Rational Futures

Opportunity Costs Drive the Market Price of Starship Launches

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Highlights

When a satellite constellation is tied to a launch vehicle, the constellation's profitability will drive the market price of the launcher's services. The profit of launching a satellite from the market should be greater than the profit of deploying the launch company's own satellites.

Elon Musk has estimated that annual revenues for Starlink may be $30B to $50B. If these revenues can be realized, the implied price of Starship is $120 million to $320 million per launch. Charging less would lead to reduced funds for shareholders or for internal programs focused on Mars.

Starship launches may be relatively scarce for the first few years of operation, constrained to 145 annually according to regulatory filings. If there is excess launch supply, Starship prices should be around the price of the nearest competitor. SpaceX has little incentive to price Starship at its cost of hardware and operations.

Executive Summary

This paper addresses a gap in the ability of the space community to make economically defensible estimates for the price of emerging goods and services. Specifically, most estimates we have seen for futures prices do not account for the potential effects of opportunity costs or market competition. To illustrate the importance of these factors, we use the Starship and Starlink vehicles being developed by SpaceX as a case study, because there are many publicly available statements made by the company about their own operations, on which we can draw.

Public assumptions about prices of Starship are contrary to basic economic principles

Starship is a super-heavy lift vehicle being developed by SpaceX that may significantly reduce the cost of access to space. Decision-makers are investing with the assumption that they can eventually buy launches at near-cost prices, which have been claimed to be as low as $10 million per launch. Regardless of the cost to build and operate Starship, the notion that a Starship launch can be purchased at near-cost prices is contrary to basic economic principles.

Revenues from launching Starlink satellites should drive the market price of Starship

A simple calculation using publicly available figures illustrates the issue. SpaceX plans to use Starship to launch its own Starlink satellites, which provide internet services to users around the world. Elon Musk projects that the constellation may earn at least $30 billion in annual revenues. With a constellation of 30,000 satellites, each satellite would earn $1 million per year on average. The lifetime of a Starlink satellite is rumored to be 5 years, in which case, each satellite earns $5 million in revenue over its lifetime. Starship is reportedly able to launch 60 Starlink V3 satellites at a time, leading to $300 million in lifetime revenue per launch on average. At an estimated cost of $3 million to build and operate each Starlink V3, the cost of the Starlinks would be $180 million per launch. The opportunity cost of each Starship launch is the revenue generated minus the cost of the Starlinks, which equals $120 million. SpaceX has little economic incentive to lower the pricing of Starship to $10 million for commercial launches when they could generate as much as $120 million by launching Starlinks.

Our analysis reveals:

- The market price for Starship may be $120 million to $320 million per launch, over Starlink's range of annual revenue estimates offered by Musk.
- Starship launches may be scarce for the first few years of operation, constrained to 145 annually according to regulatory filings. At this rate, it would take years of dedicated launches to build out and then maintain the Starlink constellation.
- If there is excess launch capacity, Starship prices should be around the price of its nearest competitor, otherwise it would forgo substantial profit.
- In general, satellite constellations integrated with launch vehicles may actually drive the market price of launches up, not down.

We have made no attempt to validate nor criticize the market sizes and performance characteristics of Starlink and Starship. Readers are encouraged to explore their own assumptions within the analytic framework and baseline data we have provided.

Contents

Introduction

Basic economics regarding estimated prices for future goods and services in space

Economic theory requires that firms should seek to maximize profits by conducting those activities that generate the highest returns. When choosing among activities, a rational actor uses the concept of *opportunity cost* to determine their best course of action. *Opportunity cost* measures the forgone profit from taking one action instead of another. If a proposed activity does not generate enough revenue to overcome the opportunity cost, then the company should not conduct the proposed activity.

This paper addresses a gap in the ability of the space community to make economically defensible estimates for the price of emerging goods and services. Specifically, most estimates we have seen for futures prices of space services do not account for the potential effects of opportunity costs or market competition.

This gap is exacerbated in the launch sector, to the extent that launch companies vertically integrate with satellite constellations. In such a case, when a satellite constellation is tied to a launch vehicle, the constellation's profitability will drive the market price of the launcher's services. The profit of launching a satellite from the market should be greater than the profit of deploying the launch company's own satellites, otherwise the company will have lost money on the launch.

Using the price of Starship launches as a case study

To illustrate the importance of accounting for opportunity costs and competition, we use the Starship and Starlink vehicles being developed by SpaceX as a case study, because there are many publicly available statements made by the company about their own operations on which we can draw. We make no attempt to validate nor criticize the reported market sizes and performance characteristics of these systems; we use them at face value to illustrate the connection between the revenue of a constellation and the market price of its vertically integrated launch vehicle.

SpaceX's Starship is a fully reusable super heavy-lift launch vehicle designed to revolutionize access to space with its advanced capabilities. It is being designed to transport 100 to 150 metric tons to low-Earth orbit (LEO) in its reusable configuration, and up to 250 metric tons in expendable mode. Once finished, it will be the most powerful rocket ever built. The vehicle's full reusability is achieved by recovering both the Super Heavy booster and the Starship spacecraft using innovative tower-catching mechanisms. This design aims to significantly reduce launch costs through frequent flights and minimal refurbishment. This reduction in costs, driven by economies of scale and mass production, positions Starship to support ambitious missions to Earth orbits, the Moon, and Mars.

