Toward Dimension X-ray Computed Tomography to Smart Manufacturing

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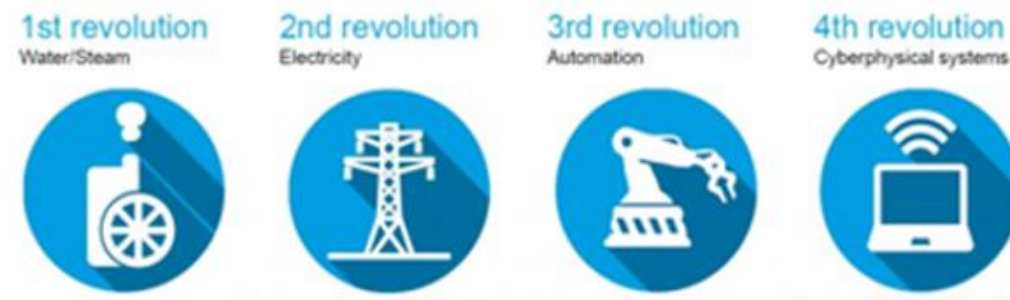
Overview

- Smart Manufacturing

  - Concept of Smart Manufacturing in Industry 4.0

  - Smart Manufacturing Principle and Activities

  - Digital Twin Manufacturing advantage

- **CT Inspections** (Measurement System) in smart manufacturing

  - Current Inspection Industry

  - CT Inspection solution

  - What NPL DXCT team can do

- The value of smart manufacturing with CT inspection
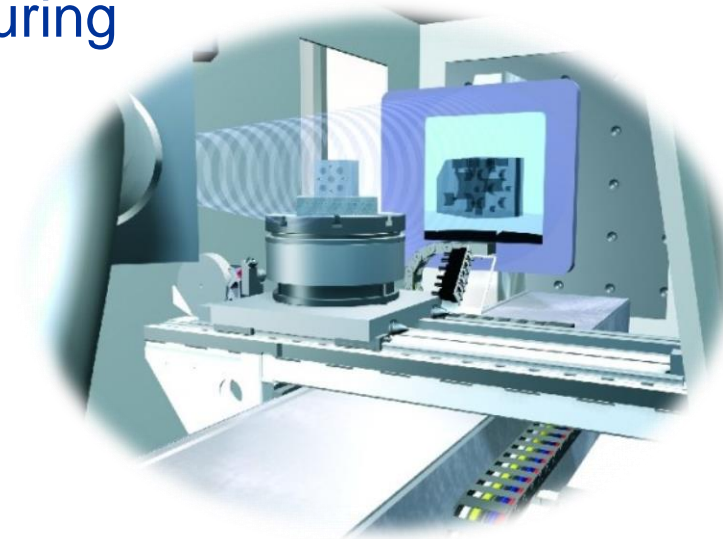
Industry 4.0

- All countries in the world are now embracing the fourth industrial revolution (Industry 4.0)

  - Big data

  - Internet of things (IoT)
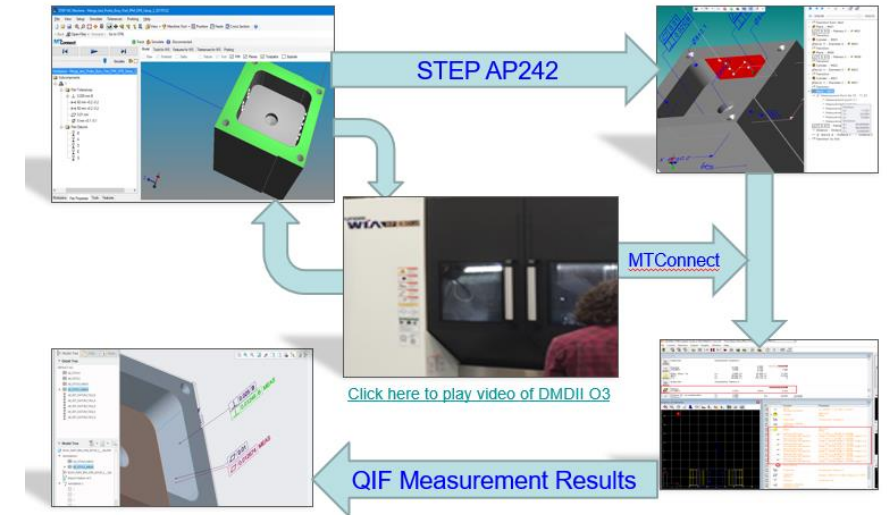
  - **Smart manufacturing** (M2M)

- Challenges of implementation in enterprise

  - Traditional mechanical manufacturing enterprises

  - Medium or small enterprises.

