MORPHING CAD MODELS ONTO AS-BUILT GEOMETRIES: ITER WP TEST CASE

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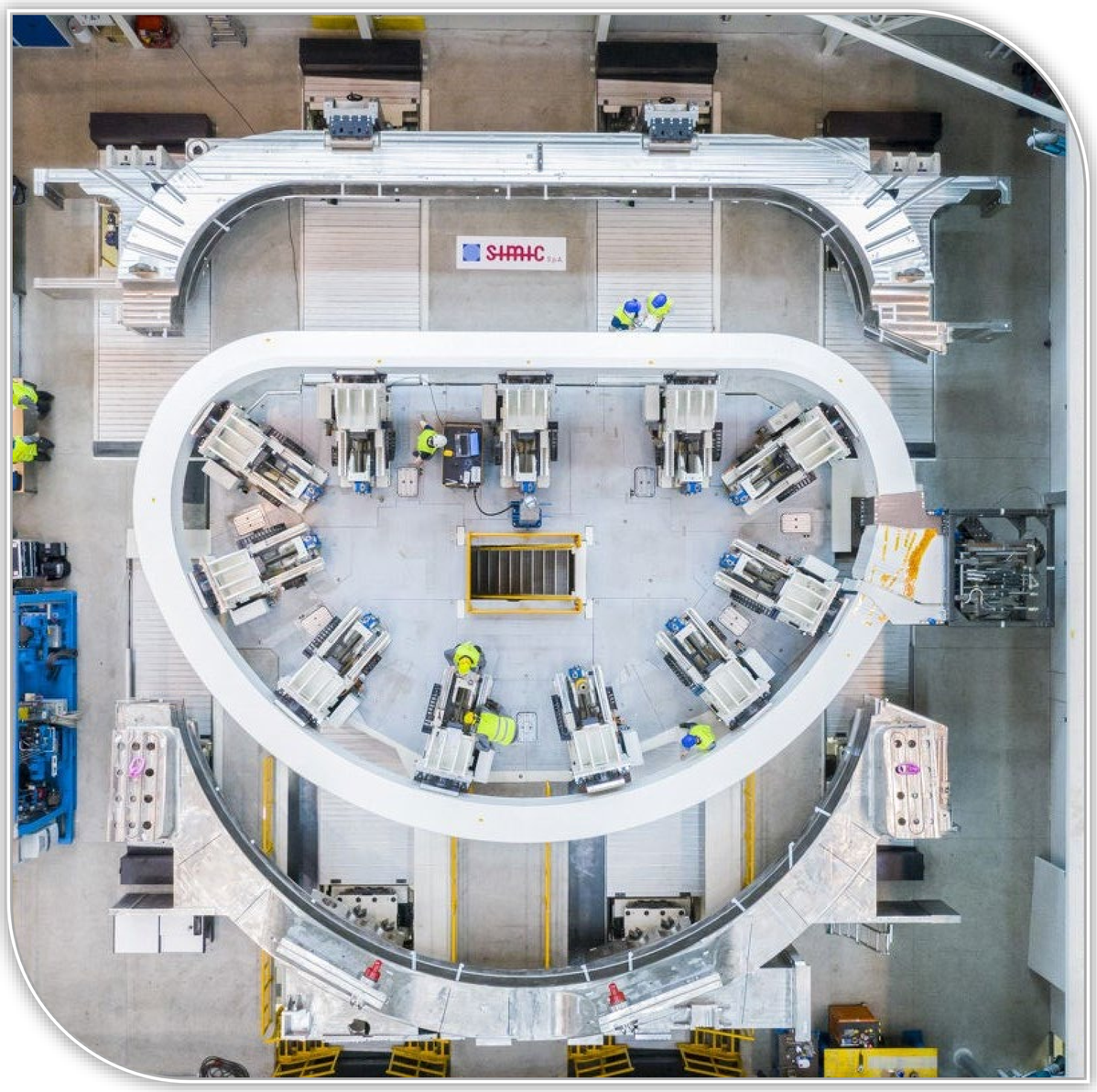
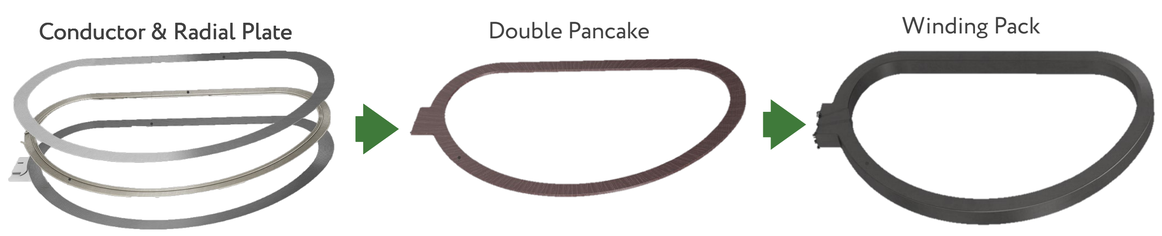
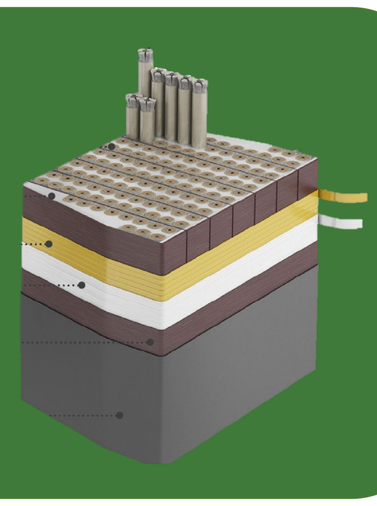


