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Space launch: Are we heading for oversupply or a shortfall?

As the space economy expands, satellite constellations are proliferating. But launch providers must make tricky decisions on how to ramp up capacity.

by Chris Daehnick, John Gang, and Ilan Rozenkopf

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To serve an expanding space economy, nearly 7,500 active satellites orbit Earth and about 50 on average are taking to the skies every week.[1] Many operate as part of multi-satellite constellations—serving commercial applications from remote sensing to communications to navigation. Governments are also expanding their satellite fleets for multiple missions. In the future, greater space exploration, the launch of commercial space stations, and even tourism could further increase launch needs. New companies are constantly entering the market and much uncertainty persists about their ambitions, as well as those of more established players. Forecasts for the number of constellations, and therefore required launch capabilities, thus vary widely.

In tandem with this rise in activity, the space industry is transitioning to a new generation of launch vehicles, leading to a range of possibilities in terms of availability and capacity. In light of these dynamics, both customers (commercial and government satellite owners) and suppliers must make tricky calculations to balance short-term opportunities against the imperative to control costs and flex to longer-term demand.

While government (military and civil) space activity remains a significant and growing source of launch demand, the private sector is the fastest-growing segment, amid technological advances and declining costs that have spurred innovation and commercial activity. The price of heavy launches to low-Earth orbit (LEO) has fallen from $65,000 per kilogram to $1,500 per kilogram—more than a 95 percent decrease.[2] In part due to these efficiencies, companies and governments are putting thousands of new satellites into orbit.[3] Elon Musk's SpaceX is leading the way, with its Starlink program planning to launch as many as 42,000 satellites to provide global broadband and other services.[4]

Satellite use cases span a range of applications. As of March 2023, there were 5,000 satellites serving communications, with the number of communications launches having grown by about 15 percent a year since 2017. There are about 1,000 active satellites for Earth observation and 1,500 for technology development, research, and other missions.[5] Looking ahead, there are plans for a significant expansion to as many as 65,000 new communication satellites and 3,000 non-communication satellites (for applications such as Earth observation).[6] In total, companies have proposed more than 100 new constellations. Direct-to-device concepts, which link satellites to cell phones, have also gained traction lately and could lead additional new entrants. Even if not fully deployed, the new constellations will drive demand for services including intersatellite links, ground terminals, analytical support and, potentially, in-orbit maneuvering and debris removal.

A key driver of satellite proliferation is lower overall costs, enabled, for example, by more capabilities in small satellites such as cubesats, built from ten-by-ten-by-ten centimeter modules, and microsats, weighing less than 100 kilograms. These are used for applications such as Earth observation and in-orbit demonstrations of miniaturized technologies. Still, useful constellations (commercially or for government purposes) will require dozens to thousands of spacecraft. Moreover, as designs mature, satellites will tend to get bigger, suggesting medium and heavy launch capabilities will remain the most cost effective choice for deployment. And the new generation of satellites will operate for just five to seven years—allowing for technology refresh and reduced manufacturing costs. These factors are set to drive demand for significant launch tonnage.

Three scenarios for potential growth to 2030

According to the not-for-profit Space Foundation, the space economy is growing strongly, up 9 percent from 2020 to reach a value of $469 billion in 2021.[7]

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[1] Radar, McKinsey, accessed March 1, 2023.
[2] Ryan Brukardt, "How will the space economy change the world," *McKinsey Quarterly*, November 28, 2022; Chris Daehnick, Rob Hamill, Alexandre Ménard, and Bill Wiseman, "Is there a 'best' owner of satellite internet?" McKinsey, August 11, 2022.
[3] Chris Daehnick, Isabelle Klinghoffer, Ben Maritz, and Bill Wiseman, "Large LEO satellite constellations: Will it be different this time?" McKinsey, May 4, 2020.
[4] Starlink is responsible for almost half of all operational satellites. All have been launched in the past three years. Ramish Zafar, "SpaceX might not need 42,000 Starlink satellites for quality internet coverage says president," Wccftech, September 14, 2022.
[5] Radar, McKinsey, accessed March 1, 2023.
[6] In most cases, the maximum number of satellites has been announced or filed for; the quantity may change
[7] "Space Foundation releases the Space Report 2022 Q2, showing growth of global space economy," Space Foundation, July 27, 2022; Michae Sheetz, "The space economy grew at fastest rate in years to $469 billion in 2021, report says," CNBC, July 27, 2022.