Smart Manufacturing

Design → Manufacturing → Inspections (Quality Assurance) → Technical Product Documentation

STEP AP242

MTConnect

Click here to play video of DMDII O3

QIF Measurement Results

- Applying the latest technologies to manufacturing process.

- In each stage, digitalizing, using computer read and understand.

- Minimize human involvements in the manufacturing processing.

- By making machine smarter, optimizing manufacturing processing

Foundation of smart manufacturing

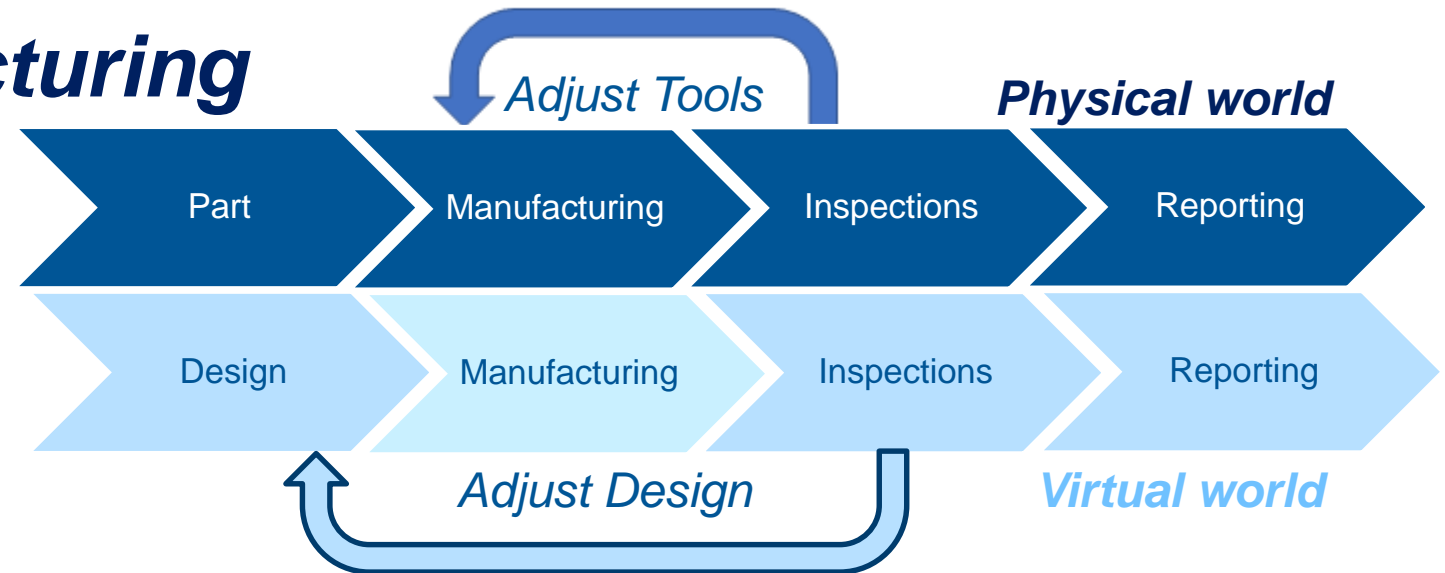## *Model-Based Definition (MBD)*

- Geometry

  - Nominal data, Feature to measure

- Graphic PMI (Product Manufacturing Information)

  - Human-readable: Text,, Drawings, and 3D Views

- Sematic PMI

  - Machine-readable: Geometry & Tolerance Values and Linkages

  - Using for driving machines and conformance to specification.

