Inspiring Great British Manufacturing

Computer Aided Inspection and Quality

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Computer Aided Inspection and Quality

Overview

Manufacturing Technology Centre

- Introduction
- Project Background
- Digital Measurement Planning Use Cases
- Conclusions
- Future Work

mtc
Manufacturing
Technology Centre

Who are we?

INSPIRING

Great British Manufacturing

HVM CATAPULT

AFRC
Advanced Forming Research Centre

CPI
Centre for Process Innovation

NAMRC
Nuclear Advanced Manufacturing Research Centre

AMRC
Advanced Manufacturing Research Centre

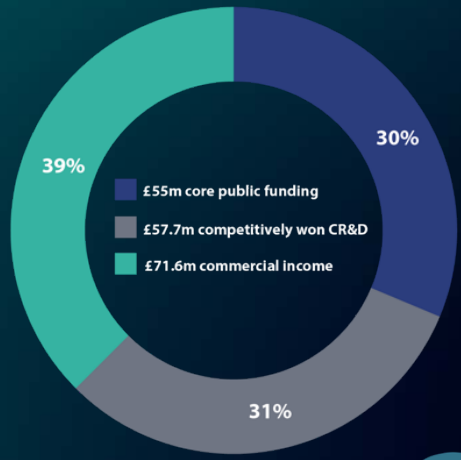
MTC
Manufacturing Technology Centre

WMG
Warwick Manufacturing Group

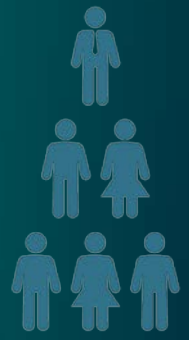
NCC
The National Composites Centre

WECD Economic Impact Evaluation study 2015.
The next economic impact study is due in 2017.

innovation projects



£188m
size of order book, of which £100m is CR&D

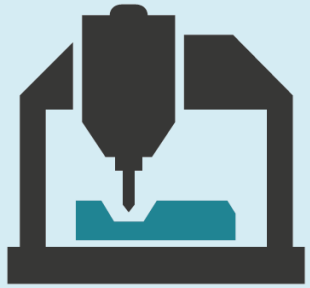


1900+
staff

£561m
total value of assets

3036
private sector clients

INDUSTRY CHALLENGES



You want to make something

- at a lower cost
- better quality
- quicker
- in higher volume
- you've never made before

You want to assemble something to

- minimise reject rate
- improve reliability
- improve consistency
- reduce waste
- reduce errors

You want to use data more effectively for

- improved design
- better quality
- efficient logistics
- new business models

Digital Measurement Planning Project Background

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Project Aim

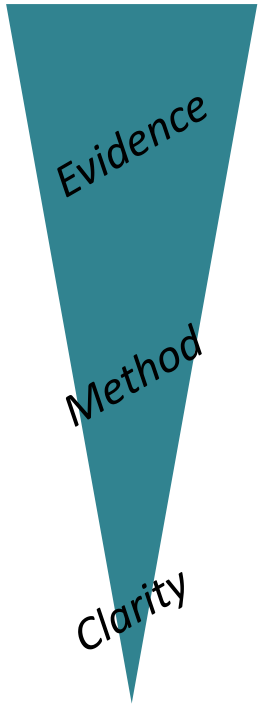
- To improve the state of current manual measurement planning processes through the use of digital tools, standards and software, paving the way for a Digital Twin for design and metrology;
- To highlight current capabilities and gaps to standards agencies, software vendors and industrial end users.

Project Objectives

1. Investigate the standards that enable model based definition (MBD) and digital measurement planning, including QIF and STEP AP242;
2. Investigate Product Manufacturing Information (PMI) as a fundamental component of digital measurement planning, focussing on ‘difficult to define’ dimensional characteristics;
3. Develop use cases to test out the capabilities and gaps of the standards and software in this field;
4. Scope routes to implementation through work with industrial end users to understand their current systems, with which digital measurement planning must integrate.

