

Validates Remote Robotic NDT for Aerospace Maintenance: Eddy Current and Ultrasonic Inspection Results

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**Airlines for
America®**



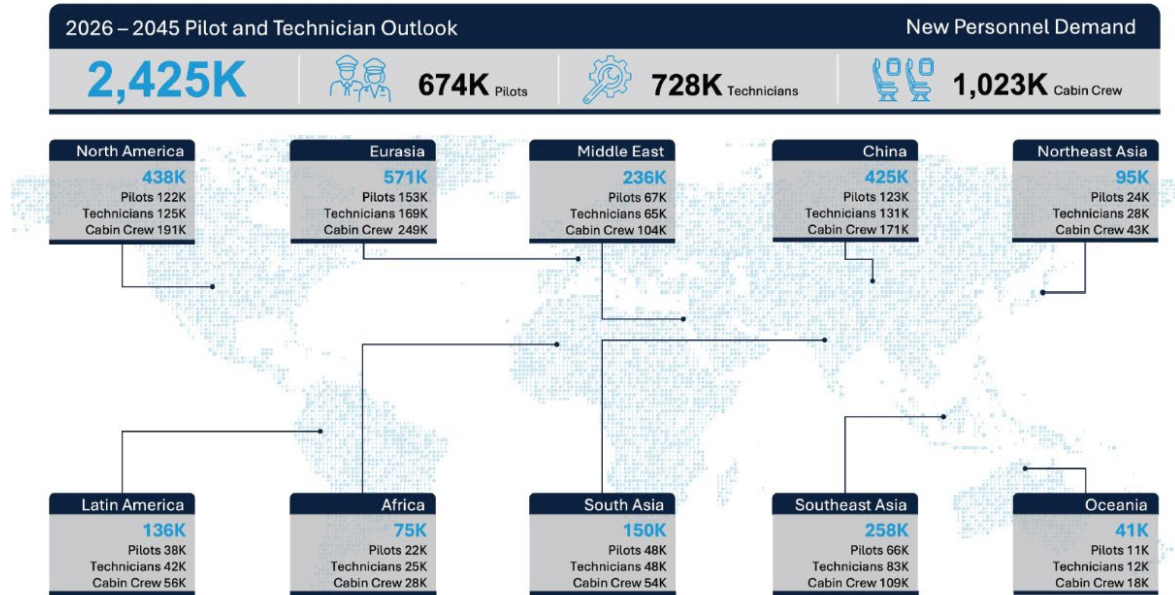
Outline

- 1. Why remote NDT?**
- 2. Can we trust in remote NDT?**
- 3. Case study #1: Remote NDT after damage**
- 4. Case study #2: Remote NDT for scheduled maintenance task**
- 5. Case study #3: Automatic UT thickness measurement**
- 6. Comparative Detection Capability Study**
- 7. Advantages & Limitations on remote NDT**
- 8. Summary & Outlook**

Overall Problem MRO

Why Remote NDT?

- **Demand**
 - Growing aircraft fleet
 - Aging aircraft
 - Higher maintenance demand
 - More inspection required
- **Workforce**
 - Retirement of experienced personnel
 - Insufficient technician pipeline
 - Long training and qualification cycles
 - Shortage of specialized NDT expertise



Source: Boeing Forecast 2026 - 2045

«We need to scale expertise — not just manpower.»

Remote NDT Inspection

Can a Level 2/3 trust remotely acquired inspection data?

- | | |
|-------------------------|--|
| 1. Positioning | Is the sensor where it needs to be? |
| 2. Acquisition | Is the inspection performed correctly? |
| 3. Data Quality | Is the acquired data reliable? |
| 4. Repeatability | Can the result be reproduced? |

Trust cannot be assumed. It must be demonstrated through validation.

Case study # 1



Eddy Current and Dent measurement: Damage at Fuselage STA 500C/S-20R (Boeing 737)

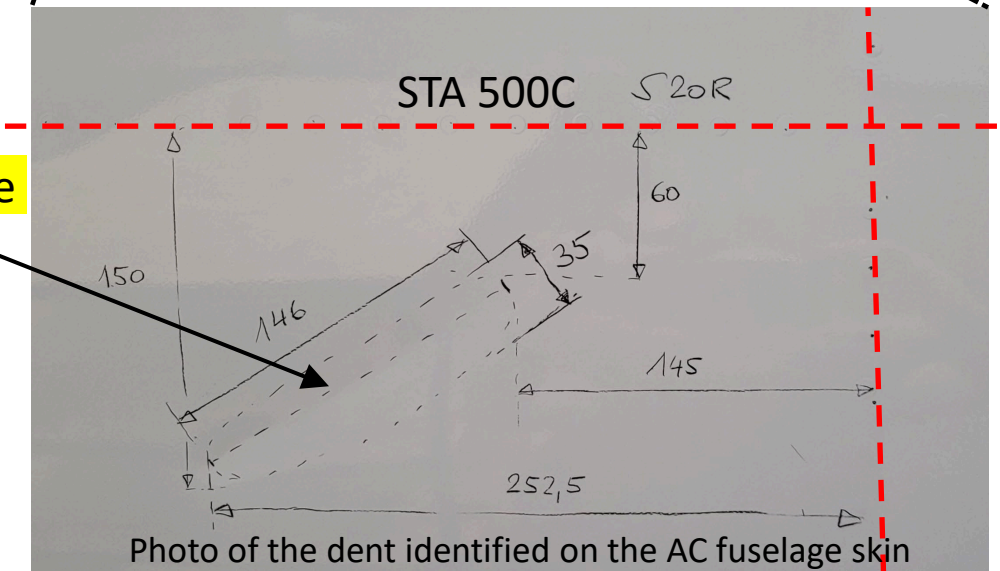
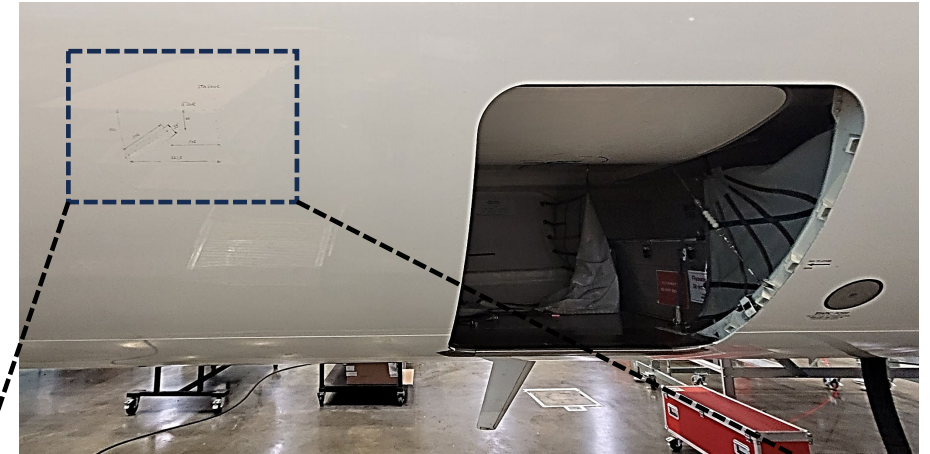
Case study # 1 – Damage at Fuselage STA 500C/S-20R