- ISO Standard: 10303 STEP AP242, "Managed model-based 3D engineering"
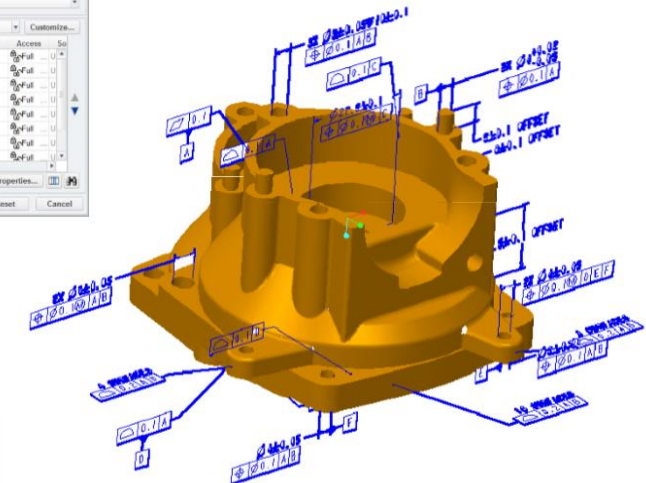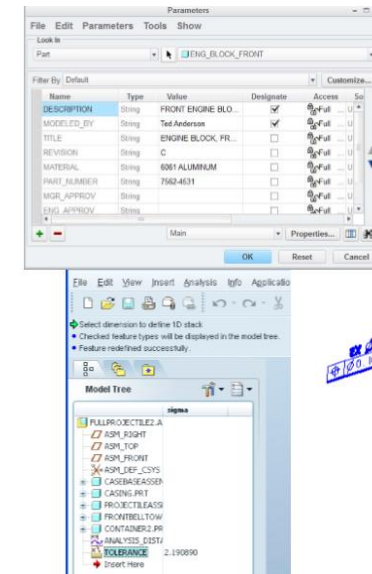
An approach of smart manufacturing
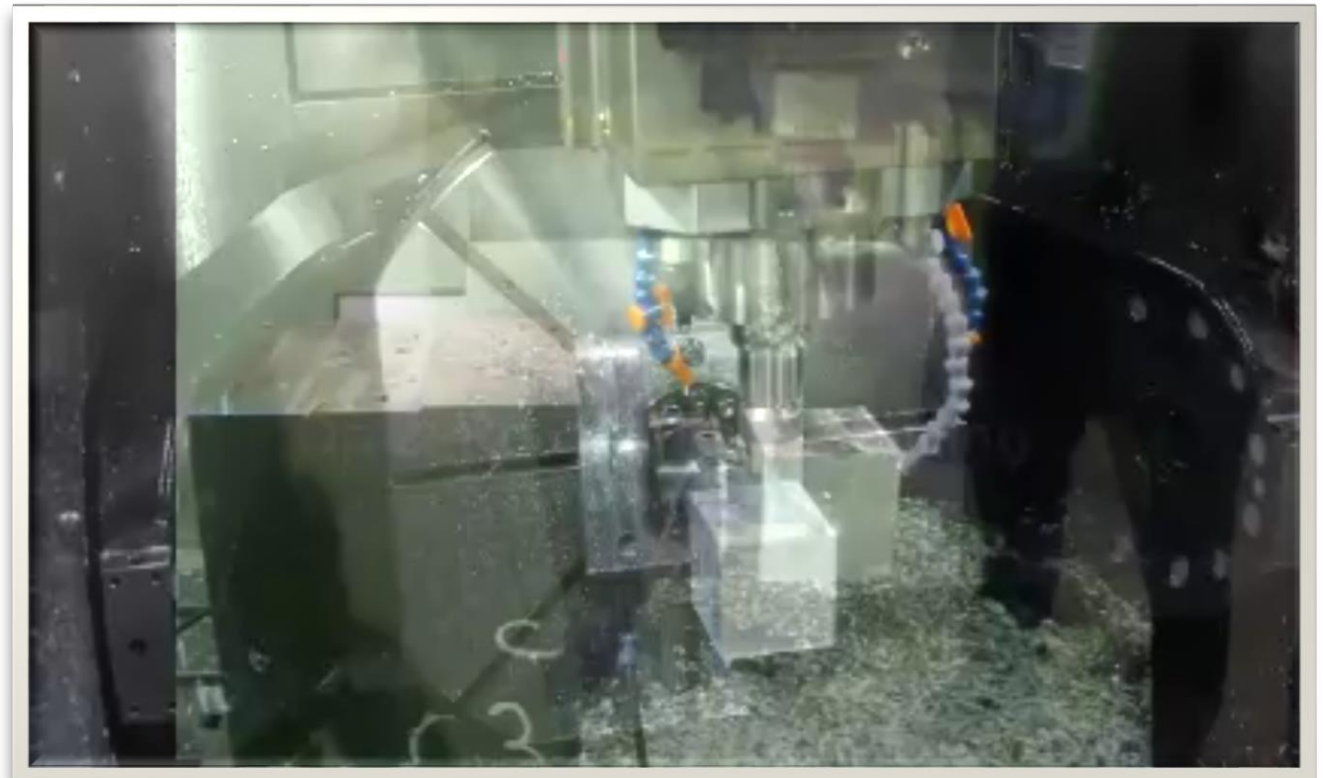
Digital Twin Manufacturing

- Virtual world and physical world. Real time synchronization.

