Airplanes and space vehicles contain many different moving parts that operate in a wide range of loads and movement speeds, and often in extreme environmental conditions like high and low temperatures (-100 to 900°C), high humidity or reduced pressure. These difficult operating conditions go together with extended maintenance-free time of these devices, which can be up to 30-50 years. In order to ensure failure-free operation of the equipment working in difficult operating conditions, one of methods is deposition on their components, anti-wear coatings via PVD (Physical Vapour Deposition) techniques. Among them, special attention in research laboratories is devoted to a multi-layer gradient coatings, belonging to the group of so-called functionally graded materials (FGM). These coatings have relatively the greatest potential to shape their mechanical properties, optimal due to given operating conditions. This was the main inspiration for planning a package of research tasks, the implementation of which should contribute to better knowledge about the basic mechanisms affecting the mechanical properties of functional gradient coatings deposited via PVD techniques on substrates made of titanium alloys. Gaining this knowledge is a prerequisite for the effective development of these properties.

The main research tool will be the tribological modeling (modeling concerning resistance to wear), which result will be a development of a procedure to facilitate the design of anti-wear gradient coatings, including the selection of spatial changes in the composition and/or a suitable gradient of changes in the structure, the selection of the thickness of the adhesive layer between the substrate and the coating and determination the optimal thickness of the top layer. In addition, the results will be the basis to develop guidelines for the design of coatings for specific applications.

An important research task will be the development of a form of mathematical function describing the spatial change of the FGM material parameters such as Young's modulus, yield strength, Poisson's ratio or coefficient of thermal expansion. Then, these functions will be implemented in the FEM computer models enabling to determine stress states in the selected system: substrate of titanium alloy/coating Zr/ZrC/DLC.

Independently, it will be developed computer model based on the concepts of MD (Molecular Dynamics), enabling investigation of the influence of the carbon concentration in the gradient ZrC layer of selected coating on the mechanical properties such as. Young's modulus, Poisson's ratio and Kirchhoff's modulus. Developed FEM and MD models will be used in the optimisation procedure, in which decisional criteria are linked to the functional properties of coatings such as fracture toughness, coating adhesion, wear. The package of research tasks will end by the analysis of the relationship between the structure of the substrate/FGM coating system (adhesive layer, gradient transition layer, the type and thickness of the top layer), and its anti-wear properties. Realization of the project, in addition to high cognitive value, has important practical significance in terms of developing guidelines for the design of multi-layer gradient wear resistant coatings deposited via PVD technique. This deposition technique creates opportunities for design of new concepts of advanced multi-functional materials with precisely defined properties.