Opportunities for innovation identified in site visits

The following opportunities were identified based on the challenges faced by several industrial end users during site visits for further investigation in Digital Measurement Planning:



Traceability

- Validation of derivative MBD;
- Traceable statistical process control;

Reproducibility

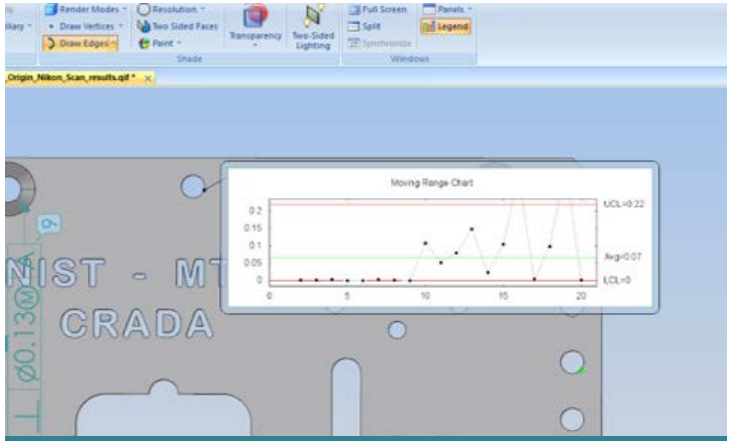
- Rule-based automatic measurement programming;
- Digital measurement planning with modular fixturing;
- Reproducible measurement result reporting;

Communicability

- Human-readable measurement planning
- Interactive model-based measurement reporting;

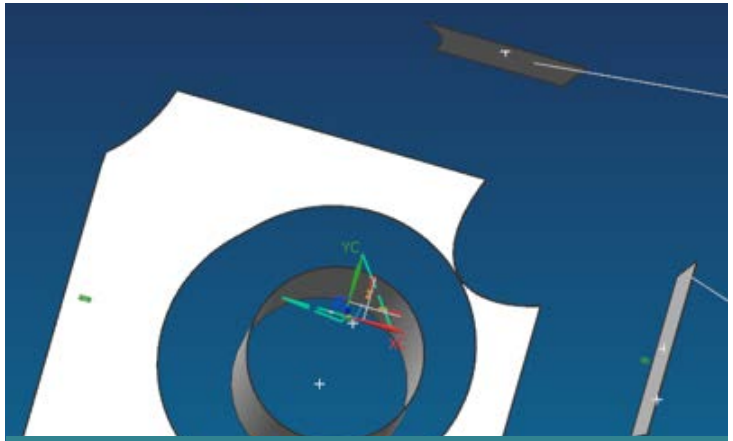
Use Cases

Three use cases were selected for demonstration of potential workflows based upon the site visits:



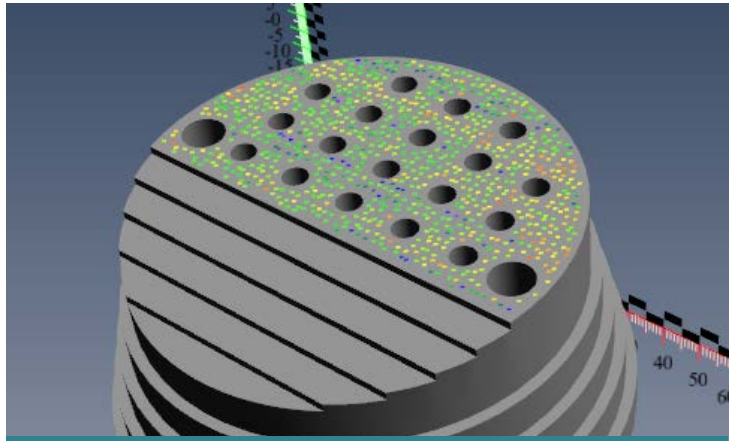
Model Based Definition-linked Statistical Process Control for Adaptive Inspection Planning

1



Rule Based Automatic Programming from Model Based Definition

2



Traceable, Reproducible, and Interactive Measurement Reporting

3

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Use Case 1

Model Based Definition - Linked Statistical Process Control for Adaptive Inspection Planning

Model Based Definition-linked Statistical Process Control (SPC) for Adaptive Inspection Planning

