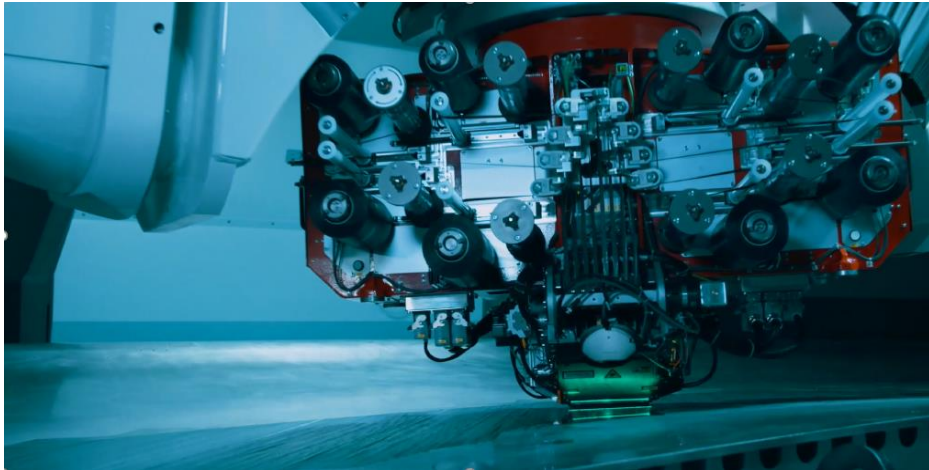
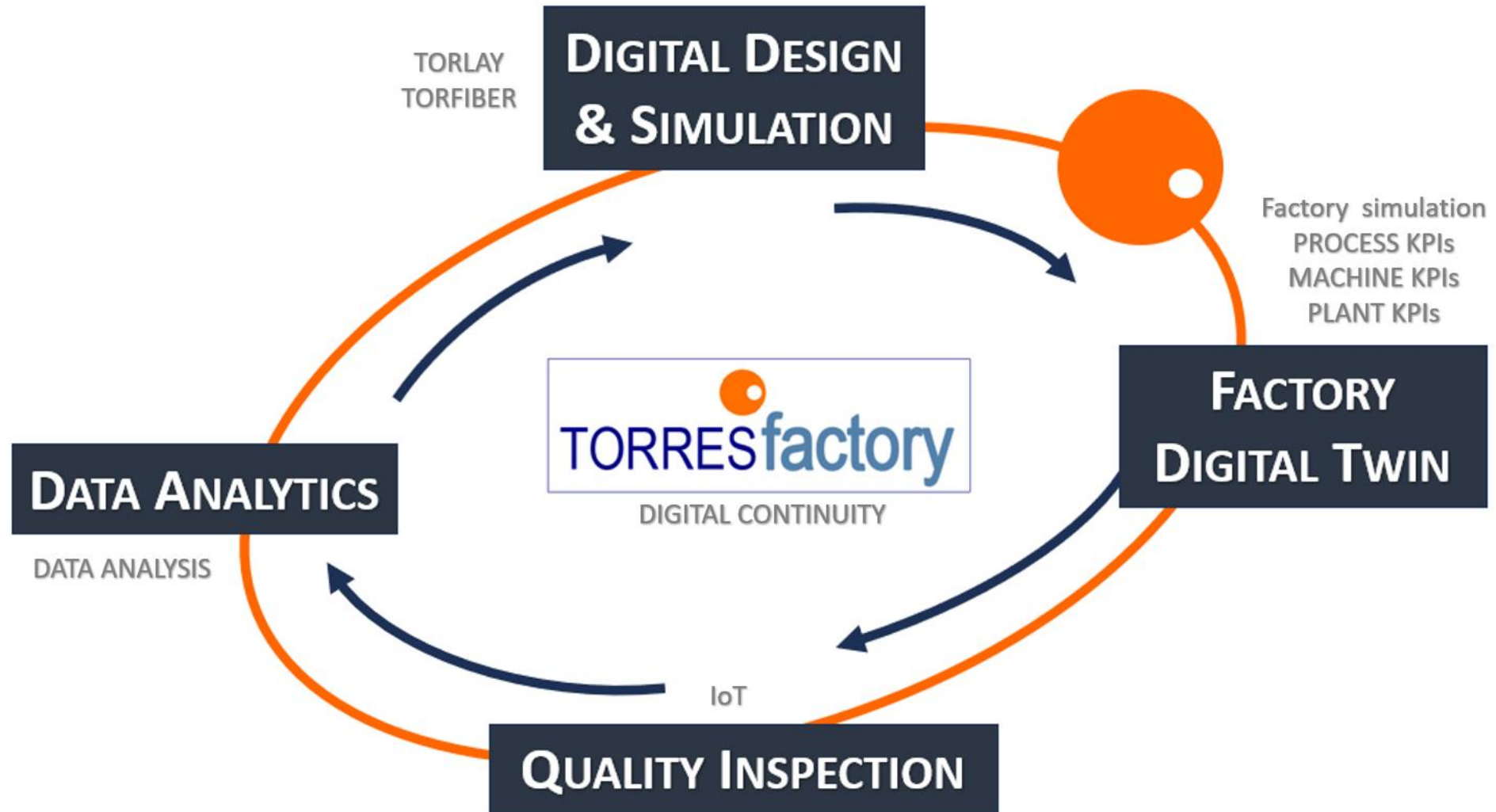


MTorres On-Line Inspection (OLI)





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2. SYSTEM DESCRIPTION
3. SYSTEM SPECIFICATIONS
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5. OLI FOR ATL MACHINES
6. SUMMARY

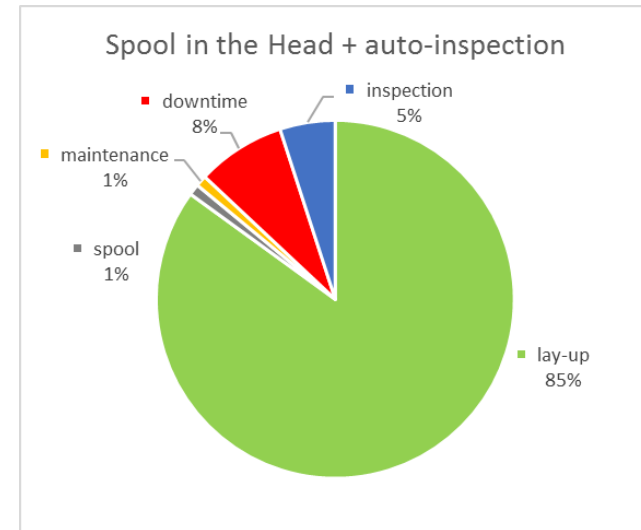
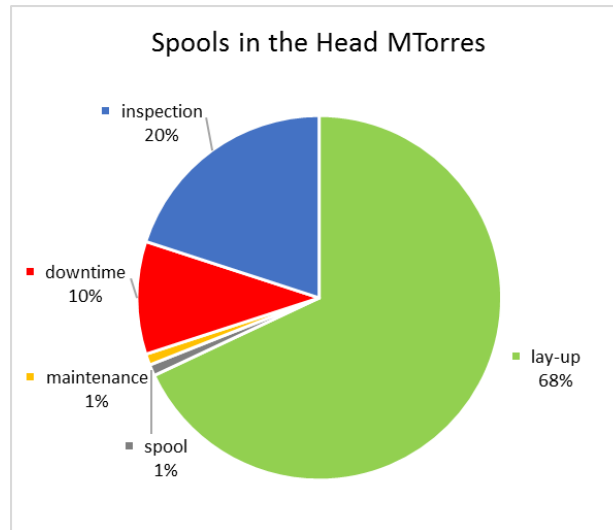
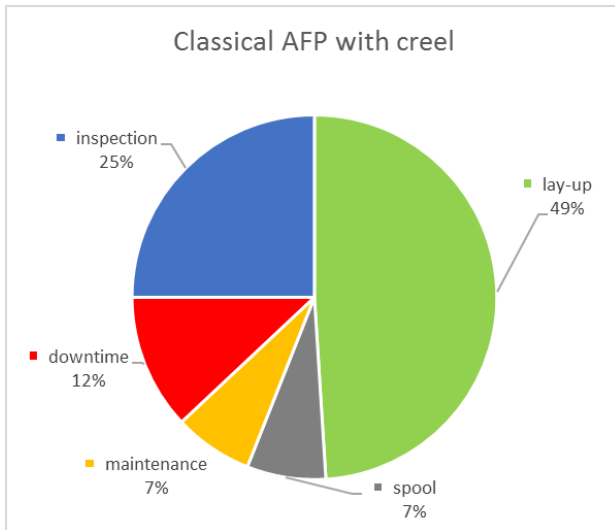


Mtorres On-Line Inspection (OLI)

INTRODUCTION



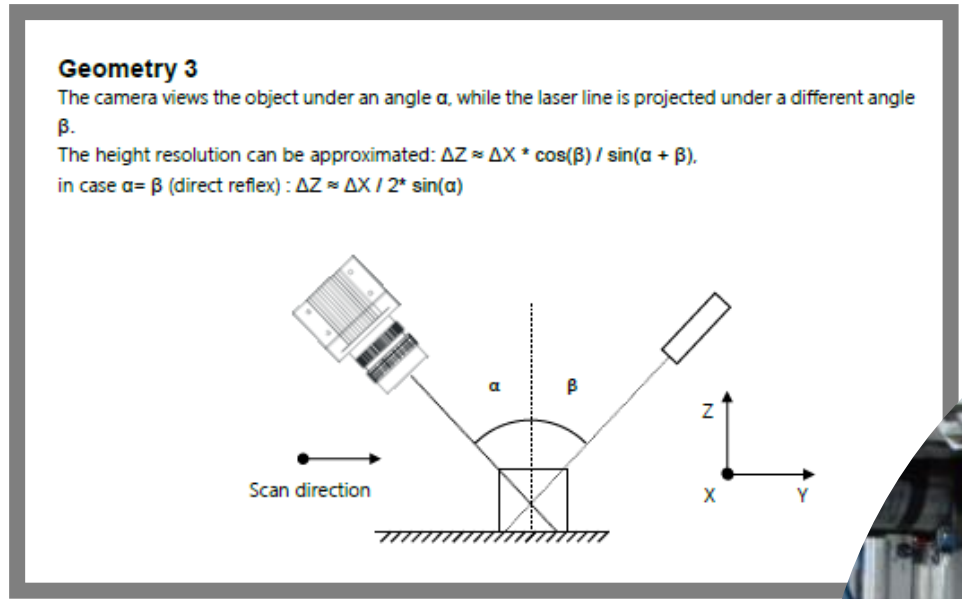
Evolution of efficiency in the machines implies the drastic reduction of the inspection analysis necessary to reach AFP maximum production rates



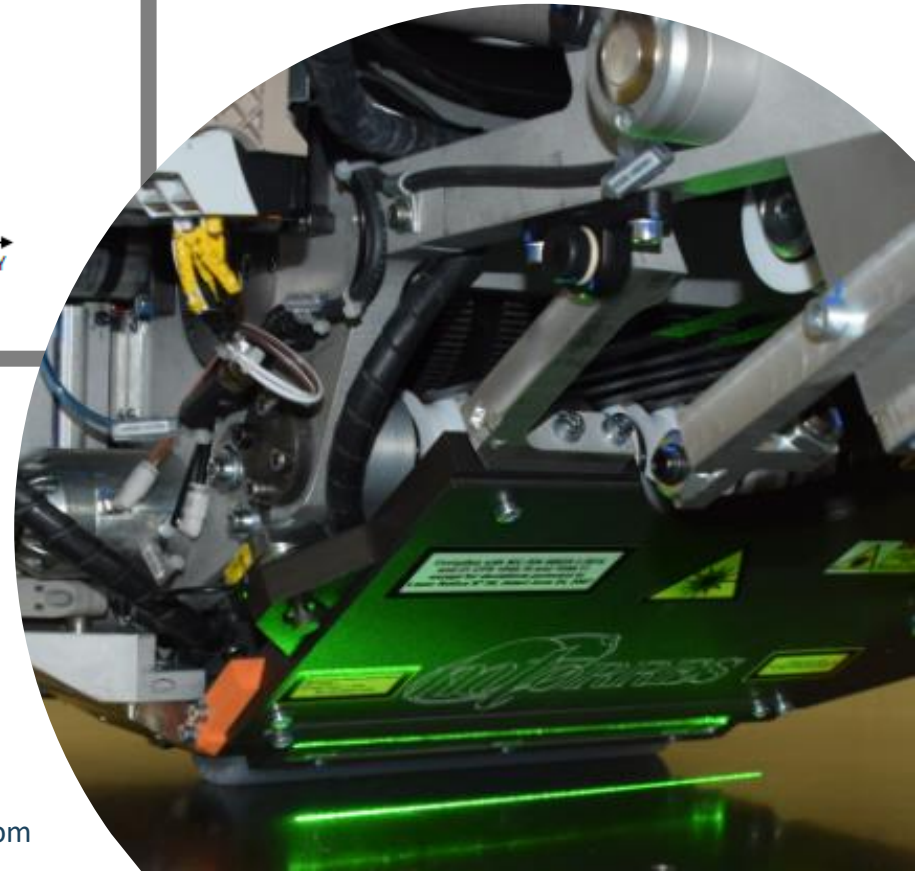
** The inspection time reduction is an internal estimation from Mtorres. It depends on the current inspection procedures and methods carried out by each customer*

