The continuous drive to save weight in the aerospace industry has led to increased use of titanium alloys, particularly in jet engine components but more recently in landing gear and fuselage sections. Microstructure of complex Ti alloys is strongly dependent on applied process conditions and it determines the properties of the end product. Morphologies of primary alpha, secondary alpha and retained beta in final microstructures are the key factors governing obtained properties such as yield strength, ductility, fatigue-crack initiation resistance and fatigue-crack propagation rate. Currently, no methodology exists in the literature that allows for a direct correlation of deformation behaviour of these complex microstructures as a function of texture and morphology of the phases - especially under hot working conditions, where accelerated recovery processes take place. Undefined interrelationships between rheology, texture and morphology of phases limit possibilities of prediction of microstructure evolution of Ti alloys modeling using numerical tools. The present project aims at development of an effective and accurate way to evaluate through-scale rheological properties of main three constituents of aerospace titanium alloys microstructures: namely, primary alpha, secondary alpha and beta phases, as a function of temperature and deformation conditions. Special focus will be put on analysis of the rheology of secondary alpha phase – both lamellar and globular morphologies will be considered as the spheroidisation process of this phase is the key way to ensure high strength and ductility. In the current project, macro and micro scale plastometric tests will be developed using state-of-the-art experimental techniques and will be utilized to determine rheological properties of each phase separately. The latest material characterization techniques will be simultaneously employed to characterize local microstructure and texture, what in turn, will enable direct correlation of the local rheological data with crystallographic orientation of the analyzed grains. Additionally, computer program will be developed, that will allow automated reconstruction of the parent beta grains based on the know orientation of the inherited alpha microstructure taking advantage of the Burgers relation between the parent microstructure and transformation products. All of acquired data will provide an input for constitutive description of material models, what in turn, will allow for development of multiscale computer model where Digital Material Representation will be employed to represent various morphologies at micro scale.

Finally, developed approach will be verified using data from industry – metal forming operations of the forging process of selected aerospace landing gear and jet engine components will be simulated and quantitatively and qualitatively compared with produced forgings.