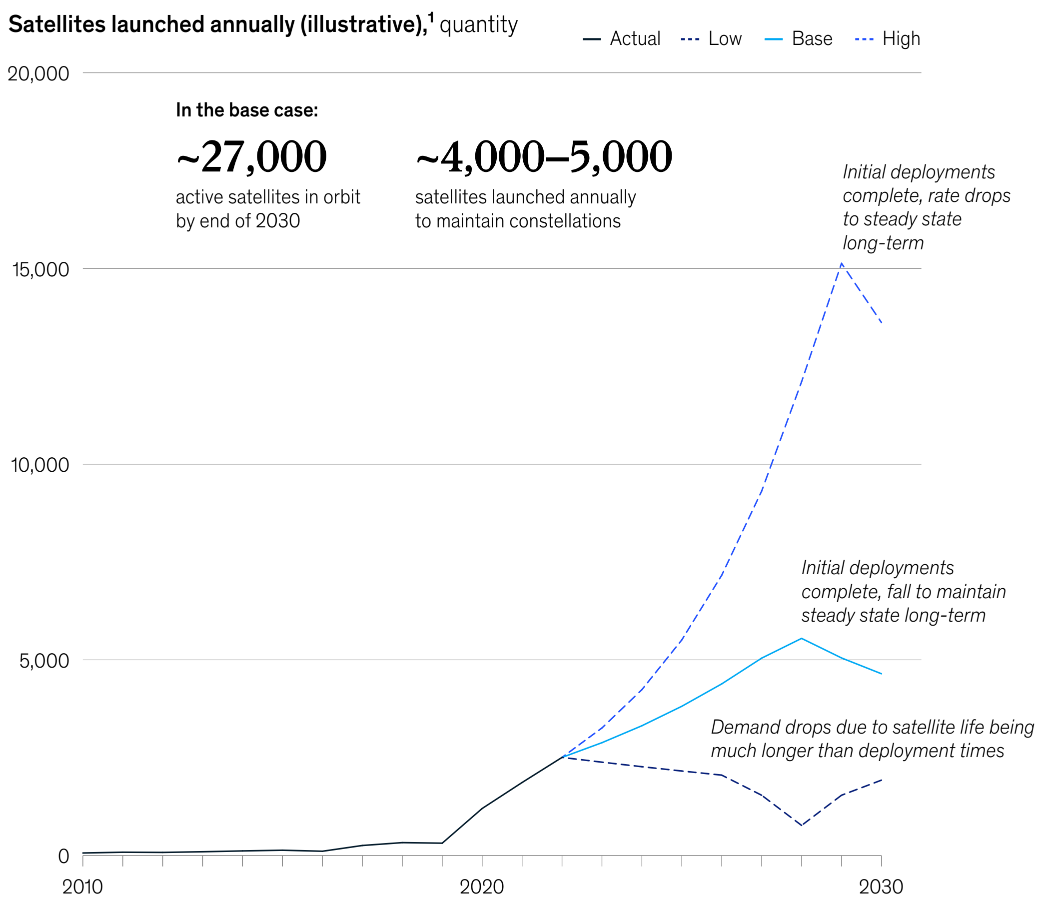
This was the highest recorded growth since 2014. To gauge the industry's potential growth up to 2030, McKinsey modelled three scenarios, predicated on assumptions around the quantity, size, and timing of deployments (Exhibit 1).[8] For each constellation, we estimated the total number of licensed or proposed satellites, expected mass, and likelihood of full deployment, which we then combined with views on launch dates and satellite lifespan. We also considered plans for non-constellation launches, such as commercial space stations, when creating the scenarios (see sidebar "Assumptions underlying the scenarios").