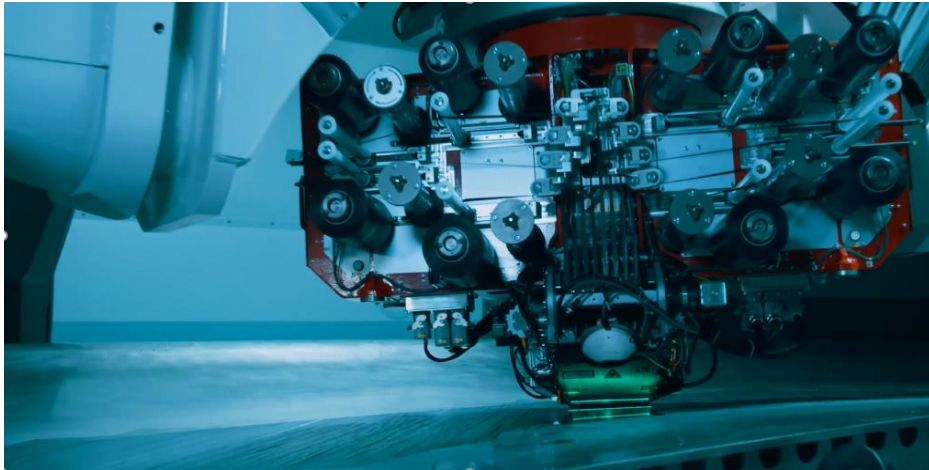
Mtorres On-Line Inspection (OLI) INTRODUCTION

A laser triangulation sensor has been developed to perform an automatic OnLine Inspection (OLI) for Automatic Fiber Placement (AFP) machines. A laser line is projected onto the CFRP surface and a camera takes an image and process it in real time to detect laminate defects and part Key Characteristics



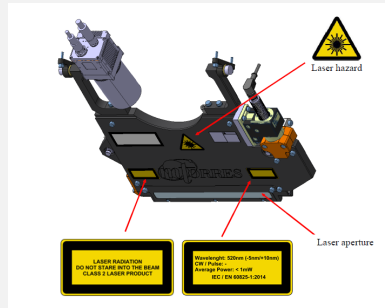
Measurement 70-80 mm after compaction roller (*)



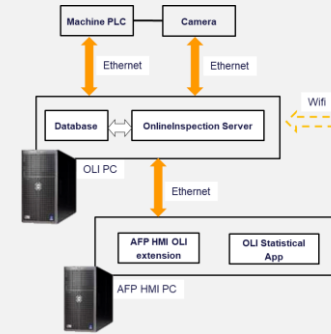


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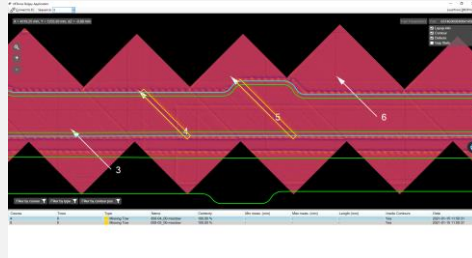
Mtorres On-Line Inspection (OLI) SYSTEM DESCRIPTION



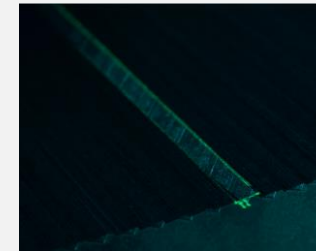
HARDWARE DESCRIPTION



SOFTWARE ARCHITECTURE



SOFTWARE APPLICATIONS

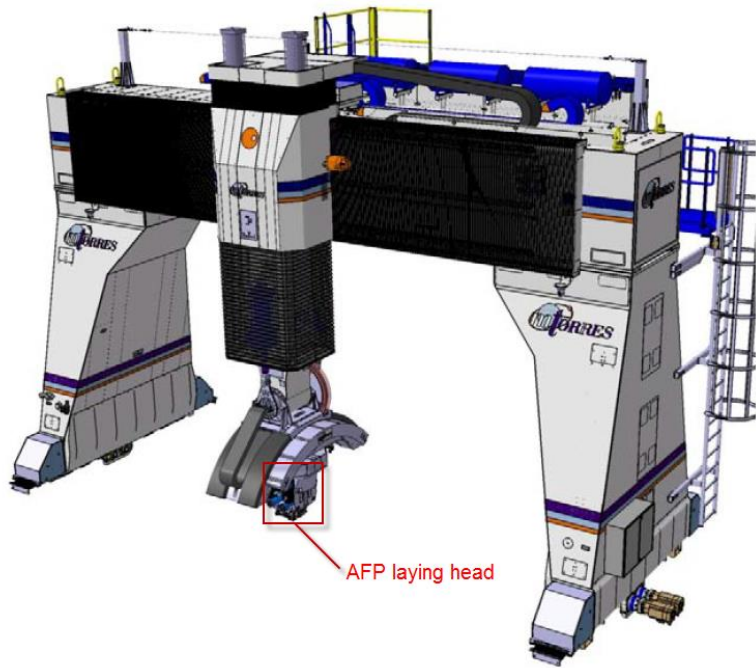


OTHER OPTIONS

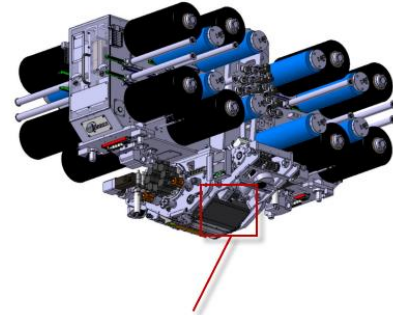
Mtorres On-Line Inspection (OLI) SYSTEM DESCRIPTION - Hardware



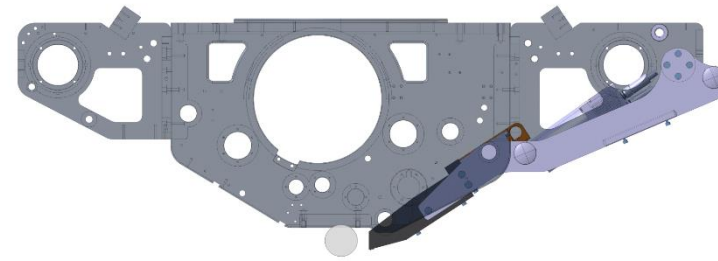
The sensor is embedded in the AFP Head → no additional hardware infrastructure is necessary



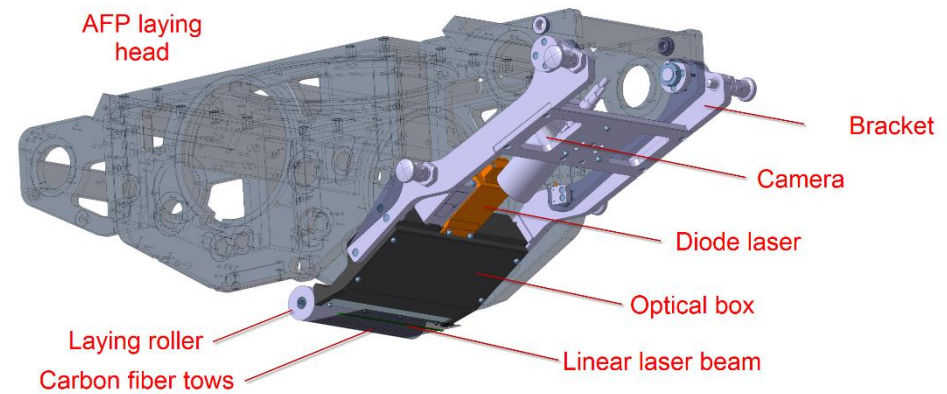
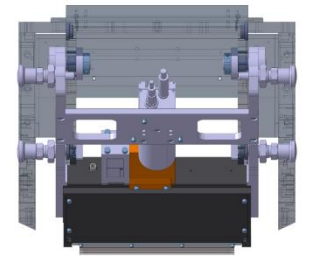
AFP laying head



Online Inspection system
integrated in a AFP laying head

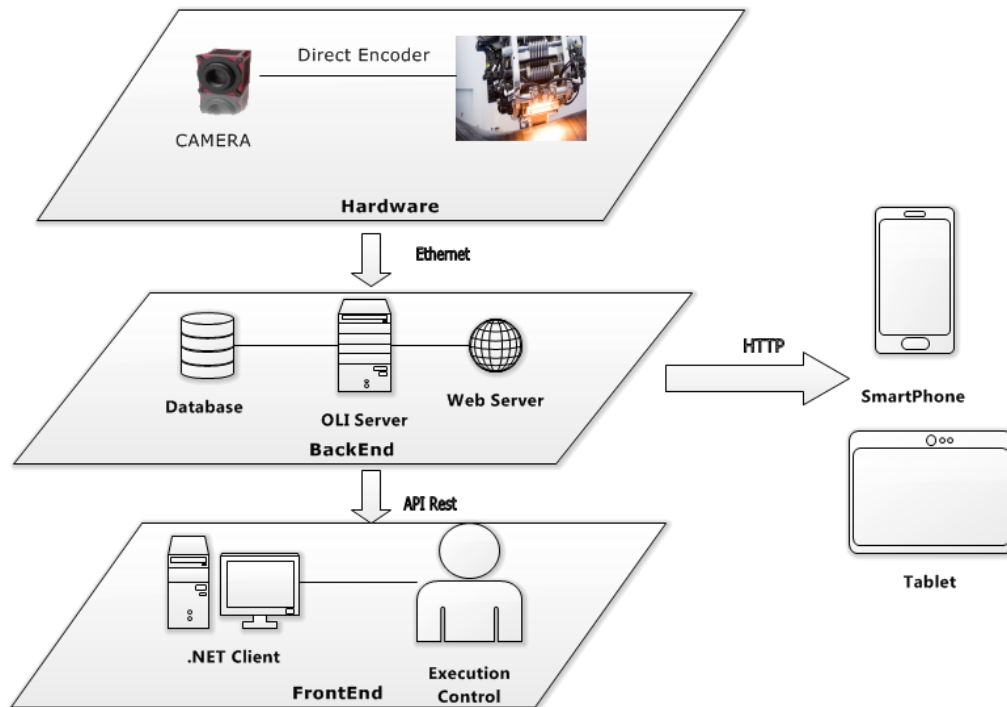


AFP laying
head



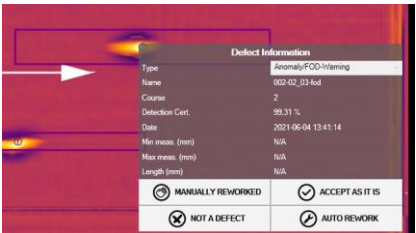
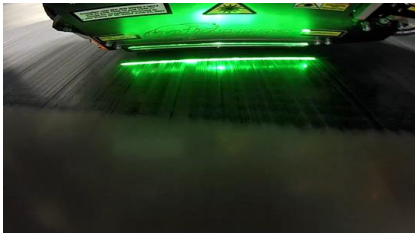
Mtorres On-Line Inspection (OLI)

