OPEN ACCESS Freely available online

Journal of Defense Management

ISSN: 2167-0374

Research Article

Landing the Booster Using Parachute

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ABSTRACT

This Paper involves designing, testing, construction and launching of rocket. The high cost of rocket technology has led to system reusability developments, particularly in the field of first stage rockets. With the motivation of decreasing production costs, successful vertical rocket landing attempts by Space X and Blue Origin have led the path for autonomous recovery and reusability of rocket engines. Landing an autonomous spacecraft or rocket is very challenging, and landing one with precision close to a prescribed target even more so. Precision landing has the potential to improve exploration of our solar system, and to enable rockets that can be refuelled and reused like an airplane. This paper aims to develop a vertical rocket landing simulation by parachute and reverse thrust methods. This paper will discuss the challenges of precision landing, recent advances that enabled precision landing on Earth for commercial reusable rockets, and what is required to extend this to landing on planet.

Keywords: Parachute; Landing booster; Rocket; Trajectory

INTRODUCTION

This project concerns itself with the multidisciplinary subject of reusable space systems, specifically first stage rockets. Vertical Take-Off and Landing (VTOL) of a rocket is a very primitive field which exploits the reusability of the launch vehicle used to transport highly valuable payloads, such as satellites, into space. Work on reusable launch systems is motivated by economic and material reasons; a significant cost reduction is attained by reusing the first stage rocket hardware [1-2]. On top of this, improved scalability, as well as increased launch frequency is two positive by-products of this reusability. The first successful prelaunch of a previously used rocket was performed by Space X with the Falcon 9 rocket [3]. It is important to point out that not the entire rocket is reused. As an example, Space X's Falcon 9 rocket is made up of two main stages, excluding the payload that fits on top of the second stage [4]. The first stage houses the clustered rocket engines as well as the aluminium-lithium alloy tanks, whereas the second stage contains a single engine to drive the payload to the desired orbit. After separation, the first stage is propelled back to earth in a controlled manner.

Back ground

Vertical rocket landing has only been practically explored in the last few years. Given that this is a multidisciplinary topic, a brief background on thrust vectoring control, with special attention given below.

Launch vehicle reuse

The motivations of launch vehicle re-use are two-fold: saving of the first stage engine and structure leading to significant economic savings. However, there can be different types of recovery systems, dependent on the type of launch vehicle. Review the different techniques used [5]. They highlight that propellant and gases contribute less than 5% of the first stage cost of the rocket, further cementing the argument for recovery [6]. However, they do mention that simpler recovery, such as with the use of parachutes, is more cost effective than booster fly back. At the same time, the landing accuracy of simpler methods is measured in miles, whereas with vertical rocket landing it is measured in meters. After separation of the first and second stages, reduction of translational velocity is necessary [7]. Blue Origin achieves these both passively with brake fins, as well as actively by restarting the main engine, powered by liquid hydrogen and liquid oxygen. On the other hand, Falcon 9 uses its grid fins for re-entry manoeuvrability before switching on its engines again. It also achieves controllability using main engine gimballing and cold gas Nitrogen thrusters [8].

Thrust vector control

Thrust vectoring will be the main control method to keep θ as close to 0 o as possible, keeping the rocket upright whilst still following a reference trajectory [9]. Vectoring refers to the gimballing action of the engine or the flexibility of the nozzle, where the nozzle direction is changed relative to the COG of the rocket. Since the

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Received: September 13, 2021; **Accepted:** September 20, 2021; **Published:** September 27, 2021

Citation: Patil IV (2021) Landing the Booster Using Parachute. J Defense Manag. 11: 5.218.

direction of the nozzle dictates the angle at which thrust is exerted, a torque about the COG is created if $\varphi \neq 0$ as 0. In reality, the nozzle is moved along three dimensions with actuators. Since the simulation developed in this thesis is in two dimensions, only a single rotational movement is needed [10]. The nozzle itself can take many forms, and the generated thrust magnitude and profile are directly dependent on the shape of the nozzle. Thrust reduction and increased wake turbulence can result from a sub-optimal nozzle profile; however, this project will assume ideal thrust profiles utilizing a single flexible nozzle joint. Hence, the gimbal can be represented by a rotary ball joint at the lower end of the rocket. The flow of the thrust will be assumed to act along a single directional vector, FE (Figure 1).