THE CHALLENGE

Digital Twin models, together with **Reverse Engineering (RE)** techniques are central elements in the integration of **design, manufacturing and maintenance** of products. The need of a digital CAD variation onto the as-built shape is particularly felt and not doable with conventional RE techniques. A new custom workflow based on Radial Basis Function morphing technique has been deployed in ANSYS Workbench and has proved to be capable to **update** of ITER Winding Pack (WP) **CAD** model on **scan data** acquired from the manufactured component. The technique is characterized by reduced computational time and capability to preserve the **original topology of the CAD model**.

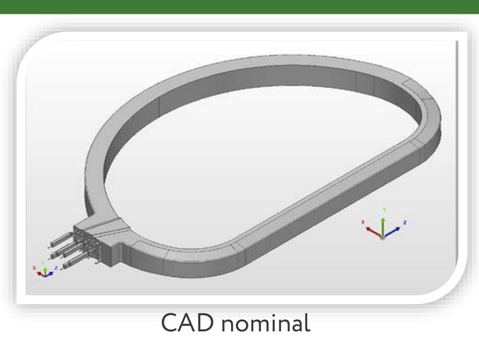


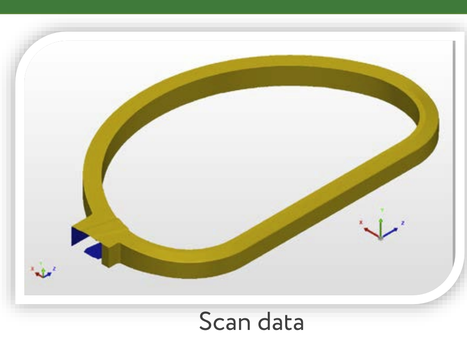
ITER **Toroidal Field Coils** are composed by a WP (Nb3Sn superconductor) enclosed into its cases (namely AU, BU U-shaped cases and AP, BP closure plates). The WP itself is formed by 750 m of conductor fitted inside the **Stainless Steel (SS) radial plate**, welded to form a **Double Pancake (DP)**. Seven DPs are stacked, electrically jointed and finally electrically insulated with glass Kapton tape to form the WP. The **optimization** of the manufacturing process, in particular the curing and thermal cycles in the DP stacking, lead to the production of WPs with reduced volumes compared to the nominal geometry.