SpaceX currently operates the Falcon 9 launch vehicle, which is widely acknowledged as providing the most affordable launch services on the market. The Falcon 9 is advertised at

approximately $70 million per launch and sends up to 17,500 kg to LEO when the first stages are recovered for reuse. Dividing these quantities gives an approximate theoretical minimum price of launch at $4,000/kg.[1] To illustrate the potential savings of Starship, Elon Musk stated "I'm highly confident it would be less than $10 million all in, fast forward two or three years from now" (Duffy 2022). In the same source, he went further, suggesting that future costs could drop "maybe even as low as a million dollars per flight." Applying Musk's estimate of a 100 metric ton mass capacity and $1 million cost leads to the oft-quoted estimate of $10/kg for launch to LEO. If realized, Starship might reduce the cost of access to space by over 100 times.

Other estimates are more conservative. A report from Citibank estimated that Starship may reduce costs to LEO to $1,600/kg if disposable, but that it has the potential to reach as low as $100/kg with reusability (Citi 2022). At $100/kg and an assumed mass capacity of 100 metric tons, the total launch price would be $10 million. Gary Henry, a former senior director at SpaceX, was reported in the Washington Post as saying that Starship may lower the cost of sending mass to orbit to around $200/kg (Gregg and Dou 2024). That implies a total cost of launch of $20 million. Even with these more “conservative” estimates, Starship would still be many times cheaper than Falcon 9.

All of these estimates appear to focus on the costs of the Starship hardware and operations. They assume that reduced hardware costs will translate directly into reduced market prices. Further, while the estimates may mention the need for Starship to support the deployment of the Starlink constellation, none account for the revenue generated by the constellation—also owned and operated by SpaceX—and the effect that may have on the market price of a Starship launch.

The price customers pay for a launch should be higher than the cost incurred by SpaceX to perform the launch. While competition from other launch providers may influence this price, the prevailing narrative in the space community suggests that Starship will be priced significantly below its competitors. Alternatively, the price of a Starship launch may be determined by the profits generated from launching its own Starlink satellites.

Starlink is a constellation of thousands of satellites in LEO that provides internet access to users worldwide. Because of their mass and volume, Starlink V3 satellites can only be deployed at the necessary scale by using Starship as the launcher. Each additional launch for Starlink enables the company to serve more customers and, consequently, to generate more profit. If SpaceX aims to maximize its profits, the company should set the market price for its launches high enough to ensure that the profits from a commercial launch meet or exceed those from launching its own Starlink satellites. Otherwise, SpaceX would forgo some profits and effectively incur losses on the launch–leaving less funds for shareholders or for other ambitious internal programs such as Mars exploration.

Elon Musk and Gwynne Shotwell have previously described Starlink as a profit center that would fund SpaceX's Mars plans (Wall 2019, Jewett 2021). Fundamentally, the global market for

[1] This simple calculation does not account for important details, such as whether customers do indeed fill the entire mass capacity or how the mass capacity is reduced as a function of the orbital altitude.

internet services is much larger than the market for launch services. Gwynne Shotwell estimated the total addressable market for launch at roughly $6 billion per year and the total addressable market for satellite internet at roughly $1 trillion per year (Jewett 2021). While SpaceX may only be able to capture a fraction of the total market for satellite internet, analysts have already estimated that Starlink revenues in 2024 well-exceeded $6 billion and may exceed $10 billion in 2025 (Erwin 2024, Kuhr 2025). Given these factors, it is reasonable to consider that Starship may be initially dedicated to accelerating Starlink's deployment, linking Starship's availability and pricing to Starlink.

Approach and Organization of This Report

In this report, we estimated the opportunity cost associated with using Starship for Starlink launches and used that to establish a floor on the price of commercial launch services utilizing Starship. Opportunity cost is an economic concept that describes the forgone profit from a missed opportunity.

We calculated the opportunity cost of providing launch services to the market instead of launching another batch of Starlink satellites. First, we estimated the revenues associated with the launch of new Starlink satellites during the initial buildout of the constellation and during the steady state, after the constellation has been fully deployed. Next, we estimated the cost to build, operate, and support the Starlink constellation using publicly available data. We then calculated the opportunity cost of a commercial launch by using the previously calculated revenues per launch of Starlink satellites and the costs associated with those satellites. This opportunity cost establishes a lower bound on the price of a Starship launch if launch supply is scarce. Next, we assessed the scarcity of Starship launches. In cases where such launches are not scarce, we discussed how the price of a Starship launch should fall to approximately the price of Starship's nearest competitor.

We have made no attempt to validate nor criticize the market sizes and performance characteristics of Starlink and Starship. Also, we are not "predicting" any specific price for Starship launches. There are many factors beyond the scope of our analysis that may alter the market price of Starship. Such changes include: anticipated market size for Starlink, number of satellites in the Starlink constellation, performance specifications for a single Starlink, number of annually permitted Starship launches, number of Starlinks that can be deployed per launch, etc. There may be other unmodeled factors, such as selling some launches at a loss to suppress competition or encourage certain markets to grow. Readers are encouraged to explore their own assumptions within the analytic framework and baseline data we have provided.

Revenue of a Starlink Satellite

We estimated the added revenue from Starlink satellites at two different points during the buildout of the constellation, illustrated in Figure 1. The first estimate corresponds to the early stages of the buildout and aligns with the initial launches of Starship. During this time, the potential gains in revenue from added satellites should be relatively large because the additional bandwidth from those new satellites would allow the constellation to accommodate many new paying users. The second estimate pertains to the added revenues when the Starlink constellation has essentially reached its steady state; at this point, all user revenues have been captured, and new satellites are launched to maintain the constellation as older satellites are removed from service.