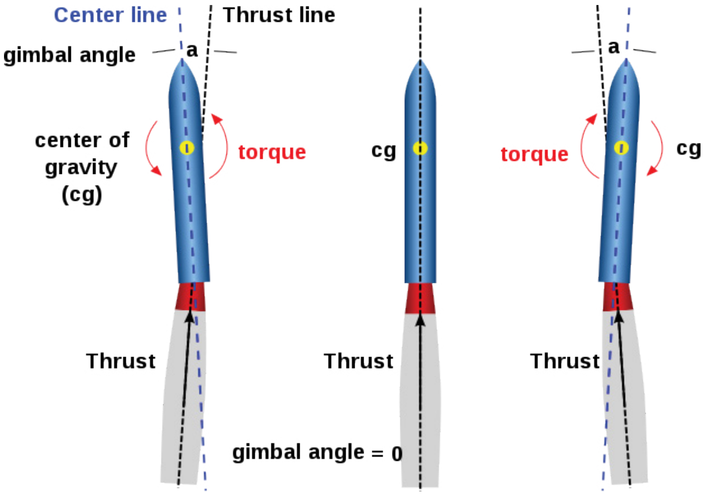


Figure 1: Thrust vector control of a rocket.

The landing site

Simple recovery methods with parachutes were used to collect launch vehicles from the ocean, however, no first stage rocket had landed on an ocean barge before. Falcon 9 successfully did this on April 18th, 2014 in a historic landing.

The rocket's take-off location is usually from the east coast of the United States (U.S), having an abundance of area away from civilization. However, if the first stage is to be recovered, not enough fuel can be carried by the rocket for the first stage to make it back to land [11]. Even then, it would be a dangerous endeavour. For this reason, Space X opted to use a floating platform in the Pacific Ocean.

The barge's landing area measures approximately 74 by 52 meters and is navigated with 4 diesel-powered thrusters and a Global Positioning System for self-navigation. Given this setting, landing a rocket on a self-navigated barge presents a control problem on its own, especially since sudden weather changes can cause disturbances in the barge's position and angle. For this reason, the floating platform's position and angle relative to the horizontal plane are variables in the simulation and can be adjusted for testing purposes and included in the mathematical model.

METHODS

Descent landing procedures

During the descent phase three different deceleration methods can be used: parachutes drag plates, and engine burns. The literature study identified a rotor landing as a possible deceleration option, however the technology readiness level was deemed too low (Figure 2).

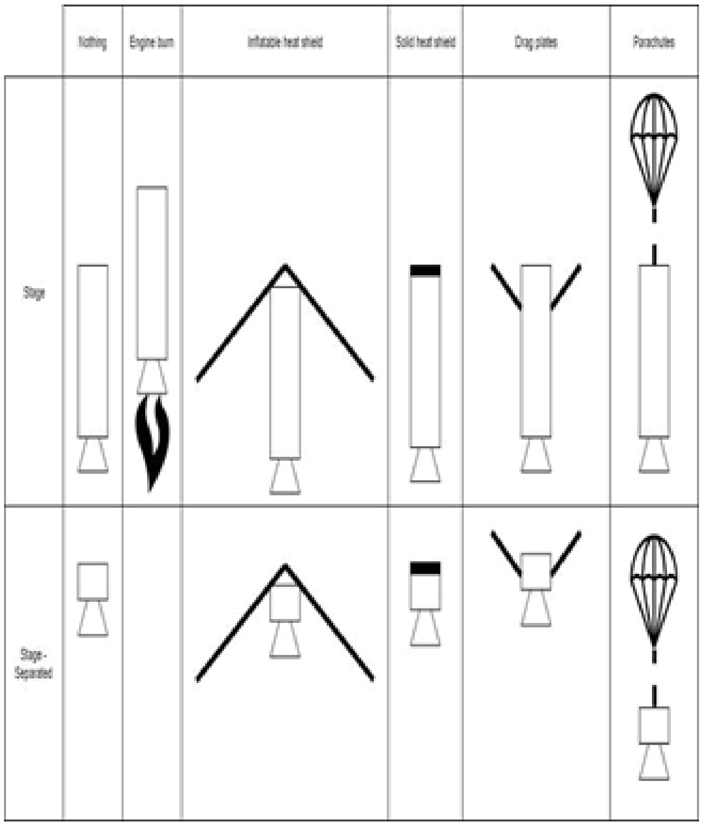


Figure 2: Stages of rocket using advancetechnology.

