A Guide for Investors, Entrepreneurs, and Aspiring Professionals

THE SPACE ECONOMY

CAPITALIZE ON THE GREATEST BUSINESS OPPORTUNITY OF OUR LIFETIME

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Introduction

If you're reading this, you probably have the sneaking suspicion that something big is on the horizon. You may even have glimpsed a harbinger of this coming change: small, Low Earth Orbit (LEO) satellites swooping across the sky, parts of the rapidly growing satellite constellations powering the global economy to a greater extent each day.

We use the term "Space Economy" to encompass every business that relies on orbital access to deliver its value, from Planet Labs*, a company imaging every inch of the ground from space on a daily basis, to Pokémon GO!, a hit mobile game that works using GPS signals from satellites.

For all the media coverage of SpaceX* and its iconoclastic founder, Elon Musk, commercial Launch services are just the beginning of the story. The Space Economy is much more than rockets and satellite hardware. Space-based technologies are next-generation digital infrastructure, the "invisible backbone" of the largest global industries. Most people have yet to grasp the genuine, world-changing business implications of lower-cost orbital access.

(An asterisk will mark the first appearance of any company Space Capital has previously invested in.)

CNBC has called space "Wall Street's next trillion-dollar industry."[1] Bank of America predicts that “the growing space economy will more than triple in size in the next decade to become a $1.4 trillion market."[2] Morgan Stanley expects a space-based business to create the world's first trillionaire.[3]

Humanity has operated in space for decades, but, for reasons covered in Chapter 1, only recently has space become a category for investment. Given that this entrepreneurial space age is only a decade old, most of the action is still in the private markets, but we're beginning to see some companies listed on public markets where retail investors can participate. If you think back to the late 1990s, there were a handful of publicly traded technology stocks. Seemingly overnight, "technology" became an

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[1] Michael Sheetz, “An Investor’s Guide to Space, Wall Street’s next Trillion-Dollar Industry,” *CNBC* (blog), November 9, 2019, https://www.cnbc.com/2019/11/09/how-to-invest-in-space-companies-complete-guide-to-rockets-satellites-and-more.html.

[2] Mary Meehan, “Trends For 2022: Change The Way You Look At Change,” *Forbes* (blog), December 21, 2021, https://www.forbes.com/sites/marymeehan/2021/12/21/trends-for-2022-change-the-way-you-look-at-change/.

[3] Rupert Neate, “SpaceX Could Make Elon Musk World’s First Trillionaire, Says Morgan Stanley,” *The Guardian*, October 20, 2021, sec. Technology, https://www.theguardian.com/technology/2021/oct/20/spacex-could-make-elon-musk-world-first-trillionaire-says-morgan-stanley.

investable category to diversify your portfolio. Today, that label has lost its meaning. Every company is a technology company. Space is in the same position that tech was then. One day, "space" will lose its usefulness as every company begins to rely on space-based technology in some way to deliver value.

Space technologies have already delivered massive returns for investors. GPS is a space-based technology that has generated trillions of dollars in economic value, as well as some of the largest venture outcomes in history. As we'll see in the next chapter, GPS provides a useful playbook for understanding how other space-based technologies will create new investment opportunities across the economy. Two of these—Geospatial Intelligence and Satellite Communications—already play critical roles in most major industries, including agriculture, logistics, telecom, financial services, and many others.

There was a time when terms like “e-commerce” and “blog” began appearing regularly in magazines and nightly news shows—remember those things? At the time, these bits of unfamiliar lingo were whimsical curiosities to the mainstream, newfangled phenomena relevant to teens, scientists, oddballs, and geeks but of only momentary interest to everyone else. How soon the internet changed things—as much for magazines and news shows as for every other business. Few people understood the scope of that onrushing change, let alone how to harness its potential. Of those who did, you know more than a handful, from Reid Hoffman (Netflix) to Jeff Bezos (Amazon) to, once again, Elon Musk (PayPal).

Chances are a warning bell has been going off in your mind about all the renewed interest and activity in space. You know something amazing is happening, but the full implications are hard to see. This book will give you the lens you need.

