Process improvement for the remaining thickness measurement after blending of corroded area

Joint development of NDT EXPERT
EADS IW
ST Aerospace

CAAS Innovation Challenge

NDT EXPERT
Aerospace Non Destructive Testing Services
Context of the work
Targeted improvements
Work performed
Results
Conclusions
ST Aerospace performs MRO activities. Detection and removing of corrosion is a task required to be carried out. Each time a blending process is put in place and completed, a comprehensive measurement of the area using an ultrasound probe is performed.

Tedious process because of the number of points to be recorded and also because the manual nature of work that is often performed in uncomfortable postures.

ST Aerospace is looking for a way to improve the process regarding operation time, user fatigue, reliability and accuracy of the data logging.
The project aim

Development of a dedicated platform for the measurement and data extraction of remaining thickness after blending with phased array ultrasound techniques.
AIRBUS requirements

Inspection according to NTM 51-10-04 & SRM 51-11-11
- Requirements of 0.05mm accuracy
- UT inspection
- Dedicated UT thickness gauge
- Reporting template

Work focus: thickness measurement on single layer structures
**ST Aerospace way of working**

After the blending process is completed a comprehensive measurement of the area using an ultrasound probe is performed:

This process is tedious:

- number of points to be recorded can be vast
- manual nature of work is often performed in uncomfortable postures.
ST Aerospace way of working, details

a) Location of the area of repair
b) Marking the location of the different points to be measured (plastic grid + permanent marker)
c) The area is documented with picture taken on the aircraft
d) ST AE uses Olympus MG2-DL portable ultrasound equipment. The equipment records the measurement directly into the predefine table each time the technician triggers the measurement
e) Preparing file (file name, number of rows and columns).
f) Thickness measurement at every dot following the order on the grid: 1A, 1B, 1C,..., 1n, 2A, 2B...

NOTE:
The quantity of measures can be vast
The posture is tiring.
Holding the grid and marking the dots is not very convenient.
The operation accuracy is not very precise but sufficient for the purpose of the task.
Writing in odd posture is not convenient, handwriting is not easily readable
Dispensing of gel in an upside-down posture is not convenient.
ST Aerospace way of working, inspection

ST Aerospace is looking for a way to improve the process regarding operation time, user fatigue and accuracy of the data logging.
ST Aerospace way of working, reporting

The reporting format is done i.a.w. SRM rules.

The report includes:

Table – Extracted from the MG2-DL and exported in an Excel file

Photo – Picture of area inspected with overlay of points to be measured and other structural features (Ribs, Stringer...)

Schematic – General location in the wing structure
Analysis of current practices enabled the identification of key benefits

- **Speed**, by faster data acquisition, analysis and reporting
- **Traceability**, by the use of UTPA technology
- **Reliability**, by automatic data extraction and calibration
- **Human factors**, by increasing ergonomics, decreasing hazardous measurements & difficult postures

Key Performance Indicators

- **Software application** with dedicated interface, data acquisition and data extraction capabilities
- **Hardware configuration** based on UTPA electronics and probe
- **Performance of Trials** in laboratory conditions with reference blocks and in real condition (on A/C)
- **Support to development of work instruction** to perform the task
Definition of solution, following analysis of current practices

Requirements of 0.05mm accuracy

UT inspection

Dedicated UT thickness gauge

EADS Background

Reporting template
Description of work, as proposed in the project

1. Thickness C-scan generation (SmartTool software)
2. UT setup optimisation (SmartTool + RollScan)
3. Validation of measurement precision after new calibration process
4. Definition of the specific measurement configuration (NDTKit)
5. Configuration of the automated analysis XML file (NDTKit)
6. Development of the NDTKit monitoring in silent mode (SmartTool software)
7. Excel report generation (SmartTool software)
WORK PERFORMED – First comparisons

Set-up:

• Micrometer (Mitutoyo)
  Range: 0 to 25mm; accuracy: 0.01mm

• Ultrasound instruments
  38DL+ (OlympusNDT)
  Smart U32 (EADS IW)

• Transducers and testing head:
  V205 (Panametrics) – 15MHz; Ø6.35mm; height of the delay line: 11mm
  Rollscan (Metalscan) – 5MHz; number of elements: 32; size: 1.6mm x 6.0mm, focusing radius: 20mm

• Liquid coupling
  gel ZG-F (Krautkramer)
  Sprayed water

• Analysis software – ULTIS NDT kit (EADS IW).
**Settings of the Ultrasound array:**

Electronic scanning and focusing defined in CIVA 10.0 software (29 sequences activating 4 elements focusing onto the membrane.

**Results:**

Amplitude decreases in the ramps, all the more as angle is high and remaining thickness is low. However:

- measurements are possible at any point of simulated blend-out
- thickness measurements in simulated blend-out with “Smart U32” instrument give low errors

*Time savings when acquiring data look very attractive (x5 < factor < x20) especially when blended out area is important.*
Results:

SMART U32

38DL+

Good correlation ($R^2$ close to 1) → Work done on set-up and equipment performed well

Accuracy to improve → Work required to enhance calibration process and to adjust offset
WORK PERFORMED – Accuracy improvement

1st solution for accuracy improvement

- Development of calibration tool 2 points
- 1st repetition echo
- 2nd repetition echo
Results:

The difference between measured values increases for thin thicknesses

- average difference is satisfying for all ramps
- the maximum can reach 0.2mm for the thinnest thicknesses

<table>
<thead>
<tr>
<th></th>
<th>2%</th>
<th>4%</th>
<th>6%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delta average (mm)</td>
<td>0.02</td>
<td>0.031</td>
<td>0.069</td>
</tr>
<tr>
<td>Delta max (mm)</td>
<td>0.06</td>
<td>0.094</td>
<td>0.19</td>
</tr>
</tbody>
</table>

This behavior can be explained by the interval of calibration (from 19.7 to 39.4 mm): the measured values on 6% slope are too far out of range.
2nd solution for accuracy improvement

To avoid the uncertainty due to positions on the ramp, measurements performed on the stepped plate ROTOENG.

