

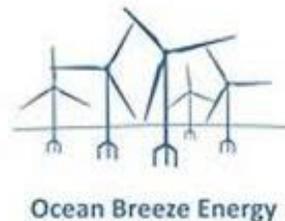
Automatic analysis and weld indications classification on TFM acquisitions

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EXTENDE
CIVA



Outline

- | CIVA Platform
- | Context
- | Advanced analysis process and automation
- | Conclusion

What is CIVA software ?

- Leading industrial software dedicated to NDE Simulation & Analysis
(more than 270 customers in 42 countries)
- Multi-techniques:

✓ UT :

- Ultrasounds Testing modelling
- UT Acquisition Data Analysis tools

✓ GWT: Guided Waves

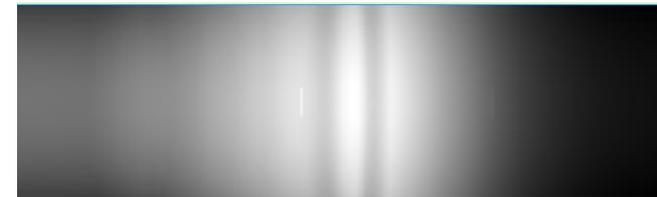
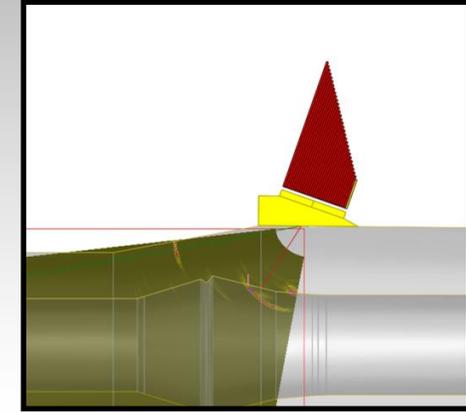
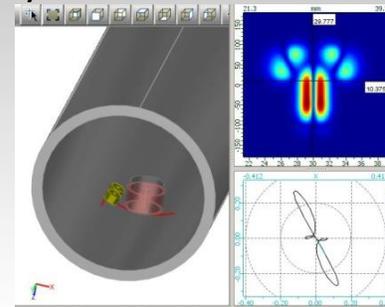
✓ ET : Eddy Current

✓ RT : Radiography

✓ CT: Computed Tomography

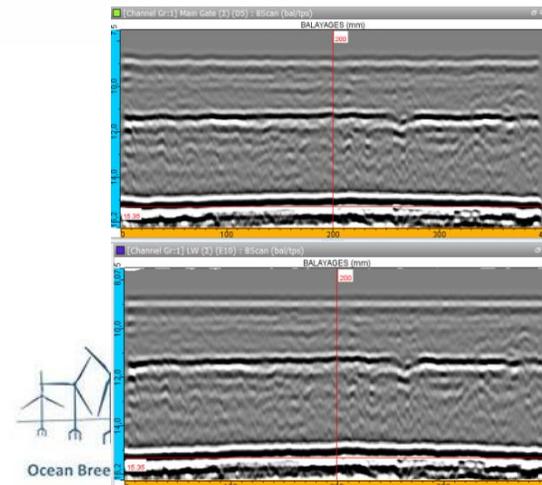
- Developed by CEA (French Atomic Energy commission):
25 years of experience with models & validations