Let's say you're a serial entrepreneur, or that you're entertaining the notion of starting something of your own. As a founder, why risk entrepreneurship if you're not going to shoot, literally, for the Moon? Or, at least, in that general direction? Even if you already see the opportunity in this rapidly growing market, however, you have many questions: For all the investment capital flooding into the Space Economy, is there any interest in what I can offer? Do I have the necessary qualifications? Do I need a background in avionics or engineering? Should I have worked at NASA? Will I need to bring a personal fortune to the table, as Elon Musk did with his proceeds from selling PayPal?

The answer to all of these questions is a resounding no, but these concerns and others will be addressed. Likewise, you may be an investor curious about the potential of these new businesses and industries but unsure how to measure their value—or weigh their risks. How much of this stuff is *really* happening, as in, likely to turn a profit over the next few years? And which of these moonshots still belong on *Star Trek*, not *60 Minutes*, despite the assurances of highly credentialed scientists and entrepreneurs? Investors have heard a lot of hype from space "experts" over the last few years. This book will separate fact from science fiction.

We're at an inflection point where what's actually happening in space is more astonishing and otherworldly than all the breathless promises of the space crazies who

keep promising a Starbucks on Mars by early next year. Fifty years ago, the first glimmers of a global computer network containing all the world's knowledge attracted scant public attention. Meanwhile, jetpacks still inspired awe and wonder even though people regularly flew on airplanes. Would jetpacks really constitute a greater paradigm shift than the World Wide Web? Of course not. To the average person in 1973, however, they were just easier to understand.

To succeed as an investor in any category, you need to grasp not only fundamentals like profit and loss but also the lay of the land where you plan to allocate resources: The companies and their customers. The markets and the major players. Consider this book your manual and your map. As investors and operators, the team at Space Capital brings a unique combination of in-house technical expertise, entrepreneurial experience, and investment track record to the table. There is no predicting the future, but some guesses are far more grounded than others. Read on for ours.

If you're not an entrepreneur or an investor yourself, you may be a professional seeking a role in the Space Economy. In fact, you may already be working in a space-related industry today, anywhere from major players like SpaceX and Planet Labs to one of the space start-ups that have been founded over the last few years alone. As a leader, manager, or front-line employee, you will find a wealth of valuable information here, including lessons and advice from CEOs, veteran space industry professionals, space policy experts, visionary technologists, and more. The diversity of perspectives this book

provides will give you an unparalleled look at the big picture, along with actionable takeaways.

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Here I go, making big promises about the future, just like all those people pre-selling lattes on Mars. Why take my word on any of this?

After managing a $50-billion real estate portfolio through the Great Recession, I found myself seeking a greater purpose than investment banking, the opportunity to make a genuine, lasting impact on the world. Drawn by its Skoll Center for Social Entrepreneurship, I went to Oxford University to earn my MBA at the Saïd Business School. There, I had the opportunity to learn from the brilliant economic sociologist Marc Ventresca.

Ventresca, an authority on technological innovation and market formation, taught me all about the nascent markets that spring up from innovative breakthroughs: the car, the PC, the mobile phone. In Ventresca's class, I learned what nascent markets look like and how they evolve over time. Just before I matriculated at Oxford, on May 24, 2012, SpaceX had successfully delivered cargo to the International Space Station (ISS) aboard its Dragon capsule, a first in commercial spaceflight. It would be hard to imagine a more fortuitous piece of serendipity: Learning about market formation, I could see recent evidence of the birth of a bona fide new market.

By successfully completing its ISS cargo mission, SpaceX had done the unthinkable, achieving a feat previously restricted to three world superpowers. Where things went next seemed obvious to me. Market competition would increase efficiency

and decrease prices. More and more businesses would be able to participate in the Space Economy. All kinds of unforeseen products and services would crop up. Fortunes would be made (and lost).

At the time, I felt certain I couldn't be the only person who saw a market forming. SpaceX wasn't operating in secret, after all. Musk delighted in trumpeting every milestone on social media. As early as 2003, he declared an unambiguous parallel between space and the internet: "I like to be involved in things that change the world. The Internet did, and space will probably be more responsible for changing the world than anything else."[4] Here was a serious tech entrepreneur telling everyone that outer space was "where the future is." Surely, now that Musk had delivered on the promise of an ISS cargo mission, entrepreneurs and venture capitalists around the world would scramble to leverage affordable orbital access. I'd have to work quickly if I wanted to participate.