Our scenarios depict situations of high demand, base-case demand, and low demand. In the base case, we anticipate 27,000 active satellites in orbit by the end of 2030, almost a four-fold increase from today. To maintain that number at the assumed lifespan, there would need to be 4,000 to 5,000 satellites launched per year.

The number of planned satellites that make it to launch is a critical metric because it has implications for the thousands of companies that serve the space economy. In a high-demand scenario, in which nearly all proposed constellations materialize, we would expect to see more than 65,000 satellites, including many heavier ones, on orbit by 2030. Annual launch capability would need to be around 15 kilotons (15 million kilograms). By contrast, the base-case scenario, in which less than half of planned

Exhibit 1

Three scenarios illustrate a wide range of launch volume possibilities.



[1]Excluding potential Russian and Chinese launches.
Source: Radar-Space by McKinsey

[8] Note these are only three of many possible scenarios; other variables include delays in launch and planned satellite lifetimes.

Assumptions underlying the scenarios

For the three scenarios, we made the following assumptions about launch demand:

- *High.* This scenario assumes that 67,000 satellites with an average mass of one ton are deployed by 2030. They are fully deployed within four years of initial launch, and satellites are replaced frequently, with an assumed service life of under six years on average. In addition, there are many heavy-payload-mass flights to space stations and beyond.
- *Base.* This scenario assumes that 24,000 satellites with an average mass of 870 kg are deployed by 2030. There is a slower rate of deployment, with constellations completed on average in five years, and an average satellite life of slightly more than six years of service. There is a moderate quantity of flights and payload mass (75 percent of high case) to space stations and beyond.
- *Low.* This scenario assumes that 18,000 satellites with an average mass of 540 kg will be deployed by 2030. There will be slow deployment, taking over five years, and satellites will be kept in orbit longer, for nearly eight years. There will be a low quantity of flights and payload mass (50 percent of high case) to space stations and beyond.

For launch supply, the high-supply scenario assumes that Starship will achieve a daily launch rate by 2030 and have a fleet of 30 boosters and 60 ships. Launches of Falcon 9 will taper off, except for existing contracts, and be replaced with Starship launches. The high-supply scenario also assumes that other vehicles will achieve their anticipated rate capabilities within four to six years.

In the alternative supply scenario, Starship is not included in the calculation. This scenario also assumes that Falcon 9 will reach and maintain a rate of 120 launches annually, while other vehicles reach expected rate capabilities within six years.

satellites materialize and sizes moderate, would require 4.5 kilotons of launch capacity. At the low end, characterized by fewer, smaller satellites, less than 2 kilotons of launch capacity would be required (Exhibit 2).

Another striking output of the modeling is the wide range of potential trajectories for launch demand. This is highly dependent on which constellations materialize and to what degree. If the high-demand scenario plays out, demand would rise quickly and then gradually fall as constellations reach a steady state—assuming there are no more new entrants. The trajectory in the base-case scenario would be slightly different, with demand peaking by 2028 and then remaining steady. In the low-case scenario, demand would remain around current levels up to 2027 and then dip briefly, since fewer of the concepts deployed require continuous replenishment. Starlink's evolution is a prominent factor in all scenarios.

