Hello everyone   
My name is Armen Baghdasaryan and am a student of Bachelors Degree in Aerospace Vehicle Engineering. Today I have the honor of presenting my bachelor's thesis which has been proposed by Professor Luis Manuel Perez, whom I would like to thank beforehand for the support during the development of the thesis. The thesis consists in an engineering project in the field of aeronautics, with the goal of Developing an Unmanned Aerial Vehicle with a mass actuated control system. So, let’s begin with the title and see what it specifically means:

Unmanned aerial vehicle stands for any aerial vehicle without on-board crew and sufficient autonomy. This basically means that from the ground station it should be possible to define a path and let the vehicle autonomously complete the route. Additionally, the vehicle should be able to be controlled remotely. These two requirements should be fulfilled by the flight control system. That's related to the second part of the title. Normally conventional aircrafts use the deflection of ailerons, elevator and rudder for the flight control. However, the mass-actuated control system which is the main topic of this thesis, is a substitute of this conventional solution. This means that the vehicle should have no aerodynamic control surfaces as those mentioned before. Instead, a system of movable masses will be used for the flight control.

Regarding the Why of such a project, there are few reasons:   
First, unmanned aerial vehicles are one of the fields of aerospace engineering that have had quite considerable growth during the last decades and they continue capturing the attention of thousands.   
On the other hand, the conventional solution (using the deflection of those control surfaces) has some drawbacks, such as maintenance and structural integrity. This is due to the fact that this approach involves a complex mechanical design. Additionally, most of those surfaces require hydraulic actuators or servos in smaller airplanes, which use to be quite expensive. Furthermore, the deflection itself normally causes loss of performance, due to the high drag during maneuvers. So, the proposed solution aims to fix those issues.

At first place and based on the requirements the project scope has been defined with the goal of understanding and identifying the level of depth of the. This normally helps to have a general view of the project and to make sure that all the requirements are covered at the end. Within the scope there was the aerodynamic design of the vehicle, thus including airfoil selection, wing plan-form design and numerical simulations. As part of the structural design of the vehicle, analytical calculations of the cross section of the most critical components should have been done. combined with numerical simulations. A propulsion system should be selected, and for this purpose the required power should be determined for different conditions. A motor and a propeller should have been selected accordingly. Furthermore, the vehicle necessary systems should be discussed and selected according to the normative and requirements. Numerical simulations require a 3D representation of the prototype. Thus a computer aided design of the model should have been done, which would also be used for blueprints. Finally, and most importantly, the vehicle flight dynamics should have been studied, including the control system design, algorithms implementation and simulations.

Then, a list of task has been defined and a Gantt diagram has been obtained, which has been followed during the project development. This helped to keep the work organized, to be focused on specific tasks and to increase productivity. In overall and considering some difficulties, I would consider the project successful from the project management point of view.

So now lets discuss the technical aspects of the project and see what has been done and what has been achieved.

Well, first of all a tailless aircraft configuration has been selected, also known as a flying wing. It is reasonable to understand that without the elevator a tail was not going to provide any substantial benefit to counter some drawbacks such as more induced drag and more weight. It could only, help with the trimmed condition.

To define a preliminary model, its weight and wingspan a brief research has been done considering existing models.

It is important to note that there exist a well defined difference between flying wing and conventional airplanes when it comes to static stability and equilibrium. Conventional airplanes compensatye any lift and moment increment with the elevator deflection. Flying wings, on the other hand, have more restriction on the placement of the center of gravity. This means that xcg should be in front of the neutral point, so the lift increment naturally will reduce the angle of attack and thus decreasing lift. However, this is not enough and the flying wing should also have some combination of swept angle, twist distribution anjd adequate airfoils. That’s the main reason why s-shape airfoils have been used, which in contrast to the conventiona, airfoils have s.shape and are called reflexed, and offer positive pitching moment coefficient. Basically this helps to nose up until the required lift is obtained and equilibrium is achieved. Also a blended-wing body design has been used which increseas the lift distribution in the root sections. Also different airfoils have been used throughout the wingspan, depending on the required thickness and bulk. The design swept angle is kept low in order to not increment the induced drag. XFLR 5 and CFD have been used for numerical simulations. Finally aerodynamic polar curves have been obtained, lift drag efficiency and pitching moment versus alpha for different xcg positions.

Planform and twist distrib have been calculated according to …

Xflr analysis, … cfd analysis,…

As of the structural design, loads have been defined considering a simplified weight distribution and the lift distribution obtained from the xflr simulation. Prior to this, the flight envelope diagram has been defined, according to the normative CS-VLA. From loads diagram shear and bending moment diagrms have been obtained, which later were used for analtial calculations of the cross section. At the end and when CAD model has been prepared, numericval simulations have been done, with satisfying results regarding the defletion and stress values.

System components have been chosen according to the project requirements and the normative. Systems components are composed of different subsystems dedicated to communication, navigation, control, etc. Components selection has been done based on a research in the market and considering weight limitations.

Regarding the propulsion system, the required power has been calculated at first place. It is important to note that take-off is supposed to be done from a launching platform, with a pneumatic catapult. However, it is not restricted to it, meaning, that the power calculation has been done for take-off and the motor has been chosen accordingly. The required power has been calculated by the momentum theorem. Special emphasis has been done to the propeller selection, where different methods have been used for the efficiency calculation, including momentum theory, simplified blade element method and advanced bem with inflow factors. The latest has shown the best accuracy when compared with the experimental data provided by the manufacturer. According to the geometry and the efficiency, a propeller has been chosen from the APC manufacturer.

About flight mechanic:

System design – components:

The control system on longitinal and lateral axis has been decided to be separated. The longitudinal system is ths .. .consists of …. And does this.

On he othe hand the lateral system includes this, and Is this…

For mienrtia tensor calculation catia has ben used, Basically, the center of gravity has been changed displacing both sistems and registering inertial propertie provided by the software. This steps have been done for a range of x and y values. Afterwards, their relativonship has been studied separately and a tendency function has been assigned. This heuristic functions helpt to calculate approximately the inertia at a given instant, based on the xcg ycg. This approach is fast computation wise, in comparison to creating a database with all the combination and searching a pattern. Also it makes analytical calculations and verification easier.ñ

The center oif gravity calculation based on the components position has been quyite straightforward. ..

Then, the relationship has been tiudied between forces and the contro system. Basically for the long control system the changes are due to the pitching momemn vs alpha slope variation. It is possible tlo see that for different xcg positions there is a possible angle of attack for equilibrium, highr than the cruise angle of attack.

On the latecontrol syust, the changes are due to lift distribution on bo9th sides of the center of grtavity. Thus, it is possible to see that when the ycg is changed, the aircraft can not achieve equilibrium and the bank angle wil be increasing more and moree… That’s the reason why tbaank turned should not be done at a ctant bank angle, but incremental bank angle.

Inertia calculation  
centr of gravity calculation  
model for derivative – long and lat ---- moment pitching and rolling

Discuss algorithm

Discuss analysis – show animation