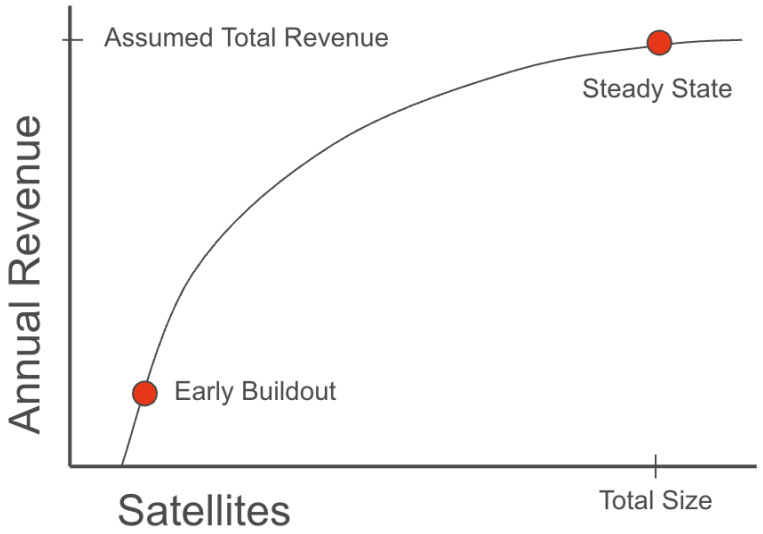

Figure 1. Approximate relationship between total revenue and the number of satellites in the constellation. Dots represent notional locations of our point estimates for revenue per satellite.

Early Buildout

During this phase, we estimated the value of adding satellites to the constellation based on the growth in revenue observed from 2021 to 2024 as new satellites increased bandwidth for the constellation.

Total Starlink revenues for 2021 and 2022 were published in the Wall Street Journal, while Payload Space provided estimates of Starlink revenues for 2024. To fill in the gap for Starlink revenues in 2023, we began with the total number of subscribers sourced from public statements by SpaceX executives. We used publicly available data on country-level internet traffic over the Starlink network to estimate the number of monthly subscribers in each country. By gathering the price of Starlink subscriptions in each country, we estimated the total revenue generated by subscribers in each country and, consequently, the total global revenues. As validation, applying this method to estimate the revenue for 2022 produced a figure within 20

percent of the amount reported by the Wall Street Journal. This method is sufficient for making a rough estimate of 2023 Starlink revenues.

We constructed annual estimates of the total capacity on the Starlink network from 2021 to 2024 based on publicly reported estimates for the bandwidth per Starlink satellite and their launch history. Combined with the annual revenue estimates over the same time period, we calculated that revenues increased by approximately $27,500 per year for every Gbps of capacity added to the network.[2] This process is illustrated in Figure 2.

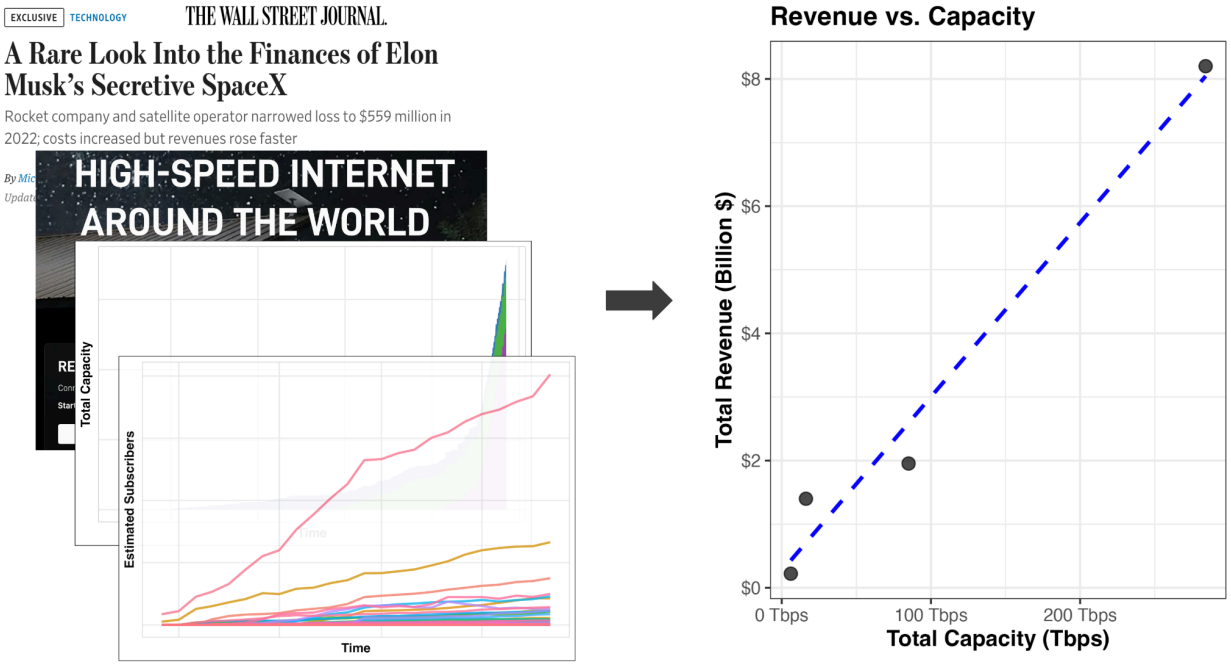

Figure 2. Illustrations of the data used to estimate marginal revenue per unit capacity are shown on the left. Marginal revenue per unit capacity was estimated as the average slope relating total annual revenue and total annual capacity, shown on the right.