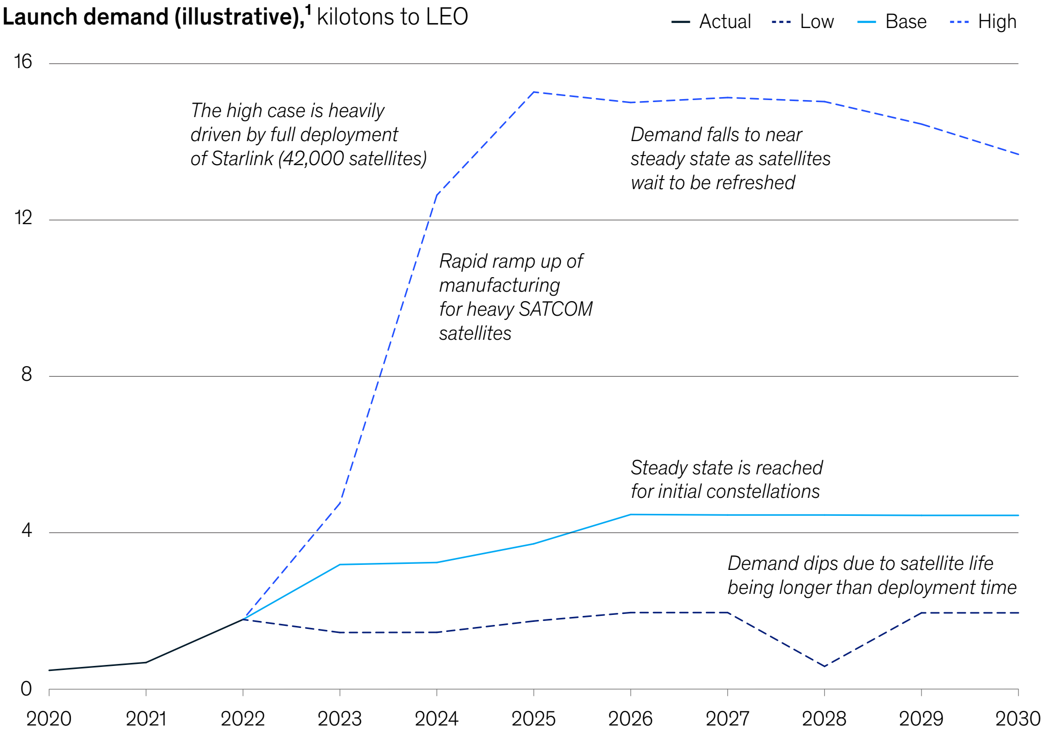
The status of launch supply

While demand dynamics are uncertain, launch is also at a tipping point. Many medium and heavy launch vehicles are being retired and most remaining capacity is already booked. ULA's Atlas V has sold its remaining launches, and Arianespace has contracts for its remaining Ariane 5 flights. Mitsubishi Heavy Industries (MHI) is in the same position with its H2 vehicle, and Northrop Grumman's final flight of its Antares 230+ is expected this year. Vehicles such as ISRO's SLV platform are available but will need to exceed launch rates achieved in recent years to keep pace with orders. This leaves Falcon 9 and Falcon Heavy as the primary active medium and heavy launchers.

Exhibit 2

Launch demand could vary greatly both in constellation ramp up and steady state.

Launch demand (illustrative),[1] kilotons to LEO



[1]Assumes steady state constellation size once fully deployed.
Source: Radar, McKinsey

Meanwhile, V2 Mini satellites allow SpaceX to move forward with its second-generation constellation while waiting for Starship capacity to come online.[9]

In the background, new launch capabilities are in development. Arianespace is developing Ariane 6, with plans for up to 11 launches per year and possibly more.[10] ULA expects up to 30 launches a year, while Blue Origin anticipates a dozen or more launches a year on its New Glenn rocket.[11] All three are aiming for first launches in 2023, but much of the capacity has also been reserved for Amazon's Kuiper constellation and, in the case of ULA, the US National Security Space Launch program. MHI attempted the first launch of its H3 rocket in March 2023 but suffered a second-stage failure. The next attempt is not yet scheduled. Finally, companies including Firefly, Northrop Grumman, and Rocket Lab are planning new medium launch capacity that may come online as soon as 2024. Specific launch rates have yet to be disclosed.