The parachutes identified to be of use for this research are ballistic, non-steerable parachutes. These parachutes come in three categories: ballute, ribbon parachutes, and Ring sail parachutes [12]. The ballute's primary function is stabilisation of the stage and is used when the upper stage is unstable during the flight. The ribbon parachutes are assumed to be supersonic drogue parachutes where the Ring sail parachutes are mainly used for final descent or main parachutes. Parachutes are used for a safe landing for almost every manned mission. The choice of parachutes is based upon the deployment altitude:

- 100000 m - 60000 m - Ballute
- 60000 m - 7500 m - Ribbon parachute
- 7500 m - 0 m - Ring sail parachute

Stages of rocket using advance technology

First stage: The rocket tanks are made up of Al-Li alloy. A material made stronger and lighter than Al by the addition of Li. Inside the two stage and two large tanks each capped with an Al dome, which store liquid oxygen and Rocket Grade Kerosene (RP-1) engine propellant. The tank and domes are fabricated entirely. Section of Al are joined together using customs made friction stir welders to execute the strongest and most reliable welding technique, available. The structures are painted, concurrent with the welding process.

After ignition, a hold before release system ensures that all engines are verified for full thrust performance before the rocket is released in flight. Unlike airplanes, a rocket thrust actually increases with altitude. The 1st stage of engine are gradually throttled near the end the end of 1st stage flight to limit launch vehicle acceleration as the rocket's mass decreases with the burning of fuel.

Inter stage: which connects the first and second stage, is a composite structure made of sheets of carbon fiber and an Al honey comb core and it holds the release and separation system. The use of pneumatic stage separation system for low shock highly reliable separation that can be tested on the ground unlike pyrotechnic system used on most launch vehicles.

Second stage: in second stage payload get cut off and reaches desired orbit the second stage engine ignites a few seconds after separation and can be restarted multiple time to place multiple payloads into different orbits. The second stage is made from a high strength Al-Li alloy using most of the same tooling, manufacturing technique. This commonality yields significant design and manufacturing efficies (Figure 3-4).

Third Stage-Landing of booster: I have given two topics on landing where I want to land using parachute for that which parachute has to test. The parachute has to 1st cheque by it held that must weight and implies drag on the rocket to reduce in vertical speed of free falling booster. In all tests, the barge length covered 46% of the total width of the simulator, approximately 5 times the length between the rocket legs as shown in Figure 5. The barge was left static, with the landing target located always at the centre point. In the graph it given about opening of parachute and landing of booster by it and then the landing gear opens at 2 km distance while landing this how the whole thing works in stage 3 (Figure 4-6).

RESULTS AND DISCUSSION

As per the above report I have made a quite changes in the modern rocketry in my own way, the information which is given is correct are not, which is been presented by me but what is tested and outcomes are fully proven in the software which I used by my idea of this can help the feature generation of the my country. The modelling, testing and calculation are given on my knowledge, it

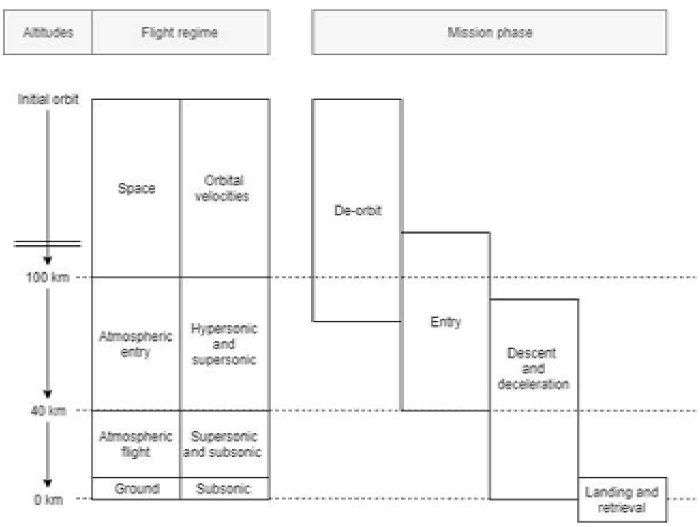


Figure 3: Complete process flow chart.