Recognizing that all the new space start-ups I envisioned would need venture capital, I decided to start an early-stage investment fund specializing in the category. To be successful in such a deeply technical field, however, my background in finance wouldn't be enough.

As a first step, I sent a cold outreach email to the CEO of Astrobotic*, a Pittsburgh-based space-robotics company making progress toward Google's now-defunct

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[4] Josh Friedman, "Entrepreneur Tries His Midas Touch in Space," Los Angeles Times, April 22, 2003, https://www.latimes.com/archives/la-xpm-2003-apr-22-fi-spacex22-story.html.

Lunar XPRIZE. In my email, I offered to help Astrobotic develop a market assessment for commercial lunar transportation services, pro bono. Astrobotic agreed, so I spent the next nine months working closely with them to study the emerging opportunities around Lunar transportation and infrastructure.

This was my first experience working within the Space Economy itself, interacting not only with the team at Astrobotic but also with other leaders in the field. To my surprise, I found that nearly everyone working in the Space Economy, as I'd already begun to think of it, was either an engineer or a scientist. There were no MBAs and very few general entrepreneurs—maybe there was room for me after all.

The report I ended up writing, the first assessment of its kind, generated attention for Astrobotic, which even used it to pitch NASA. (Though the Lunar XPRIZE ended after a decade without a winner, Astrobotic went on to win hundreds of millions of dollars in Commercial Lunar Payload Services contracts and is due to send its Peregrine lander to the Moon aboard United Launch Alliance's Vulcan Centaur rocket by the end of 2022.[5])

Meanwhile, in exchange for my contribution, I walked away with invaluable understanding of this new market. After Oxford, I went on to publish several academic papers on related topics. One explored the ramifications of the ISS cargo run, explaining

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[5] Rebecca Boyle, "The New Race to the Moon," *Scientific American*, August 2022, https://doi.org/10.1038/scientificamerican0822-72.

how public-private partnerships had made commercial spaceflight economically feasible and arguing for the real, near-term economic potential.

"The docking of Dragon represented a historic moment where a commercial enterprise managed to achieve that which had previously only been accomplished by governments," the paper read.[6] What I'd written went on to be cited widely, but I was just getting started. There's a difference between research and application, and I wasn't there just to study the Space Economy. I wanted to help build it.

In 2013, there was close to zero private activity or investment in the Space Economy outside of SpaceX. Despite my sense of urgency, I seemed to be one of the few people on the business and investment side who saw this as an opportunity. (In chapter 6, we'll look at the troubled history of the commercial space industry and how prior failures led many to miss the turnaround when it happened.)

Without enough deal flow or investor interest to support a fund, I helped stand up an innovation center focused on the commercialization of the United Kingdom's space sector. At the Satellite Applications Catapult, I incubated and accelerated startups and mobilized investment in space businesses. Working at the Catapult, I built my professional network and cultivated a reputation within the field. At night—work hours back on the East Coast—I built Space Capital. Lacking sufficient capital to invest, I leveraged my expertise and the unique data set I'd gathered to educate and inform the

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[6] Chad Anderson, "Rethinking Public–Private Space Travel," Space Policy 29, no. 4 (November 1, 2013): 266–71, https://doi.org/10.1016/j.spacepol.2013.08.002.

market, combat misconceptions, and help investors understand where things might be headed.

By 2015, I had enough momentum to raise seed capital. Moving to New York City, I established Space Capital's headquarters and, in April of that year, launched our inaugural SPV (Special Purpose Vehicle) fund, collecting money from groups of individuals to, at first, invest in Planet Labs. These weren't blind pools of venture capital. They were funds I'd cobbled together myself, deal by deal. I'd find an opportunity, do the due diligence, and bring it to the investors directly.