- Distributed by EXTENDE



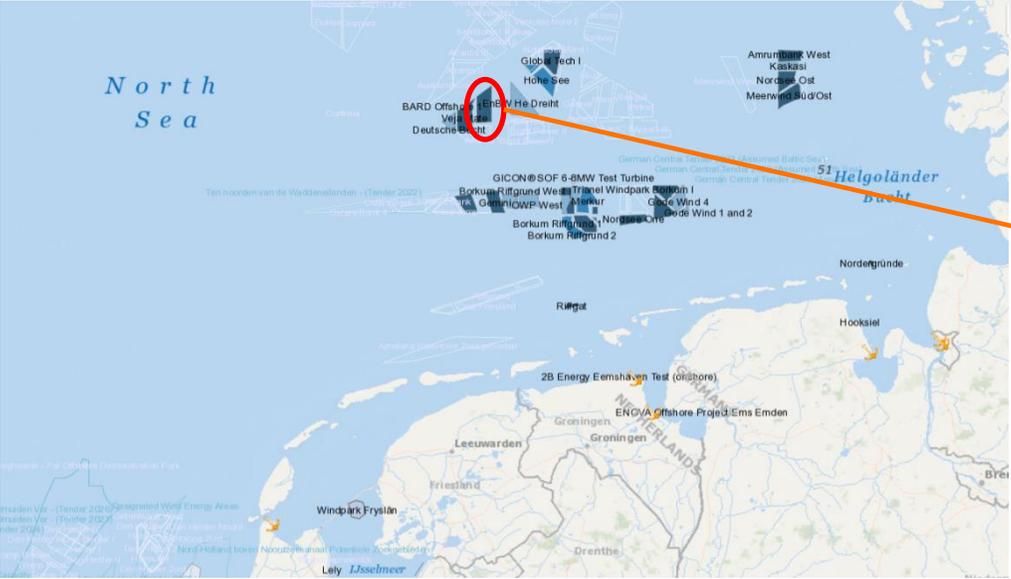
UT Data Analysis:

- A set of « 1 click Tools » for a fast and easy 3D visualization and extractions of indications from UT Data (conventional, TOFD, Phased-array)
- Advanced and Cutting-edge tools:
 - Automation of the analysis process, Segmentation, TFM, Signal Processing, Simulation on Acquisition, ...
 - Capability to customize the own analysis procedure by adjusting the color map, the layouts, synchronizing one gate to a second one...
- Allowing to open acquisition files from M2M and Olympus
- But also availability to read data acquired by other systems through the application of a development kit including a plugin for data reading



Context

Ocean Breeze Energy GmbH & Co. KG is owner and operator of the windfarm, BARD Offshore 1 (BO1), approx. 100 km off the German North Sea Coast

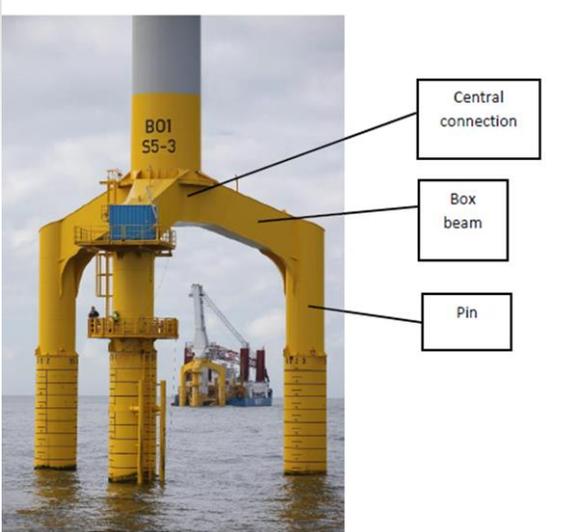


This windfarm is made up of 80 wind energy generators from the 5 megawatt class, which reaches a rated power capacity of 400 megawatts.

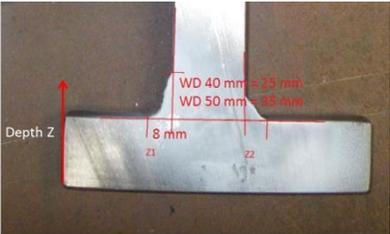
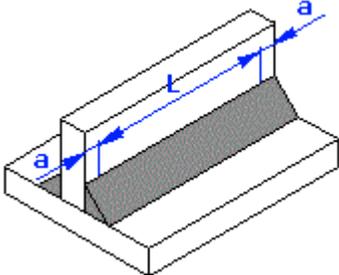


