Airborne launch system for delivery of small payload to low earth orbit

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Abstract:

A payload can be delivered into orbit by using a space rocket launched from the ground, but that is not the only possible solution. For instance, low Earth orbits can be reached using airborne launch systems. But such flights are associated with a payload weight limits and the use a traditional space rocket allows for the delivery of heavier payload. Nevertheless this type of solution can be an opportunity for a low-cost space launch for example in case of research carried out by universities. Moreover it is a chance to access the space in case of countries or stakeholders without the space launch complex in their disposal.

This paper considers of two possible concepts of the airborne launch system. The first project consists in utilizing a retired supersonic aircraft like MIG-29 or Su-22 to adjust them to carry a rocket with small satellite payloads to LEO (Low Earth Orbit). The project verified and evaluated mission profile and rocket separation manoeuvre concepts. Additionally, it was supplemented by simulations and wind tunnel tests verifying the impact of applied space rockets on the aerodynamic and mechanical properties of the carrying aircraft. Results indicated that the impact of the attached space-rocket on the aerodynamic characteristics and in-flight characteristics of the aircraft is not significantly large. Similarly, the load and strength analysis conducted on the internal structures revealed no discernible changes or deformations caused by additional mass forces from the added rockets [2].

The second project assumes adaptation of the rocket plane originally developed for suborbital space tourist flights [1] and [3]. The rocket plane is going to be converted into unmanned vehicle which carries inside a small rocket that delivers a payload into an orbit [2]. The rocket plane is lifted by a carrier aircraft above the most dense part of the atmosphere.

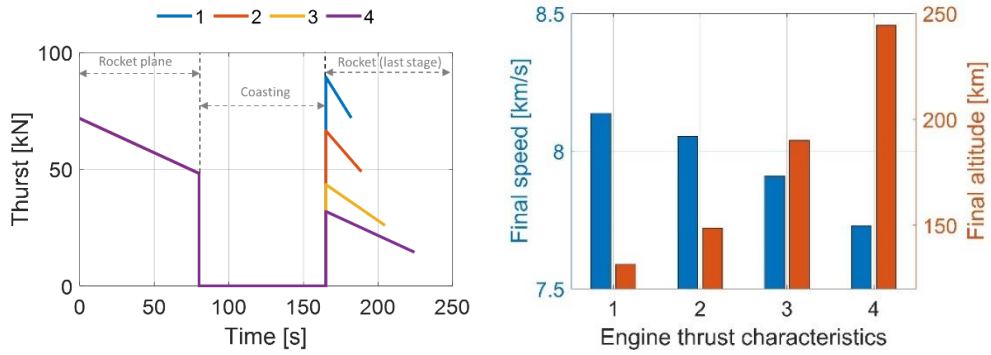

Figure 1 Results of engine characteristics impact on flight parameters in case of payload mass of 30kg carry by the rocket released by the rocket plane. Plot on the left shows different engines characteristics while the plot on the right shows corresponding final flight parameters.

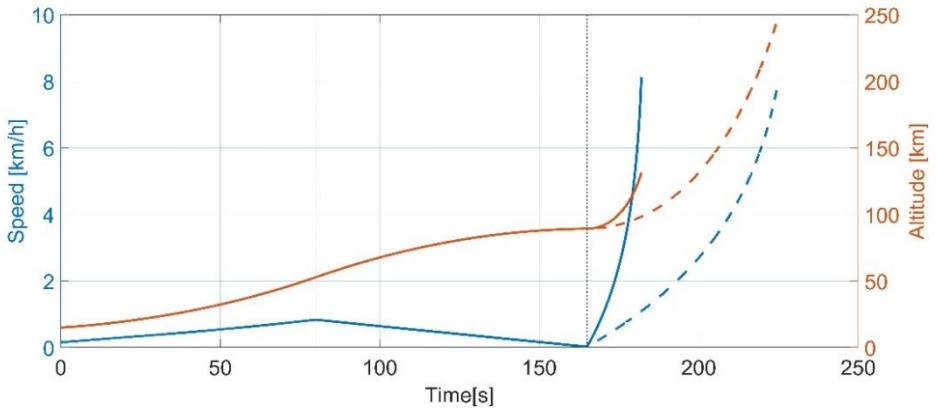

Figure 2 The comparison of the speed and altitude versus time in case of different engine characteristics implemented in the rocket released by the rocket plane at 160s. The solid line represents case 1 where dash line represents case 4.

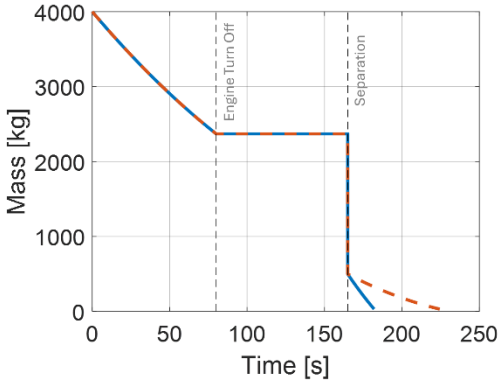

Figure 3 The comparison of the mass change in case of different engine characteristics implemented in the rocket released by the rocket plane at 160s. The solid line represents case 1 where dash line represents case 4.

Exemplary results acquired by the Simulink simulations for the rocket plane concept are presented in Figure 1, Figure 2, and Figure 3. The mathematical model implemented in the Simulink taking into account a simple engine thrust model, statistical mass model as well as aerodynamic data. Due to preliminary stage of this study simplifications as neglecting the losses due to control and Earth's rotation were assumed. For the presented set of results, the masses of the payload and propellant are the same but the engine characteristics of the rocket differ. The flight parameters before the rocket separation are the same, but the impact of the second stage engine thrust on final parameters of the flight can be observed.

This paper outlines sensitivity analysis for different mission profiles as well as payloads and propellant mass. Using a simple mathematical model allowed for robust analysis of many scenarios.

References

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