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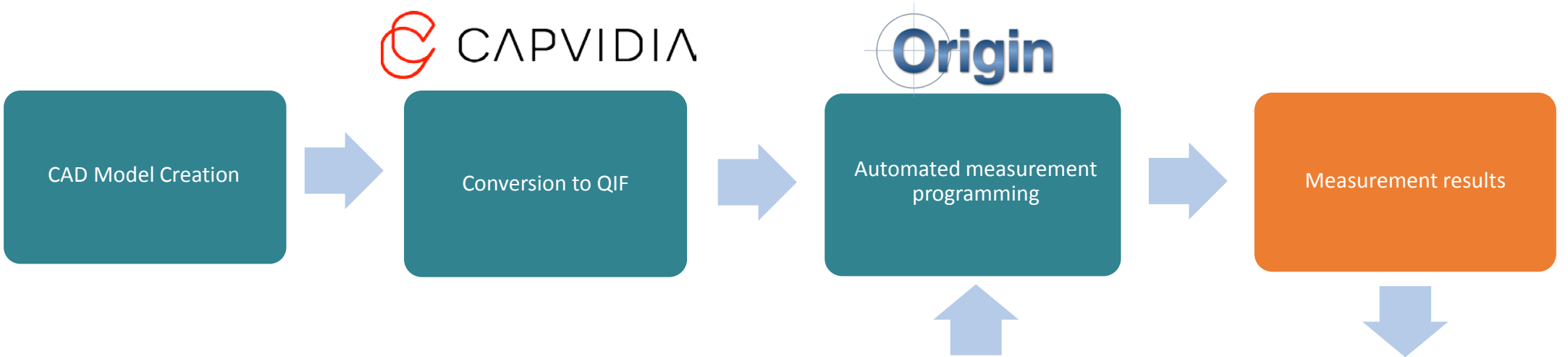
- **Volume of data generated in production is vast, but underutilised.**
- There is a **desire to use SPC to improve quality.**
- Model Based Definition (MBD) with semantically linked features can provide **traceability of useful information** throughout production.
- SPC can result in **higher conformance**, but could potentially **reduce the overall time for inspection.**

Could knowledge of process capability drive the digital measurement plan through required demand?

Current State Workflow Using QIF

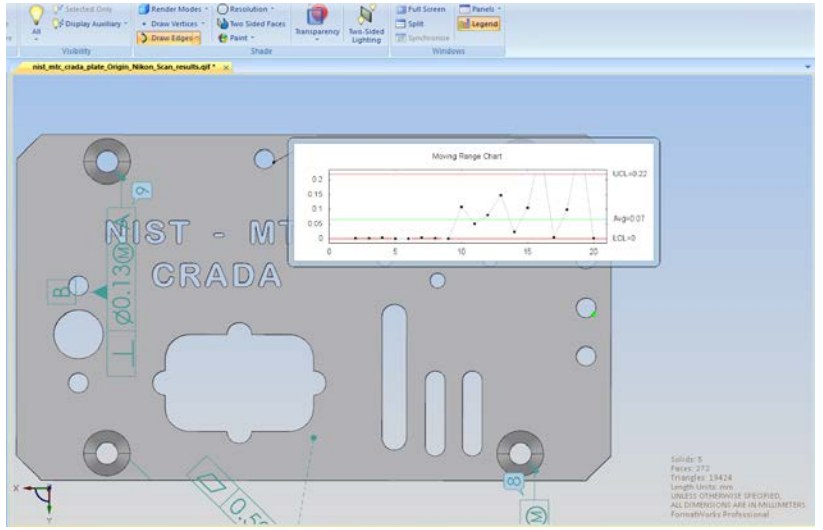


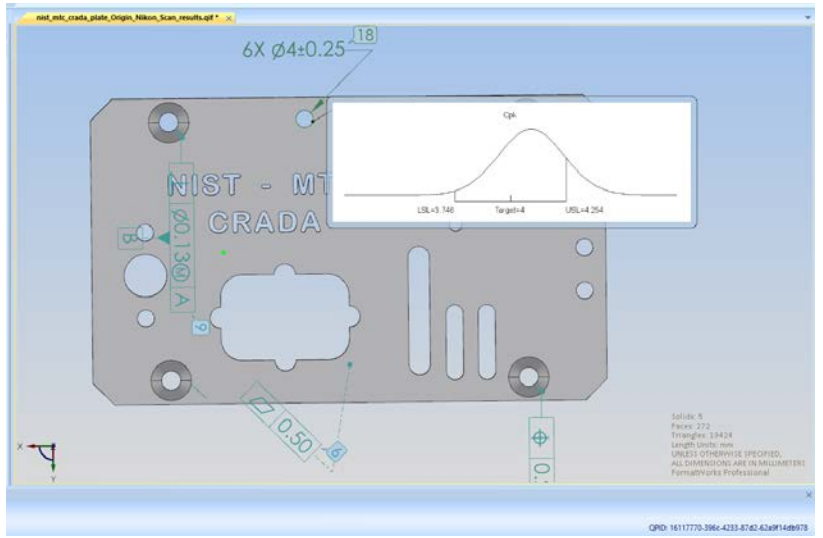
A workflow has been developed which demonstrates the addition of **SPC data to CAD models within the QIF framework** and shows the potential for adaptive inspection program changing based on these results.