- Create virtual/cyber machine, modeling manufacturing process,

- As earlier as possible find error and solve the problems

Adjust Tools

Physical world

| Part | Manufacturing | Inspections | Reporting |

| Design | Manufacturing | Inspections | Reporting |

Adjust Design

Virtual world

Example of smart manufacturing

Projects: Siemens, GE, Lockheed Martin, RR, etc.

Design → Manufacturing → Inspections (Quality Assurance) → Technical Product Documentation

Grand Challenge Project By Dr. Martin Hardwick (Step Tools) Lead

Inspection Technologies

- Inspection in manufacturing process

  - Complex, key stage, more critical.

- Pre-measuring:

  - CMM, Tools configuration, Planning

- Measuring:

  - Touch-probe, Scan, Optical, Laser, **_XCT,_**

    Vision, Potable, Arm, Multi-sensor,

- Post measuring:

  - Evaluation following ISO 1011 GPS, ASME

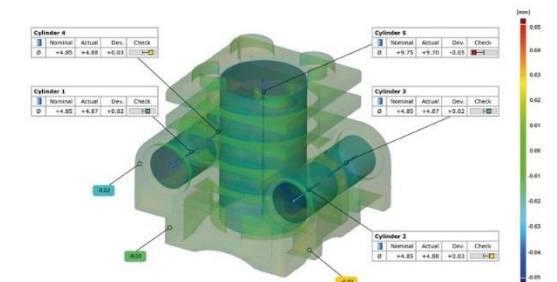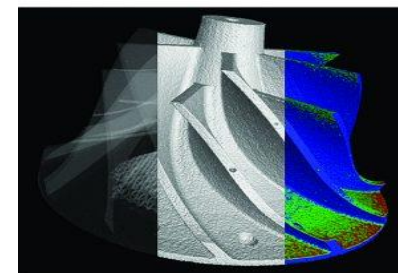   Y14.5 GD&T