SYSTEM DESCRIPTION – Software architecture



- Real time data acquisition up to 2000 profiles /sec
- Specific OLI Server for defect detection and defect database storage
- Application communication with machine HMI and OLI specific visualization Apps
- Ability to share traceability inspection data for all produced parts
- Optional to integrate with laser projection hardware
- Optional to integrate with inspection tablet

Mtorres On-Line Inspection (OLI) SYSTEM DESCRIPTION – Inspection process



1. An automatic calibration process (20-30 secs) is done periodically (once a week for example)

2. Scanning is done in parallel to lay-up process

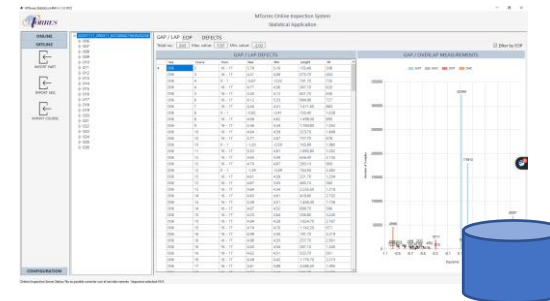
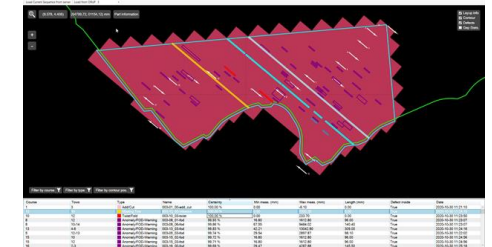
3. Defects are presented to the operator once the sequence is finished (configurable)

4. Operator use the Skippy Map to manage the defects

5. Managing the defects can also be done using the Tablet and the laser projectors to identify them and rework them (if needed)

6. Once all the defects have been managed, the operator jumps to the next sequence

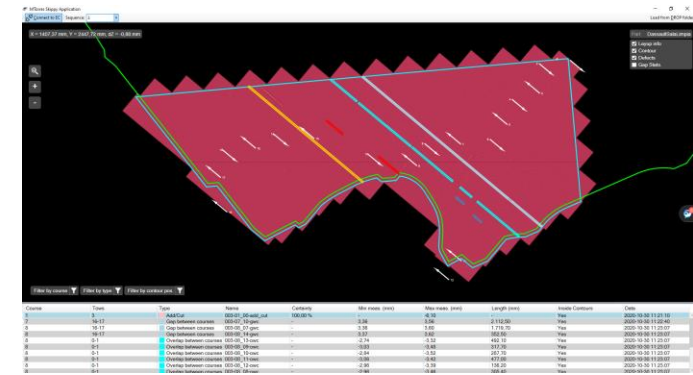
7. The defects data is stored both in the Part history file (production) and in the Defects Statistical App for the quality department to review if needed



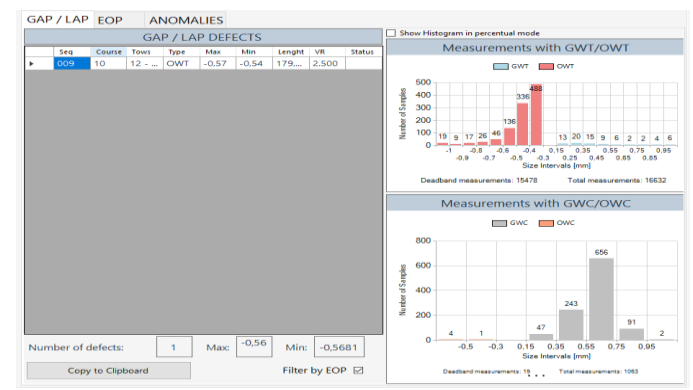
Mtorres On-Line Inspection (OLI) SYSTEM DESCRIPTION – Software Applications



HMI UPDATE. OLI inspection process integrated in the normal operation of the machine with the HMI



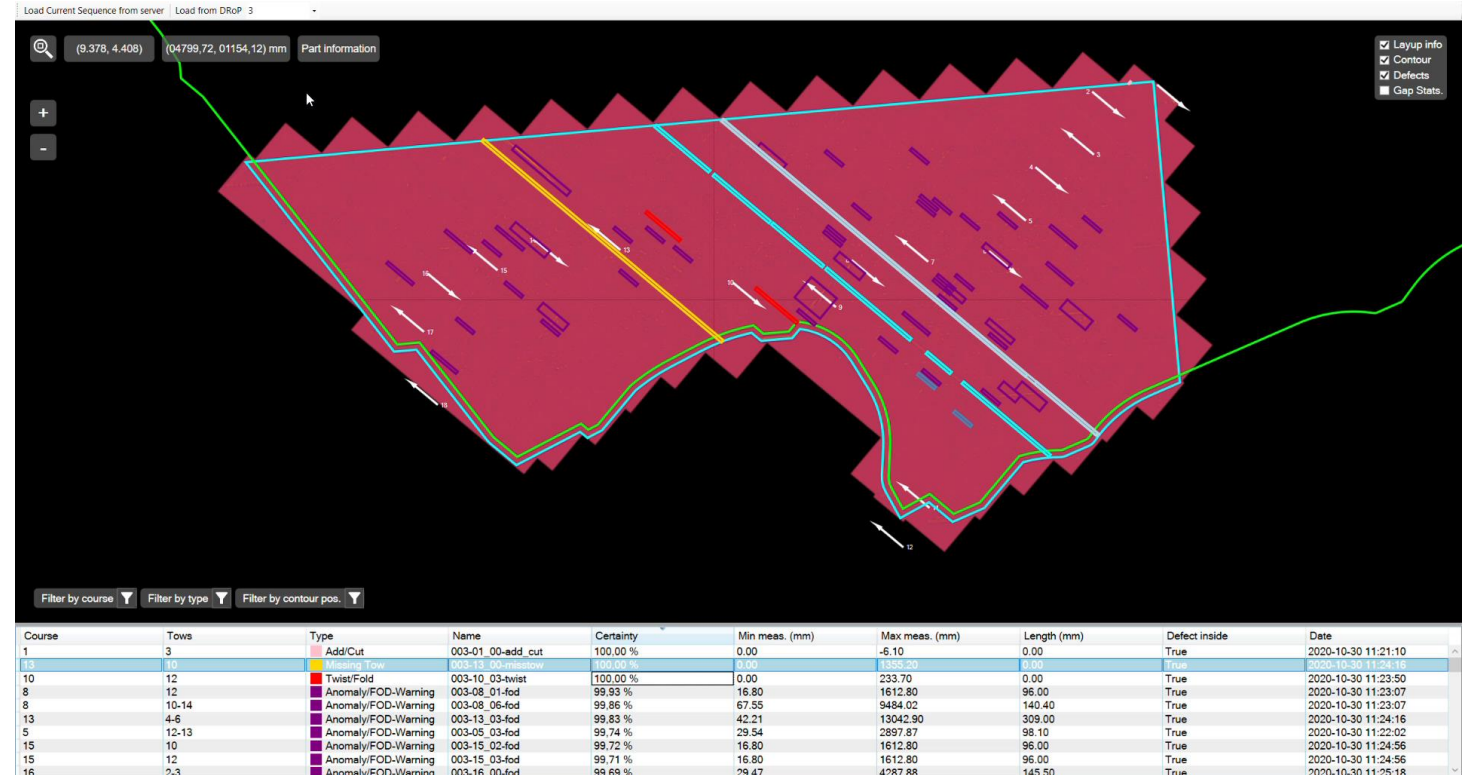
SKIPPY MAP. Additional visualization application to view the defects and manage them directly from the operator desk



STATISTICAL APP. Off-line software tool to browse and view the quality part information stored by OLI

Mtorres On-Line Inspection (OLI) SYSTEM DESCRIPTION – Skippy Map

- High resolution map of the part, enhanced with Layup and Inspection features.
- Allows to follow the Inspection Process during the manufacturing (real-time)
- Full-sequence gap/lap measurements.
- Defect management and check can be done using this viewer avoiding entering inside the layup cell.
- Ability to import DRoPs (Digital Record of the Part) of previously saved parts.

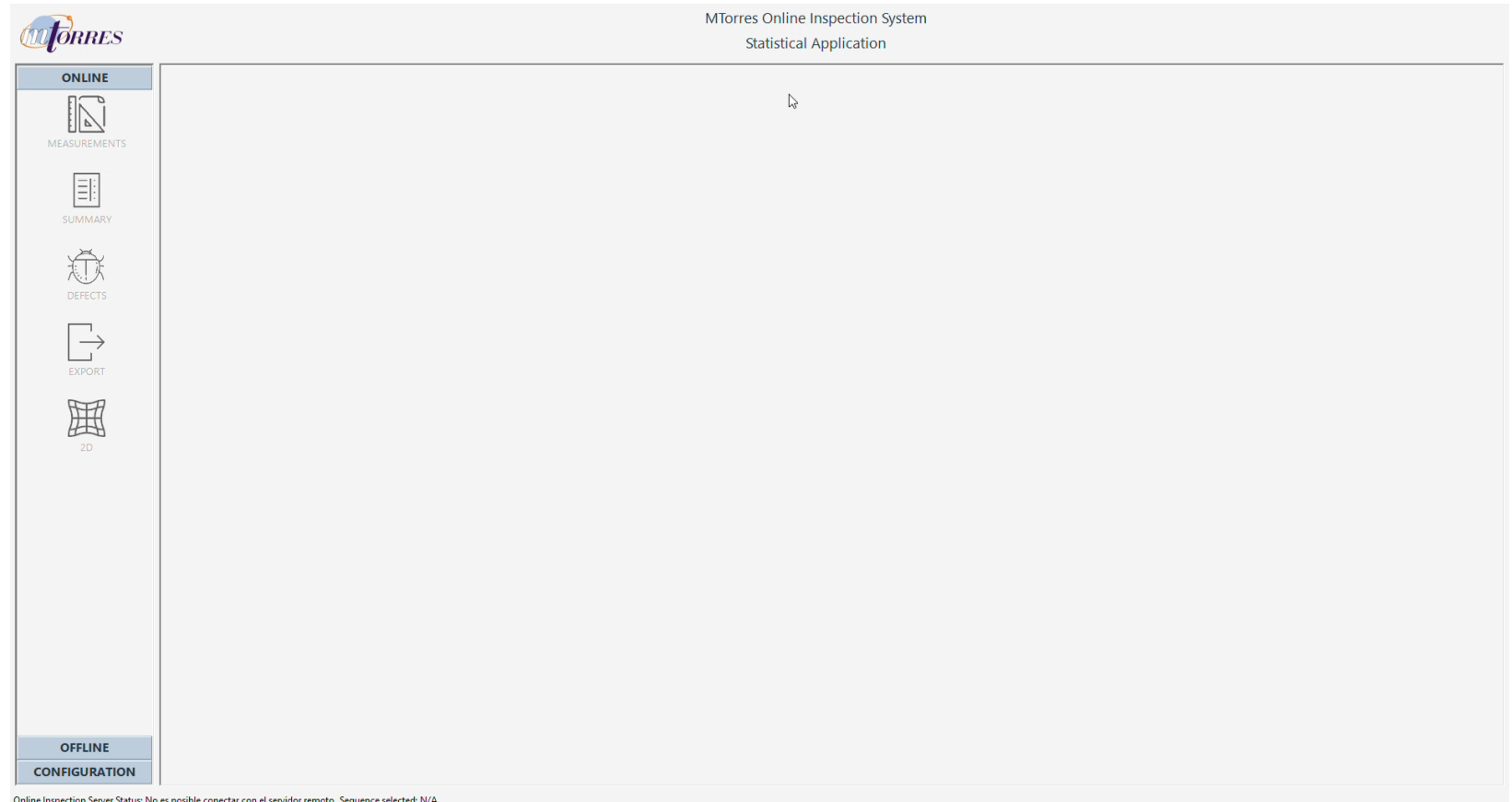


Mtorres On-Line Inspection (OLI)