A Starship fully loaded with V3 satellites will add approximately 60 Tbps of capacity to the network (SpaceX 2024). At $27,500 per Gbps, the marginal revenue from a Starship flight during the early buildout phase would be approximately $1.65 billion. There is no demand for commercial launch services that could compete with this level of revenue per launch, leading us to believe that SpaceX would reserve Starship launches for Starlink during the early buildout phase. Once the constellation is closer to its steady state, the marginal revenue per Gbps–and per launch–will fall significantly.

[2] Our steady state analysis in the following section showed that the average revenue per Starlink satellite will eventually fall significantly. Our opportunity cost estimates based on the recent past are therefore most informative about the near future. We left assessment of how fast satellite revenues might transition to the steady state for future analysis.

Steady State

As the constellation reaches its final size, the revenue gained from additional launches of Starlink satellites should decline until the constellation generates the total profit it can capture from the market. At this point, there is little incentive to increase the size of the fleet, as doing so would not generate additional profit. Launches of new Starlink satellites should only occur to replace old satellites that are being taken out of service, ensuring that the constellation does not lose customers.

At the steady state for the constellation, we estimated the average revenue per spacecraft by dividing the expected revenue of the constellation over its lifetime by the number of spacecraft in the fleet. Table A shows the average revenue per Starlink satellite using Elon Musk's estimates for the total revenue of the constellation. In 2019, Musk stated, "total internet-connectivity revenue in the world is on the order of $1 trillion [annually], and we think maybe we can access about 3% of that, or maybe 5%" (Wall 2019). This corresponds to $30 billion to $50 billion in annual revenues for Starlink.

Table A. Revenue per Starship Launch in Steady State

Source of Revenue Estimate	**Musk Low**	**Musk High**
Annual Revenue Estimate ($M)	$30,000	$50,000
Years in Replenishment Cycle	5	5
Total Revenue in Cycle ($M)	$150,000	$250,000
Satellites in Constellation	30,000	30,000
Revenue per Satellite ($M)	$5.00	$8.30
Satellites per Starship Launch	60	60
Revenue per Starship Launch ($M)	**$300**	**$500**

The lifetime of the constellation is determined by the expected lifetime of a single satellite, which is widely rumored to be five years.[3] In other words, the constellation would be completely refreshed in five-year cycles. We multiplied the annual revenues by five years to find the total revenue generated during a single cycle of the constellation, then divided by the total number of spacecraft in the constellation to estimate the average revenue generated by a single satellite over its lifetime. As discussed in a previous section, SpaceX materials suggest that Starship will launch 60 Starlink V3 satellites at a time. Multiplying the revenue per spacecraft by the number

[3] Interestingly, we were unable to find a reliable source for the five-year lifetime of the satellite. Most sources appear to be misinterpreting the post-mission disposal plan for Starlink satellites, which requires them to be deorbited within five years of their end-of-mission.

of spacecraft per launch yields the revenue generated per launch of Starship, which varies from $300 million to $500 million.

Cost of a Starlink Satellite

We also require an estimate of the cost to build and operate a Starlink satellite as an input to the opportunity cost. SpaceX has already launched thousands of Starlink satellites; however, these do not reflect the V3 model of satellite that will fly on Starship and are anticipated to comprise the final fleet of 30,000. We were unaware of any reported or rumored costs of the Starlink V3 satellites; thus, we estimated the cost of Starlink V3 satellites using public statements from SpaceX executives, open-source information about the mass of different Starlink satellite variants, and financial information from the Wall Street Journal. We divided the satellite cost into two categories. The first category includes costs associated with the satellite hardware itself. The second category encompasses “non-hardware” costs, which include all other elements required to generate revenues from the satellite, such as ground stations, user terminals, and associated labor.

We assumed that the hardware cost scales with the mass of the satellite. This is a relatively standard–though not necessarily accurate–assumption used to extrapolate costs from known systems to unknown systems. Referring to the V1 satellites, Gwynne Shotwell mentioned that Morgan Stanley’s cost estimate of $1 million per satellite was “way off” (Sheetz 2019). We used a hardware cost of $250,000 per V1 satellite, which is the lowest estimate we have seen in the trade press (Wang 2019). The original V1 satellites launched in 2020 had a mass of 260 kg, while FCC filings indicate that the V2 satellites would be approximately 2,000 kg (Goldman 2022). In the absence of a reported mass for the V3 satellites, we used the V2 mass. The ratio of masses for V3 to V1 is about 7.7. Using this ratio, we scaled the hardware cost of the V1 to estimate the V3 cost at approximately $1.9 million, as shown in Table B.