Achievable, but currently requires bespoke scripting

Addition of measurement data to MBD - MBDVidia

- **MBDVidia can display measurement data of features on the CAD.**
- Inspection **report templates** can be generated (in Microsoft Excel format), and entered data is interactively linked to the model.
- **Cpk and Ppk** can be calculated without the need for additional statistical software.
- **Moving range charts** allowing visualisation of the part variation across production runs can be generated.





Addition of measurement data to MBD - MBDVidia

Demonstration of measurement data addition to MBD

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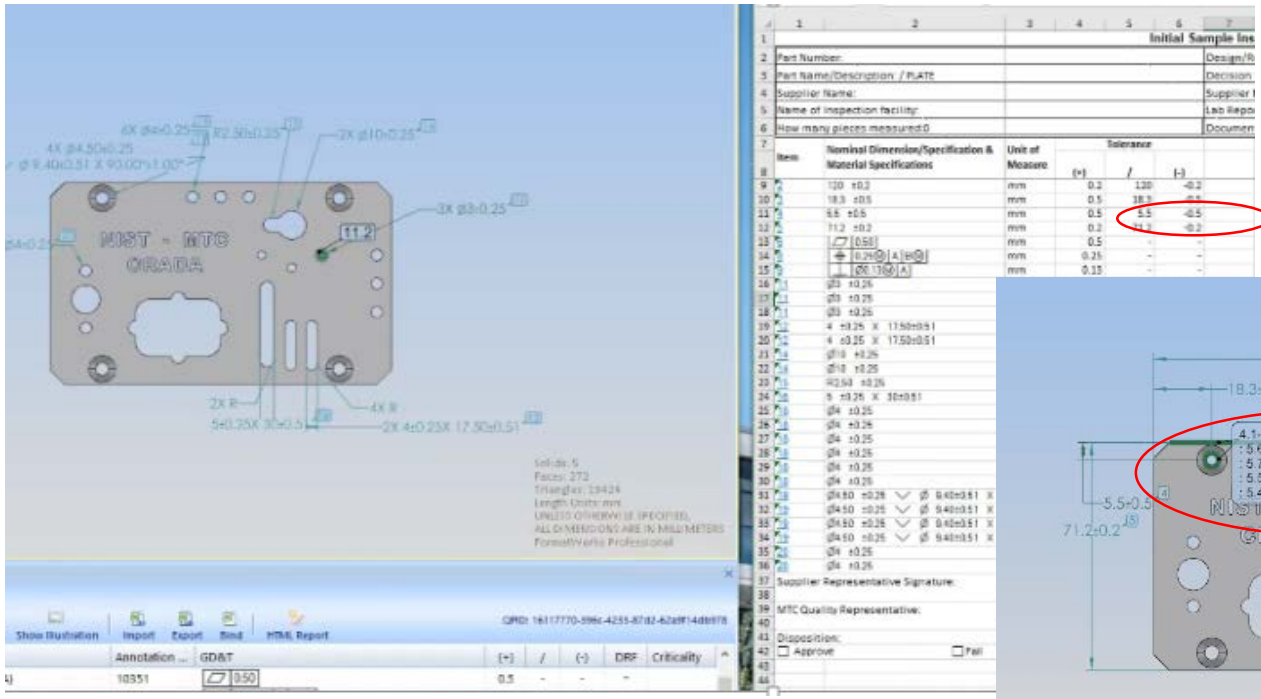
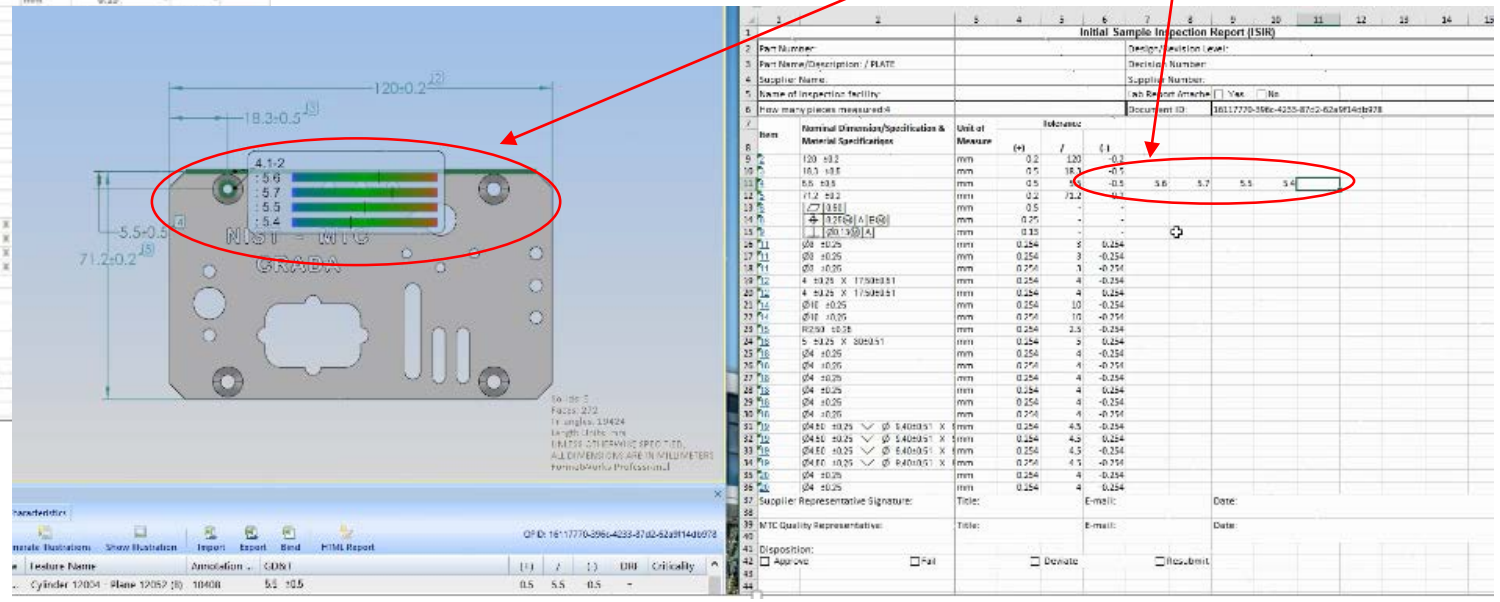