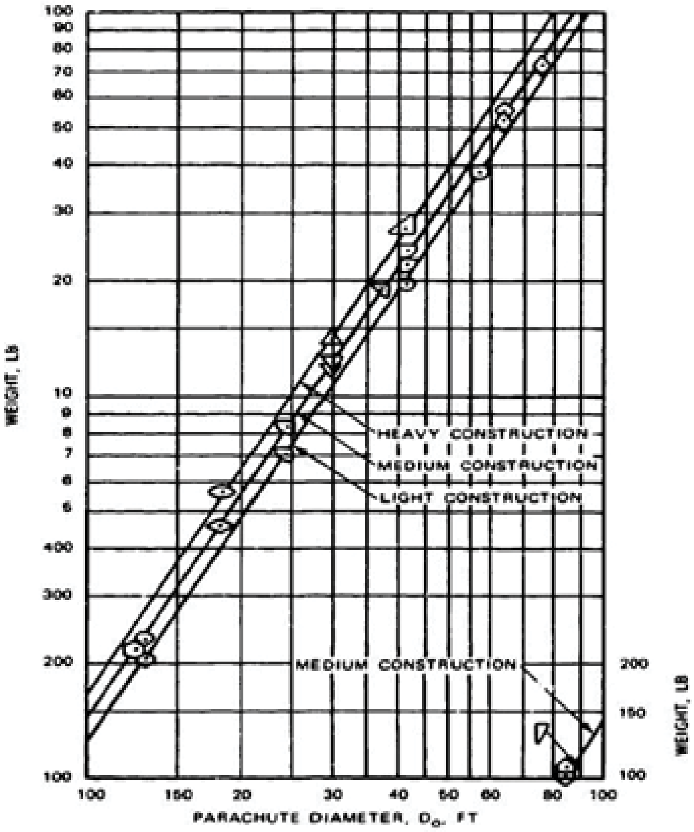


Figure 4: Parachute and diameter weight test.

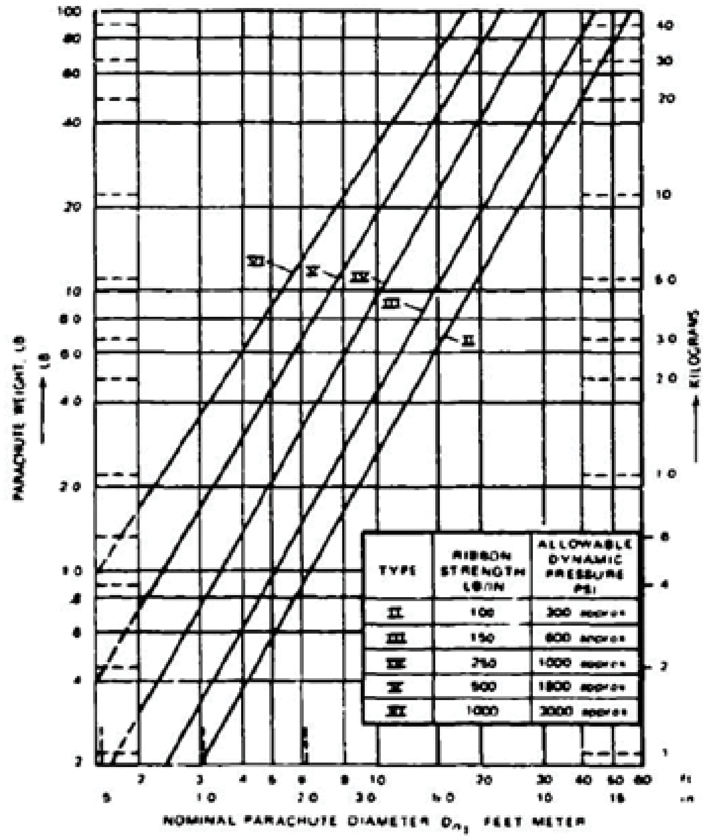


Figure 4a: Normal parachute diameter weight test.