Context

Tri-pile support structure is used in the Bard offshore 1 wind farm

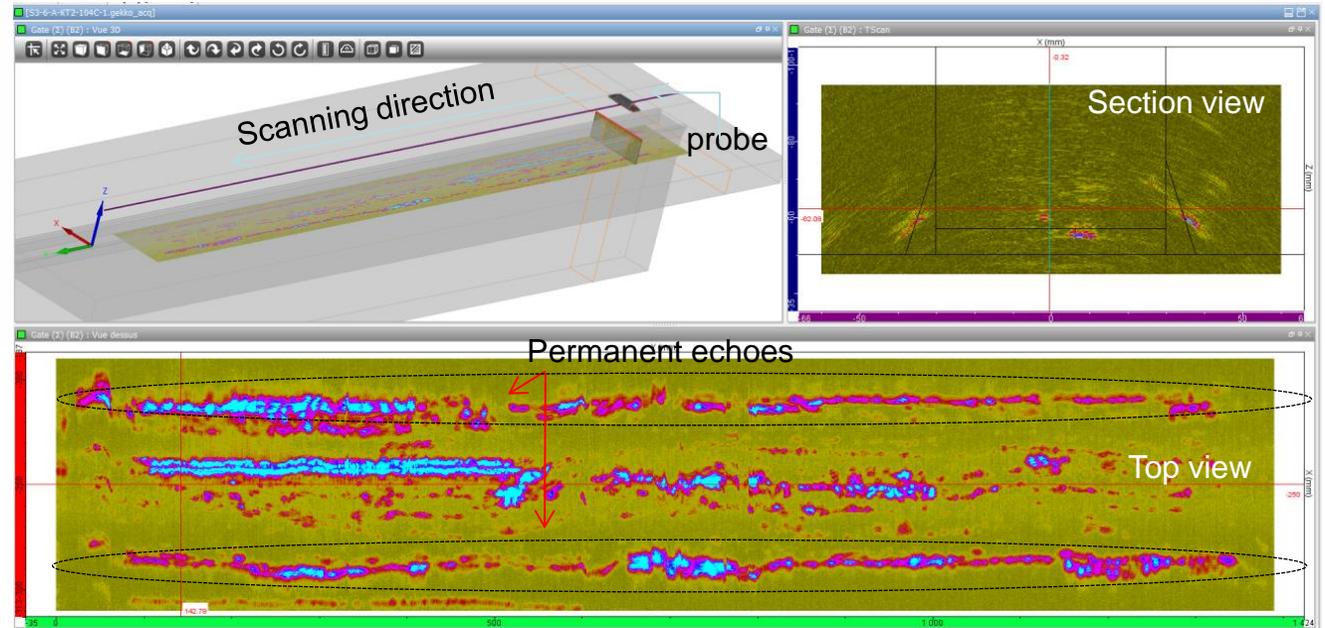


Pins, box beams and central connection are welded structures. The structure presents mostly fillet welds in T-connections and butt welds.



Context

- | NDT inspections were performed and shall be performed on cross welded beams of the BARD1 Offshore wind park
- | Part of these inspections are achieved with the Total Focusing Method ultrasonic measurement (TFM) using a Gekko system



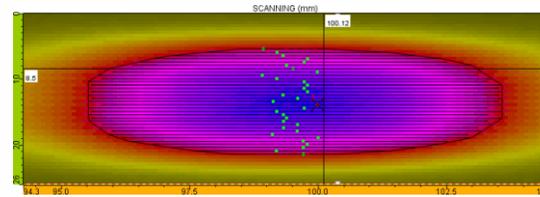
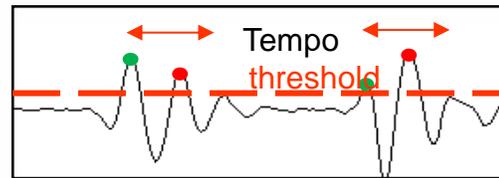
Advanced analysis process and automation