Empty bill of characteristics awaiting measurement results

Measurement results added updated live real time to the QIF model.



Demonstration of the addition of measurement data to an MBD and calculation of Cpk.

Adaptive Inspection Planning – QIF Rules Potential

- **QIF Rules** can **alter inspection parameters** using Boolean IF rules:
  - Number of measurement points
  - Measurement point density
  - Point sampling strategy (taken from ISO-14406:2010)
  - Feature fitting algorithm to use.
- Rules can be called within **QIF Plan.**
- Rules currently only take arguments related to the model itself – taking **measurement data as arguments not currently supported** by QIF Rules.
- Extending the scope of QIF Rules to include results may allow **process-lead measurement** plans.

Examples include:

- **More rigorous inspection** for more variable features.
- **Removal of measurement instructions** when process confidence is high.

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Use Case 2

Rule Based Automatic Programming from Model Based Definition

Rule based automatic CMM programming from MBD

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- In the development and new product introduction (NPI) phase, new inspection programs have to be produced **frequently**.
- Programmers draw on **knowledge and experience** to assign measurement strategies with similar characteristics to **previously qualified** parts and features.
- Programs are often written online, from scratch, when the first component is produced.
- MBD allows for the **automatic generation** of the bill of characteristics (BOC).
- For simple components it has been demonstrated that it is possible to **automate inspection programming**, resulting in dramatic process **time savings**.
- Measurement strategies employed for these components are held in templates and routines can be called according to simple **rules related to feature characteristics**.