Eddy Current testing & Dent depth measurement at Fuselage:

Condition found:

- A dent between STA 500C and STA 500D, S-20R and S 22R
- Dent length 146 mm, width 35 mm
- Sharp linear edge in the center of the dent over the entire length
- The damage was previously documented in the aircraft dent and buckle chart

Sharp linear edge in the center of the dent



Case study # 1 – Damage at cargo door area

Eddy Current testing & Dent depth measurement at fuselage (Boeing NDT manual 55-10-27, Part 6, Rev. Jul 01/2016):

1. Automatic calibration on the **ET reference** standard (Al2024-T3 with 3 EDM notches) and **depth sensor** on a step wedge
2. Rails applied to the fuselage (Operator)
3. Device applied to the Rails (Operator)
4. Compensation and **Lift-off** correction on AC skin
5. Start Remote ET Inspection
6. Impedance plane data and C-Scan data transmitted to **Remote NDT Inspector** in real time
7. Afterwards, automatic **Post-calibration** on ET reference standard.

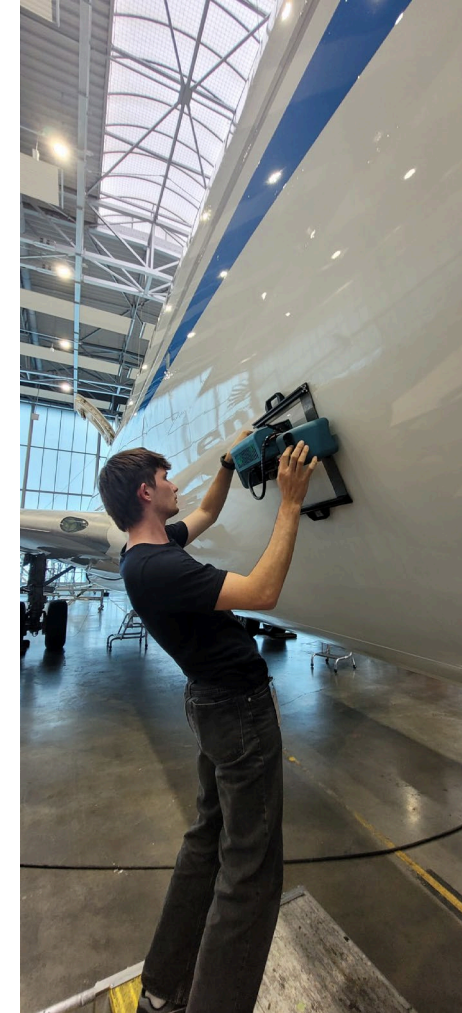


Photo of ACID application done by the Operator



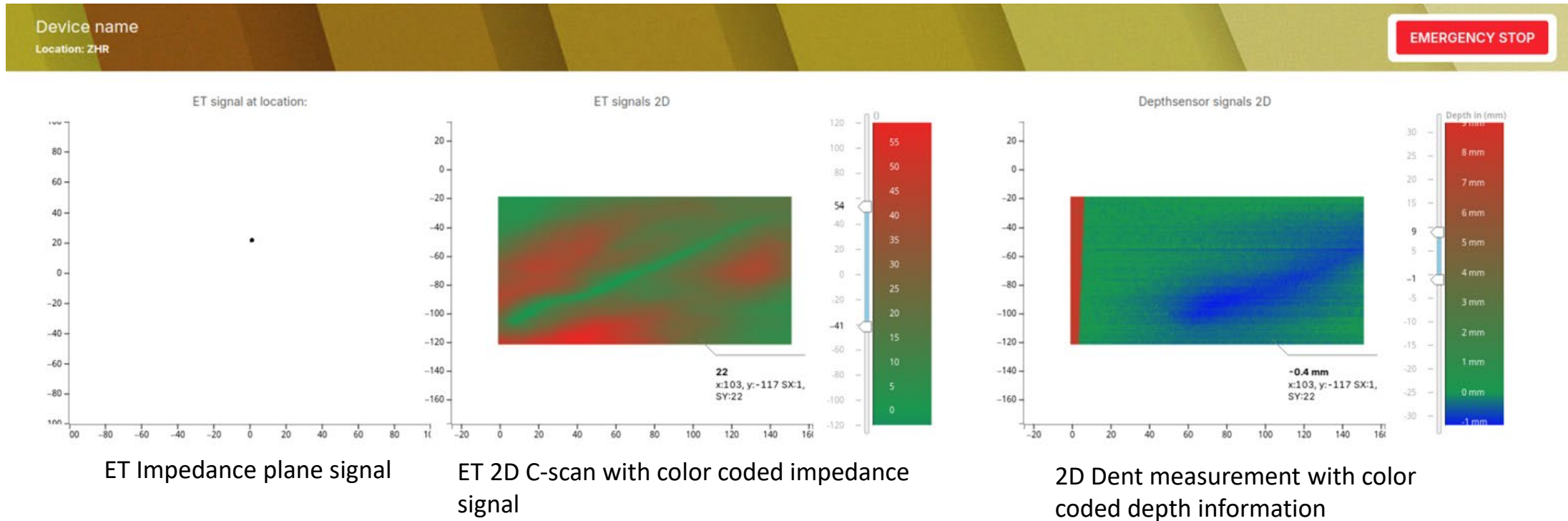
Photo of ACID on the rail frame

Case study # 1 – Damage at cargo door area

Eddy Current testing & Dent depth measurement at fuselage:

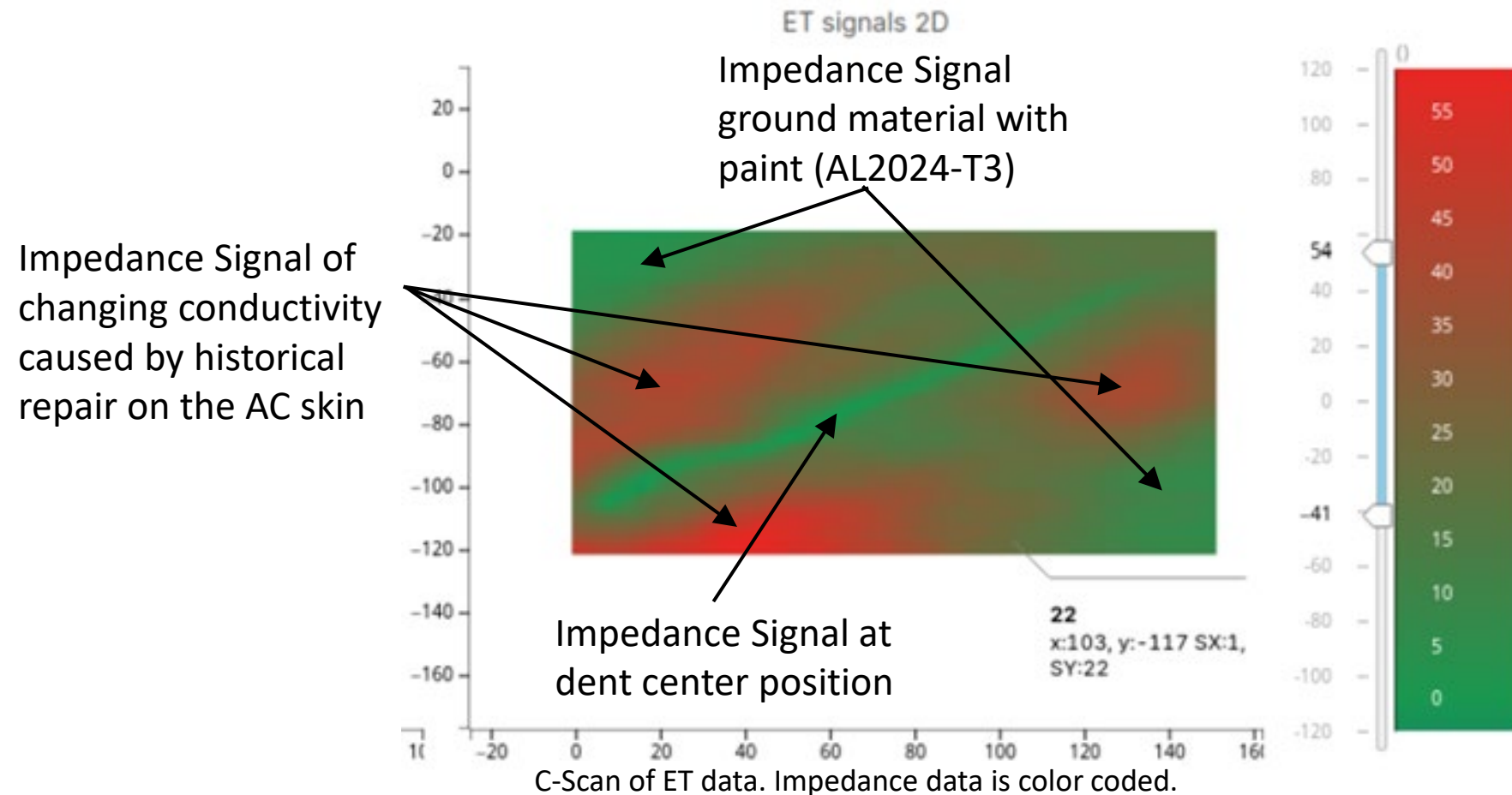
After finishing the remote scan following results were presented:

- Eddy Current signal – Impedance plane
- Eddy Current signal – C-Scan with corresponding Impedance plane signals as color coded Heat-map
- Depth and size of the dent as color coded Heat-map



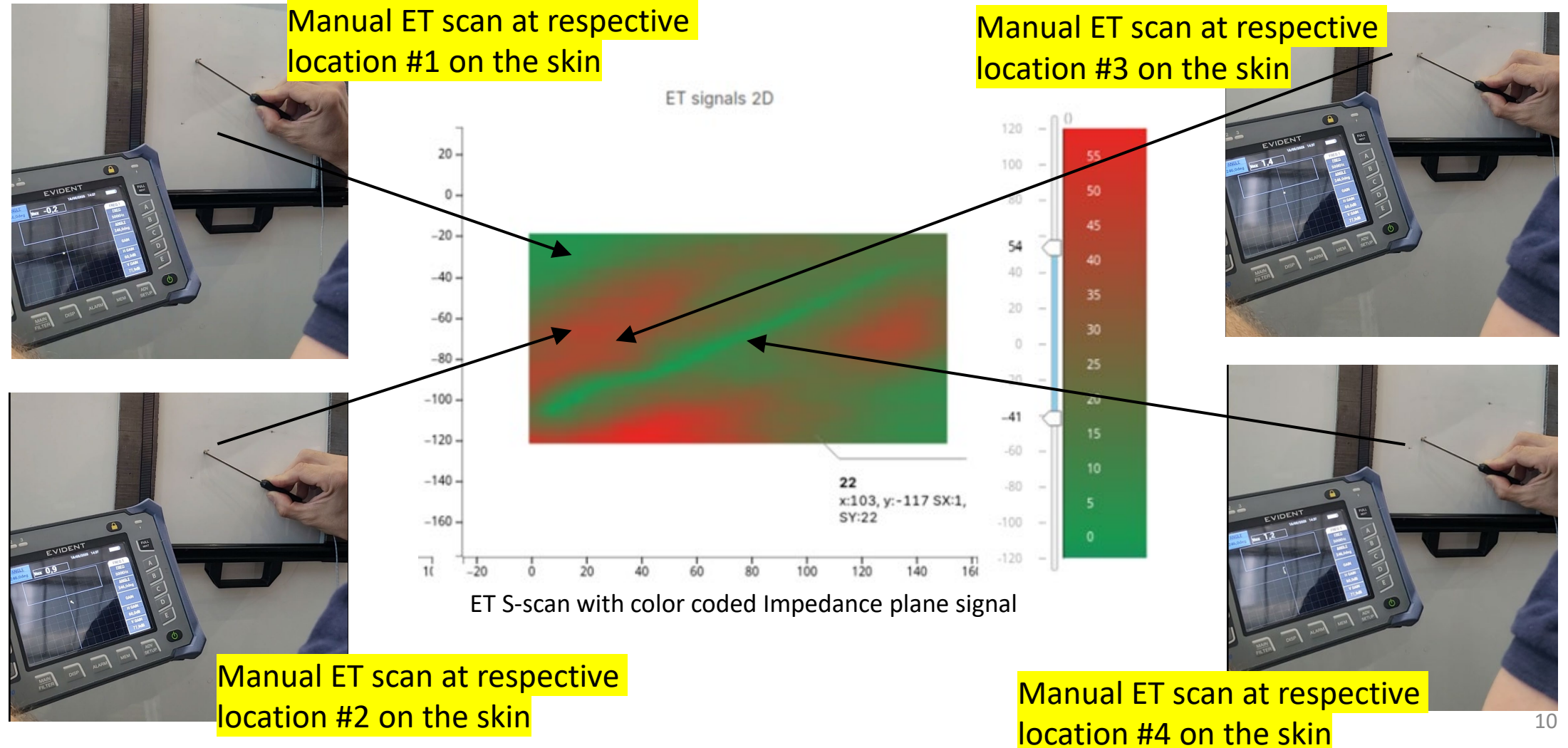
Case study # 1 – Damage at cargo door area

Eddy Current testing results:



Case study # 1 – Damage at cargo door area

Eddy Current testing at fuselage – comparison with manual ET Inspection:



Case study # 1 – Damage at cargo door area

SUMMARY Case study # 1:

Eddy Current testing & Dent depth measurement at fuselage:

- The ET and dent depth measurement were performed on a real damage at the fuselage skin close to the FWD cargo door based on Boeing NDT manual 55-10-27, Part 6, Rev. Jul 01/2016
- The entire Damage Area was scanned by using the Remote ET device
- One IMITec Operator was applying the Rails and ACID for this test case
- The Remote NDT inspection was done by an NDT Level 2 Qualified based on EN4179
- The ET measurement results of the **Remote scan** were **cross check** by **manual ET inspection**

RESULT:

- All data collected during **remote ET scan** were correct **verified by the manual ET scan**.
- The measured depths of the damage correlated with the manual measured values on the dent & buckle chart.