To estimate the non-hardware costs, we relied on publicly available financial data. Wall Street Journal reporting on SpaceX financials provided top-line total expenses ($3.3 billion) and R&D ($1.17 billion) figures for SpaceX as a whole in 2021 (Maidenberg, Driebusch, and Jin 2023). We attributed the difference between these expenses to the costs of running the Falcon 9 and Starlink programs. In 2020, Chris Couluris (then Director of Vehicle Integration at SpaceX) stated that the Falcon 9 “costs $28 million to launch it, that’s with everything.” SpaceX conducted 31 launches in 2021. Multiplying the number of launches by the cost per launch provided the total cost for the year associated with the Falcon 9 program. Subtracting that cost from the total operational expenses left the annual costs of operating the Starlink constellation. Dividing by the number of Starlinks launched in that year yielded the cost per Starlink. Finally, subtracting the hardware cost produced the non-hardware costs per Starlink. Table B shows the results of these calculations. In the absence of data on the V3 satellites, we used the same non-hardware cost from the V1 satellites.

We summed the hardware and non-hardware (operational) costs to find that the total cost of a V3 Starlink is approximately $3 million, based on the input parameters we have quoted. We

make no claims about the likelihood that V3 satellites will have this cost in practice. However, it is sufficient for use for our analysis, because it is transparently connected to data and assumptions about earlier generations of Starlink. Further, this implies that the full constellation of 30,000 satellites may cost around $90 billion to build and operate, which would yield incredible profit margins if Musk is correct that the satellites may bring in $150 - $250 billion over their lifetime ($30 - $50 billion in annual revenue times a 5 year operational lifetime).

We encourage readers to use other values to explore the effect that satellite cost has on the opportunity cost. Namely, as the cost of the satellite goes down, the opportunity cost of a Starship launch goes up. This is because reduced costs make each Starlink launch more profitable for the company, driving up the market price for a Starship launch. Conversely, if Starlinks are more expensive than our estimate, the market price of a Starship launch falls.

Table B. Inferred Costs of Starlink V1 and V3

Version	**V1**	**V3**
Hardware		
Mass (kg)	260	2,000
Hardware Cost ($M)	**$0.25**	**$1.92**
Non-Hardware		
SpaceX Top Line Expenses ($M)	$3,300	
R&D expenses ($M)	$1,170	
Implied Expenses for Starlink and Falcon 9 ($M)	$2,130	
Total cost to launch one Falcon 9 ($M)	$28	
Number of Falcon 9 launches	31	
Total cost related to Falcon 9 ($M)	$868	
Implied Total Cost for Starlink ($M)	$1,262	
Number of Starlinks launched	989	
Cost per Starlink ($M)	$1.28	
Non-hardware Cost per Starlink ($M)	**$1.03**	**$1.03**
Total Cost Per Satellite	$1.28	$2.95
Total Cost Per Satellite [Rounded]	**$1**	**$3**

Opportunity Cost from Starlink Launches

The opportunity cost of launching a payload from an external customer is equal to the revenue generated from launching additional Starlink satellites minus the cost of those satellites. Table C shows the opportunity costs implied by the Starlink revenue estimates from Table A and the cost estimate from Table B. The cost per satellite encompasses all hardware and business costs associated with the satellites, excluding the cost to launch them. This value is taken from our previous discussion of these costs. With 60 Starlink satellites in each Starship launch, we estimated that the total cost of the Starlink satellites is roughly $180 million.[4] The opportunity cost is the difference between the implied revenue and the Starlink cost per launch, which we estimated to range from $120 million to $320 million.

Table C. Opportunity Cost of Launch in Steady State

Source of Revenue Estimate	**Musk Low**	**Musk High**
Annual Revenue Estimate ($M)	$30,000	$50,000
Revenue per Starship Launch ($M)	$300	$500
Starlink Cost per Satellite (excluding launch)	$3	$3
Starlinks per Launch	60	60
Starlink Cost per Launch	$180	$180
Opportunity Cost	**$120**	**$320**

If the total number of Starship launches is constrained such that SpaceX must choose whether to launch a payload from an external customer, then the opportunity cost represents the minimum price that the external customer must pay for the launch. This opportunity cost includes the hardware and operations costs associated with performing the launch, as well as the profit generated by the launch. By comparing the revenue from an external customer launch with the opportunity cost of a Starlink launch, we assess the profitability of each; the costs to perform the launch are fixed. Therefore, we do not need to estimate the costs associated with Starship itself to perform a Starship launch and can focus instead on the opportunity cost.

For example, let the cost of performing a Starship launch be $1 million, aligned with Musk's most optimistic estimate. In the case where the opportunity cost is $120 million, the profit associated with a Starlink launch would be $119 million. As previously discussed, Citi has offered a long-term estimate of $100/kg, or about $10 million total for a launch. At this market price, Starship could earn $10 million in revenue and make $9 million in profit on the launch;

[4] In a recent Starlink progress report, SpaceX announced that each V3 satellite would provide 1 Tbps of download throughput capacity and that each Starship launch would deliver 60 Tbps of capacity (SpaceX 2024). Simple division indicates that this corresponds to 60 V3 satellites per Starship launch.

however, this is $110 million less profit than launching its next batch of Starlink satellites. There is little incentive for a firm to regularly forego hundreds of millions in pure profit. To incentivize SpaceX to provide commercial launch services, the market price of a Starship launch should exceed the opportunity cost.

If Musk's lower estimate of $30 billion in annual revenue for Starlink becomes a reality, the market price of a Starship launch may be high enough to overcome the opportunity cost. However, as the assumed profitability of Starlink increases, the market price of Starship also rises, possibly beyond the reach of external customers. For example, Musk's higher revenue estimate of $50 billion implies an opportunity cost of $320 million. SpaceX currently garners a few billion in annual launch revenues, suggesting that there is sufficient total market demand to purchase at this price. However, that demand is spread among a diverse set of customers, and it is unclear whether these customers could coordinate sufficiently—on timelines and destination orbits—to place $320 million of business into a single launch.