- | An huge amount of acquisition files representing approximately 7 Km of measurements must be analysed in a very short time
- | Based on algorithms and tools already available in CIVA (segmentation, table of indications, report, semi-automation of process) specific developments where achieved to fully automate the analysis of the acquisitions:
 - The automatic detection of indications in the whole data set above a given threshold, using the CIVA segmentation algorithm
 - Automatic detection of the permanent echoes generated from the weld beads
 - A geometrical classification of the indications following a given procedure provided by Ocean Breeze.
 - Grouping the indications according to given rules in the 3D dimensions
 - Extraction of a report where each indication (as well as grouped indications) is represented by an ellipsoid. The ellipsoid is defined by the three axis length and their respective orientations
 - Automation of the whole procedure.

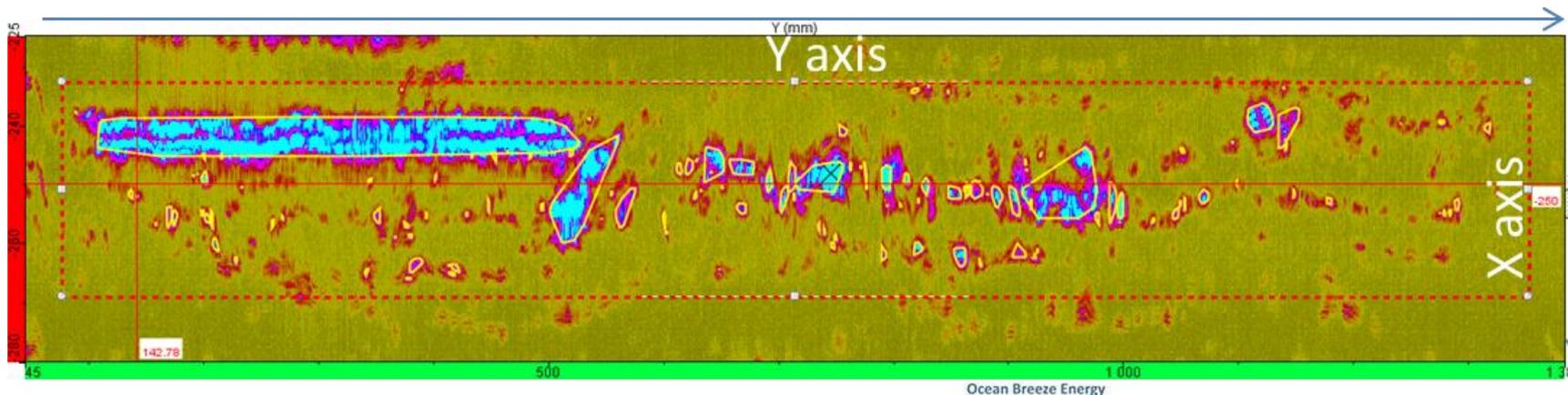


Advanced analysis process: Segmentation

- The goal of the segmentation algorithm is to group signals (echoes) that come from the same defect and to easily establish an examination report by applying filters with criteria (given threshold for CIVA to records the points (signals) that are at amplitude over this threshold, extraction of segments and grouping based on an algorithm that combines spatial and temporal criteria

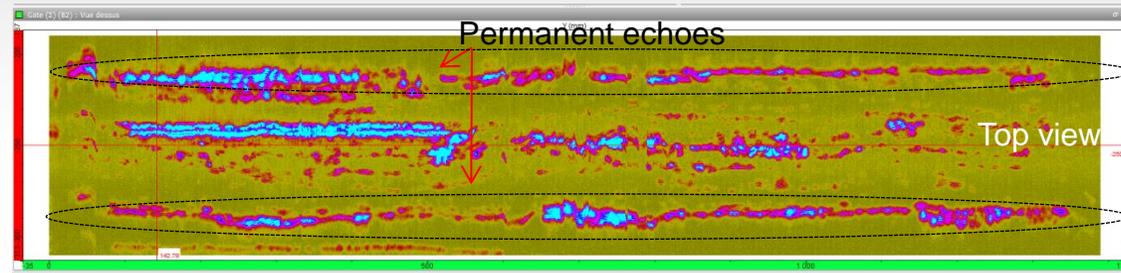


- The first step was to apply manually the segmentation on the data and ensure the relevance of the result