Case study # 2

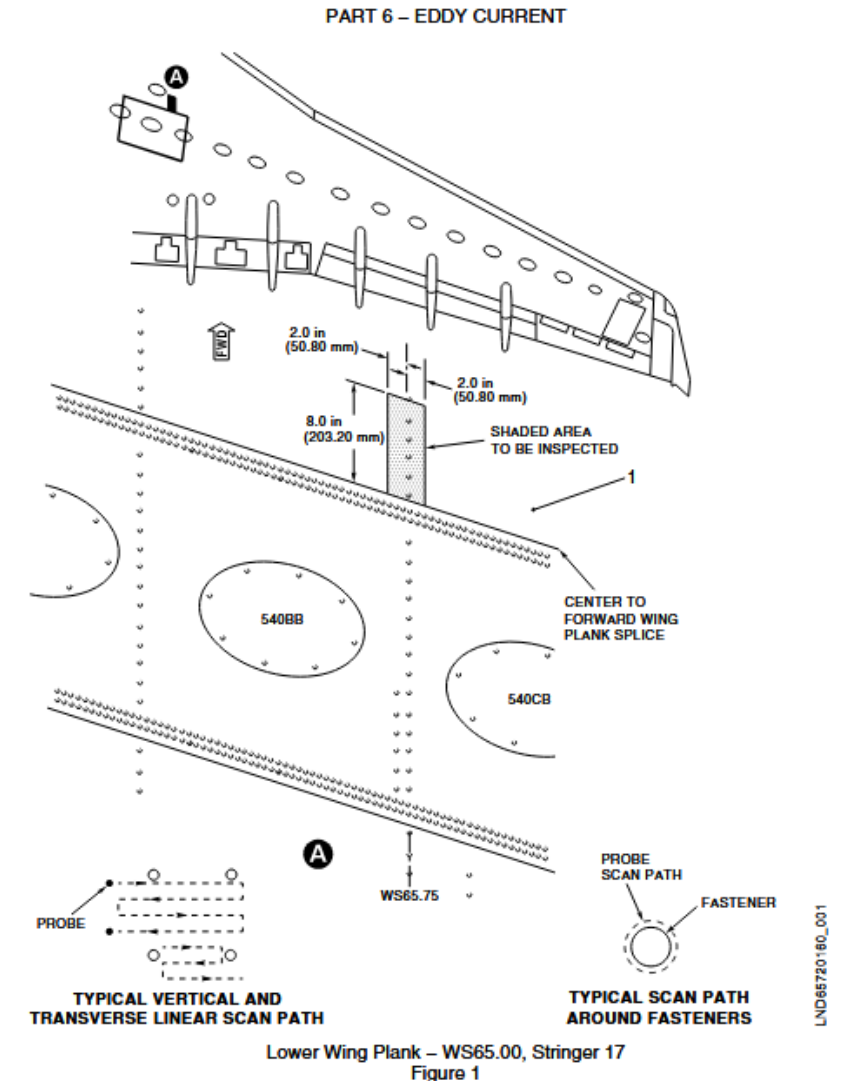


Eddy Current Inspection Task 57-20-007 – “LOWER WING PLANK – WS148.00, STRINGER 8 TO 10 AND STRINGER 15” (Bombardier Challenger 650)

Case study # 2: LOWER WING PLANK Bombardier

Eddy Current testing “Lower Wing Plank”:

- Complete ET inspection performed at **lower wing surface**
- Inspection **remotely controlled** from IMITec office
- Communication between **Operator** (Hangar) and **Remote NDT Inspector** (Office) via mobile phone



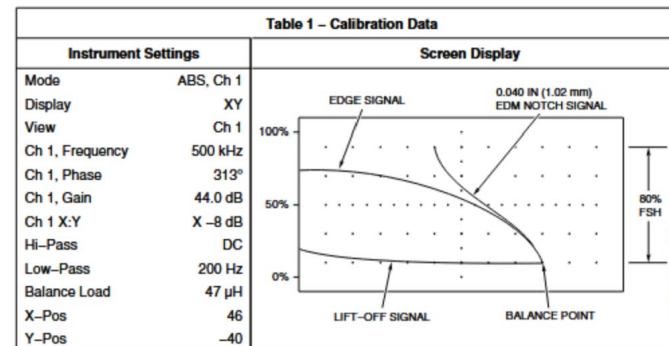
Case study # 2: LOWER WING PLANK Bombardier

Eddy Current testing “Lower Wing Plank”:

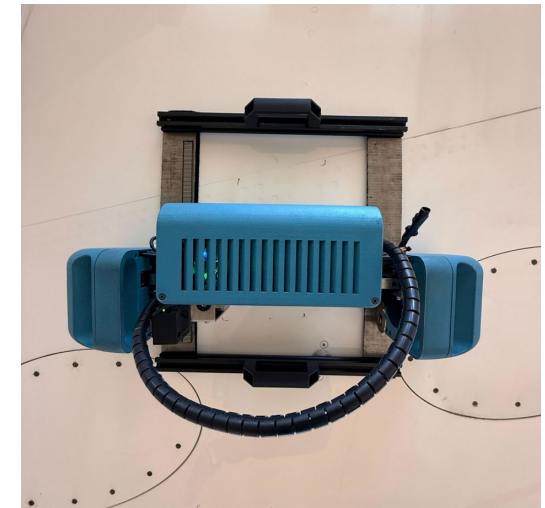
- **Pre-Calibration** based on NDT manual ET 57-20-016, PART 6 – Eddy Current, Section 8
- **Lift-off compensation:**
 - Based on ET 57-20-016, PART 6 – Eddy Current, Section B
- **Post-calibration**
 - Based on ET 57-20-016, PART 6 – Eddy Current, Section B