Our estimates of opportunity cost are sensitive to the assumed parameters. In this analysis, we have illustrated the sensitivity to the annual revenues of Starlink. The assumed cost of a Starlink satellite and the total number of satellites in the fleet are other important parameters that drive the opportunity cost. For example, the opportunity cost will decrease as the cost of Starlink satellites increases or as the number of satellites in the fleet increases to service the same number of users.[5] This is because increased costs or decreased revenues per satellite make each Starlink launch less profitable.

How many satellites will Starlink ultimately have? A profit-maximizing firm would continue to launch more spacecraft until there are no additional profits to be gained. This occurs when marginal revenues equal marginal costs. As the cost of a Starship launch decreases or the annual revenue of the Starlink constellation increases, launching more Starlinks becomes profitable. Conversely, if Starship costs increase or Starlink revenues decrease, the optimal constellation size may be less than 30,000. For this analysis, we relied on FCC filings to size the constellation. Since the constellation has not yet reached its initial steady state to generate its full revenue potential, nor has Starship developed operational flight heritage to assess its true costs, we cannot speculate on what the optimal constellation size may be. Thus, we make no claims about the final constellation size SpaceX will ultimately choose. We use 30,000 satellites for illustrative purposes, but different values can be applied.

Excess Supply of Starship Launches

The opportunity costs described above apply when the number of annual launches is constrained, requiring SpaceX to choose between launching Starlinks or an external customer payload. We examined the launch sites where SpaceX is pursuing licenses to launch Starship and the proposed annual launch rates. These launch sites are located in Boca Chica, Texas; Kennedy Space Center, Florida; and Cape Canaveral Space Force Station, Florida. Based on

[5] Holding total revenue constant, more satellites means less revenue per satellite.

assumptions about when operations may begin at these sites, we assessed the annual supply of Starship launches in excess of Starlink's needs.

Cape Canaveral Space Force Station's Space Launch Complex 37 (SLC-37) may support up to 76 launches of Starship per year. The Space Force website for this action indicates that the final Environmental Impact Statement and Record of Decision should be completed in the autumn of 2025. Assuming a favorable decision is made, construction at SLC-37 may involve demolishing existing Delta IV infrastructure and building new facilities (e.g., launch mount, catch tower, tank farm, deluge system), which will require permits from the U.S. Army Corps of Engineers. The permitting process will take time, and construction cannot begin until the permits are secured.

To estimate the year when SLC-37 may begin operations for Starship, we draw on a historical analogy from another launch pad. SpaceX signed an exclusive 20-year lease on LC-39A in April 2014 (Dean 2014), but did not have the site minimally completed until February 2016 (Foust 2016) and did not perform its first launch from the site—a cargo resupply flight to the ISS—until February 2017 (Graham 2017), nearly three years after signing the lease. For the sake of analysis, we assume that launches from SLC-37 may take a similar amount of time. In other words, Starship may begin launching at its desired rate in 2029, approximately three years after the Record of Decision at the end of 2025.

Kennedy Space Center's Launch Complex 39A (LC-39A) may support up to 44 launches per year. SpaceX and NASA are in the process of finalizing the Environmental Impact Statement, with a potential decision expected at the end of 2025 (Clark 2024). This launch site had previously been planned to support 24 annual launches, and SpaceX has already engaged in substantial construction to accommodate Starship at the site. Assuming a favorable decision is reached at the end of 2025 and allowing another year to complete the necessary construction, it is conceivable that Starship could begin launches from this site in 2027.

Starbase at Boca Chica, Texas, was already licensed to support 5 Starship launches per year. However, SpaceX submitted an updated Environmental Assessment to support an expansion to 25 launches and 25 landings per year (FAA 2024). This extension was granted in May 2025 (Kolodny 2025). Since Boca Chica already supports Starship launches, it is conceivable that Starship could begin 25 annual launches in 2026 if the vehicle is ready.

Using the approximate years that Starship may begin launching, Table D illustrates the implications for the buildout of the Starlink constellation based on the launch constraints suggested above. During the years 2021 to 2025, Falcon 9 delivers Starlink satellites in the V2-mini class. These satellites are significantly less capable than the V3 satellites that will be launched by Starship. However, our launch model does not account for such differences. Once Starship begins the operational deployment of Starlinks from Starbase, the model ceases deployments of Starlinks using Falcon 9. In practice, Falcon 9 may continue to be used for commercial launch services for several years, and there may even be a period during which both Falcon 9 and Starship are deploying Starlinks. For simplicity, the model does not account for this transition period; starting in 2026, Starship is the only vehicle launching Starlinks.

Starlinks are deorbited after their operational lifetime of five years; thus, in 2026, the spacecraft launched in 2021 would be removed from the fleet. The model does not account for other reasons that satellites may be removed from orbit, such as hardware failures, collisions, or extreme space weather conditions.

Starlink may reach a fleet size of 30,000 satellites if Starship launches at its maximum allowable rate through 2031. During this time, the opportunity cost of launching another Starlink satellite would be relevant to the market price. From 2031 to 2033, there would be a window where Starship has excess annual launch supply of approximately 70 launches per year. We have not accounted for the effect of other non-Starlink launches for the U.S. Government on this excess supply. Such launches may include demonstrations and operational missions to support the Moon to Mars program. For example, a mission for the Artemis program may require around 15 Starship launches (Smith 2023).