That December, SpaceX achieved a successful landing and recovery of their rocket, ushering in greater reusability and further reducing the cost of reaching orbit. This feat catalyzed sufficient investor interest to launch Space Capital's first institutional venture capital fund in 2016. At that point, I knew it was time to bring in a partner. I needed someone who would complement my finance background with heavy-duty industry experience and technical expertise. Unfortunately, I found that many of the people visibly operating at the intersection of space and business were…overly enthusiastic. Or, to put it bluntly, hucksters. Venture capital is a reputation business. I couldn't afford to associate myself with a snake-oil seller. I needed to ally with a serious businessperson with a deep background in space. Making a list of candidates, it soon became clear that Tom Ingersoll was the person I needed to meet.

At the time, Ingersoll had been advising blue-chip venture capital funds on commercial space opportunities. As a CEO, he had already led two successful exits of venture-backed space businesses, making him one of the most accomplished operators in

the Space Economy. As an engineer and entrepreneur, Ingersoll had an impeccable pedigree, vast industry experience, and enough expertise on the investing side to meet me halfway. You can imagine my delight when he agreed to join Space Capital as my fellow managing partner.

Tom Ingersoll started his career with a decade-long stint in the Phantom Works advanced prototyping division of McDonnell Douglas, the legendary aerospace company that eventually merged with Boeing. There, Tom worked with Apollo astronaut Pete Conrad on several key projects, including the Delta Clipper Experimental (DC-X), a reusable single-stage-to-orbit launch vehicle.

In 1996, Tom co-founded Universal Space Lines with Pete Conrad, T.K. Mattingly, and Bruce McCaw. Ahead of its time but with a grand vision to become an operating company for the burgeoning commercial space industry, Universal Space Lines founded two subsidiaries: Universal Space Network, a provider of commercial tracking, telemetry, and control services for spacecraft, and Rocket Development Company, a commercial launch company.

A decade later, Ingersoll, with the help of McCaw, led the sale of Universal Space Network in one of the earliest successful exits in the Space Economy. (Now a subsidiary of Swedish Space Corporation, the network Ingersoll helped build has been instrumental in scientific missions in both LEO and Lunar orbit, as well as for commercial satellite services like Sirius XM.)

Next, Ingersoll was brought in to lead Skybox Imaging, a company developing satellites to provide frequent, reliable, high-resolution imagery of the Earth. In 2014, he

led the sale of Skybox to Google for $500 million in one of the largest venture-backed exits in the Space Economy at the time. (Skybox was later acquired by Planet Labs, where its assets are a key revenue driver.)

With the sale of Skybox behind him, Ingersoll stepped back for a look at the overall landscape. While more investment capital was flowing into commercial space efforts than ever before, too much of it was heading into "the wrong places."

The timing couldn't have been better when I reached out to him about Space Capital.

"People were making claims they couldn't achieve," Ingersoll told me. "It wasn't healthy for the investment environment. It made me nervous. Space Capital was a way I could make a difference by steering money away from the space crazies. If people aren't making money in space, capital will dry up."

Today, Ingersoll believes the space-crazy tide has turned: "Things are absolutely going in the right direction. There's froth, and some bad investments are always made, but we're on a great trajectory in general. There are better insights. There are more serious investors entering the picture."

Soliciting Tom Ingersoll's participation in Space Capital has easily been one of the best decisions I've made with the firm. There are few people on the planet with his soup-to-nuts technical and operational experience in the commercial space industry. Few but Ingersoll have brought not only spacecraft but entire space businesses from seed to success not once but several times. Ingersoll's expertise and intelligence are an invaluable part of Space Capital's value proposition. I count myself lucky to call him my

partner. Without a doubt, it's the talent we've assembled that explains why top-tier venture capital and private equity firms consistently look to us for operational guidance.

At Space Capital, we are experienced fund managers and operators, deeply embedded in the Space community, with a strong technical understanding. Our partners have built rockets, satellites, and operating systems. We have founded companies with assets currently in space and have led multiple exits as operators. We have been investing in this category for over a decade, and top-tier venture capital and private equity firms have consistently looked to our partners for operational guidance. As thesis-driven investors, we attract the best founders, ask better questions, and make better decisions.

