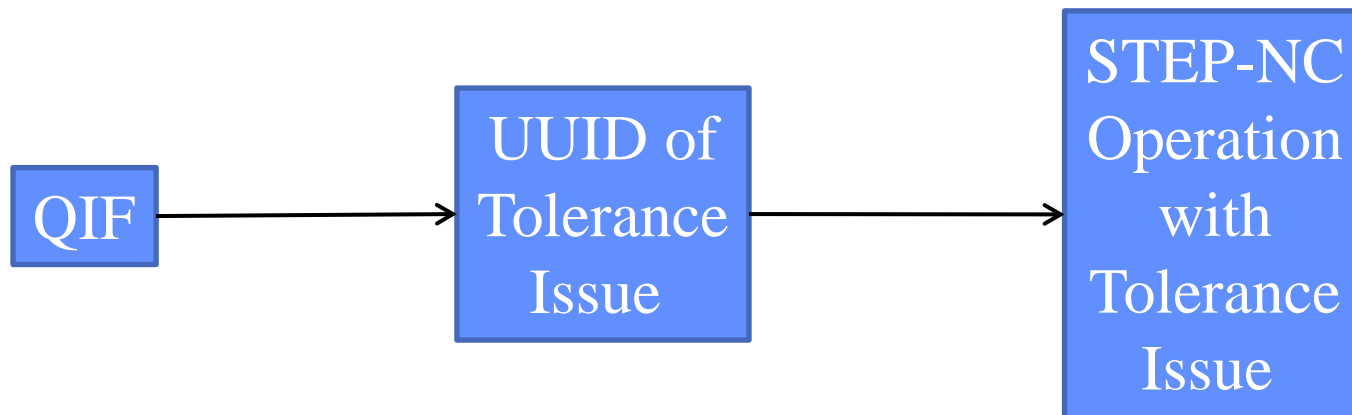
Basement Room
O3 Phase 1 (of 3) demonstration

- Measurement of previously machined parts
  - Translation of stage model to ACIS
  - Touch probe measurement on a CMM
  - QIF results report

Point cloud

From MtG

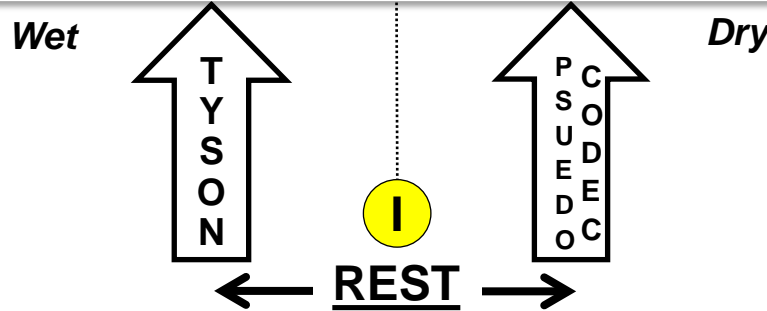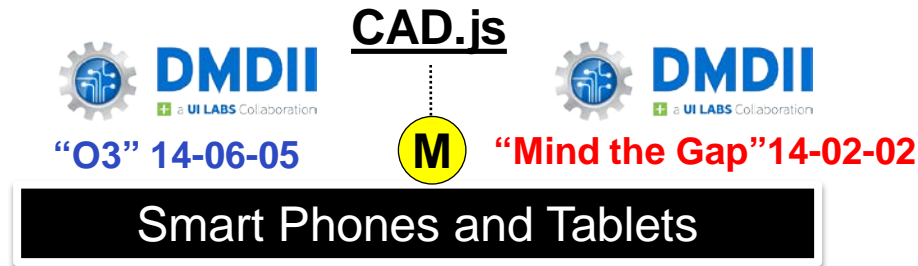| AP242 Stage Model | → Translate → | Coordinate Measurement Machine | → | QIF |

To MtG

For issue resolution

Resolving Issues

- **MtG** makes stage models, **O3** measures stage models
- When there is an issue
  1. Find the machining program that made the tolerance
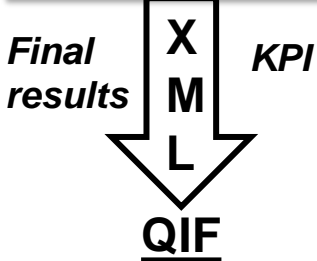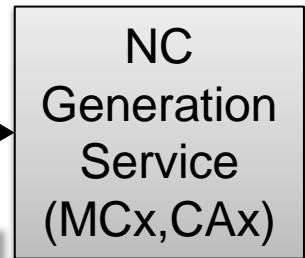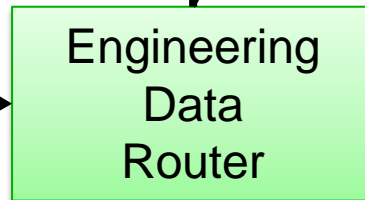 2. Find the operation responsible for the tolerance

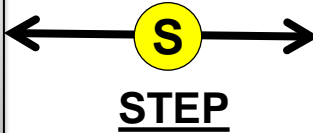QIF → UUID of Tolerance Issue → STEP-NC Operation with Tolerance Issue

ISO TC 184/SC4 AG1   **MTConnect**

Roadmap for deployment

2020 **Smart Manufacturing**

2019 **Smart Control**

2018 **Smart Programming**

2017 **Smart Metrology**

2016 **Smart Visualization**

Hyper-Connected Machining

Closed Loop Machining

Optimized Machining

Tracked Inspected Machining

Tracked Machining

5 => Results integration for automated assembly

4 => Intelligent Apps on the CNC detect discrepancies and compensate

3 => CAM data exchange enables intelligent optimization by many parties

2 => Detailed simulation enables virtual measurement of process results using virtual CMM

1 => New software stack enables remote visualization and validation of machining processes on smart phones and tablets