CT Inspection Solution
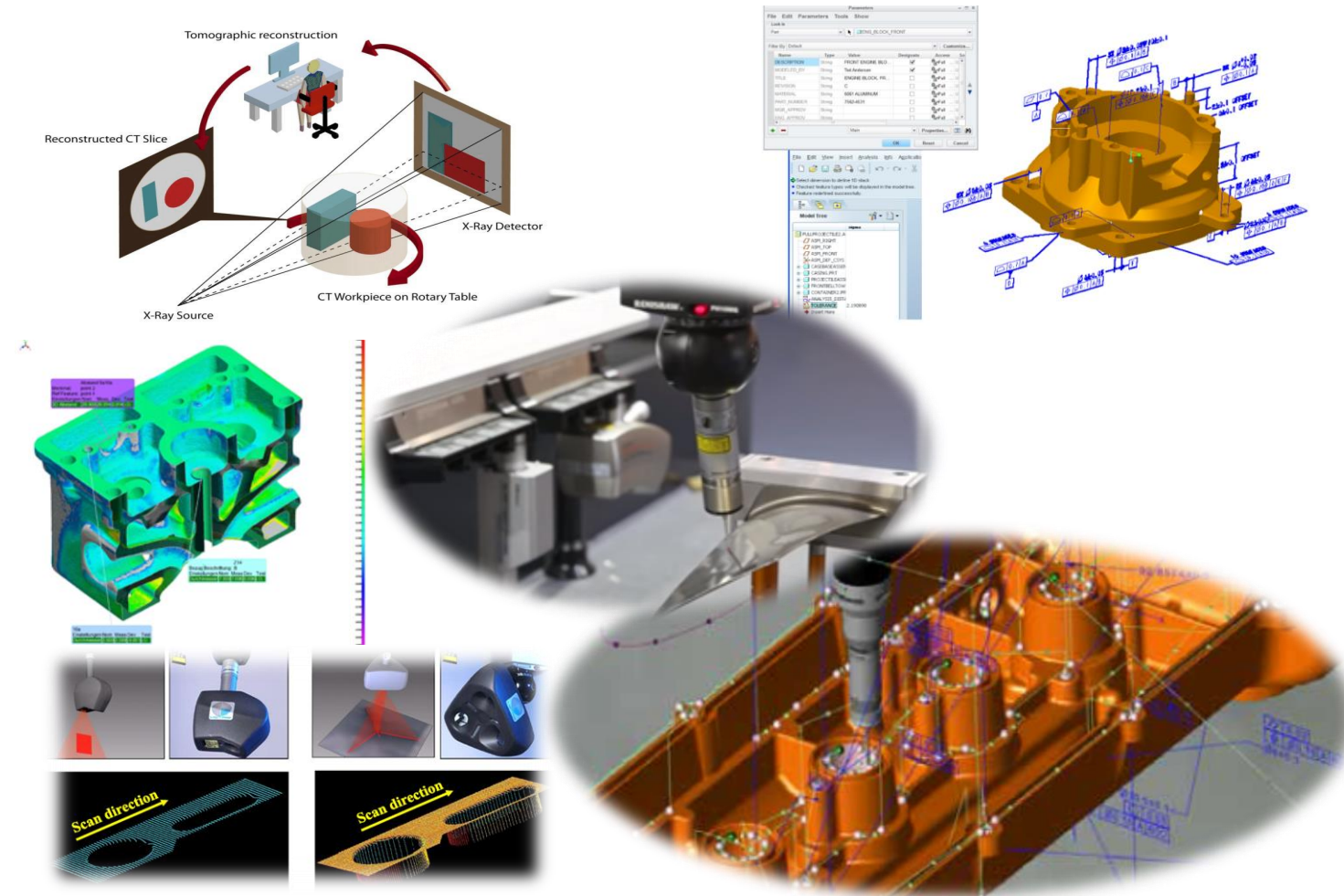
Design → Manufacturing → Inspections (Quality Assurance) → Technical Product Documentation
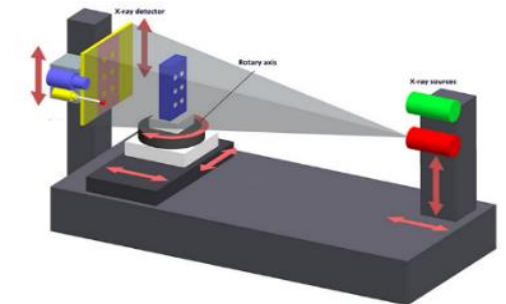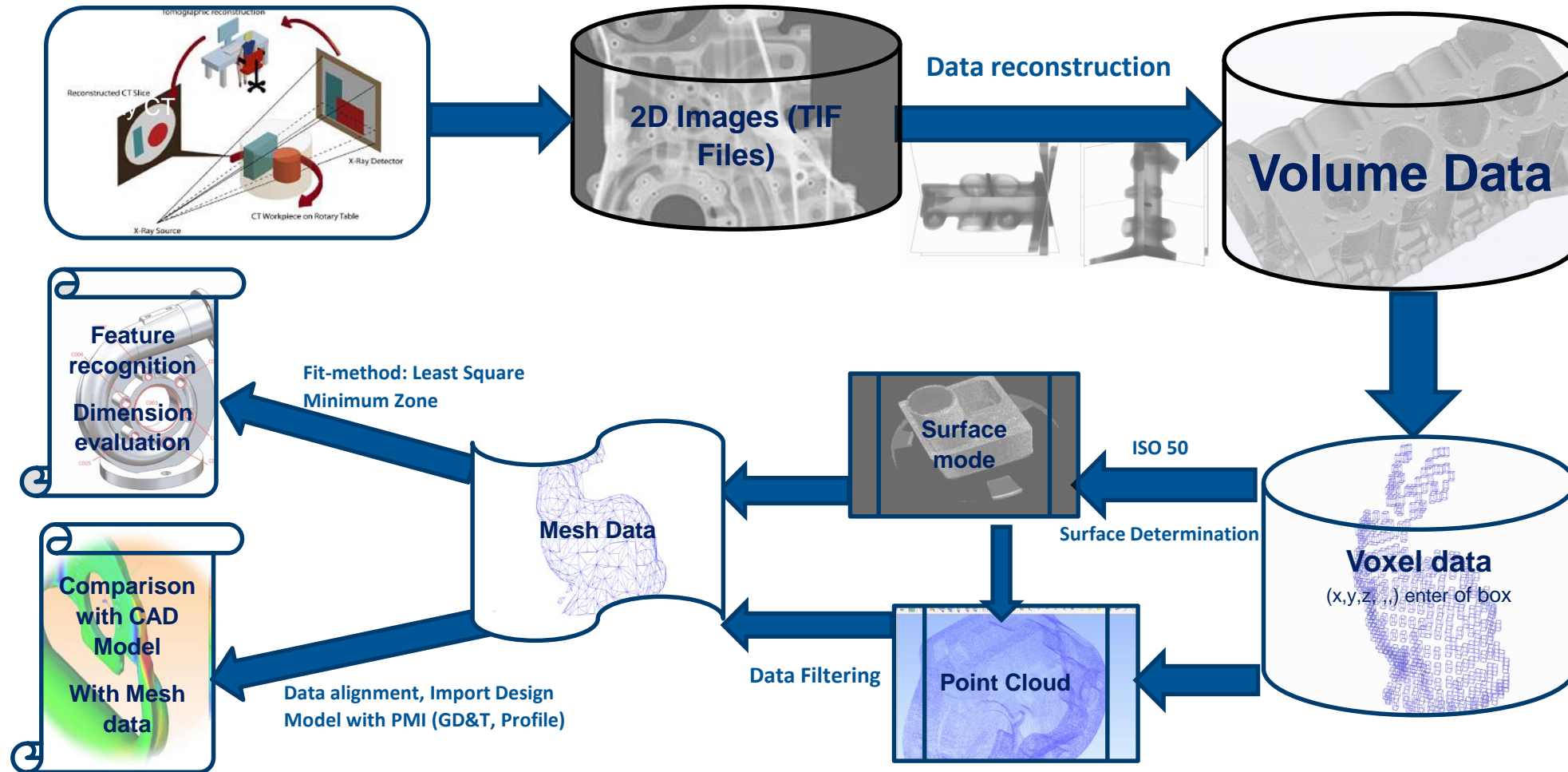
- Advantage