REVERSE ENGINEERING WORKFLOW AND RESULTS

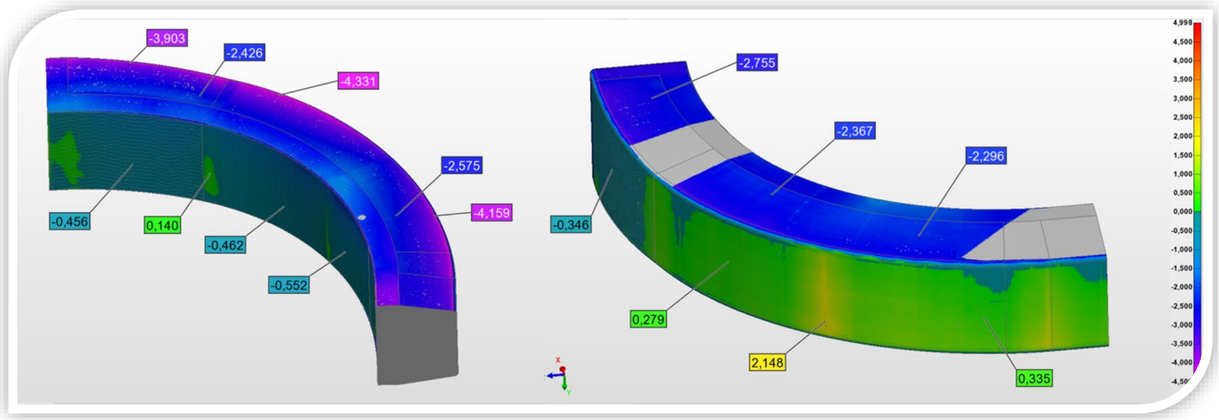
Several **dimensional checks** are carried out at the end of the WP manufacturing in order to assess and plan the TF assembly. For the generation of a Digital Twin model, high quality metrological techniques are a fundamental tools. The scan of the as-built component is performed using **laser scanning**. The STL file is composed of approximately **50M elements and 24 million points**.

