Summary

The purpose of this Thesis is two-fold: (i) developing a mathematical model of the cardiovascular system able to efficiently reproduce the human circulation behaviour of both a generic subject and specific individuals, and (ii) providing additional answers to still open questions associated to either the clinical and aerospace worlds.

A closed loop multiscale (0D-1D) mathematical model of the cardiovascular system was developed, by combining a 1D model of the systemic arterial tree, a 0D description of the microcirculation, venous return and heart-pulmonary circulation, a multiscale (0D-1D) framework of the coronary circulation, and a baroreflex model to maintain homoeostasis. By using the geometrical and mechanical properties of a healthy and young man, the resulting model was proved to properly reproduce the physiological cardiovascular behaviour, in terms of haemodynamic parameters and pressure/flow rate waveforms and mean values. The reliability of the proposed modelling solution was also tested through a patient-specific version of the general model, requiring as input data non-invasive patient-specific information only: from anthropometric and personal details (weight, height, age, sex) to common clinical measurements (time-averaged heart rate and left-ventricular contraction time - through the ECG - and beat-averaged mean/pulse brachial blood pressures - through automatic oscillometric recording). We verified that the patient-specific model is able to give accurate central blood pressure estimates for 12 specific subjects, despite it should be further tested in a larger cohort of individuals.

The model was also exploited to investigate different topics in case of atrial fibrillation and long-term microgravity exposure. In particular, we studied (i) the consequences of the sole heart rhythm variations on the systemic arterial tree in atrial fibrillation, (ii) the effects of different ventricular heart rates during atrial fibrillation on the coronary circulation performance, and (iii) the cardiovascular system response to long-duration microgravity (5/6 moths), without the application of countermeasures and with respect to a supine configuration on Earth.

Interesting insights, impossible or hard to obtain through direct experimental approaches, were gained from these studies. These latter confirm the huge potentiality of the modelling approach in responding to clinical and space medicine questions, overcoming the principal limitations of *in-vivo* studies, which are usually invasive, expensive, time-consuming, and difficult to carry out.