  - Inner and external

  - Efficiency for complex part (NDT)

  - Collecting data fast

- Challenges

  - Complex setup-operation procedure

  - Huge data, data handling slow

 - Lack of traceability/accuracy

CT Inspection Data/Work flow

CT Inspection Using Model-Based Definition

Model-Based Definition (MBD) driving CT Inspection

Design → Manufacturing → Inspections (Quality Assurance) → Technical Product Documentation
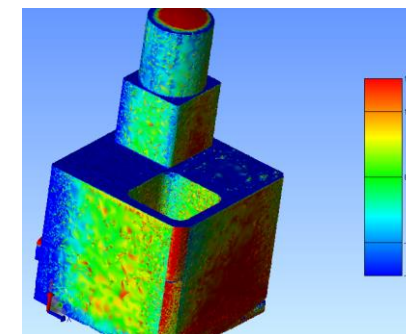
- Optimizing CT measurement (Automated, better accuracy, shorter measuring time)
  - Orientation, position of object (Part)
  - CT sources, detector

- Speed up *CT data evaluation*
  - Filtering, feature recognition, comparison
  - Evaluate geometry dimension & tolerance

- Generate standard graphic report
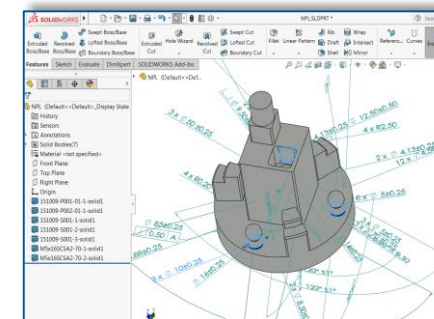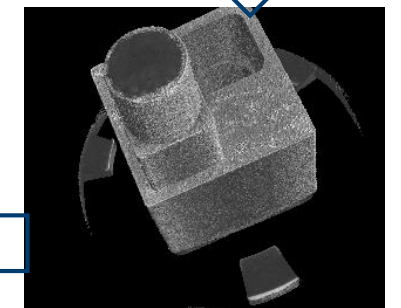
Design
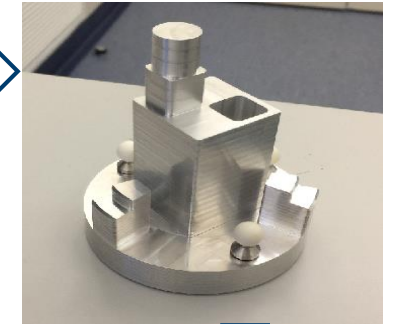
Manufacturing