Advanced analysis process: Detection of the permanent echoes

important work has been performed to remove the permanent echoes coming from the weld from the analysis

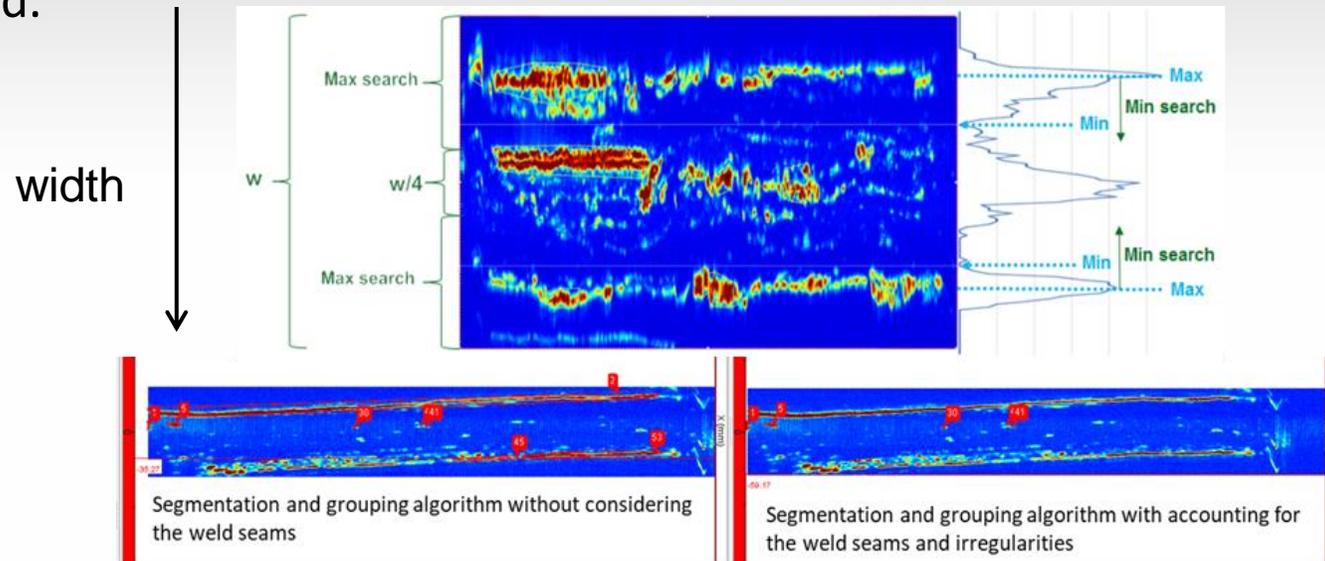


Additional parameters have been added in the algorithm:

- These parameters filter the region of interest, where the automatic analysis is applied, according to the location of the indication inside the chamfer.
- It considers the width of the part, i.e. the distance between the geometrical echoes of the two weld seams and also potential irregularities in the profiles of them as the permanent echoes are not always perfectly parallel to each other.

Advanced analysis process: Detection of the permanent echoes

- To detect the position of the chamfers, the algorithm takes as hypothesis that the acquisition system follows the weld.



