Application of electric or at least hybrid electric propulsion systems is the only way allowing the aviation to achieve 2050 EU Green Deal target. First attempts to use electric propulsion on aircraft models and airplanes were taken shortly after World War II, but the first significant achievements took place in seventies an eighties. Then best known research was conducted by NASA between 1993-2003. It resulted in building demonstrators of airplanes: Pathfinder, Centurion and Helios. In 2005 the boundary of continuous 24h flight was broken and soon the achievement of 48h flight was confirmed. It is believed that in the future sun powered unmanned airplanes will fly at very high altitudes for many months replacing some of geostationary satellites decreasing demand for space launches. Recently new record in solar electric flight was set by making round the world flyover with manned aircraft in 17 stages. Commercial institutions also have their achievements in this field. In 2008 Boeing made successful flight of the Hoffman Dimona motoglider equipped with fuel cells. In 2014 Airbus presented E-Fan aircraft with hybrid electric power supply. It can fly on batteries for 1 hour, but due to the hybrid power supply it can be extended up to 3.5 hours. Development of a hybrid electric regional airliner is expected in the near future. Finally Pipistrel introduced all electric airplanes to their commercial line of products. Polish research on electrically driven manned airplanes was performed so far on AOS-71 and AOS-H2 motorgliders. First of them flew for the first time in 2012 using electrical motor supplied from lithium-polymer batteries. Second one is equipped with fuel cell power source. It was rolled out this year and ground testing have begun.

However, designers of electric propelled airplanes are still facing some barriers making the use of electric propulsion in aviation difficult or even sometimes impossible to perform. One of the most important problems is insufficient information on real characteristics of components that could be used in propulsion systems. Available information usually was obtained at the sea level, whereas, the systems are to be used at high altitudes where ambient conditions are different. Creation of the flying laboratory onboard a UAV aircraft enabling the investigation of a flight altitude influence on characteristics of electrical propulsion system components (motors, lithium batteries and photovoltaic cells) is the main goal of the project. It will be inexpensive thanks to the small size and simple handling. The process of development of flying laboratory includes such tasks as: aerodynamic optimization, investigation of properties of photovoltaic cells, structural and wind tunnel testing, design of energy management system, development of measurement methods and finally assembly and flight tests of the laboratory.

Aerodynamic optimization in the proposed project will be focused on the reduction of a total drag of the wing. The wing has to be rectangular to facilitate installation of photovoltaic cells. Moreover, upper trailing parts of each wing cross-section (airfoil) have to create a flat surface in order to assure that each photovoltaic cells will be exposed to the same angle of the radiation. Therefore, total drag reduction will be possible only thanks to the modification of front and bottom parts of the airfoil which is an unique approach.

Flat upper surface of the wing should be obtained during steady horizontal flight when the wing is loaded by lift and thus deformed in order to assure the same angle of exposition to solar radiation for all photovoltaic cells. As a result, unloaded shape of the wing has to be curved in such a way that after deformation it becomes flat. Therefore, aeroelastic tailoring has to be applied to design the wing. To enable this design technique, mechanical properties of photovoltaic cells will be investigated together with the influence of the cells deformation on their photoelectric properties. Designed shape of the wing has to be copied precisely during wing manufacturing, so tooling will be designed considering the deformations of structural components during the curing of the carbon composite structure. Structural and wind tunnel testing will be performed to verify results of the design and previous analyses.

Flying laboratory will be equipped with advanced energy management system, control system with autopilot and propeller-gearbox systems to perform safe and efficient operations. Data generated in the course of the whole design and testing phase of the project will be used to simulate the mission to define the optimal strategy of climbing, depending on atmospheric conditions – wind speed in particular. First flight tests of the laboratory will be dedicated to the set-up of the autopilot to enable safe performance of the following investigation. Than propulsion system consisting of an electric motor and lithium batteries only will be investigated. Finally photovoltaic cells will be installed and high altitude flights will be attempted to collect information on the whole system and the properties of its components.