Reporting

CT measuring
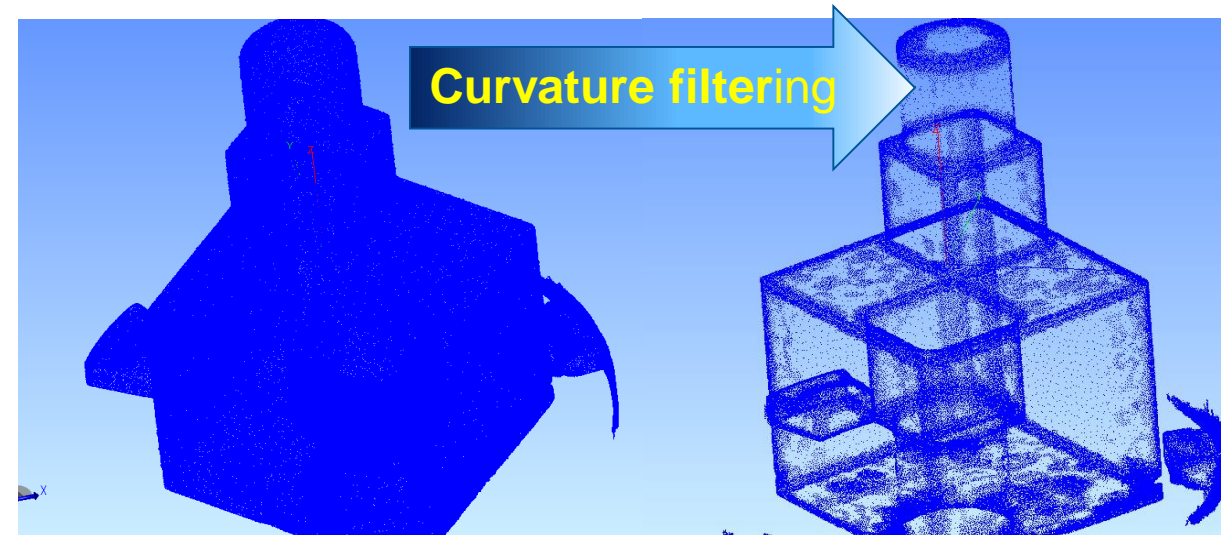
CT Inspection – Data Filtering
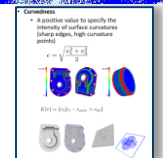
CT Data Evaluation - Filtering

- Reduce the size of data to speed up

- Without influencing on the level of accuracy

- Filtering types:

  - Grid, Normal vector, Sphere, Curvature

- Develop algorithms by using MBD information

2,056,413 points   250,120 points

Curvature filtering

[4] Anwer N, Scott PJ, and Srinivasan V. Toward a classification of partitioning operations for standardization of geometrical product specifications and verification, 15th CIRP Conference on Computer Aided Tolerancing, CIRP CAT 2018, Milano, Italy, June 11-13, 2018.
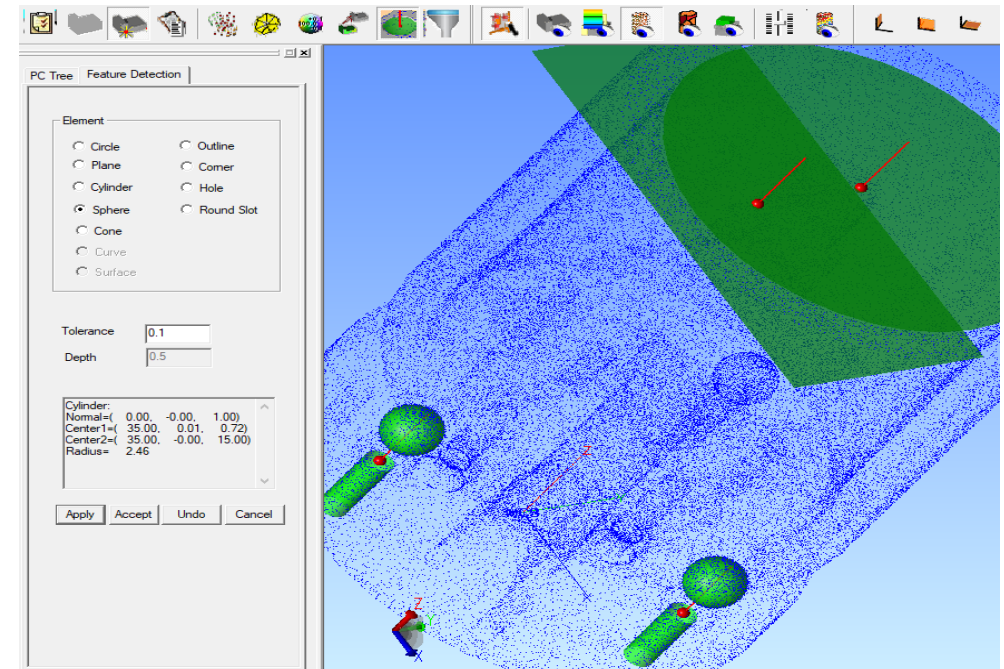
CT Inspection – Feature Recognition
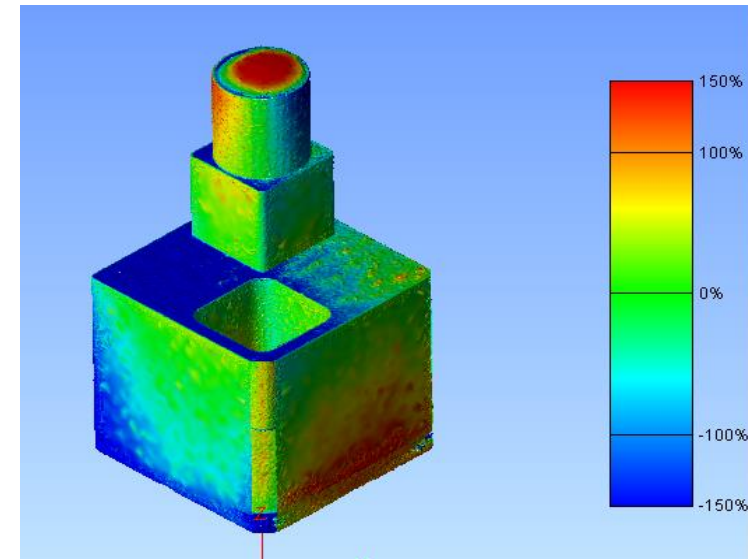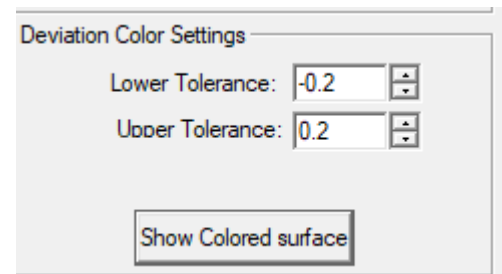
CT Data Evaluation – Feature Recognition

- Using MBD data, develop algorithms

  for feature recognition

  - Least Square constrains

  - K-neighborhood.

- Fast and keep the level of accuracy

CT Inspection - Comparison

Comparison with CAD model

- Part Alignment
- Comparison
  - with CAD model
  - with Mesh Data
- Color Mapping
- Tolerance setting

CT Inspection - Reporting

Technical Product Documentation

- Using MBD graphical PMI

- Standard report for measurement results

  - ASME reporting standard
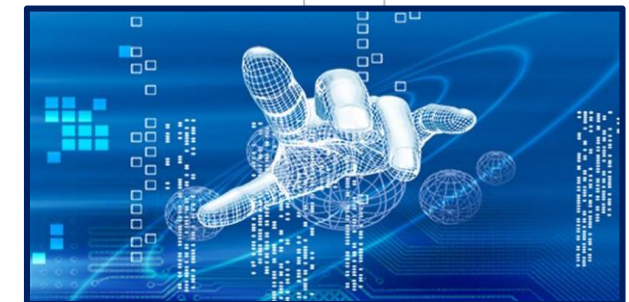
  - ISO AS9000…

- 3D PDF reports

Future of CT measurement system

- Manufacturing Industries
  - Aerospace, automobile, etc.
  - Demands ,requirements
  - Additive manufacture (AM)
- Institutes in world wide
  - NPL, NIST, Universities
  - Researches
- Inspection Venders
  - Nikon, GE, Zeiss, YXLON,…
  - Research & development
  - Products

CT Inspection Venders

Customers

Benefit for manufacturing industry

- Smart manufacturing with CT Inspection fitting in the industry 4.0.

  - Streamline production, cut cycle time

  - Compliant with standards, easy globalization

  - Reduce errors, improve product quality

- Helps enterprises optimize the entire product processing and meet market needs

- Greatly increase the company's output value, and profits by reducing costs.

Questions

Thanks!