Looming over the market is SpaceX's Starship, also expected to fly for the first time in 2023. When it reaches full capacity, SpaceX hopes to fly Starship every day, sending over 100 tons to orbit per launch. This kind of capability would fundamentally transform industry capacity and launch economics,

[9] Eric Ralph, "SpaceX unveils next-gen Starlink V2 Mini satellites ahead of Monday launch," Teslarati, February 26, 2023.
[10] CEO of Arianespace Stephen Israel at World Satellite Business Week, September 2022.
[11] ULA VP of Vulcan Development Mark Peller at World Satellite Business Week, September 2022; "New Glenn payload user's guide," Blue Origin, October 2018.

with a promise of launch costs as low as $100 per kg to LEO.[12]

Of course, in space commerce, there is often a yawning gap between intention and execution. A rocket in development is not equivalent to being able to offer an immediate or scheduled ride into orbit. In all cases, we expect a significant ramp-up period, even after a successful first flight.

As a guide to when new systems might add useful capacity, a potential benchmark is the historical lag between first flight and peak launch rate. In the medium- to heavy-size category, vehicles have typically seen a five-to-nine-year gap, with Falcon 9 being an outlier in that its launch rate is still rising. A major caveat to this approach is that there are many differences in the characteristics of individual programs, and in some cases, a full rate may have been limited more by demand than by a delay in production or operational ramp up. In addition, as the industry deploys new technologies and approaches, such as additive manufacturing and reusability, historical experience may be less directly relevant.

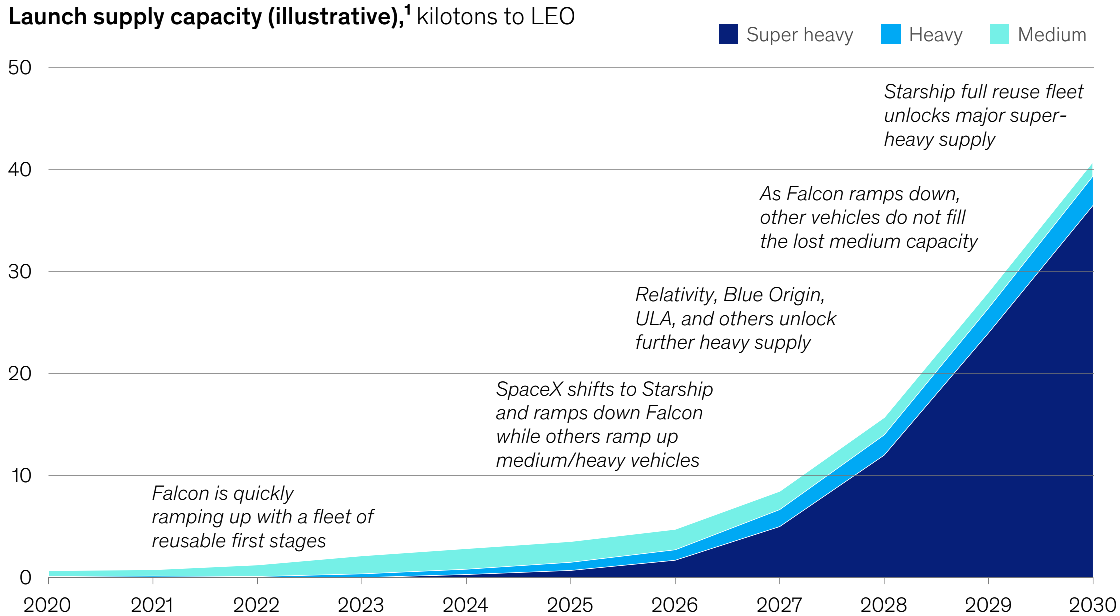
Our Monte Carlo modeling suggests that, despite technological advances, new vehicles are unlikely to reach full capacity earlier than six years after first flight. Indeed, we believe new platforms such as Starship and New Glenn are likely to take longer than evolutionary launch vehicle families (e.g., Ariane 6, Vulcan) to get to peak performance, reflecting challenges expected with new designs.

A "most-likely" supply curve suggests an eventual surge in capacity as new players join the market and incumbents including Arianespace, MHI, SpaceX, and ULA bring vehicles online and ramp up launch rates, with Falcon 9 possibly reaching 100 or more annual launches in the near term (Exhibit 3).