Table D. Potential Starship Launch Schedule to Deploy Starlink Satellites

Year	From Starbase	From LC-39A	From SLC-37	Total Launches		Starlinks Deployed	Starlinks Deorbited	Total Fleet Size
2021				0		989	0	989
2022				0		1,722	0	2,711
2023				0		1,984	0	4,695
2024				0		1,955	0	6,650
2025				0		2,461	0	9,111
2026	25			25		1,500	989	9,622
2027	25	44		69		4,140	1,722	12,040
2028	25	44		69		4,140	1,984	14,196
2029	25	44	76	145		8,700	1,955	20,941
2030	25	44	76	145		8,700	2,461	27,180
2031			72	72		4,320	1,500	30,000
2032			69	69		4,140	4,140	30,000
2033			69	69		4,140	4,140	30,000
2034	25	44	76	145		8,700	8,700	30,000
2035	25	44	76	145		8,700	8,700	30,000

Grey indicates that no Starships were used to launch Starlinks. Red indicates that Starship is launching Starlinks at the maximum allowable rate of the launch site. Green indicates there may be an excess launch rate at the launch site. Prior to the first Starship delivery, Starlinks were deployed by Falcon 9. Once the Starbase facility begins launching Starships, deliveries by Falcon 9 cease in this model.

Unless the constraints on the launch sites are loosened, the excess launch supply would disappear in 2035, as Starship would again launch at its maximum rate to compensate for the satellites that are deorbiting. In this model, cycles of scarcity and excess supply recur throughout the lifetime of the constellation. These cycles could be smoothed out such that there is a constant number of Starlink deployments per year, resulting in some excess supply each year if SpaceX were to remain under or over the steady-state size for several years. However, a firm that maximizes profit is incentivized to deploy its satellites in this more cyclic fashion.

For example, if SpaceX decided to dedicate a maximum of 100 Starship launches per year to Starlink, the constellation would reach its desired fleet size by the end of 2033. This approach would result in 45 launches of excess supply each year, but it would also delay Starlink's full revenue potential by 2.5 years. This delay could represent many billions of dollars in foregone profit. All else being equal, profits now are preferable to profits later, due to the time value of money.

Market Price of Starship Given Competition

The previous discussion indicated that there may be times when Starship launches are not scarce, and thus the market price would not be driven by the opportunity cost of Starlink deployment. Table D showed that this excess Starship launch supply would appear in the year 2031. It is also possible that other factors beyond our model could cause SpaceX to not launch Starlinks at their maximum rate. Regardless of the reason, when launch supply is not scarce, the market price of Starship would no longer be influenced by Starlink’s opportunity cost but by competition in the launch market.

For example, consider a customer shopping for commercial launch services. Assume their payload is 30 metric tons and they wish to have it delivered to LEO. New Glenn is reported to have a launch price of about $70 million and the ability to carry that mass (Sheetz 2025). Assuming that price is accurate, the customer knows it and so does SpaceX. Starship only needs to charge slightly below $70 million to win this business. The company will make a profit so long as Starship launches are not scarce and the cost to perform the launch is below the price. Charging substantially below the price of its nearest competitor would cause SpaceX to forgo profits unnecessarily.

Notice that the price per kilogram of launching the payload is approximately $2,300, regardless of whether Starship or New Glenn is used. While Starship may be able to launch 150 metric tons, that does not matter. The relevant mass for calculating the price per kilogram is the actual amount of mass flown by the customer.

This example can be extended to include multiple customers, but the resulting behavior remains the same. Adding smaller payload masses as secondary customers does not change the price of New Glenn and thus would not alter the price of Starship; both vehicles would still sell for approximately $70 million. The price per kilogram paid by the customers decreases, but it decreases equally for both vehicles.

Consider the case where there are two customers, each with 30 metric ton payloads. They cannot both fit on New Glenn; they can either purchase New Glenns separately or combine their demand to ride on Starship. The customers know this and so does SpaceX. Having already demonstrated the ability to offer different prices to different customers based on their willingness to pay (Kim 2025), SpaceX would only need to price their Starship at slightly below $140 million to win the business if the customers combine their demand. If they act independently, Starship needs to only price its individual launches at $70 million to secure the business.

These examples illustrate a basic economic truth: the market price of a service is not driven by the provider with the lowest costs; rather, the price is determined by the nearest competitor in the market. In a market with relatively few competitors, prices may be well above costs.

Summary and Conclusions

The stated objective of SpaceX's Starship program is to send humans to live on Mars. This ambitious goal is expensive. In 2019, Elon Musk estimated that the project would cost between $100 billion and $10 trillion (Musk 2019). According to Musk and Shotwell, Starlink was created to generate profits to fund this goal (Jewett 2021). Forgoing Starlink profits to launch commercial payloads at low prices would reduce the capital that SpaceX could use to pursue its Mars ambitions. Although the goal of living on Mars may not be motivated by profits, SpaceX is incentivized to behave like a profit maximizer to reach Mars quickly.

Profit maximizers allocate scarce resources to their most profitable uses, suggesting that Starship may be more expensive in the 2020s than optimistic hardware-only cost assessments imply. Indeed, so long as launch windows remain scarce compared to the number of launches Starlink requires, greater Starlink profitability may lead to higher Starship prices. Our analysis indicates that Starship may be unavailable for most external customers during its initial years of operation, as SpaceX has a strong incentive to focus on building up Starlink. In the absence of competition, annual Starlink revenues of $30 billion to $50 billion imply that the market price of Starship launches may be no lower than $120 million to $320 million, respectively.