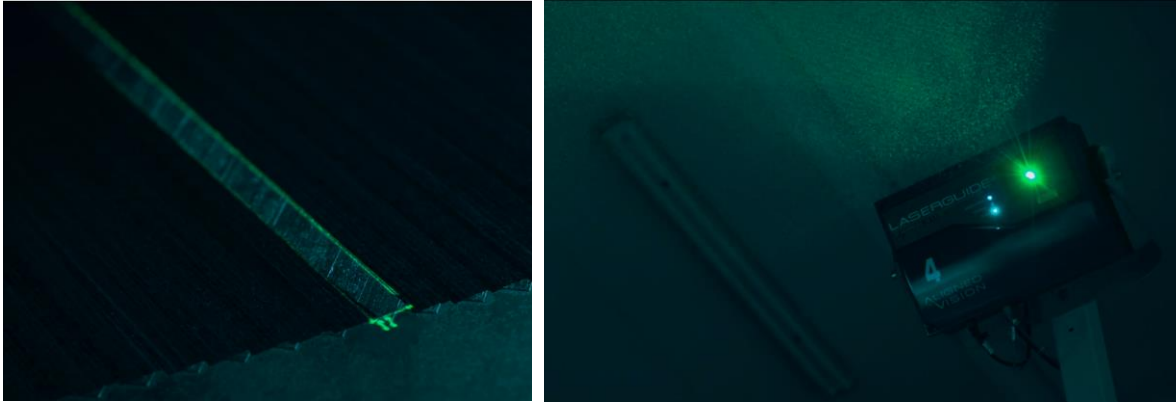
SYSTEM DESCRIPTION – Statistical App



- Specific defect browsing App for quality technician (in parallel to the HMI defect managing interface for the operator)
- Displays the defect details and statistics for each course, sequence and part
- You can browse the sequence pictures and defects in a 2D part interface
- You can export Gap/Lap/EoP/Other defects in customised reports
- Ability to open the DRoP “Digital Record of the Part” of previously saved part defect summary data.



Mtorres On-Line Inspection (OLI) SYSTEM DESCRIPTION – Other options

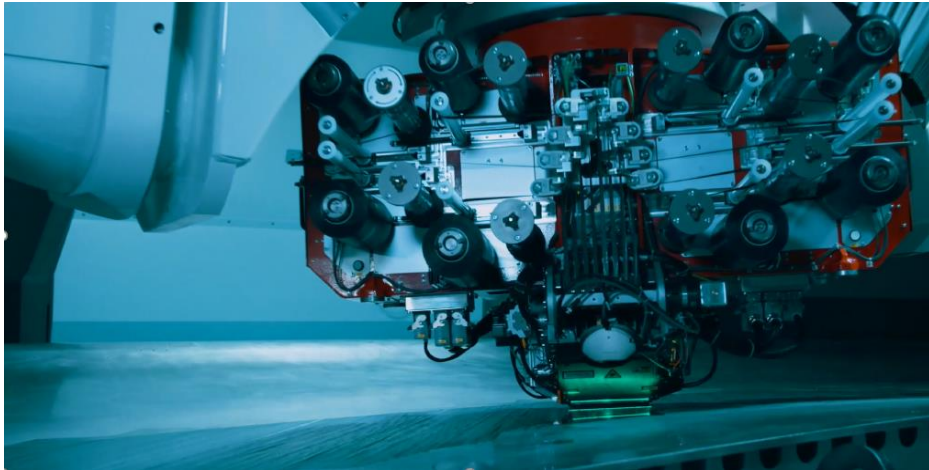


LASER PROJECTORS. OLI defect bounding boxes can be directly projected with laser projectors



TABLET FOR INSPECTION. OLI software applications can be user with a specific tablet connected via wifi to OLI Server

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Mtorres On-Line Inspection (OLI)

SYSTEM SPECIFICATIONS – Defects detected



MEASUREMENT RESOLUTION	X (mm)	Y (mm)	Z (mm)
FiberLayup Machine (up to 24 tows 1/2")	0,3	0,07	0,03
MACHINE FEATURES	Max Speed	Max Acceleration	
FiberLayup Machine (up to 24 tows 1/2")	80 m/min*	2m/s ²	

DEFECT TYPE	Detection limits (*)
PLY location	> 0,7 mm Uncertainty +/- 0,7 mm (*)
Missing tow	
Splices	Length > 20 mm
Gap between tows	Width > 0,3 mm Length > 20 mm Uncertainty +/- 0,2 mm (*)
Gap between courses	Width > 0,3 mm Length > 20 mm Uncertainty +/- 0,2 mm (*)
Overlap between tows	Width > 0,4 mm Length > 20 mm Uncertainty +/- 0,3 mm (*)
Overlap between courses	Width > 0,4 mm Length > 20 mm Uncertainty +/- 0,3 mm (*)
Anomalies / FOD-Warnings	Area > 25 mm ² Height > 0.2 mm
Tow twist / Fold	Length > 20 mm

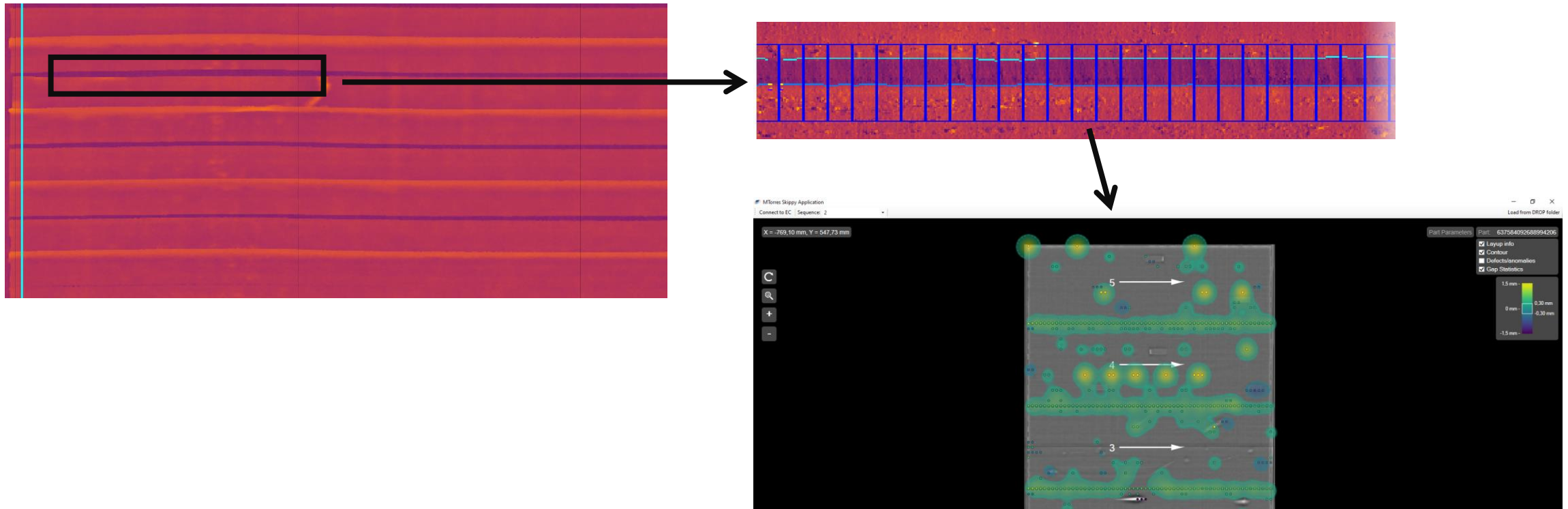
(*) Final limits depends on the end effector width, type of CFRP material and part curvature

Mtorres On-Line Inspection (OLI) SYSTEM SPECIFICATIONS – Gap & lap

TRIGGER DEFECTS. The system will detect gap/overlap between every tow and between courses. The following parameters can be configured to trigger defects:

- Length of the gap/lap
- Size of the gap/lap
- Type of Gap/lap (between tows or between courses)

STORE KCs. Additionally the system store a gap/lap datapoint every 20 mm (configurable). The gap/lap mapping of the layer is stored in the DROP file of the part

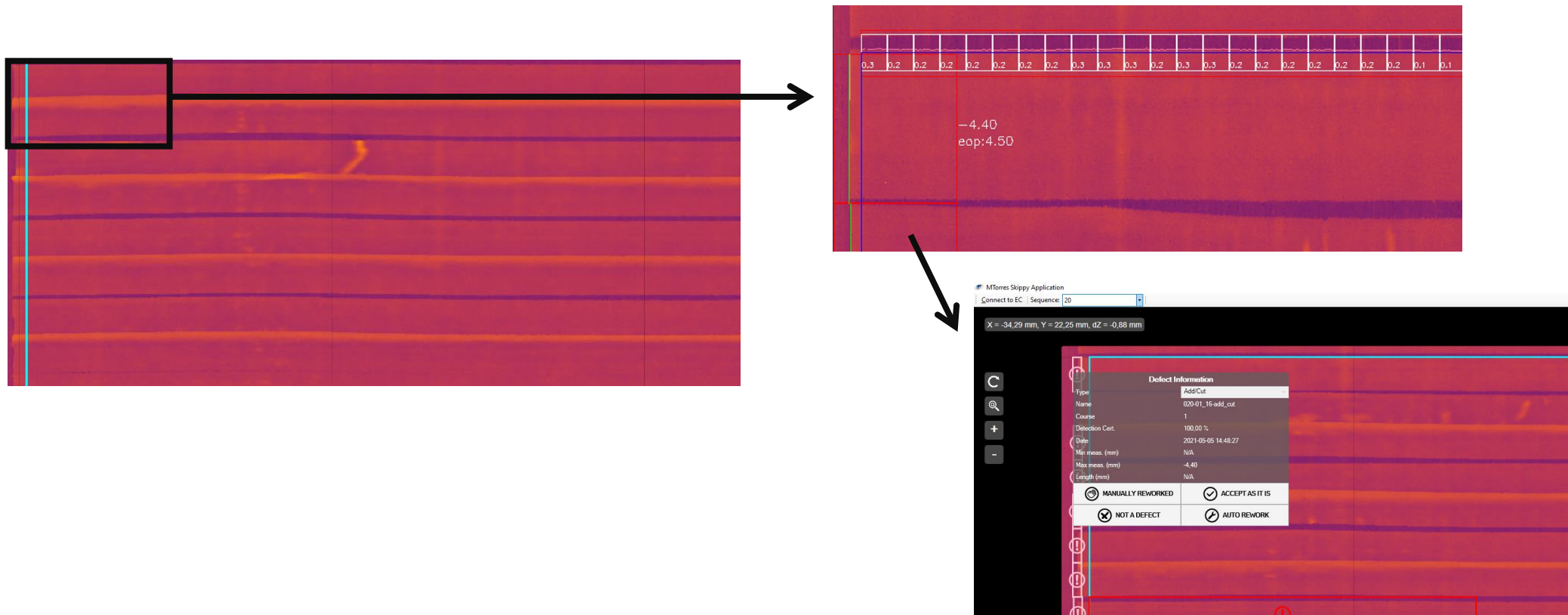


Mtorres On-Line Inspection (OLI) SYSTEM SPECIFICATIONS – add&cut



TRIGGER DEFECTS. Add and cut of each tow is automatically measured to compute the error between the theoretical position of each tow and the inspected add & cut point. Comparison against threshold

STORE KCs. Additionally, the system store ply datapoint every add&cut. The ply location data is stored in the DROP file of the part