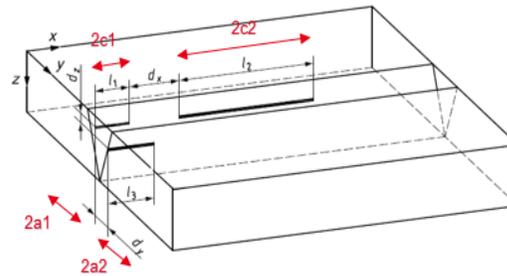
- Detection of the two max corresponding to the permanent echoes(position of the chamfers) along the width
- Then line by line detection of the minimum amplitude to size the permanent echoes along the width (to define the extension of the chamfer)
- Recording of the ROI

Advanced analysis process: Grouping of the indication

Once the relevant indications are stored thanks to the “advanced” segmentation a specific plugin groups the flaws in the X-Y plane according to FKM guidelines (*FKM Guideline, 2009. Fracture Mechanics Proof of Strength for Engineering Components. 3rd revised edition, VDMA Verlag GmbH, Frankfurt a.M)*)

For evaluation, a group of indications shall be considered as a single one if :

1. The distance d_x , is less than the length of the shorter indication ($d_x < \min(2c_1, 2c_2)$)
2. The distance d_y , is less than half the sum of the width of the two indications ($d_y < a_1 + a_2$)



- The indications are characterized by their extension at $-ndB$, X_{min} ; X_{max} ; Y_{min} ; Y_{max} ; Z_{min} ; Z_{max} (in indications table)
- For each indication we look for the neighboring flaws and check the FKM conditions. Those indications will be considered as one indication

Advanced analysis process: Grouping of the indication

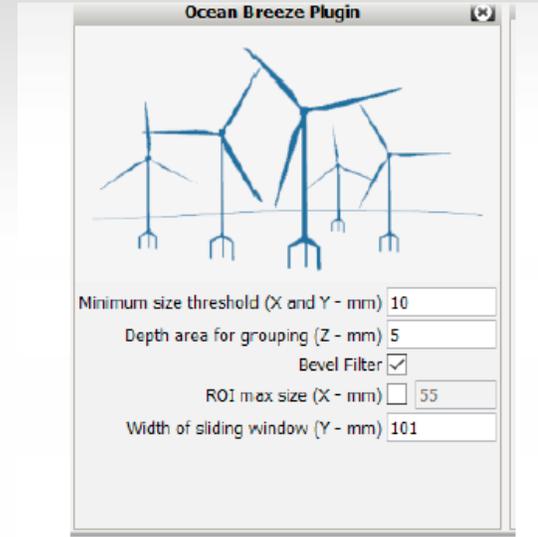
- | Region where the indication must be grouped:
 - differentiation must be done along the depth (thickness of the part): below a given Z value the FKM rules will be applied for the grouping of the indications
 - for depths higher than the give Z value all the indications will be analyzed individually and therefore the grouping rules shall not be applied
 - For example 50 mm +/- 5mm. All indications in this zone can be grouped depending on the FKM rules. Outside the indications are considered as individual and reported in the indications table.