CHALLENGER 650
CL-650 NONDESTRUCTIVE TESTING MANUAL
PART 6 – EDDY CURRENT
ET-57-20-016



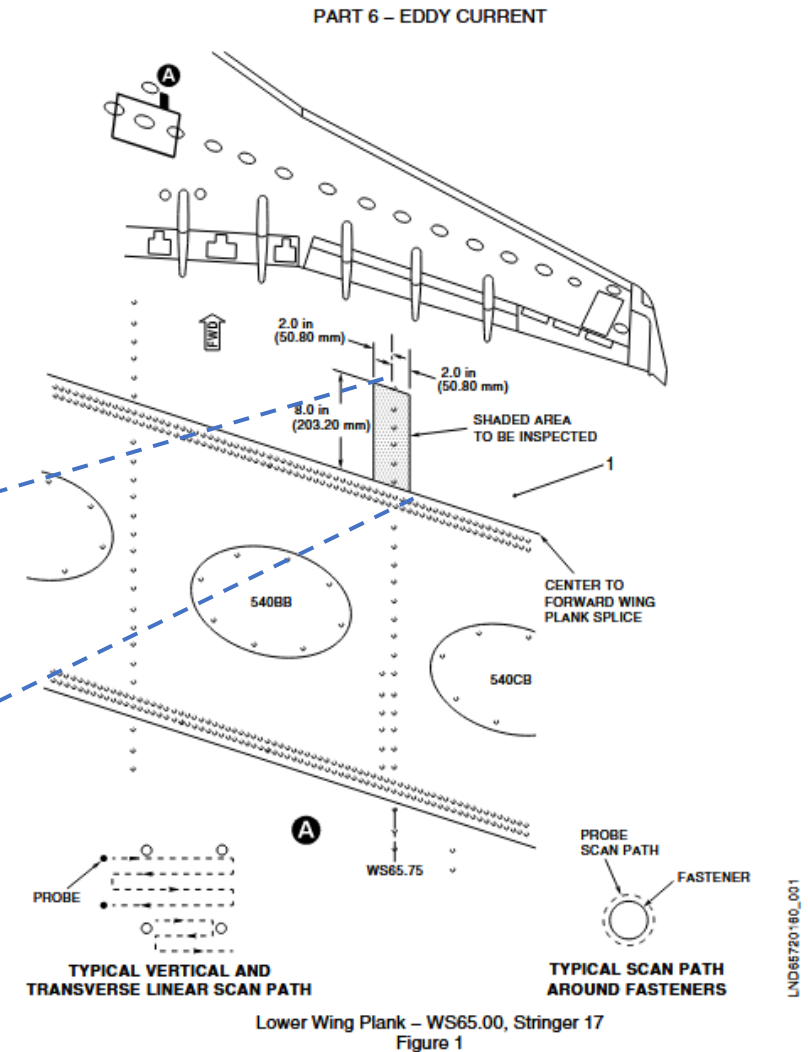
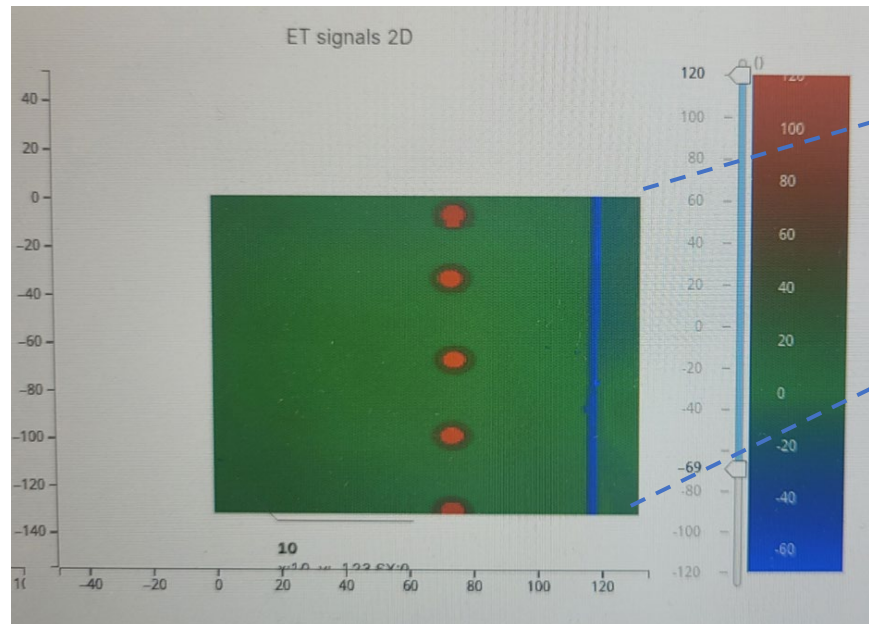
NOTE: The instrument settings listed may vary from instrument to instrument.



Case study # 2: LOWER WING PLANK Bombardier

Eddy Current testing “Lower Wing Plank”:

- Installation of Rails and Device: 7 minutes
- Calibration of Device: 2 minutes
- ET Inspection: 11 minutes
- Removal of Rails: 2 minutes



Case study # 2 – LOWER WING PLANK Bombardier

SUMMARY Case study # 2:

Remote Eddy Current testing on lower wing plank:

- The remote ET device was mounted at lower wing plank
- The required inspection area was scanned by using the remote ET device
- Inspection was **controlled remotely from IMITec office** by an **NDT Level 2 inspector** qualified on EN4179
- The **ET measurement results** of the Remote scan were **cross check by manual scanning** the damage area with an Impedance plane instrument and all required standards as per Boeing NDT manual 55-10-27, Part 6, Rev. Jul 01/2016

RESULT:

- All data collected during **remote ET scan** were correct **verified by the manual ET scan**.
- The measured depths of the damage correlated with the manual measured values on the dent & buckle chart.

Case study # 3

Ultrasonic Remaining Thickness Measurement - Fuselage Test Panel

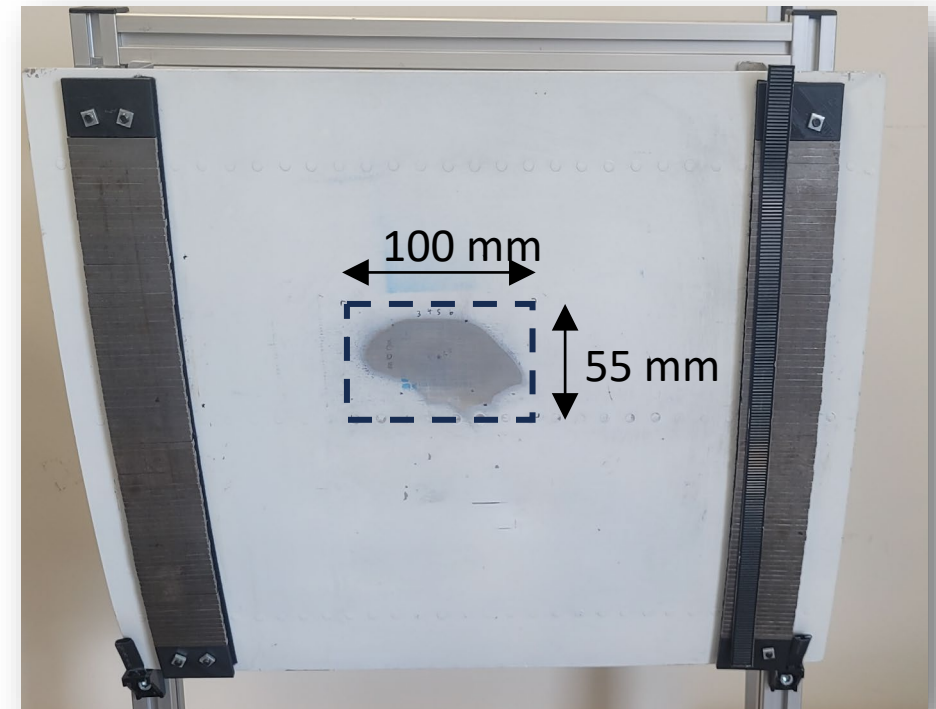
Case study # 3 – Ultrasonic Thickness measurement