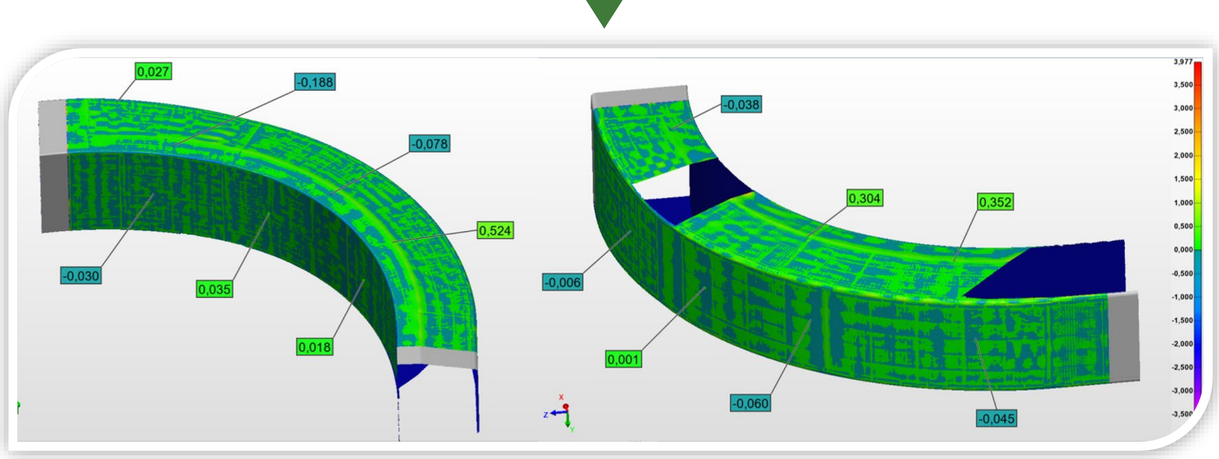

CAD nominal


Scan data

Sampling areas resolution vs. uncertainty

Resolution [mm]	Unc. at 2σ [mm]
4	0.224
1	0.210
0.4	0.197

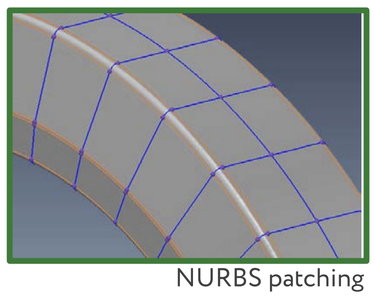


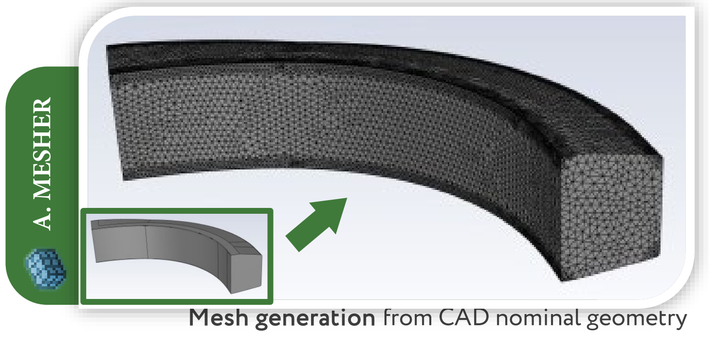


The initial **deviations of the scan data from the nominal CAD** show the optimization of the double pancakes stacking, (**2.5-4 mm on top and bottom surfaces**). The morphing and surfaces reconstruction **respected the initial CAD topology**, and adapted it onto the actual manufactured shape.

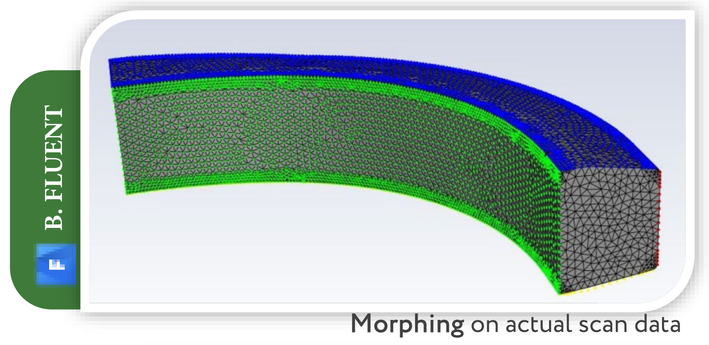
Method	Morphing	NURBS
StdDev (σ)	0.221	0.087
Pts in ±1σ	86.4%	82.4%
Pts in ±2σ	94.6%	94.9%
Pts in ±3σ	97.6%	98.2%

To give an insight into the performances of the methodology, a **comparison** with a **commercial RE Software** using Non-Uniform Rational Basis Spline (NURBS) patching method is proposed. Performance are similar but NURBS patching results in a different topology.

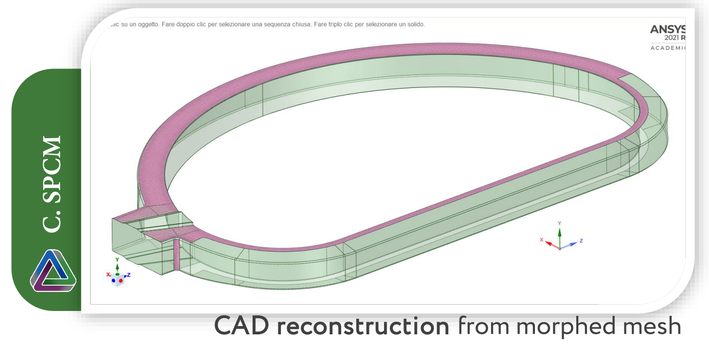

NURBS patching



Mesh generation from CAD nominal geometry



Morphing on actual scan data



CAD reconstruction from morphed mesh

CONCLUSIONS

The study demonstrated the effectiveness of the proposed procedure with very limited deviations between the target scan data and morphed CAD configuration. RBF mesh morphing confirmed to guarantee **high accuracy and flexibility** in tackling geometrical reconstruction problems providing the capability to **significantly reduce the effort** if compared to a model reconstruction procedure adopting RE software. Future applications entail the possibility of the implementation of both methodologies in an RE workflow.

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References:
[1] Porziani S & al. 2019 CAEUp - Update of CAE models on actual manufactured shapes Procedia Structural Integrity 24 775-87
[2] Biancolini M E 2018 Fast Radial Basis Functions for Engineering Applications (Springer)