Exhibit 3

A 'most-likely' supply curve shows evolutions in medium and heavy supply.

Launch supply capacity (illustrative),[1] kilotons to LEO



[1]Excludes Russia, China, and small launch; Assumes a Starship fleet of 30 boosters and 60 ships, with 30-day and 60-day landing to launch turnaround, respectively, in 2030.
Source: Radar, McKinsey

[12] Kate Duffy, "Elon Musk says he is highly confident that Space X's Starship launches will cost less than $10 million within 2-3 years," *Business Insider India*, February 11, 2022.

Looking ahead, as demand continues to rise, the medium segment may make up a smaller portion of launch as heavy and super-heavy supply (from Blue Origin, Relativity, and ULA, among others) rises and total supply increases. A significant factor in the capacity equation is the potential capabilities of Starship, which theoretically could offer a launch a day by 2030. Daily Starship launch is possible with a fleet size of 60 and just 15 reuses, and turnaround times slower than the historic bests of Falcon 9 for boosters and the space shuttle for orbital vehicles.[13]

Because the rate at which Starship will develop is uncertain, and because initial launches are likely to be heavily committed to Starlink, it is useful to consider a near-term scenario in which both Starship and full-size Starlink are excluded (Exhibit 4). While Falcon could continue in service, annual capacity across medium and heavy vehicles would reach a maximum of just five to six kilotons by 2030.

Matching supply and demand

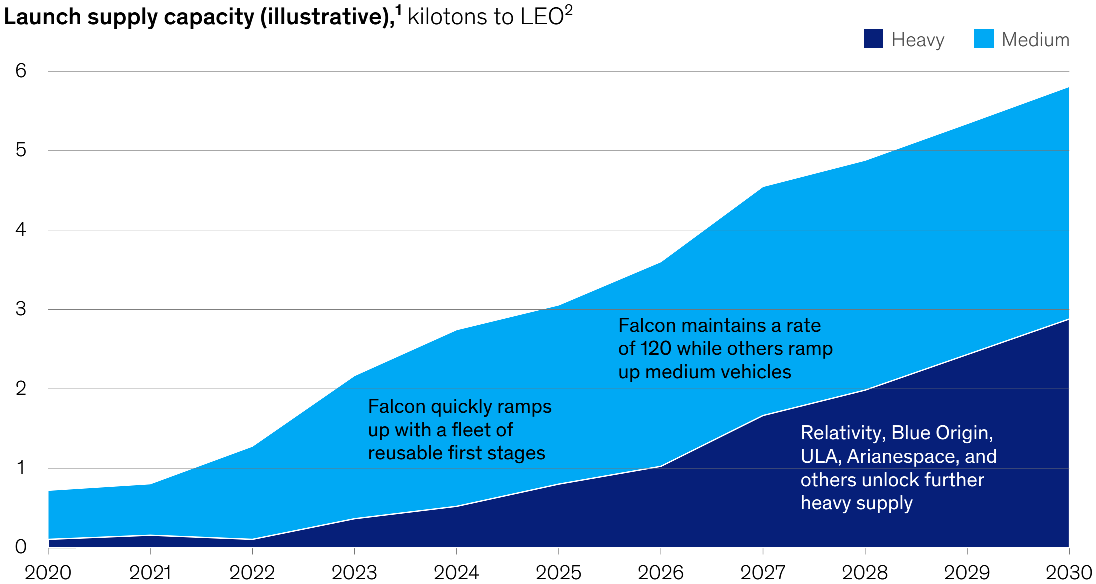
The data, in aggregate, suggest that the space industry faces a potential double bind. In the short term, the most likely scenario is a capacity shortfall, but in the longer term, the biggest risk is oversupply.