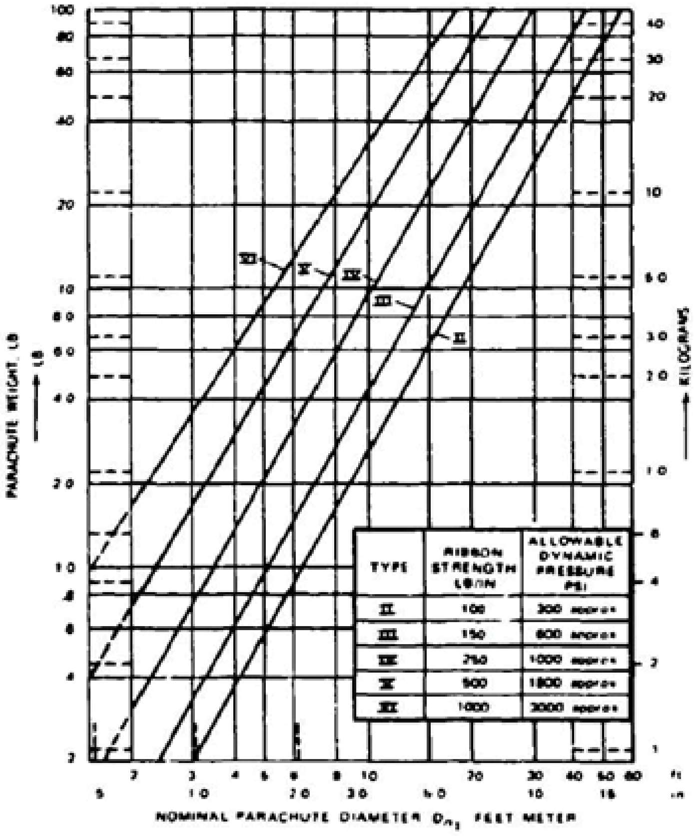
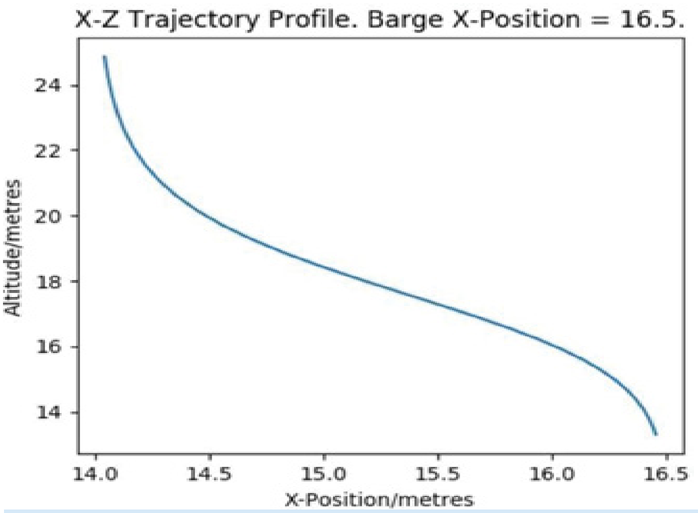


Figure 5: Reference trajectory showing the x-z profile.



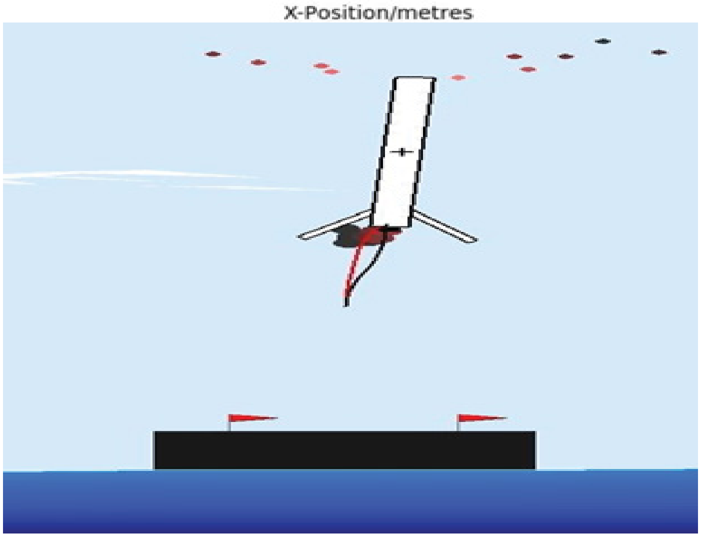


Figure 6: Corresponding simulation.

may change practically because of errors and mistake because it is science which is systematic approach towards knowledge.

CONCLUSION

Now on question left as you read the report the reader eager to now the probability rate or chances of the rocket? but my answer is, you are only made up of probability why because in 2.5 billion race you had a getting chance to born which is less than 0.1 per cent as my approach towards project of getting succeed is quite higher than yours so if in that case I will surely succeed. But the time had to decide when it is going to come.

At here I and my team are given this idea of systematic approach towards a rocket science. In our manner so please support and make a way to get it all succeed signing off from "small change in rocketry" team.

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