We develop an innovative approach, X-MESH, to overcome a major difficulty associated with engineering analysis: we aim to provide a revolutionary way to track physical interfaces in finite element simulations using extreme deformation of the meshes. Unprecedented low computational cost, high robustness and accuracy are expected as the proposed approach is designed to avoid the pitfalls of the current methods, especially for topological changes.

The key idea of X-MESH is to allow elements to deform up to zero measure. For example, a triangle can deform to an edge or even a point. This idea is rather extreme and totally revisits the interaction between the meshing community and the computational community who, for decades, have striven to interact through beautiful meshes.

Different areas in fluid and solid mechanics as well as heat transfer are targeted. Interfaces will be either (i) material, i.e. attached to particles of matter (the interface between two immiscible fluids or the dry interface in a wetting and drying model) (ii) immaterial, i.e. migrating through the material (a solidification front, contact front, yield front in yield stress fluid flow or a crack front).

In this presentation, we will focus both on the mathematical issues related to the use of zero-measure elements and on the eXtreme mesh deformation scheme that will be used to track physical interfaces. Two applications will be targeted : phase change Stefan model and two phase flows.