Advanced analysis process: Automation

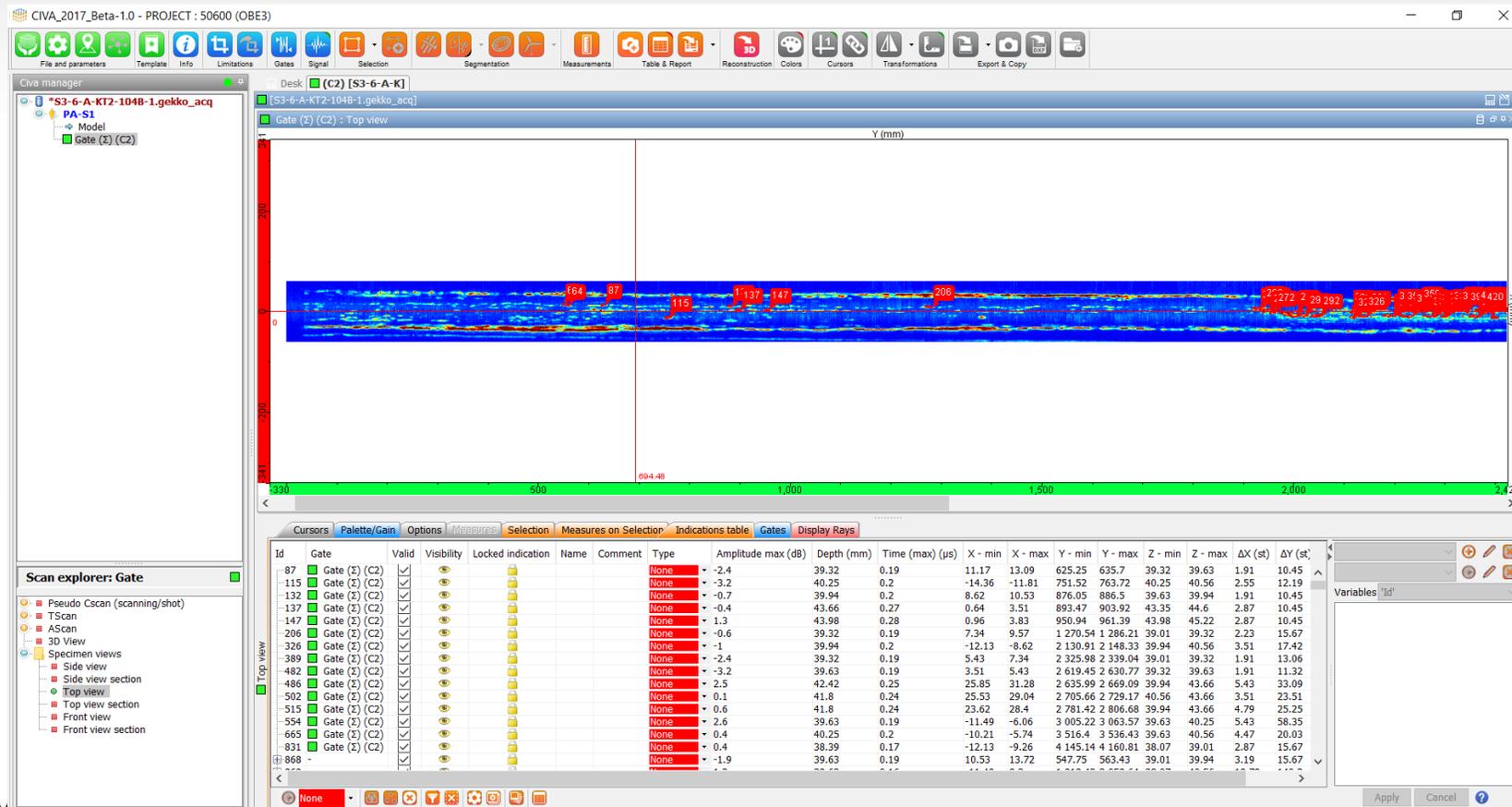
The last stage was to automate the full process:

- Perform a manual analysis on one acquisition
- Ensure that CIVA records the step by step process
- Call the different steps thanks to a template including:
 - Arrangement of the images defined by the user,
 - The definition of the region of interest and thus the scanning dimension,
 - The detection of the indication above a given threshold,
 - The grouping of the indication according to specific rules and for a given depth,
 - The extraction of the permanent weld seams echoes,
 - The extraction of the indications in the indication table.

