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Aircraft Based Rocket Launch

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ABSTRACT

Rocket launches are risky, expensive and statistically more likely to fail as compared to a conventional aircraft take-off. Additionally, a larger amount of energy is needed, primarily in the lower troposphere, to propel the rocket upwards[1].
It was theorized that if a rocket is launched above the earth's troposphere, the amount of fuel and subsequently the size of the rocket would be reduced by a significant margin. This report aims to explore, and also provide a basic understanding on, the methods that are currently implemented in *aircraft based rocket launching systems*.

1 History

Military conflict is an excellent catalyst for development in the aeronautical field. In 1941, a feasibility test was carried out in Germany, to air launch the V1 using a bomber. It was a crude attempt to increase the effectiveness of the V1. The concept never entered the realms of reality, planting a seed which would then be nurtured by the world in the future. In the mid 1950s, the need to better understand the aerodynamics at supersonic speeds gained momentum; it was envisioned that the tests be carried out in the upper reaches of the Stratosphere. In order to accomplish that, aircraft-based launch systems were developed, such as the famous X-1.
An aircraft would carry the test vehicle to the launch altitude. Subsequently, the vehicle propelled itself using rocket motors. This concept bore results not only in the realms of experimental studies, but also delivered practical results such as air-to-air missiles.

2 Engineering Aspects

Decades of launches from various platforms have resulted in a detailed paradigm for aircraft-based rocket launches. The predominant factor being, the aircraft be capable of carrying the test vehicle to the desired altitude - with minimum structural wear and tear due to aerodynamic forces.

The most successful launch platforms , the Boeing NB-52(NASA) and the Boeing 747 (Virgin Aerospace), have a couple of things in common - a high aspect wing and high-bypass turbofans - that enable the aircraft to carry a range of payloads to the desired altitudes[2][3].

Fig. 1 Pegasus Rocket being launched from a Boeing 747

During the mid-2000's a new application to the concept was envisioned, a low-cost way to insert satellites into the low Earth orbit (LEO). Virgin Galactic's LauncherOne was designed to insert "SmallSats" in the LEO at a fraction of the cost of traditional rockets. Contemporary developments in the field focus on increasing the payload carrying capacity while developments in material science, engine technology, autonomous systems, and avionics suites have further economized the operation[4][5].
Scaled Composites Model 351 Stratolaunch (fig 2)

Fig. 2 Scaled Composites Model 351 Stratolaunch during maiden flight[6]

embodies these developments in a much wider scale. It has been designed in a twin fuselage configuration, which lets it carry payloads of up to 250 000 kg. Boasting the longest wingspan among all aircraft, it will emerge as a direct competition to the conventional systems in operation[6].

Exploring space has been a childhood dream for many individuals. A business model was developed, utilising aircraft-based rocket systems, to simulate the experience of space travel. A suborbital flight would provide these experiences to customers.

3 Pros and Cons

3.1 Pros

The primary advantage is the reduced amount of thrust needed by the rocket - as the atmosphere is less dense - which in turn reduces the amount of fuel required, as the delta V requirements are lower[7].

The system could chase orbits and achieve the desirable launch azimuth without out-of-plane orbital manoeuvres.

Launch can occur on demand during contingencies.

Rockets can be smaller, and carry a bigger payload.

Launch can be conducted at an inclination, independent of the weather effects.

Nozzles can be designed for low ambient pressures, and therefore don't have to deal with over-expanded/under-expanded conditions at exhaust.

3.2 Cons

The payload is limited by the size and load carrying capacity of the launching aircraft. The payload might also be damaged by the lateral forces generated by the aircraft[8].

Additional parameters that need to be taken under consideration are the time to launch, proximity to the launcher aircraft during the launch and its inclination. Launchers should be designed to withstand, and more importantly recover from, the abrupt forces that arise from the launch and should also be equipped to quickly manoeuvre away from the launch site.

Another aspect to consider, is the effective mode of separation between the launch vehicle from the carrier aircraft. Even the slightest deviation induced, could majorly affect the launch vehicle trajectory.

While it can be argued that launching from the equator - at a 0°inclination - is possible, it is not always feasible for the launcher to carry the rocket to that point. Hence the inclination, and thereby the power needed by the projectile to escape the Earth's atmosphere should also be considered.

4 Conclusion

Contemporary methods of air launch are currently limited to projectiles and low Earth satellites; there exists a scope for further improvement.

Keeping present day developments in focus, a reduction in the size of the launch vehicle, and thereby its weight, can be envisioned. Subsequently, with operations becoming more economically feasible and simultaneous improvements in Aerospace Technology, the ability to launch heavier payloads can be expected.

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