This work presents a generic framework to construct trivariate isogeometric meshes of complicated geometry and arbitrary topology required for reduced order model applications. Indeed, structured meshes such as isogeometric or pure hexahedral ones are difficult to obtain in an automatic manner. Statistical shape analysis and reduced order modeling require structured and ordered data to be efficient. For that purpose, we use the triangulated solid 3D model's boundary provided from B-Rep CAD (Boundary-Representation in Computer Aided Design) models. Firstable, the workflow includes an integration of a geometry-feature-aware pants-to-cuboids decomposition algorithm. The input triangulated mesh is decomposed into a set of cuboids in two steps: pants decomposition and cuboid decomposition. Cuboid decomposition splits a surface into a set of quadrilateral patches which can define a volumetric layout of the associated boundary surface. Cross fields, i.e., 4-symmetry direction fields are used to guide a surface aligned global parameterization. Optimizing this parameterization, patches of the quadrilateral layout inherited from the cuboid decomposition are re-positioned on the surface in a way to achieve low overall distortion. The optimization process is thought to design cross fields with topological and geometrical constraints. Using the optimized cuboid decomposition, a volumetric layout is extracted. Based on the global parameterization and the structured volumetric layout previously computed, a trivariate isogeometric parameterization is deducted. Learning generalized forms of theorems in the topology field, invariant topological properties are analyzed throughout the proposed process. To finish, for different geometrical instances with the same topology but different geometries, our method allows to have the same representation: trivariate isogeometric isotopological meshes holding the same connectivity. The efficiency and the robustness of the proposed approach are illustrated through several examples of reduced order models using IGA (IsoGeometric Analysis).