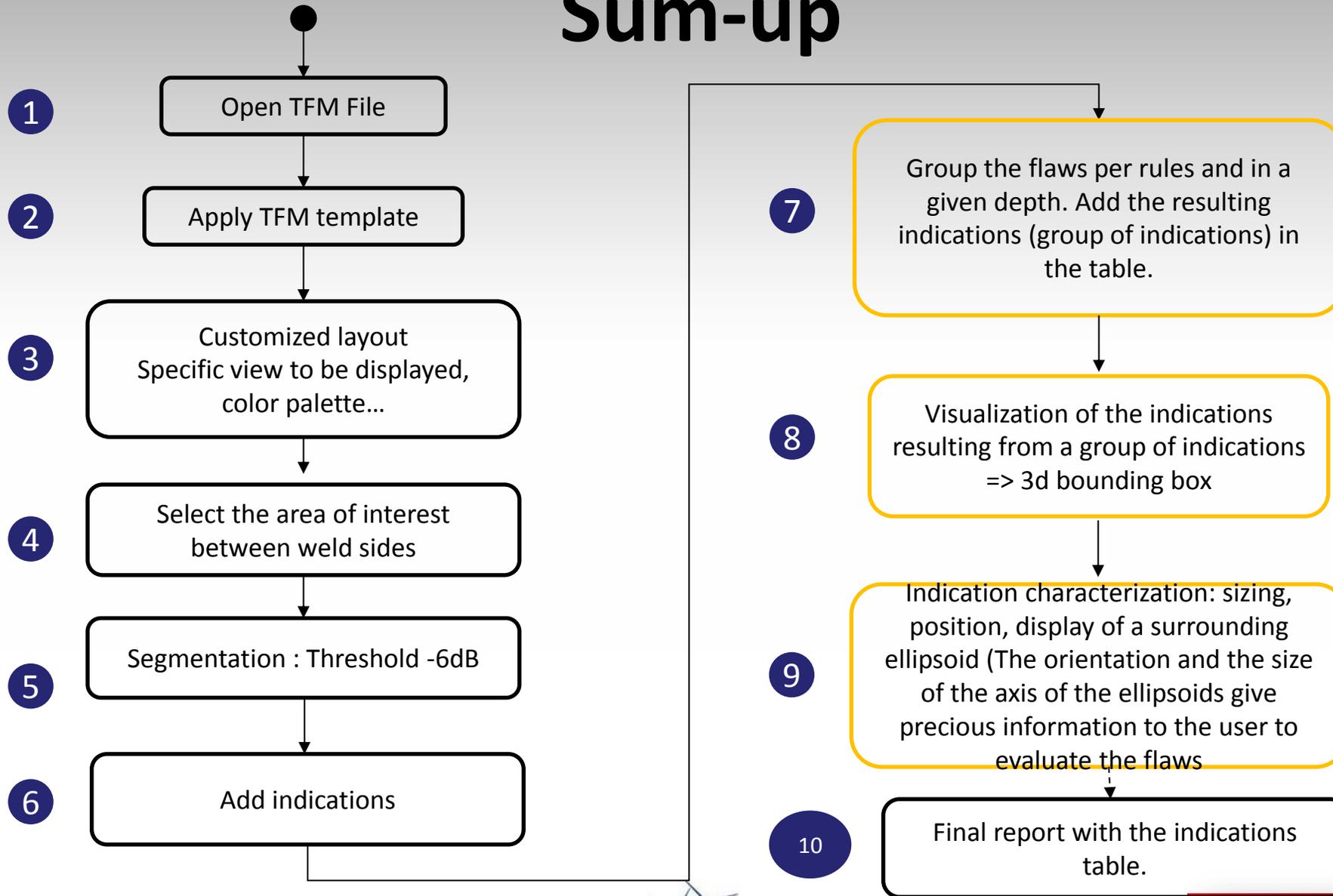


Advanced analysis process: Automation

| From
| to



Sum-up



Conclusion

- | Based on the existing analysis module available on the CIVA UT software, specific developments were achieved by the CEA through a dedicated Plug-In to fulfil OCEAN BREEZE requirements,
- | The goal was to optimize the analysis of a large amount of TFM acquisition data by obtaining an automatic detection and geometrical classification of the flaws in weld seams,
- | Practically, the post processing work for the whole park was reduced from month to days. The automatic processing part happens in hours,
- | To validate this process, manual analysis were achieved on a large amount of acquired data and compared with the automatic analysis performed by CIVA leading to a very close correlation on the number of indications, dimensions and if these indications had to be grouped or not,
- | Nowadays OCEAN BREEZE has fully automated the analysed procedure of their TFM acquisition files in CIVA drastically reducing the time for analysing every file (20s / one day).