A4_4 Infinity In Consumption, Or Just In Name?

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Abstract

In the Halo series of video games, the largest man-made ship is the UNSC Infinity. In this paper, we calculate that to launch the UNSC Infinity to low Earth orbit, it would require 2538 of the space shuttle solid rocket boosters to achieve this. We did this by considering the conservation of momentum and constructing a rocket equation.

Introduction

The Halo series is a set of sci-fi video games created by Bungie and 343 industries set largely in the 2550s [1]. In Halo 4, the UNSC Infinity is introduced which is the largest man-made ship in that universe [2]. In this paper, we will be calculating how many boosters would be required to launch the UNSC Infinity into low Earth orbit with our current levels of technology.

Theory

To determine the change in velocity due to the boosters, we can start by applying the conservation of momentum for a rocket accelerating. This can be seen in equation 1 where m is the mass of the rocket at that instantaneous point, v is the velocity of the rocket and v_e is the exhaust velocity.

$$m\dot{v} + v_e\dot{m} = 0 \tag{1}$$

Rearranging equation 1 and integrating from the time of ignition of the engine to the time when the fuel runs out with respect to time, we can calculate the total change in velocity caused by the engines. This can be seen in equation 2 where Δv is the change in speed, M_0 is the initial mass of the rocket including boosters, M_f is the final mass of the rocket and the boosters.

$$\Delta v = v_e \ln \frac{M_0}{M_f} \tag{2}$$

As we are wanting to determine the velocity change from sea level to low Earth orbit, we have to account for the effects of gravity. When under the effects of gravity, assuming constant acceleration, the speed would be lower by a factor of gt where g is the acceleration due to gravity and t is the time taken to reach the velocity. In our case, t is equal to the burn time of the engines. This leaves us with equation 3.

$$\Delta v = v_e \ln \frac{M_0}{M_f} - gt \tag{3}$$

The solid-fuel rocket boosters for the space shuttle have an initial mass of 5.9×10^5kg and a dry mass of 9.0×10^4kg [3]. The boosters contain enough fuel to burn for 127 seconds with an exhaust velocity of 2571ms^{-1} [4]. As multiple boosters are required, we need to modify equation 3. For n boosters with the same exhaust velocity, the rocket equation becomes equation

4. The increase in mass is incorporated into the mass terms.

$$\Delta v = n v_e \ln \frac{M_0}{M_f} - gt \qquad (4)$$

These equations are very simplistic and we have assumed several things to achieve this. We have ignored air pressure which has a sizeable impact on the spacecraft when it is at low altitudes. Also, we have assumed that the acceleration due to gravity is constant at $9.81\mathrm{ms}^{-1}$ when it varies with height. We are also ignoring any thrust from engines which propel the UNSC Infinity but still considering their mass.

Discussion

The given mass for the UNSC Infinity is 907 million metric tons [5]. For the space shuttle to reach low Earth orbit, it accelerated up to a speed of $7850\mathrm{ms}^{-1}$ [6] so we assumed that this is the velocity the UNSC Infinity needs to reach. To determine how many rocket boosters would be needed, we calculated equation 4 for values of n between 0 and 3000. The results can be seen in figure 1 where we have plotted the number of boosters on the x-axis and the velocity at the end of the burn on the y-axis. The horizontal red line represents the velocity needed to reach low Earth orbit. We calculated that the minimum number of boosters that gave a velocity greater than $7850\mathrm{ms}^{-1}$ was 2538 boosters.

Conclusion

To launch the UNSC Infinity into space with our current technology, it would require 2538 of the space shuttle solid rocket boosters so the ship can reach the speed required for low Earth orbit. The cost of doing such a launch would be extortionate and require far more materials than the mission would be worth. Whilst the UNSC Infinity may be a technological marvel, sadly with our current level of technology, it will stay that way until major advancements are made in the field of propulsion.
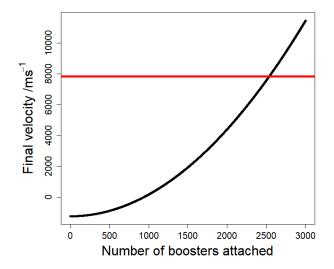

Figure 1: Graph showing the relationship between the number of boosters attached to UNSC Infinity and the velocity at the end of the burn time in black with the velocity required for LEO in red.

References

[1] https://www.halowaypoint.com/en-gb [Accessed 30th October 2020]

[2] K. Travis *Halo: Grasslands* (Leisure, Tor Books, 2011), p421-422.

[3] https://science.ksc.nasa.gov/shuttle/technology/sts-newsref/srb.html [Accessed 30th August 2020]

[4] https://www.centennialofflight.net/essay/SPACEFLIGHT/rockets/SP6.htm [Accessed 30th October 2020]

[5] K. Peters *Halo: Warfleet* (Leisure, Egmont Publishing, 2017) p42-43.

[6] https://www.nasa.gov/pdf/466711main_AP_ST_ShuttleAscent.pdf [Accessed 30th October 2020]