In the high-demand case, the shortfall would be up to 11,700 tons (equivalent to approximately 300 heavy or 800 medium vehicles) through 2025, implying that optimistic constellation deployment forecasts are unachievable in the near term—even if financing, manufacturing, and other challenges are overcome. In our base case, a smaller but still significant shortfall in medium and heavy lift is likely over the next three years. Looking further ahead, Starship would be a game changer, if it meets its launch and reuse targets, with other providers adding to the surfeit of supply (Exhibit 5).

Exhibit 4

Without Starship, supply would increase but at a much slower rate.

Launch supply capacity (illustrative),[1] kilotons to LEO[2]



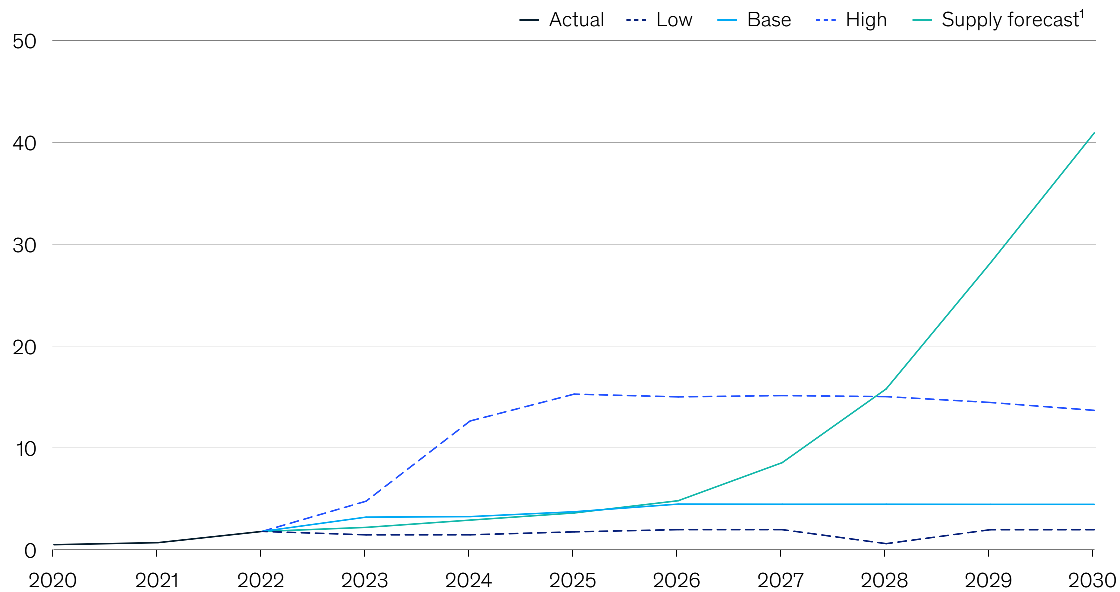
[1]Excludes Russia and China.
[2]Excludes small and super heavy.
Source: Radar, McKinsey

[13] Darrell Etherington, "Elon Musk shares details about SpaceX's Starship, including estimated 20 to 30-year service life," TechCrunch+, January 17, 2020. SpaceX plans to run a Starship fleet of hundreds – SpaceX VP Tom Ochinero, World Satellite Business Week, September 2022.

Exhibit 5

Base- and high-demand cases show near-term shortage and longterm oversupply.

Launch demand and supply (illustrative), kilotons to LEO, 2020–30



[1]Numbers exclude Russia and China; Supply forecast includes Starship.
Source: Radar-Space by McKinsey

Because of the outsize potential impact of SpaceX on both supply and demand, the industry should consider a scenario where Starship does not ramp up as expected and a full Starlink V2 deployment (which requires Starship) is delayed. In that scenario, with "base-case" assumptions for other constellations, there would still be a short-term launch shortage; cumulatively about 3,000 tons or effectively a year of launches, unless SpaceX delays Starlink V2 mini deployments to serve other customers with Falcon (Exhibit 6). If, on the other hand, something like the low-demand scenario emerges, medium and heavy launch providers would have excess capacity near-term.