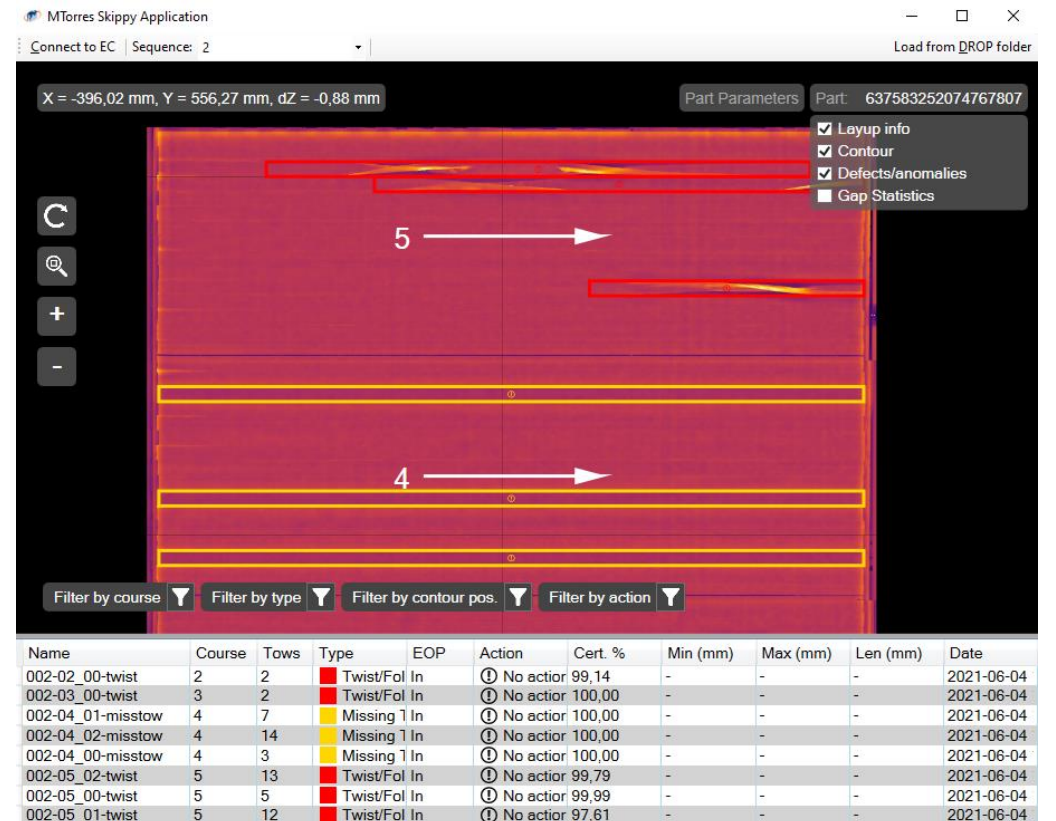
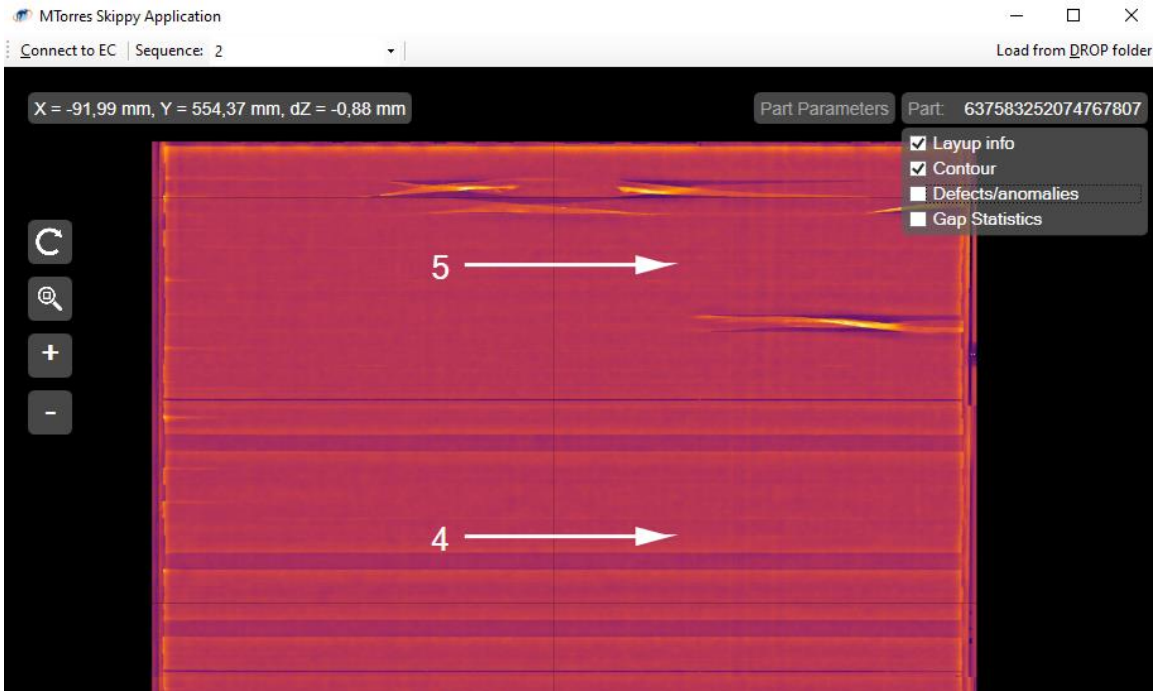
Mtorres On-Line Inspection (OLI)

SYSTEM SPECIFICATIONS – Other defects

MISSING TOWS. Detection using AI algorithms and neuronal networks

TOW TWIST / FOLD. Detection using AI algorithms and neuronal networks

STORE KCs. Additionally, the system store bonding information of defects. The defect data is stored in the DROP file of the part



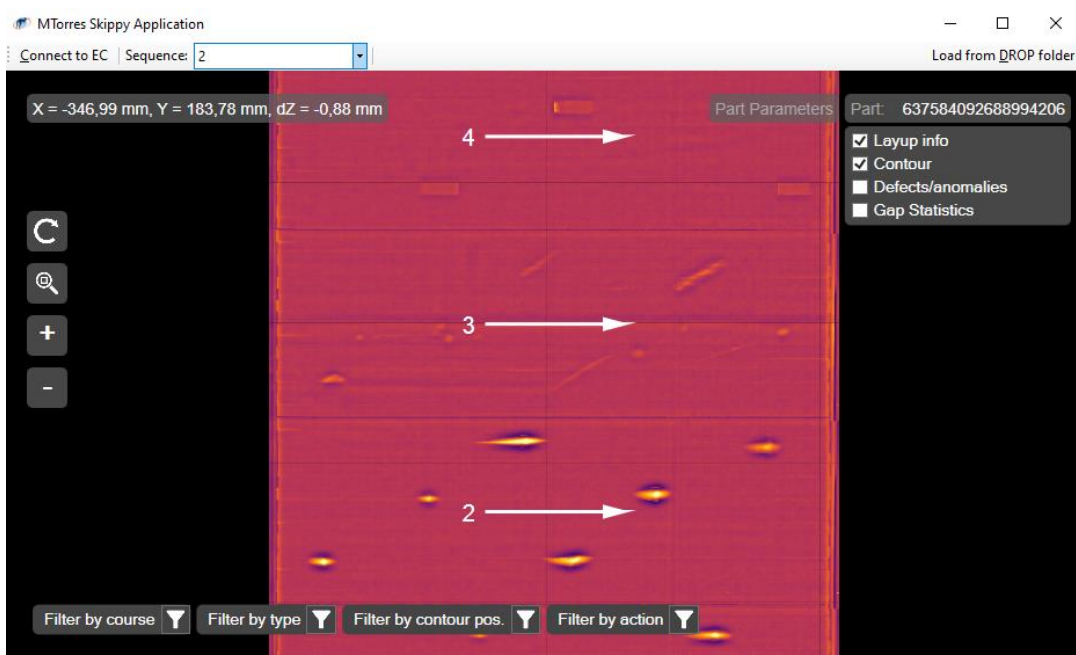
Mtorres On-Line Inspection (OLI)

SYSTEM SPECIFICATIONS – Other defects

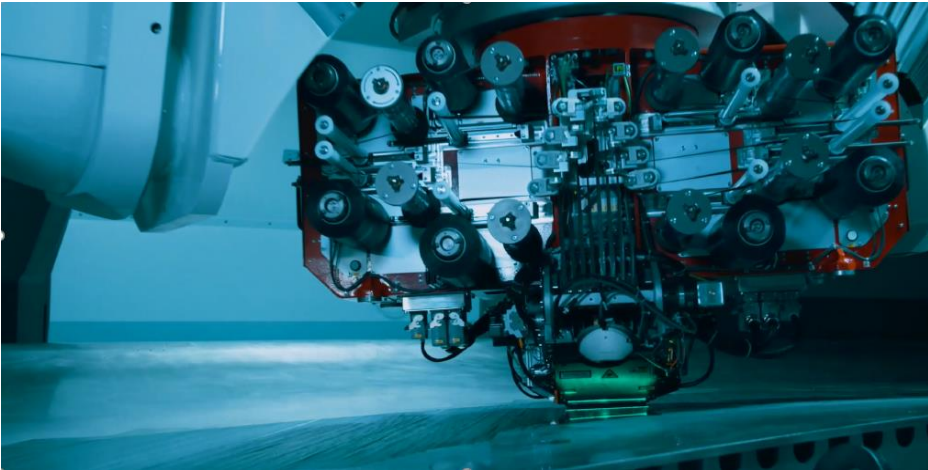
SPLICES. Detection using AI algorithms and neuronal networks

FOD Warning / Anomalies. Detection using AI algorithms and neuronal networks

STORE KCs. Additionally, the system store bonding information of defects. The defect data is stored in the DROP file of the part



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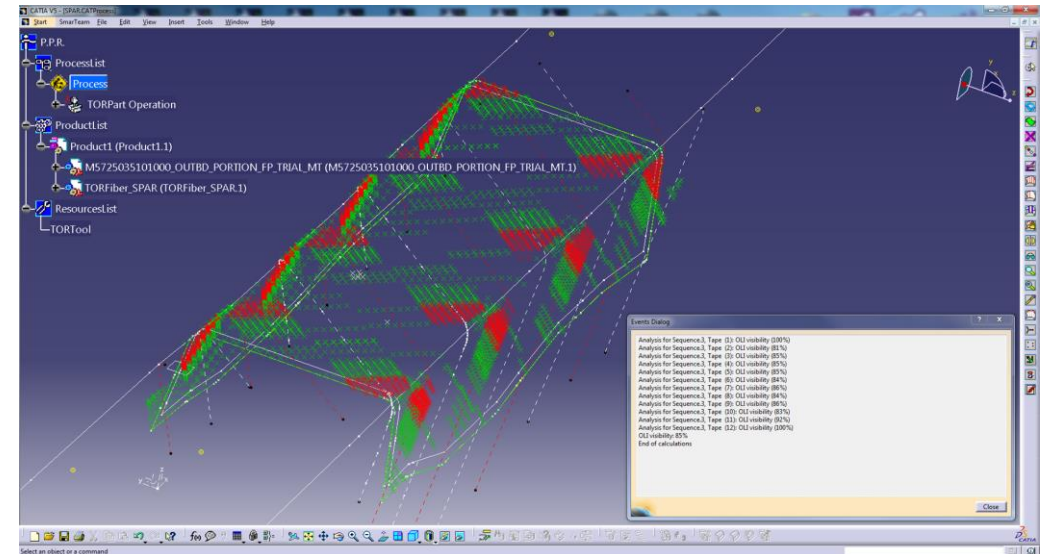
Mtorres On-Line Inspection (OLI) RELATED SOLUTIONS – Complex 3D shapes

3D shape of the layup can limit the use of automatic inspection in some cases. Special cases are also taken into account

TORFIBER SHADE CALCULATION

Specific tool in the CAM programming software to estimate the theoretical shading zones (due to distance between roller and laser line)