We examined Starship flight prices in total dollars rather than dollars per kilogram. While dollars per kilogram help compare different launch vehicles, this metric can be misleading for practical planning. Launch providers like SpaceX charge for vehicle use, not by payload mass. Customers rarely utilize full mass capacity—Falcon 9 missions often fly partially empty, resulting in actual costs exceeding $20,000 per kilogram compared to the theoretical minimum of $4,000 per kilogram (Lionnet 2024, Kuhr 2025). The dollars per kilogram metric incorrectly combines payload mass speculation with flight price assumptions, making total dollar cost a more reliable measure for planning purposes.

While competition may temporarily reduce prices during periods of excess Starship supply, prices should remain close to those of SpaceX's nearest competitor. Reducing prices below this threshold would sacrifice profits that could be used to advance SpaceX's Mars colonization

objectives. Launch service providers competing in the Starship era should recognize that, despite lower hardware and operations costs, SpaceX may lack an economic incentive to substantially undercut market rates. Furthermore, Starlink's profitability serves as an indicator of SpaceX's launch pricing strategy—prices reflect opportunity costs rather than merely production costs.

Crewed Missions and Rideshares

Starship may still be available for commercial or government-sponsored missions that include crew. Unlike launches to place satellites into orbit, crewed missions could build flight heritage that supports SpaceX's plans for Mars. NASA contracts for the Human Landing System–to place astronauts on the lunar surface–have also provided substantial funds for the development of crewed capabilities that overlap with those needed for Mars exploration. In this way, Starship prices may not always be driven by the opportunity costs discussed in this paper.

We did not analyze the case of rideshares on launches dedicated to Starlink satellites. This is because Starlinks are delivered to a very low orbit, below 300 km in altitude, from which they use their electric propulsion systems to boost themselves to their final orbit a few hundred kilometers higher. Most revenue-generating satellite operators do not currently use the type of propulsion capabilities that would allow for them to make a similarly large transit; even then, they would be restricted to fairly low orbits. We did not assess how quickly satellite operators that use relatively low orbits could transition to propulsion systems that would allow them to take advantage of rideshares on Starlink launches.

We also did not assess when SpaceX might be incentivized to sell such rideshares. Fundamentally, selling a rideshare on a Starlink launch implies either that an external customer displaced one or more Starlink satellites–in which case that slot should be priced according to its opportunity cost–or that there was volume on the flight that could not be used for Starlink satellites. If the latter is true, SpaceX would have an incentive to alter the design of the Starlink satellites to use the remaining volume, thereby generating more profit per launch.

Supply Expansion

Starship launch windows may remain scarce relative to Starlink's needs until the early 2030s, keeping opportunity costs high. Would SpaceX eventually expand the supply of annual Starship launches to offer dramatically lower prices to external customers? This depends on three potential drivers, each with different timing and price implications: external demand, internal Starlink demand, and demand for interplanetary missions.

Increases in external demand could prompt SpaceX to invest in greater annual Starship launch supply. However, this is a "chicken and egg" problem. So long as Starship prices remain high, Starship prices could not be the economic driver that generates substantial new external demand. But without substantial new external demand, price reductions would not lead to additional profits. SpaceX may invest in increasing the annual supply of Starship launches in

anticipation of additional external demand, but whether that demand actually appears is a subject for future research.

If SpaceX decides to make the Starlink constellation larger, they may invest in greater annual Starship launch supply. Whether this leads to lower Starship prices or not depends on the ratio of satellites added to new launch supply. Conversely, reductions in constellation size or the number of launches required to replenish the constellation would free up launch opportunities for sale to external customers. Here, reductions in launch prices could occur to the extent that competition drives them down.

Finally, increases in demand for interplanetary missions may require additional launch supply. For example, if SpaceX needed 20 more launches for each Mars mission and planned Mars missions every other year, the extra launch supply in the years between Mars missions could be sold to external customers. Whether this would push prices down depends on the level of competition.

Vertical Integration

A narrative within the space community suggests that vertical integration of satellite constellations and launch providers may drive down launch prices. This is because increased launch rates for the provider allow fixed costs associated with reusability to be spread across more flights. While this may hold true for internal costs, internal costs do not equate to market prices in markets with thin competition. Contrary to this narrative, we have shown that constellations integrated with launch vehicles may actually drive the market price of launches up, not down. If launches are scarce, the price of a launch should reflect the profitability of the vertically integrated constellation, not the internal cost of performing the launch. As the profitability of the constellation increases, so too does the implied market price of the launcher.

On the other hand, constellation operators with their own launch services can avoid market rates and launch at cost, thereby increasing the profitability of the constellation. This creates an incentive for a constellation operator to merge with a launch provider to capture these increased profits. Such consolidation may raise the price of the launch services offered by those providers. This situation is unfavorable for launch customers, who would then pay more for launches than they otherwise would. However, the increased market price allows pure-play launchers to capture greater revenues from the remaining customers in the market.

To be clear, we have not asserted that launch prices will increase. We make no claims about the overall trend of launch prices in the coming decade. However, we hope to have demonstrated that some narratives regarding substantial reductions in launch prices rest on assumptions that appear inconsistent with basic economic principles.

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