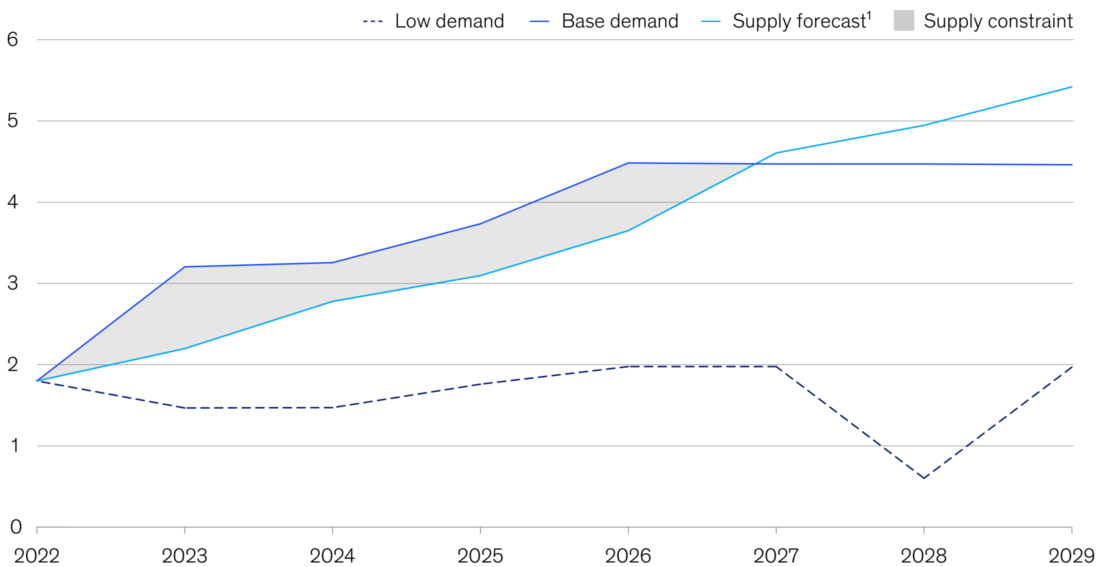
As legacy vehicles ramp down and the industry transitions to next-generation platforms, a short-term supply shortage may open the window to a period of opportunity. Providers that can speedily ramp up their operational capabilities have a chance to capture market share, assuming vehicle reliability and the ability to control costs. In the longer term, as providers increase launch rates and vehicles become more reliable, there is a risk of oversupply, at which point cost control is likely to become a vital factor in remaining competitive.

The best placed launch companies in this context will pursue strategies that maximize flexibility and cost control. This implies design and manufacturing approaches that allow for rapid deployment and scaling of capacity without incurring large fixed or variable costs, and operational approaches that reduce time to launch and associated labor costs—likely leveraging reusability to drive the cost per launch as close as possible to the cost of fuel and vehicle maintenance. Safety and reliability will continue to be overarching concerns, suggesting

Exhibit 6

Excluding Starship and full-size Starlink v2, a near-term shortage is still likely.

Launch demand and supply (illustrative), kilotons to LEO, 2022–2029



[1]Numbers exclude Russia and China; Supply forecast excludes Starship and assumes Falcon 9 maintains a rate of 120 annually through 2030.
Source: Radar-Space by McKinsey

excellent execution will be table stakes for a competitive launch company. Customer service, in terms of flexibility and tailoring of a launch to customer needs, could provide an advantage, as long as prices remain competitive. Longer-term or multiple launch contracts may be a way to provide certainty and could become more widespread than historic launch-by-launch deals.

In an environment with uncertain but potentially large demand, there is significant near-term opportunity, but also considerable risk that a launch provider could be late to market and lose out to more nimble competitors. At the same time, the real chance of oversupply in the mid-term means cost control and the ability to economically dial back capacity must be a consideration from the start. As decision makers ponder their options, it will be vital to closely monitor the industry's progress and take active steps to preempt potential outcomes.

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