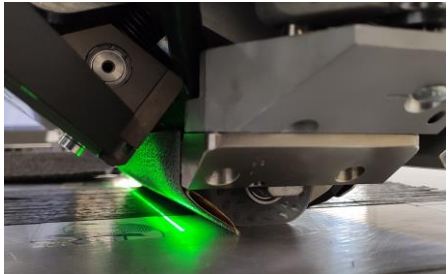
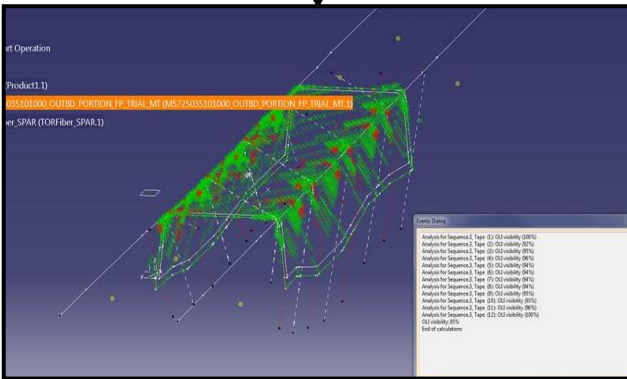
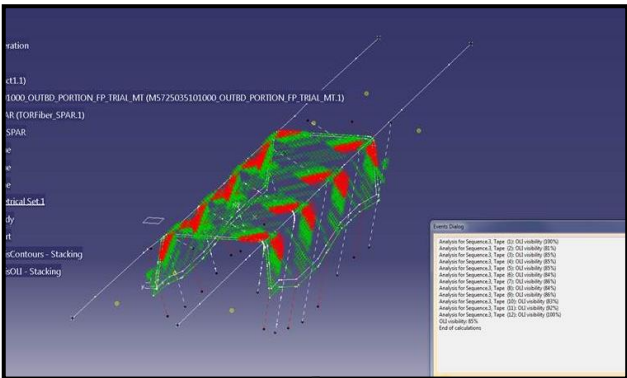
Automatic laser projection information can be generated for manual inspection of special cases



Mtorres On-Line Inspection (OLI) RELATED SOLUTIONS – Complex 3D shapes



New OLI design is ready for complex parts and compact end effectors. Minimization or elimination of shadowing effect

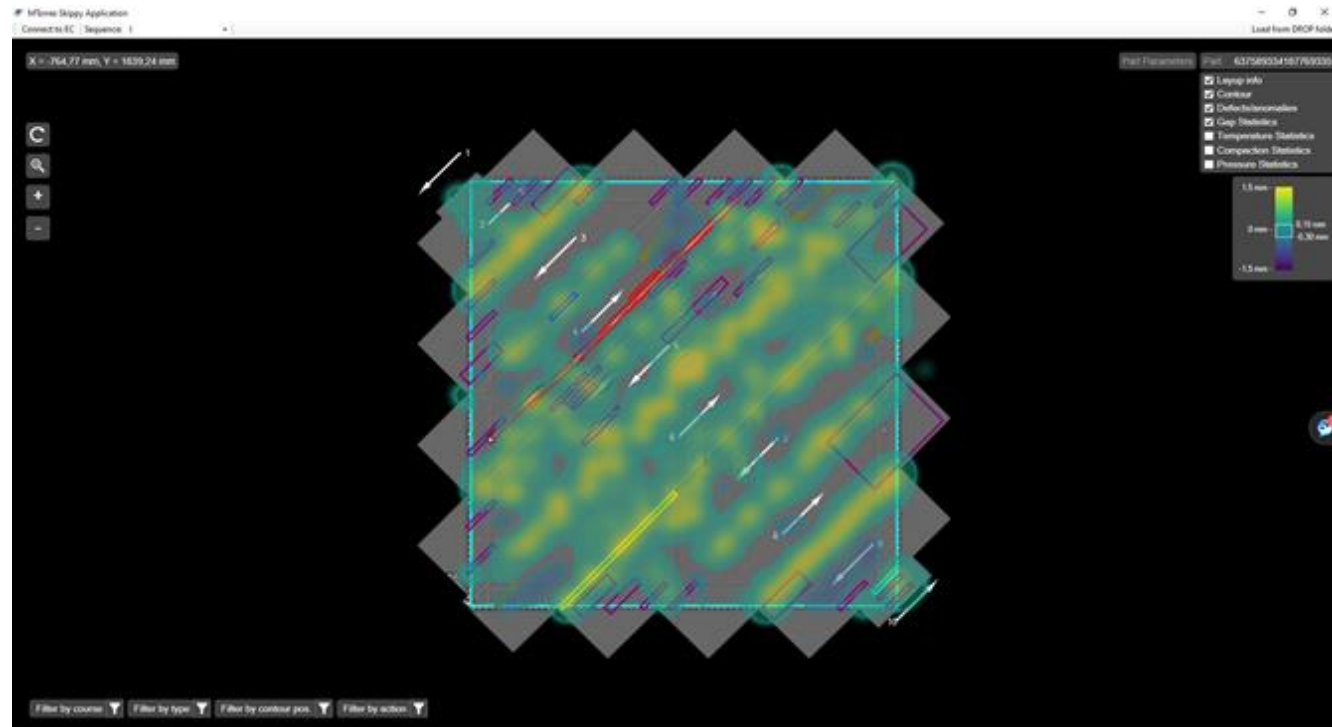


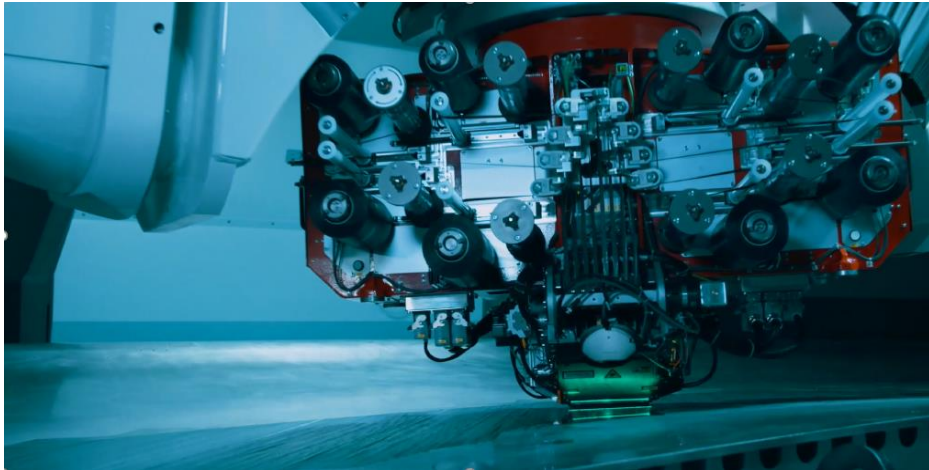
Mtorres On-Line Inspection (OLI) RELATED SOLUTIONS – Torresfactory Quality KPPs



TORRESFACTORY. Mtorres Industry 4.0 solution for advanced quality health includes obtaining the KPPs (Key Process Parameters) of the layup in real-time during the lay-up. The information can also be included in the DRoP file of the part produced

- Tension
- Pressure
- Temperature





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Mtorres On-Line Inspection (OLI)

OLI for ATL machines



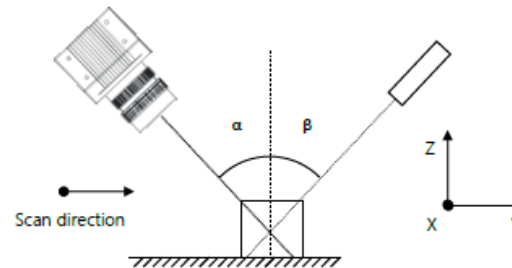
A laser triangulation sensor has been developed to perform an automatic OnLine Inspection (OLI) for Automatic Tape Layer machines. A laser line is projected onto the CFRP surface and a camera takes an image and process it in real time to detect laminate defects:

Geometry 3

The camera views the object under an angle α , while the laser line is projected under a different angle β .

The height resolution can be approximated: $\Delta Z \approx \Delta X * \cos(\beta) / \sin(\alpha + \beta)$.

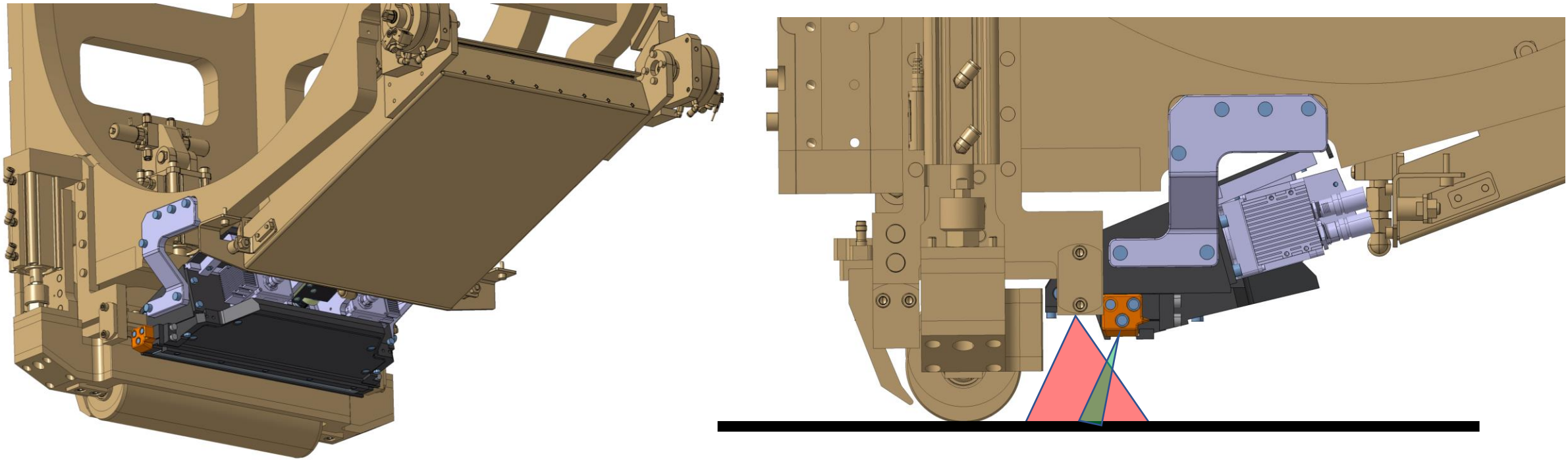
in case $\alpha = \beta$ (direct reflex) : $\Delta Z \approx \Delta X / 2 * \sin(\alpha)$



Measurement ~95 mm after compaction roller (*)

ATLIS (ATL Inspection System) Description of the system

The ATL Online Inspection System has been already developed for the new ATL generation head (ATLv3) as shown in pictures.
The hardware is located after the compaction line and scans the lamination surface.



ATLIS (ATL Inspection System)

Description of the system: Specifications



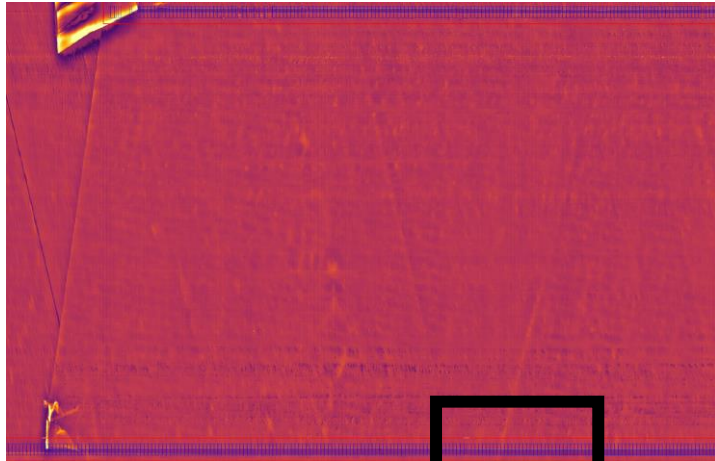
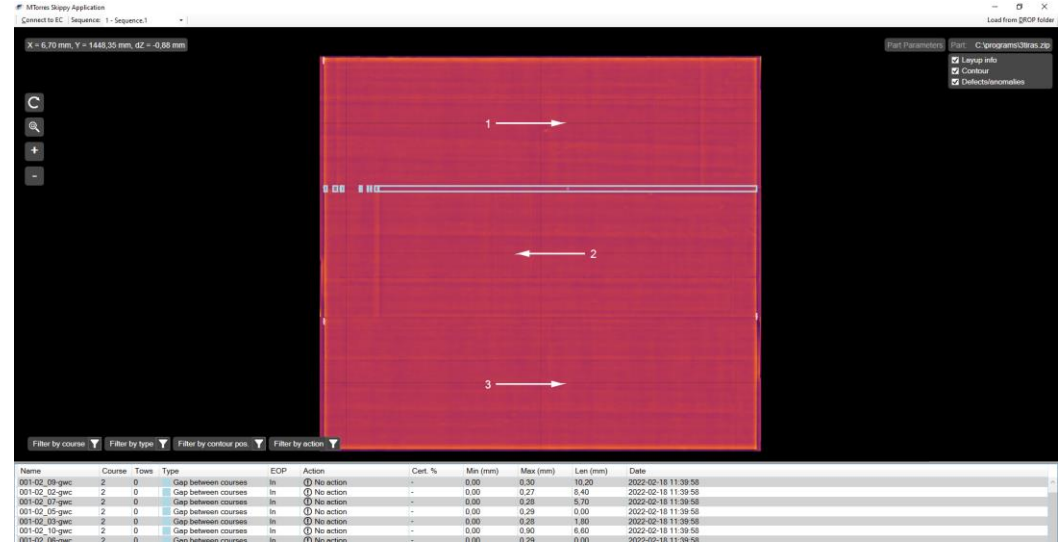
MEASUREMENT RESOLUTION	X (mm)	Y (mm)	Z (mm)
ATL machine up to 300mm (12")	0.4 @ max speed	0.07	0.03
MACHINE FEATURES	Max Speed	Max Acceleration	
ATL machine up to 300mm (12")	100 m/min*	2 m/s ²	