Rule based automatic CMM programming from MBD

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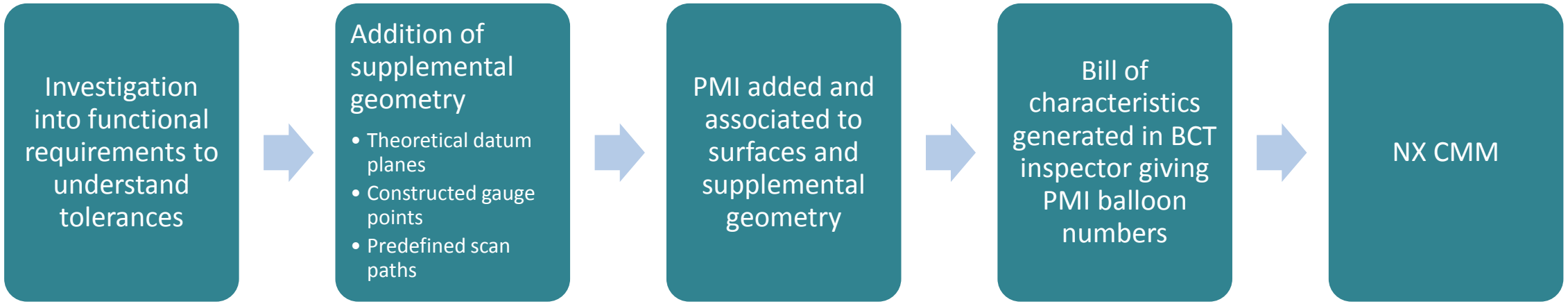
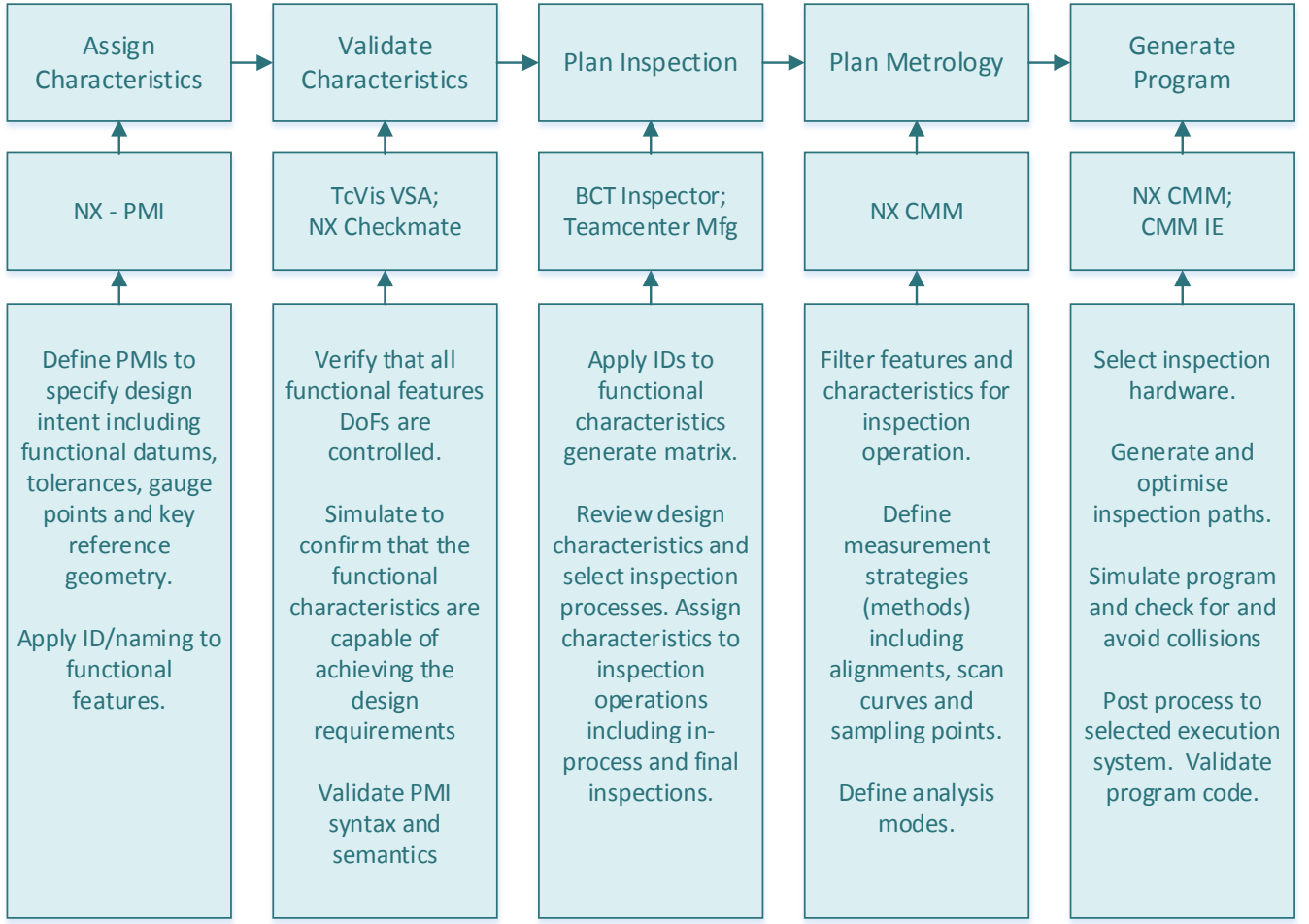
The following workflow was used for this use case:



Key Points

MBD Assisted Programming

- Rules architectures exist to support strategy selection based on **single feature characteristics**.
- Automation of programming, point cloud evaluation or strategy validation can be achieved.
- Capvidia Pundit CMM, Origin Checkmate, Siemens NX CMM and Kotem SmartProfile were all trialed in this project - each supported aspects of this.
- No automatic rule based strategy selection exists to combine multiple constructed features.
- This project workflow has shown that tools are available to assist this **multi-feature strategy** selection process.
- Once defined, PMI can be created to **assist CMM programmers** to implement strategies containing, gauge points; constructed features and iterative alignments, whilst retaining traceability to the model. However, this does reduce the level of automation in the process.



Summary of the Siemens workflow for model based quality

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Use Case 3

Traceable, Reproducible, and Interactive Measurement Reporting

Traceable, Reproducible, and Interactive Measurement Reporting

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- **Ad-hoc** measurement requires **documentation** of the measurement setup;
- A measurement report prefaced by a **retrospective measurement plan** is produced;
- Users of the report often have to spend time making sure they understand the procedure, and have enough **evidence** upon which to **sentence parts** appropriately.
- Static representations of results can be **unclear downstream**.
- 3D PDF is one example in which 3D objects can be viewed **without the need for CAD software**.

Can we use 3D PDF to visualise measurement result data, to extend and augment the Human Readable Measurement Plan?

Workflow

Traceable, Reproducible, and Interactive Measurement Reporting

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Human Readable Measurement Planning

