An investigation into directional characteristics of the rocket plane in a tailless configuration

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Abstract:

The suborbital flights can be a cheaper alternative for orbital space flights. For a such kind of flight, multiple applications can be listed [1] and [2], including educational purposes and improving products' TRL level. While manned suborbital flights can be an opportunity for people who were not trained as professional astronauts but would like to visit the outer space as a tourist. The booster for the development of the concept of reusable suborbital vehicles to commercial space tourist flights was the Ansary X-Prize competition that was won in 2004 by the Tier One Project (Space Ship One rocket plane and White Knight mother plane). The first suborbital flight with a customer on-board is planned on the 20th of July 2021 using the New Shepard (Blue Origin) spacecraft. A fully crewed flight above 50 miles was performed on 11th of July 2021 by the Virgin Galactic VSS Unity rocket plane, with the founder Richard Branson and the company vice president Sirisha Bandla on-board. Also, the Virgin Galactic's licence issued by FAA for commercial space flights was expanded to fly customers. Those events indicating that the era of suborbital manned commercial flights is just about to begin.

The paper embraces result of wind tunnel tests of a rocket plane [3] designed to space tourism application. The research was carried out in the subsonic closed circuit wind tunnel with an open test section, located at Faculty of Power and Aeronautical Engineering, Warsaw University of Technology.

Figure 1 Layout of the Modular Airplane System (MAS)

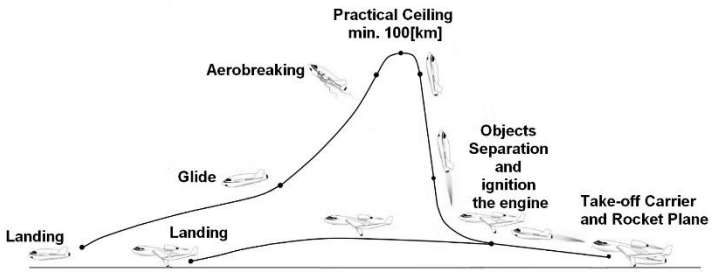

Figure 2 Mission profile of the MAS

The rocket plane is part of a Modular Airplane System (MAS) which consists of two vehicles in tailless configuration – the rocket plane and a mother plane [3] and [6]. While both vehicles are connected then creating the aircraft in a conventional configuration; the rocket plane takes over the role of the MAS empennage, Figure 1. The MAS is designed to suborbital commercial flights above the Karman Line (100 km above SL, Figure 2). The unique features of this concept that distinguish it from exiting

vehicles are the mentioned configuration of using two tailless vehicles which creating a conventional configuration of the aircraft. A leading edge extension (LEX) which is implemented for the rocket plane to increase the generated aerodynamic force (by utilized of the vortex lift phenomenon) to help reduce the sink rate during the return phase [4]. And the side plates that are part of the control surfaces. In general, the concept of the rocket plane assumes two kinds of control surfaces the elevons located on the wing and the side plates which are going to work as an all moving tail (Figure 3).

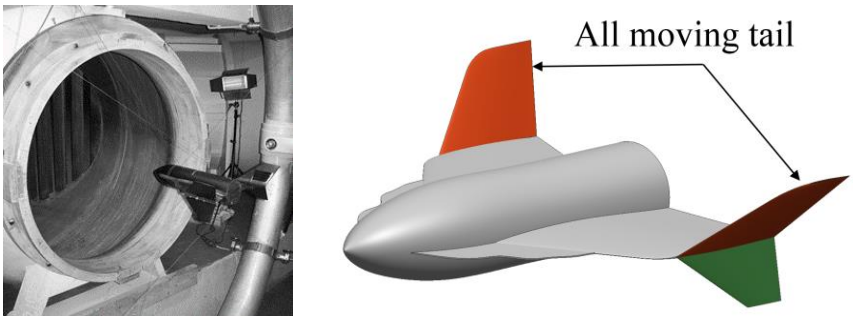

Figure 3 The rocket plane model inside of the wind tunnel (left). Side plates utilized as the all moving tail (right)

The concept of the all moving tail is not a new idea but due to a primarily military applications of a such design widely available literature in this area is limited. Especially there is a lack of papers about the design guidelines for this kind of control surface arrangement. Examples of aircraft which are equipped with this type of the control surfaces are F14, F16, F18, MIG 29, and MIG 35. All those aircrafts using as control surfaces the all moving tail and a classical rudder. The movable surfaces are position in a horizontal direction while in the considered concept there is no classical rudder, and the movable surfaces are mounted with a significant dihedral angle.

The first research question is to investigate how the configuration of the side plate affects the directional stability of the rocket plane. The second aim is to study the efficiency of the side plates deflected like an all moving tail for both low and high angles of attack. As a result of this investigation, the directional stability derivatives and the control derivatives were obtained. Both experimental and numerical methods were utilized to carry out this investigation.

Reference

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