**Future Launch Costs**

Oct. 20, 2020

**1 First-stage Reusability**

SpaceX is the only company currently operating with a reusable first stage rocket. Because SpaceX is a private company all values given below are estimates, based on interviews with Elon Musk and other news articles.

There are two main drawbacks to reusing rockets: (1) less payload can be taken into space as extra fuel for recovering the first stage needs to be factored into the total weight of the rockets; (2) refurbishing costs

There are several basic components included in the cost of each launch [1].

1. **R&D**: Elon Musk has stated that R&D has cost about or over $1bn (this may be a conservative estimate) [2]. The cost of R&D will be slowly recouped with each launch. I suspect that this recouping will come in the form of simply not transferring 100% of cost savings to customers (cost savings from reusing rockets).

“We do have to figure out some way to pay off the development costs of reusability… The price savings can’t be as much as the cost savings because we need to repay the massive development costs.” – Musk (2017)

For now, we will ignore the costs of R&D.

1. **First stage**: $37.2m. Musk has stated that he believes the boosters can be reused up to 100 times [3].
2. **Second stage**: This stage has not been recovered with the Falcon 9. The second stage costs $12.4m.
3. **Fairing**: Musk has recovered the fairings by boat before. From past launches, I estimate that the fairings can be recovered twice before a new one needs to be built (based on current recovery capabilities). The fairings cost $6.2m.
4. **Fuel (and other costs)**: $6.2m per launch.
5. **Refurbishing first stage**: $1m [4]

**2 Fuel Efficiency Costs**

**3 Mass Efficiency**

**Other Considerations**

To this day, no single-stage-to-orbit (SSTO) vehicles have been successfully built or used, as a propulsion system efficient enough to overcome Earth’s strong gravitation field as well as high pressure has yet to developed. However, a SSTO launch vehicle (if reusable) would be a completely reusable launch vehicle rather than just the first stage being reusable.

In addition, Musk is also currently developing a second stage that is reusable as well. For Falcon 9, he found that a reusable second stage wouldn’t be financially beneficial, but he may try to make this second stage of his new rocket, Starship, reusable.

[1] Cost breakdown: <https://www.cnbc.com/2018/05/11/full-elon-musk-transcript-about-spacex-falcon-9-block-5.html>

[2] R&D costs: <https://spacenews.com/spacex-gaining-substantial-cost-savings-from-reused-falcon-9/>

[3] <https://www.nextbigfuture.com/2019/02/elon-musk-expects-at-least-20-to-30-launches-from-each-falcon-9-block-5.html>

[4] Refurbishing Costs for the Falcon 9: <https://aviationweek.com/defense-space/space/podcast-interview-spacexs-elon-musk>

Other Sources:

*Falcon 9 Flight Log*

<http://www.spacelaunchreport.com/falcon9ft.html#f9ftlog>

*Estimates of SpaceX Revenue and Costs:*

<https://www.wsj.com/articles/exclusive-peek-at-spacex-data-shows-loss-in-2015-heavy-expectations-for-nascent-internet-service-1484316455>