- Each step has a homogeneous thickness and values are in the calibration range.

The differences between the measured values with the Smart U32 and with the micrometer are very low (max: 0.04mm, average: 0.023mm).
Final solution for accuracy improvement

Calibration on 4 different thicknesses to improve accuracy of the measurement.

Then, a C-Scan was performed on the plate to check homogeneity and accuracy of the measurements.

The accuracy (comparing with the actual announced thicknesses) is very satisfying: +/- 0,04mm.

<table>
<thead>
<tr>
<th>GEOMETRY</th>
<th>Requirement</th>
<th>Tolérance</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Escalier N°1</td>
<td>5</td>
<td>± 0.05</td>
<td>4.98</td>
</tr>
<tr>
<td>Escalier N°2</td>
<td>10</td>
<td>± 0.05</td>
<td>9.97</td>
</tr>
<tr>
<td>Escalier N°3</td>
<td>15</td>
<td>± 0.05</td>
<td>14.96</td>
</tr>
<tr>
<td>Epaisseur plaque</td>
<td></td>
<td></td>
<td>19.70</td>
</tr>
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Modified NDTE 2024-012 calibration block
The results obtained are satisfying: there is a consequent improvement comparing with the previous measurement, explained by the new roller probe and the new calibration method.

With the appropriate reference standard, the accuracy of + 0.05mm (minimum requirement in A320 SRM 51-11-11) is reached for the required range of thicknesses.

<table>
<thead>
<tr>
<th>MEASURED THICKNESSES (mm)</th>
<th>ACTUAL THICKNESS (mm)</th>
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<tbody>
<tr>
<td>19.70</td>
<td>14.96</td>
</tr>
<tr>
<td>19.68</td>
<td>14.98</td>
</tr>
<tr>
<td>19.63</td>
<td>14.97</td>
</tr>
<tr>
<td>19.73</td>
<td>15.00</td>
</tr>
<tr>
<td>Mean</td>
<td>19.68</td>
</tr>
<tr>
<td>Min</td>
<td>14.98</td>
</tr>
<tr>
<td>Max</td>
<td>14.97</td>
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<td>Std. dev.</td>
<td>0.02</td>
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The accuracy (comparing with the actual announced thicknesses) is very satisfying: +/- 0.04mm.
NEXT STEPS FOR ON A/C VALIDATION

a. Implementation of a laser guiding system
b. Graphical user interface improvement
c. Automatic generation of the inspection report with scans, positions display and results table.
d. Validate multi-strip scans on a reference part with marks or drilled holes (Rotoeng calibration block)
**Laser guiding system**

- Development
- Integration
- Tests
- Modifications
Graphical User Interface

- Development
- Tests
- Modifications
  - Simplification
  - Ergonomics
INSPECTION REPORT on 230mm X 450mm

- Development
- Tests
- Modifications /simplification

Figure 1: Illustration of corrosion blend-out location on wing
INSPECTION REPORT

- Development
- Tests
- Modifications /simplification
INSPECTION REPORT

- Development
- Tests
- Modifications /simplification
INSPECTION REPORT

- Development
- Tests
- Modifications /simplification
MULTI-STRIP SCANNING

- Development
- Tests
- Modifications
The scenario is a top skin inspection, 170mm x 400mm

Data acquisition time
- Marking the location of the different points to be measured (plastic grid + permanent marker)
- Preparing file on MG2-DL (file name, number of rows and columns).
- Thickness measurement at every dot following the order on the grid: 1A, 1B, 1C,..., 1n, 2A, 2B...

Data exploitation and NDI report
- Excel file
- Transfer from MG2-DL to an excel format/word format
- Inspection report
The scenario is a top skin inspection, 170mm x 400mm

Gains should be more pronounced on bottom skins

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<th>Final Reporting</th>
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<td></td>
<td>180 minutes</td>
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<td>SMART U32</td>
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<tr>
<td>SMART U32</td>
<td>tbd</td>
<td>&lt; 5 minutes</td>
<td>1 minute</td>
<td>3 minutes</td>
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The solution developed allows:
- Perform inspection i.a.w. Airbus requirements with:
  • Increased speed
  • Improved traceability
  • Decreased human factors
The equipment can be further developed to include the following:

- Conventional UT flaw detection
- UTPA flaw detection

Either on metals or composites, for corrosion assessment, disbondings, delaminations, porosity...
**Definition of calibration block**

**Block 1**: aluminum plate ref. NDTE 2024-012 with three ramps machined in the back face (angle: 2%, 4% and 6%) to simulate blended out areas

**Block 1 (modified)**: 3 machined steps were added to increase calibration accuracy and to compare against dedicated thickness gauge single crystal probe

**Block 2**: aluminum plate ref. ROTOENG with steps from 2mm to 8 and 9mm to 15mm, to check accuracy, multi-strip scans and boreholes contouring