Report Template Creation

Export 2D PDF

RENISHAW
apply innovation™

CMM Fixturing Scene Creation

Export STEP and assembly instructions

Physical Measurement

KOTEM EVOLVE™ SmartProfile

Inspection Results Output

Export Point Cloud with Deviations CSV

PDF3D

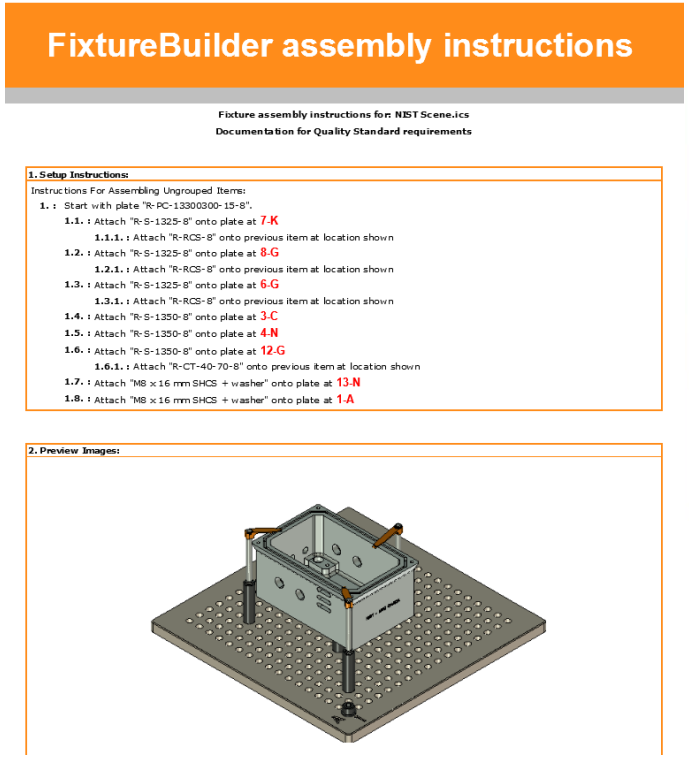
3D PDF Report Generation

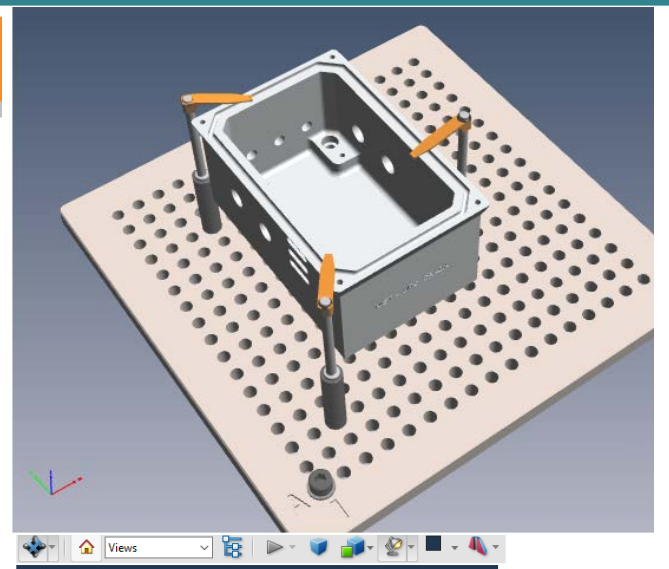
3D PDF

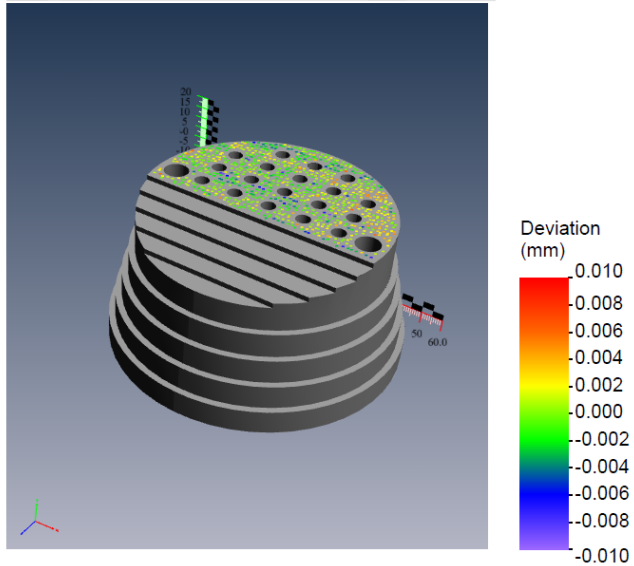
Traceable, Reproducible, and Interactive Measurement Reporting

Key Points

- Measurement plan and report generation can be achieved using a **familiar, straightforward** workflow.
- Report templates can be created using **readily available software**.
- 3D PDFs requires only Adobe Acrobat Reader, meaning that expensive **CAD software not required**.
- Interactive elements can **complement existing documentation**.
- **Traceability** can be further improved with increased support for **use of QIF in 3D PDF** tools.







Summary

- The Digital Measurement Planning project has investigated a wide range of **technologies, tools and standards** to highlight to industry the current capabilities and challenges when moving towards digitalisation.
- Potential **benefits demonstrated** to the end users through use cases include:
  - Reduction of manual processes in measurement planning;
  - Shorter inspection lead times;
  - Standardisation of measurement planning;
  - Traceability of results and reports.
- **End user demand for data standards would increase support amongst software vendors.**
- The benefits to traceability and interoperability need to continue to be demonstrated to drive this demand.

End Users

Standards Agencies

Software Providers

Thank You

Consortium Members			Collaborators
AWE	GKN Aerospace	Parker Aerospace	NIST
BAE Systems	Hexagon MI	Renishaw	DMSC
Capvidia	IPI Solutions	Rolls-Royce	NCC
CDS	Kotem	Sandvik	
Doncasters	Origin	Siemens PLM	

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Thank you for your attention – any questions?

CATAPULT High Value Manufacturing

Version Control				
Version	Date	Author	Status	Change Description
1.0		David Ross-Pinnock	Issued	

Key Project Contacts	
Customer	
Principal Customer Contact	
Principal MTC Contact	

MTC Endorsement		
Reviewed By	Signature	Date
Andrew Clough		02/03/2018