In recent years, turbulent boundary layer flow control has become an important area of fluid dynamic research. The principal driver of this activity is the expectation to reduce fuel consumption and hence CO2 emissions, especially in civil aviation and in road and shipping transport. In the case of a modern airplane, friction drag amounts to about 60 percent of the total drag, while the remainder being mostly form drag. Hence, viscous drag, but also form drag remains the area of largest potential for drag reduction. A broad variety of control methods aiming at the reduction of the global drag has been introduced in the past. Most of them, however, are not efficient enough as well as not always the underlying mechanism of the effect of their action is well understood. This especially applies to the flow with possible of detachment as during the take-off conditions being the result of strong adverse pressure gradient (APG). The more so current turbulence models used in computational fluid dynamic (CFD) are still not enough adequate to effectively and efficiently optimizing devices geometry to properly predict occurring separation.

The primary aim of the project is to extend the current state of the knowledge in the field of turbulent boundary layer approaching and being separated for a wide range of Reynolds number. Such a turbulent flow is among the basic questions in contemporary fluid mechanics. In particular, the underlying mechanism of pressure gradient effect is still not well understood. It is known that the behavior of near wall region is dictated by the dynamics of flow vortical structures. Since these organized motions play key role in the production and dissipation of wall turbulence, especially the study of coherent structures contributes to the advances in flow control strategies. The particular emphasis of the project will be on the study of so-called passive methods of separation control. Except the analysis of already known methods an attempt of originally new passive method based on the recently acquired knowledge on the behaviour of vortical structures in turbulent boundary layer (TBL) will be undertaken. This especially applies to the phenomenon of large scale vortices impact on the near wall small scale voritcal structures. The project strongly relies on the results obtained in the frame of the previous research project founded by National Science Center under which an original test facility was designed to allow analysis of the attached and separated turbulent boundary layer. The aim is to study the effects of Re and APG in a wider range of those parameters to generalize the observation and to quantify the level of mutual vortex structures interaction. Explanation of their behavior will provide insight into the physics of APG flows near the separation with and without flow control and will improve its modeling.

Experimental investigations will be carried out in ITM CUT at the facility equipped with a open–circuit wind tunnel, where the turbulent boundary layer develops along the flat plate, which is almost 7000 mm long. Experimental research will be extended by numerical simulations using Large Eddy Simulation (LES) academic SAILOR code developed at Institute of Thermal Machinery. This code uses the LES method combined with the so-called immersed boundary method (IBM).

The results obtained within the project may be particularly useful in development of new flow control system and what is more important they can accelerate the scientific progress and extend the knowledge in the field of near wall flows and flows with separation. Results of the proposed research can be applied for evaluation or modification of structural designs and processes important for practical applications e.g. for aeronautics.