Ultrasonic Thickness Measurement “Fuselage Test Panel”:

- Inspection based on Airbus NTM 51-10-04-270-802-A-01 “Measurement of Remaining Thickness in Large Blended Out Areas of Metallic Sheet and Plates”
- Inspection performed at IMITec Test Facility (Meilen / Switzerland)
- Nominal Skin Thickness 1.6 mm
- Material AL2024
- Paint thickness 30 – 60 μm

Blend Out with Grinding Machine:

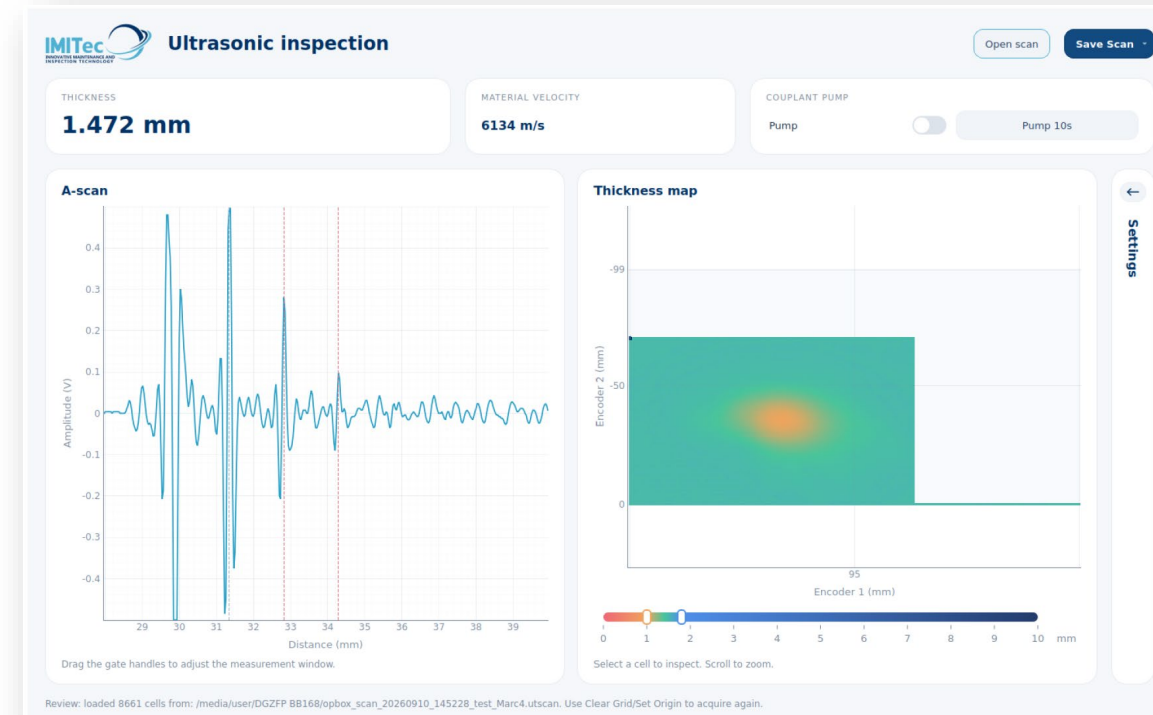
- Blended Area 100 x 55 mm
- Based on potential application
- Removed material approximately 500 μm



Case study # 3 - Ultrasonic Thickness measurement

Automatic UT measurement:

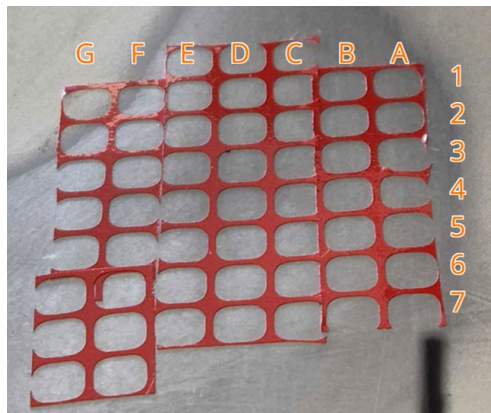
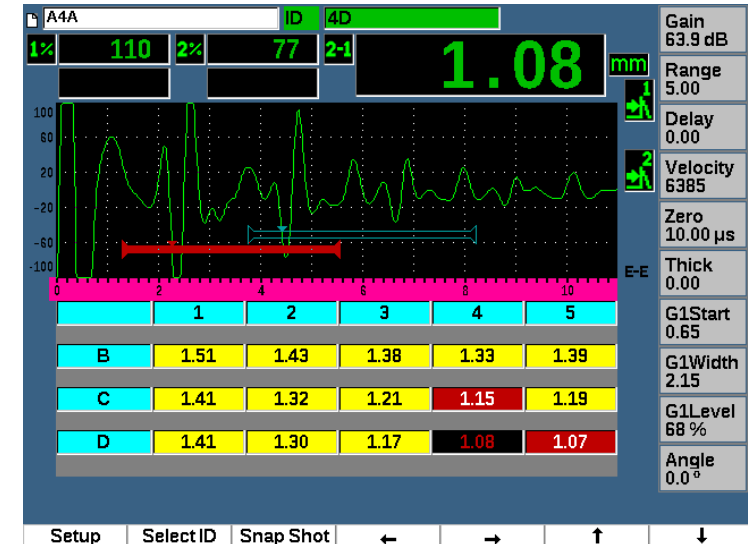
- IMITec Remote NDT Device for UT
- Approx. 7'000 measurement points
- Probe: **Pencil Probe Evident** with delay line
- Reference Standard: Aluminum Step Wedge AL2024 1mm – 20mm
- Coupling: water
- Minimal measured thickness: **1.032 mm**



Case study # 3 - Ultrasonic Thickness measurement

Manual UT measurement:

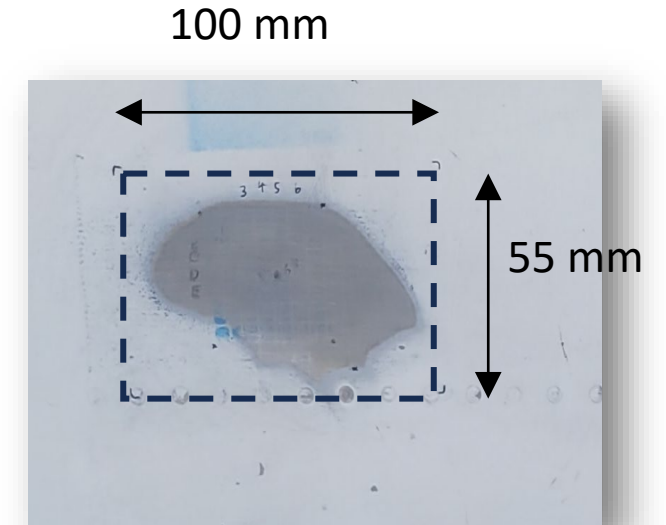
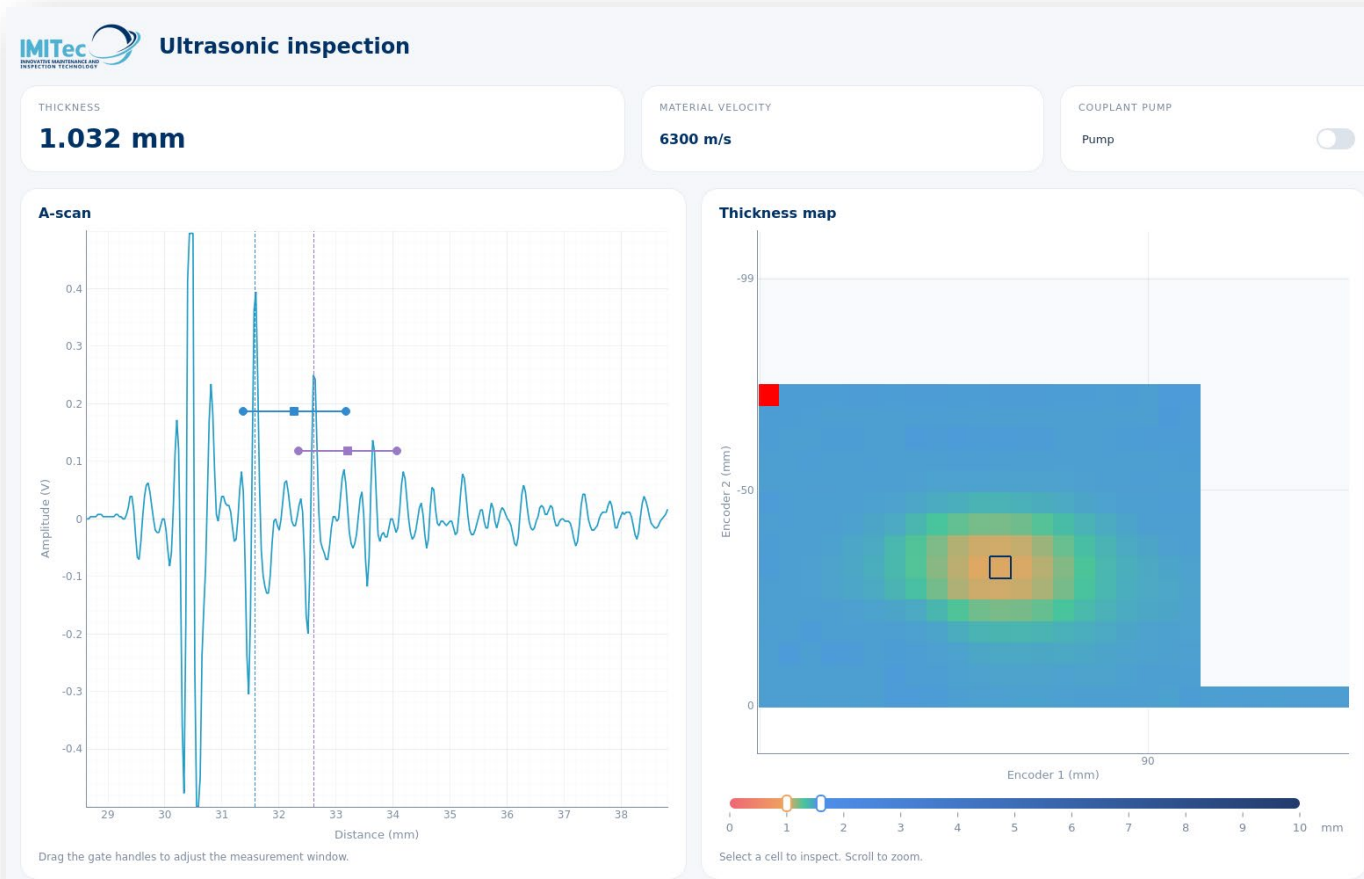
- Measurement Grid (manual UT): 5 x 5 mm
- Evident Epoch 650, Grid function activated
- Probe: Pencil Probe 15 MHz
- Reference Standard: Aluminum Step Wedge AL2024: 1mm – 20 mm
- Coupling: Water
- Minimal measured thickness: **1.07 mm**
- Measurement data as CSV file exported



A4A	1	2	3	4	5	6	7
A	1.56	1.54	1.52	1.52	1.52	1.53	1.54
B	1.51	1.43	1.38	1.33	1.39	1.42	1.48
C	1.41	1.32	1.21	1.15	1.19	1.27	1.38
D	1.41	1.3	1.17	1.08	1.07	1.17	1.3
E	1.51	1.43	1.32	1.23	1.21	1.28	1.34
F	1.55	1.52	1.52	1.41	1.4	1.41	1.44
G	1.56	1.56	1.54	1.52	1.51	1.51	1.51

Case study # 3 - Ultrasonic Thickness measurement

Automatic UT measurement versus Manual Inspection:



A4A	1	2	3	4	5	6	7
A	1.56	1.54	1.52	1.52	1.52	1.53	1.54
B	1.51	1.43	1.38	1.33	1.39	1.42	1.48
C	1.41	1.32	1.21	1.15	1.19	1.27	1.38
D	1.41	1.3	1.17	1.08	1.07	1.17	1.3
E	1.51	1.43	1.32	1.23	1.21	1.28	1.34
F	1.55	1.52	1.52	1.41	1.4	1.41	1.44
G	1.56	1.56	1.54	1.52	1.51	1.51	1.51

Case study # 3 - Ultrasonic Thickness measurement

SUMMARY Case study # 3:

Remaining thickness measurement after blend out:

- **Real fuselage test panel** with frame and stringers and blend out area
- Remaining thickness at **Blend out area** measured with Automatic UT device
- Measurement results validated by conventional **manual UT inspection**
- Automatic and manual measurement based on Airbus NTM 51-10-04-270-802-A-01
“Measurement of Remaining Thickness in Large Blended Out Areas of Metallic Sheet and Plates”

RESULT:

- Manual UT inspection and automatic UT inspection show comparable results
- Manual UT measurement data available as CSV file
- Automatic UT inspection measurement data available as C-Scan with corresponding A-Scan
- Inspection time:
 - Manual UT inspection: appr. 15 min
 - Automatic UT inspection: appr. 3 min

Limitation on Remote NDT Inspection

Advantages Remote & Automated NDT Inspection:

- 1. Consistent & Repeatable**
Standardized inspection parameters and automated scan paths
- 2. Complete & Traceable Inspection**
Defined scan paths with digital inspection records
- 3. Reduced Operator Dependency**
Automation reduces manual scanning variability
- 4. Remote Access to Expertise**
Qualified NDT experts can monitor and support inspections remotely
- 5. Increased Inspection Capacity**
One expert can support multiple inspection activities remotely
- 6. Digital by Design**
Inspection data is captured, stored and linked to the inspection

Limitation on Remote NDT Inspection

Challenges of Remote & Automated NDT:

- 1. Higher Initial Investment**
Robotic equipment, sensors and system integration
- 2. Setup & Deployment Time**
Robot positioning, calibration and scan planning
- 3. Limited Flexibility**
Complex geometries or unexpected inspection conditions
- 4. Positioning & Calibration Requirements**
Accurate robot positioning and sensor coupling are critical
- 5. Application-Specific Economics**
Automation benefits depend on inspection volume, accessibility and task complexity

Summary and Outlook

Summary

- **Remote NDT is technically feasible** for selected inspection tasks
- **Eddy Current and Ultrasonic results demonstrate reliable defect detection** under representative inspection conditions
- **Case studies confirmed repeatability and accessibility benefits**
- **Automated UT thickness measurement enables consistent and traceable data acquisition**
- **Comparative testing shows that remote NDT inspection can achieve inspection performance comparable to conventional methods**
- **However, remote NDT is not a universal replacement for conventional inspection**

Summary and Outlook

Outlook

- Expand validation to **additional aircraft structures, defect types and inspection scenarios**
- **Establish standardized qualification and acceptance criteria** for remote NDT
- Develop **digital inspection records** and **automated data evaluation** to improve traceability and reduce inspector workload
- Increase the level of **automation and autonomy**, while keeping the **inspector in the decision loop**
- Integrate robotic NDT into existing **maintenance procedures, NDT standards and MRO workflows**
- Move from technology demonstration -> **validated inspection capability** -> **operational deployment**

«We need to scale expertise — not just manpower.»

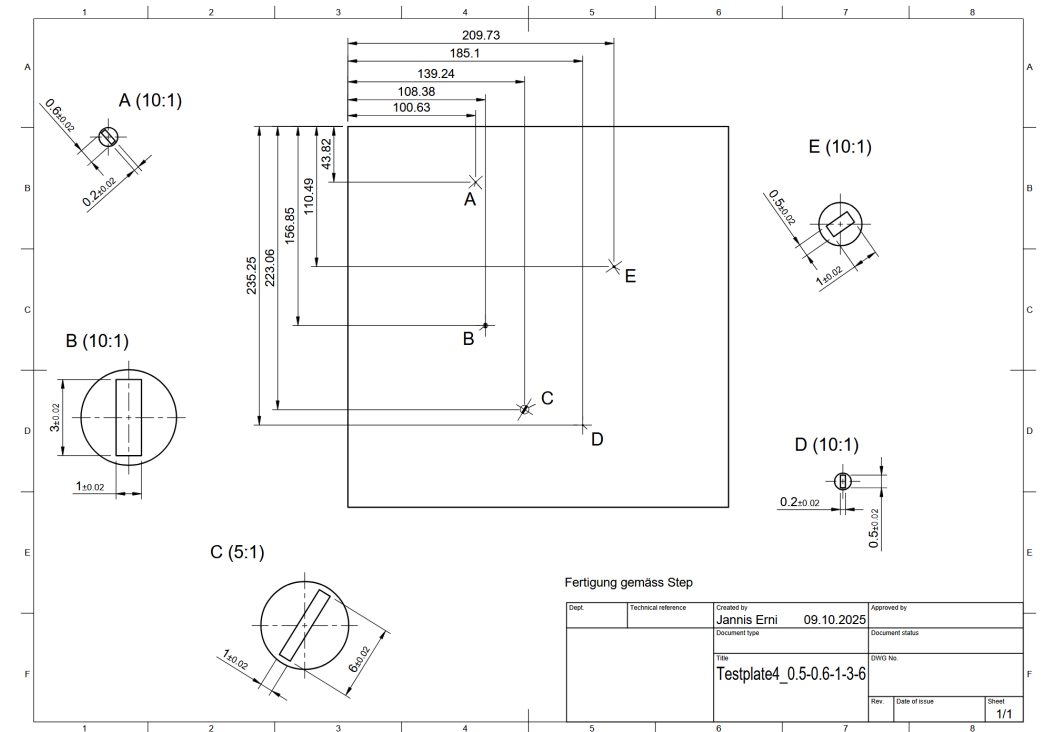
CDC study

Comparative Detection Capability Study - CDC: High-Frequency Eddy Current Testing – Manual versus Remote Inspection

CDC study

■ Panel # 2:

	Size [Width, Depth, Length] [mm]	Orientation [°]	Position on Panel [x, y] [mm]
A	0.2, 0.2, 0.6	+135	101, 44
B	1, 1, 3	-135	108, 157
C	1, 1, 6	90	139, 223
D	0.2, 0.2, 0.5	+135	185, 235
E	0.5, 0.5, 1	0	209, 110



CDC study

- Panel # 2:
 - 10 different NDT Inspector ET Level 2

Defect	Remote	Insp. 1	Insp. 2	Insp. 3	Insp. 4	Insp. 5	Insp. 6	Insp. 7	Insp. 8	Insp.9	Insp. 10
A	YES	YES	YES	YES	NO	YES	YES	YES	YES	YES	YES
B	YES	NO	YES	NO	YES	YES	YES	YES	YES	YES	YES
C	YES	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES
D	YES	YES	NO	YES	YES	YES	YES	YES	YES	YES	YES
E	YES	NO	NO	YES	YES	YES	NO	NO	YES	YES	YES

Manual ET Inspection					Real Defect			Remote Inspection		
Defect	Found:	Length [mm]	X-Position [mm]:	Y-Position [mm]:	Length [mm]:	X-Position [mm]:	Y-Position [mm]:	Length [mm]:	X-Position [mm]:	Y-Position [mm]:
A	9	1.5 - 9	110 - 115	45 - 55	0.6	114	54	3	113	55
B	8	2.5 - 6	210	45 - 50	3	209	51	2.5	210	50
C	9	2.5 - 7	200 - 210	125 - 135	6	209	130	7	210	130
D	9	2.5 - 8	110 - 120	250 - 260	8	119	255	9	120	253
E	6	2.5 - 9	110	160 - 165	1	108	163	1	110	165