AN ANALYSIS OF THE FALCON 9 AND ITS REUSABLE LAUNCH SYSTEM

Nicholas J. Weaver, Department of PAGET
Faculty Sponsor: Dr. Barry Hojjatie, Engineering Technology Program

Source: https://spaceflightnow.com/2018/12/05/spacex-falcon-9-boosts-dragon-cargo-ship-to-orbit-first-stage-misses-landing-target/

Abstract

This project will give an in-depth presentation of Space X's medium lift launch rocket, the Falcon 9 and its reusable launch system. The Falcon 9 is the first rocket ever designed to undergo the process of re-entering the atmosphere and landing vertically. Ensuring its re-usability for future rocket launches and allowing for space manufacturers such as, Space X, to save more their funding for other space-faring projects. This project will present a background of Space X and the Falcon 9. Information regarding the Falcon 9 and its capabilities including, the Reusable Launch System will be given as well. Data regarding the Falcon 9 such as, its Orbital Velocity and Initial Velocity at a certain distance of orbit will be given as a form of written calculations demonstrating the Falcon 9's amazing capabilities

Introduction

The "Space Exploration Technologies Corporation", also known as "Space X", was founded in 2002 by engineer and technological entrepreneur, Elon Musk. Space X is a privately owned space manufacturer and transportation services company dedicated to reducing the cost of spaceflight and travel in order to initiate the Human colonization of Mars and other habitable celestial bodies in the Universe. The corporation has multiple government and military contracts that provide funding to the company's projects. Space X is currently receiving $4.2 billion dollars from NASA alone, as of January 2020.

The Falcon 9 is a two-stage rocket designed for the transportation of satellites and the eventual transportation of astronauts thought the Dragon spacecraft. It is the first orbital class rocket capable of being reusable. It uses cryogenic liquid oxygen and rocket-grade kerosene as propellants and is equipped with 9 merlin engines. It has a height of 70 m (229.6 ft) and weighs 549, 054 kg (1,207,920 lb.). Being made with aluminum-lithium alloy, it costs $62 Million to construct.

The Reusable Launch System

In 2011, Space X initiated the "Reusable Launch System Development Program" with the intention of creating a rocket that was able to land itself and be reused for future planned missions. To give an in-depth analysis of the system overall, the booster of the first half of the rocket is programmed to follow a precise flight path back to Earth by undergoing a series of autonomous maneuvers on its decent back to the surface of the planet. After separation, the booster performs a "boost backburn" after repositioning itself and follows a proper trajectory towards Earth. The booster takes check of its own position and velocity doing this process.

The Falcon 9 is equipped with an onboard computer that reads data from the Inertial Navigation System, which measures the current position and velocity. It also reads data from the GPS to track its position globally. The computer compares data read from the INS and GPS to its initial flight path. If there is any changes of deviations to the flight path, the computer will re-adjust the rocket's decent according to the data received.

Source: https://www.businessinsider.com/a-spacex-rocket-survived-space-but-was-torn-apart-by-high-seas-2019-4

Methodology, Data and Calculations

Orbital Velocity

$$v = \sqrt{\frac{G * M}{r}}$$

Initial Velocity

$$Vf = Vi + at$$

- What is the Falcon 9's orbital velocity when it reaches the "Main Engine Cutoff" stage just before separation?

$$\sqrt{\frac{6.67x10^{-11}\frac{Nm^2}{kg^2} * (5.97x10^{24}kg)}{6{,}446{,}330\ m}} = 7.8\frac{km}{s}$$

- What is the Falcon 9's orbital velocity when it reaches a maximum attitude of 165 km?

$$\sqrt{\frac{6.67x10^{-11}\frac{Nm^2}{kg^2} * (5.97x10^{24}kg)}{6{,}541{,}830\ m}} = 7.8\frac{km}{s}$$

- What is the Falcon 9's initial velocity at t = 2:43 at max velocity of 7801.31 m/s?

$(7801.31\ m/s) - (47.9\ m/s^2)(163s) = 6.39 m/s$

Sources:

"Falcon 9 First Stage Velocity and Altitude Comparisons." The Planetary Society Blog, www.planetary.org/multimedia/space-images/charts/falcon-9-first-stage.html.

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