DEFECT TYPE	DETECTION LIMITS
Contour location	> 0.7 mm
Gap between courses	Width>0,3mm / Length >20mm
Overlap between courses	Width>0.4mm / Length >20mm
ANOMALIES / FOD Warnings	Width>5mm/ Length >5mm Area>25mm ² / Height>0.2mm

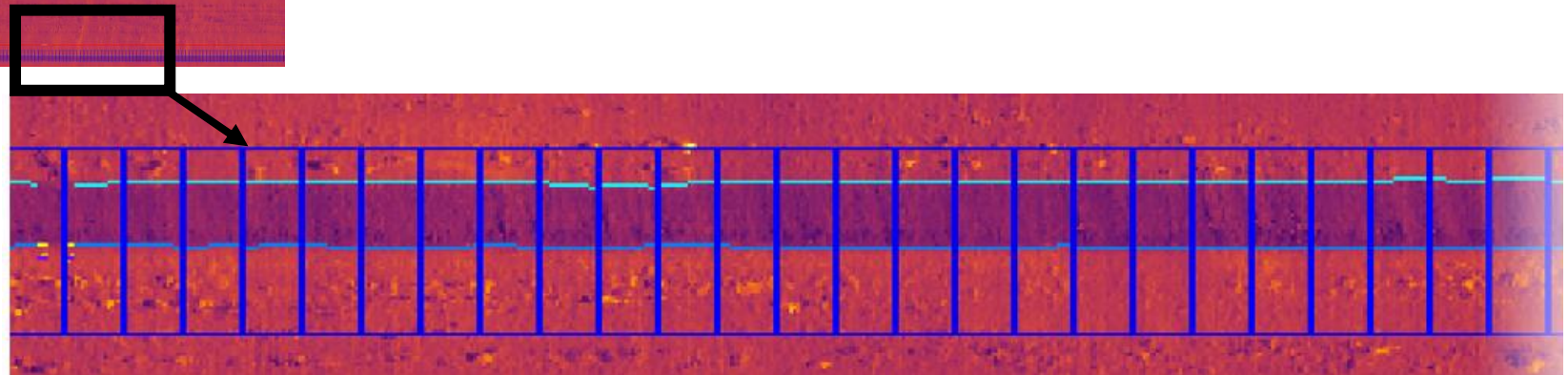
ATLIS (ATL Inspection System)

Description of the system: GAP/OVERLAP detection

GAP/OVERLAP detection

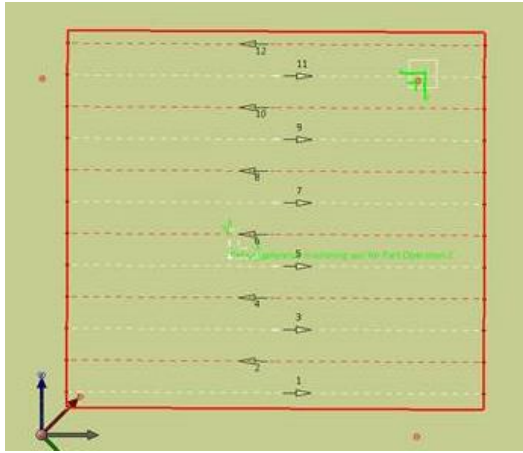
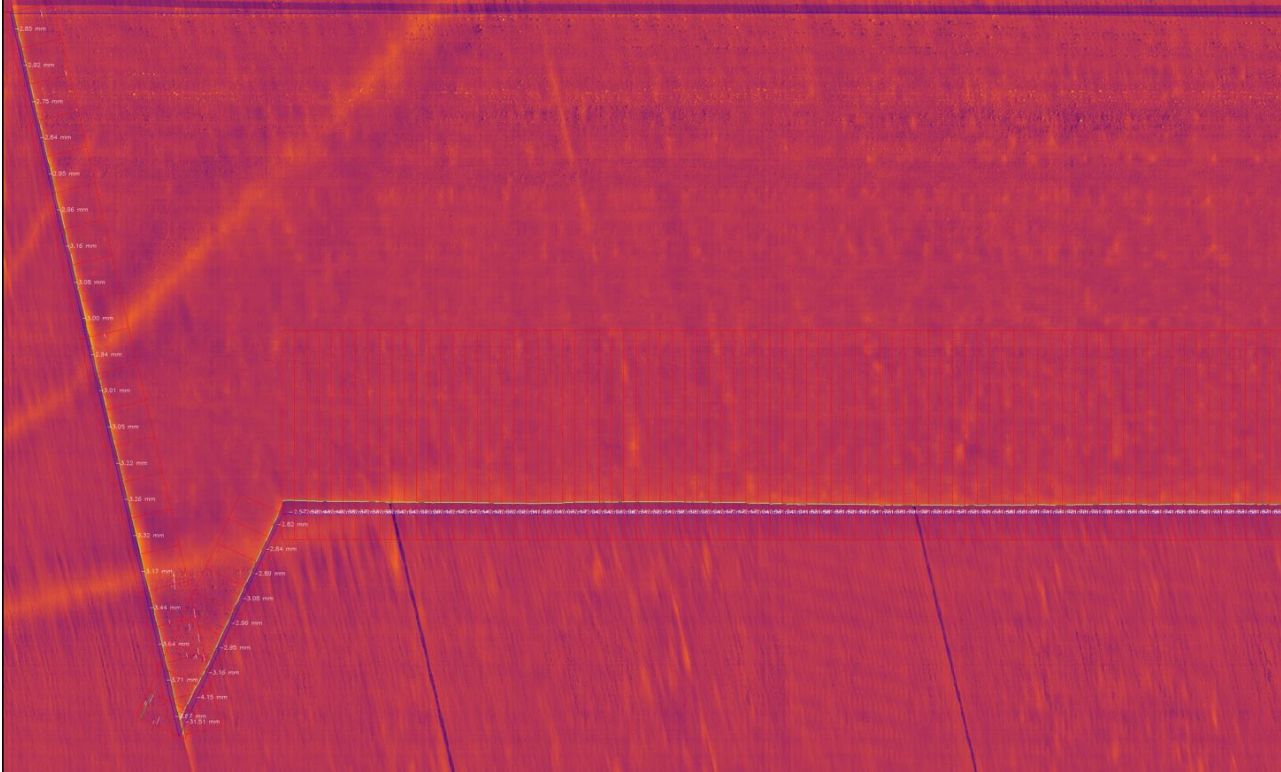
Name	Course	Tows	Type	EOP	Action	Cent. %	Min (mm)	Max (mm)	Len (mm)	Date
001-02_09-gwc	2	0	Gap between courses	In	No action	-	0.00	6.30	19.20	2022-02-18 11:39:58
001-02_02-gwc	2	0	Gap between courses	In	No action	-	0.00	0.27	8.40	2022-02-18 11:39:58
001-02_03-gwc	2	0	Gap between courses	In	No action	-	0.00	9.28	8.70	2022-02-18 11:39:58
001-02_05-gwc	2	0	Gap between courses	In	No action	-	0.00	0.29	0.00	2022-02-18 11:39:58
001-02_03-gwc	2	0	Gap between courses	In	No action	-	0.00	0.28	1.80	2022-02-18 11:39:58
001-02_10-gwc	2	0	Gap between courses	In	No action	-	0.00	0.90	6.60	2022-02-18 11:39:58
001-02_08-gwc	2	0	Gap between courses	In	No action	-	0.00	0.96	0.00	2022-02-18 11:39:58



ATLIS (ATL Inspection System)

Description of the system: Ply Location

PLY LOCATION

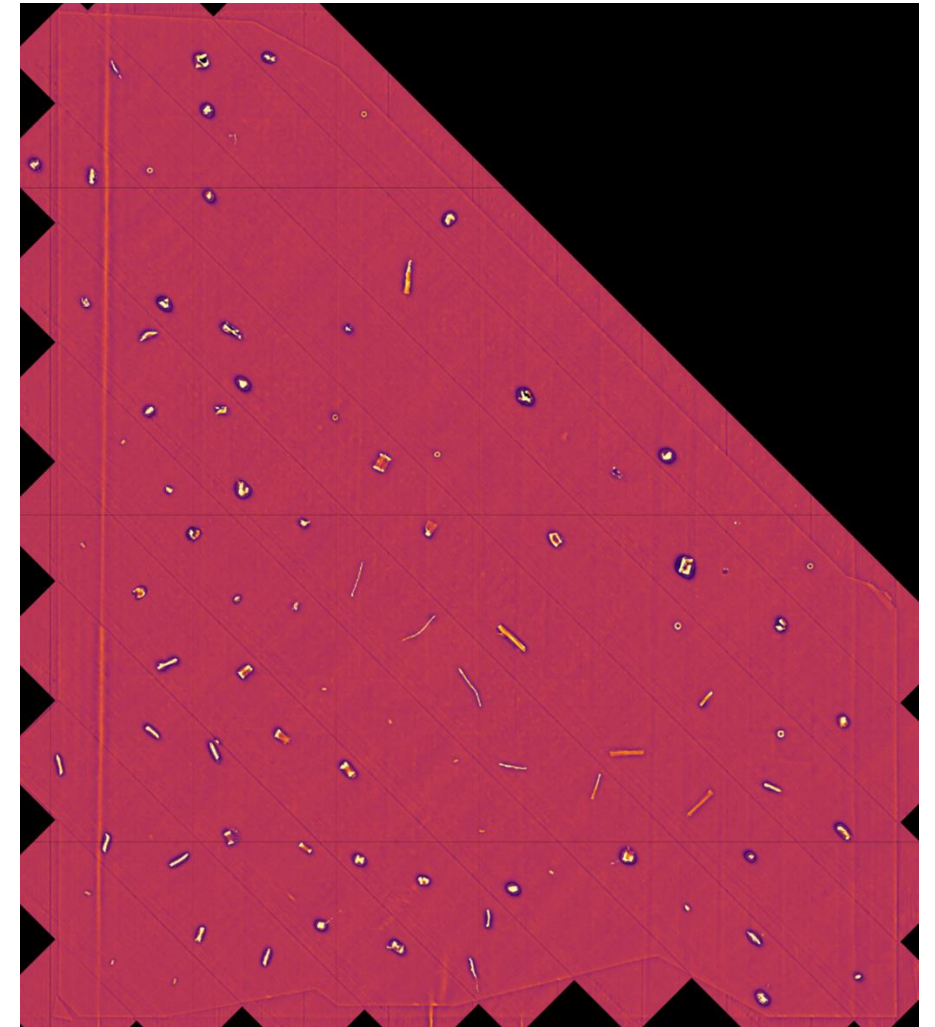
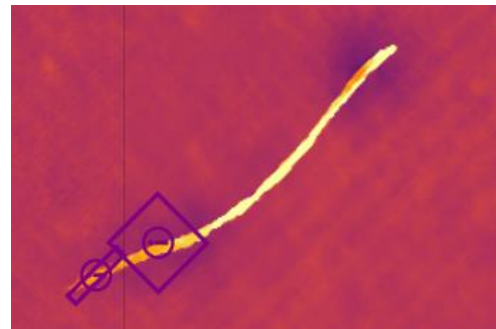
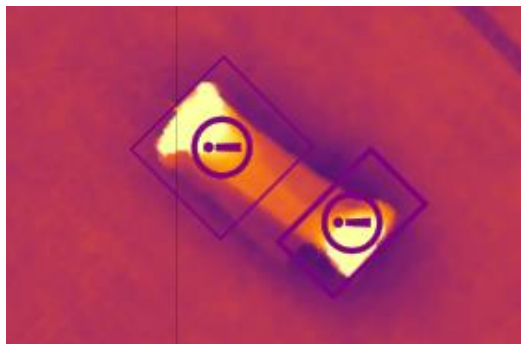


ATLIS (ATL Inspection System)

Description of the system: FOD detection

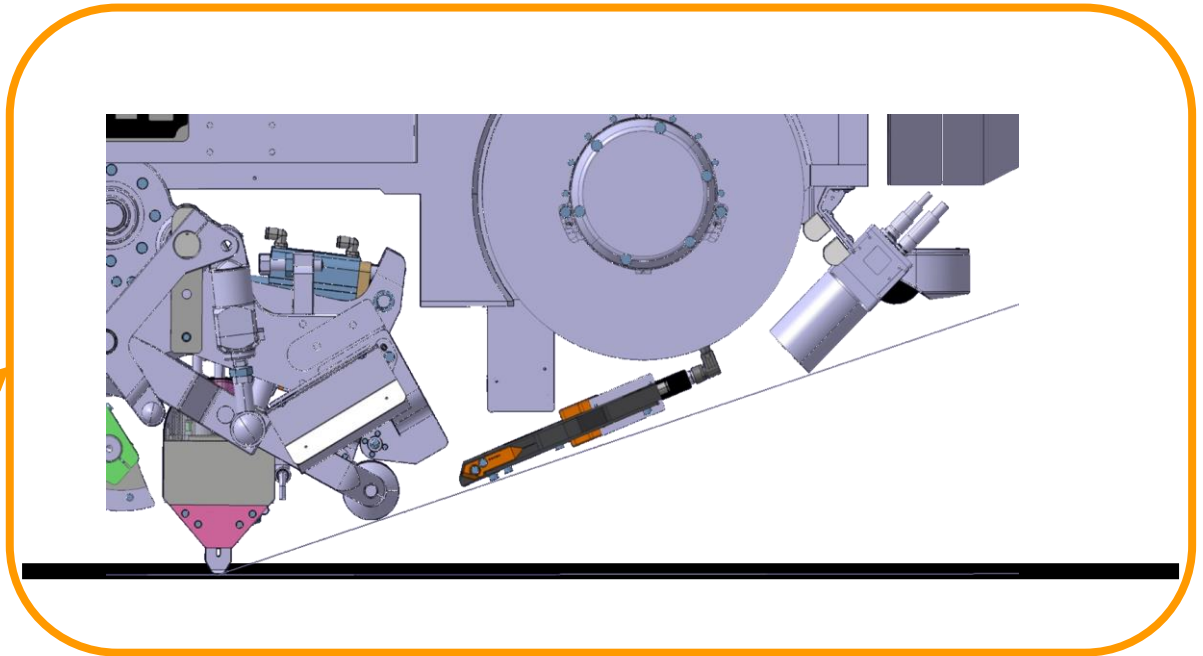
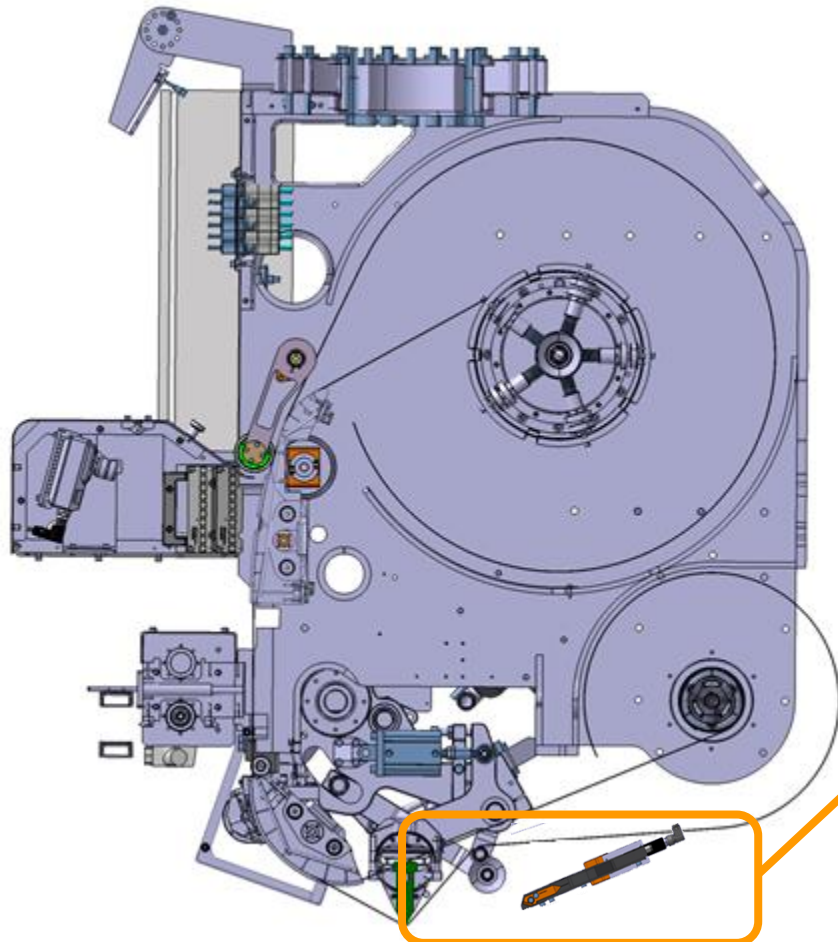
FOD

- Fuzzballs, resin, threads, backing paper
- Wrinkles



ATLIS (ATL Inspection System) ATLv2 Scenario

The hardware can be implemented as well in existing ATL heads:



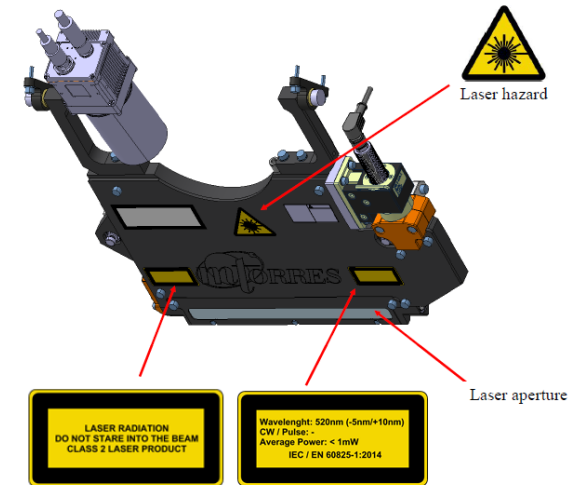
Angle reduced to 18-20°
Measurement ~280 mm after compaction roller (*)

ATLIS (ATL Inspection System)

Description of the system: Main components and location

HARDWARE

- 1 camera + 1 Laser line ~ 280 mm behind the roller (extra trajectories to be considered)
- Optical box & mirrors design
- Machine CNC modificatios
- Electronic components for electrical integration in the ATL head + Dedicated PC
- New Calibration table in layout

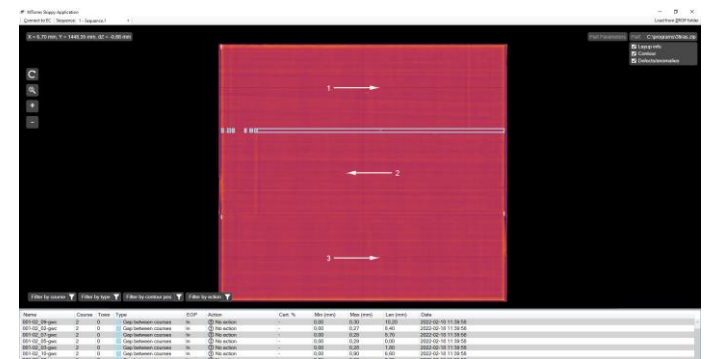


ONLINE INSPECTION NEW SOFTWARE

- OLI Server and software
- SKIPPY MAP. Defects map application to navigate the scanned part

SOFTWARE CHANGES

- Changes in Torlay Classic or new Torlay+ postprocessor to include OLI (part programs must be reprogrammed/repostprocessed)
- HMI / Execution Control software update for automatic inspection process
- CNC/PLC changes to include VR axis and manage OLI



Mtorres On-Line Inspection (OLI) Summary

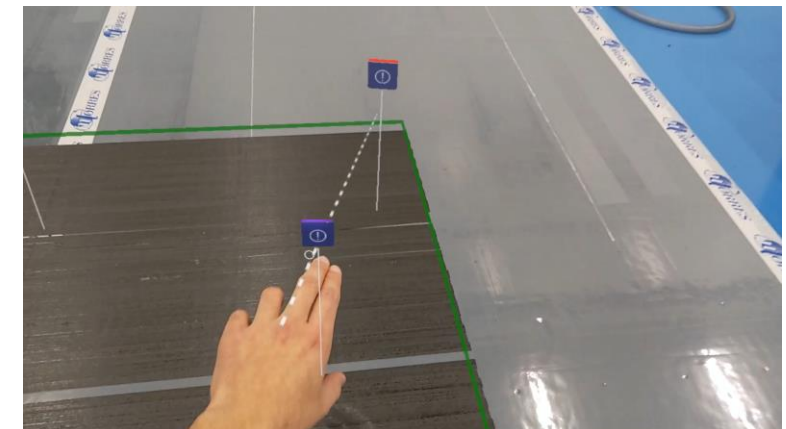


In summary OLI supports the operator in the inspection and reworking process and saves time used for inspecting, repairing and trace down quality data

- Avoiding visual inspection in carbon fiber laminates and detecting anomalies in-line with better accuracy than the human eyes
- Focusing on the anomalies detected by the system, enabling the qualification of the anomaly from the operator desk and providing the necessary tools to correctly and timely do the rework of the anomalies to be repaired (tablet with map software and connection to the laser projectors).
- Automatically collecting and saving the scanned part data for further KPIs analysis of the manufacturing process



Course	Time	Type	Name	Capacity	Min. holes (mm)	Max. holes (mm)	Length (mm)	Defect inside	Date
1	3	ADDCl	003-01_08.a6d_out	100.00 %	0.00	6.19	0.00	True	2020-10-30 11:21:10
10	12	TrueFail	003-10_03.a6d	100.00 %	0.00	233.70	0.00	True	2020-10-30 11:23:50
8	12	Anomaly/FCD-Warning	003-08_07.a6d	98.95 %	18.80	1812.80	88.00	True	2020-10-30 11:23:07
8	10-14	Anomaly/FCD-Warning	003-08_06.a6d	99.88 %	27.55	9484.00	140.40	True	2020-10-30 11:23:07
13	4-8	Anomaly/FCD-Warning	003-13_02.a6d	99.83 %	32.21	13042.00	200.00	True	2020-10-30 11:24:56
5	10-13	Anomaly/FCD-Warning	003-05_03.a6d	99.74 %	29.84	2887.80	98.10	True	2020-10-30 11:23:00
10	12	Anomaly/FCD-Warning	003-10_02.a6d	99.72 %	18.80	1812.80	88.00	True	2020-10-30 11:24:56
11	12	Anomaly/FCD-Warning	003-11_03.a6d	99.71 %	18.80	1812.80	88.00	True	2020-10-30 11:24:56
16	2-3	Anomaly/FCD-Warning	003-16_02.a6d	99.68 %	19.47	4287.68	147.00	True	2020-10-30 11:19:10



Thanks for your attention