You may be wondering why a company that trades on its expertise would bother sharing its understanding in a book. As I said earlier, before I had a cent of capital to invest, I used my expertise in the Space Economy to educate and inform the broader market. Investor education is still an integral part of our strategy. This book joins a wide array of Space Capital white papers, blog posts, podcast episodes, and television appearances. As investors, we believe that, for all the activity in today's Space Economy, the world is nowhere close to fully embracing the exponential growth opportunity at hand. With orbital access for all within reach, there are so many ideas and innovations from other industries that can now be applied to space. We hope to spur greater participation among the most talented entrepreneurs, investors, and professionals.

Over a quarter of a trillion dollars has been invested into nearly two thousand unique space companies over the last decade alone. Simultaneously, public interest in space-related careers has surged: Space Talent, our space-focused talent community and

job board, currently lists thirty thousand open positions across seven hundred companies. The Space Economy is here, and its growth is trending almost straight up.

As of this writing, orbital launches are on a record pace for the year, led by SpaceX and China's state-run launch operators. There were seventy-two launches in the first half of 2022, a pace that, if it continues, will break the record of 135 successful orbital launches set last year.[7] Much is happening, but if you rely on mainstream news that touches on space and space-based technology, it's easy to miss the forest for the trees. Stories that touch a nerve generate clicks. As we've seen with every other area of news coverage, this tends to distort the big picture.

Some businesses in the Space Economy are making real progress toward genuine and lasting improvements to our quality of life, from reducing pollution to ensuring our food supply, but in ways that are hard to summarize for a general audience. Other businesses wow a gullible press with flashy and dramatic promises, but pursue approaches that aren't grounded in good science.

It's a complex and powerful story like this one that demands a book-length treatment. The Space Economy isn't something you're going to understand from reading the latest headlines. It's too easy to confuse recency with relevance. Keeping up with space-related posts on the tech blogs won't clue you in to what's really going on. To

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[7] Stephen Clark, "World's Rockets on Pace for Record Year of Launch Activity," Spaceflight Now (blog), July 6, 2022, https://spaceflightnow.com/2022/07/06/worlds-rockets-on-pace-for-record-year-of-launch-activity/.

understand today's Space Economy, you need a balanced, fact-based perspective with just enough context to understand the implications.

At Space Capital, my partners and I spend most of our time talking to companies about their goals. Crucially, however, we follow up by doing our homework. We validate assumptions and estimate odds based on the facts. The reason we've been so successful is that we have the requisite expertise and investment experience to dig deeply into even the most technologically ambitious entrepreneurial vision.

At Space Capital, we know most of the key figures operating within today's Space Economy. Over the years, we've had the opportunity to talk shop with many of the leaders, government officials, technologists, and innovators driving progress in space, and I have conducted a series of dedicated interviews specifically for this book. Backed by these incredible outside contributions, I feel confident that *The Space Economy* will stand for some time as the most comprehensive and authoritative look at this exciting field.

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The book is comprised of ten chapters, each of which is designed to stand alone as a comprehensive resource on one or more key facets of the Space Economy.

The first chapter defines the Space Economy lens and makes the case that space is about much more than just rockets and satellites. As you'll see, the next-generation digital infrastructure provided by satellites is becoming part of the foundation on which every part of our economy—retail, shipping, manufacturing, *everything*—depends, unlocking a universe of new possibilities and changing the world in profound ways.

Chapter 2 offers a map of today's Space Economy, explaining the different categories we've identified and identifying some of the key players. One of the most interesting things about the Space Economy is just how much incredible innovation is going on just outside the spotlight. Companies are already finding product-market fit and generating tremendous amounts of value in this arena, and my hope is that a better understanding of the playing field will help you understand where you might make your own greatest contribution.

Chapters 3, 4, and 5 offer targeted advice for founders, managers, and leaders of companies within the Space Economy. Whether you're an entrepreneur toying with an idea that relies on space-based technology like GPS, the leader of a small but growing application developer using Earth Observation data in novel ways, or the CEO of a satellite manufacturer on the verge of an IPO, you will find valuable advice here from an array of major figures in the field combined with our own observations, insights, and best practices at Space Capital.

The Space Economy is unusual in how closely it interfaces with government organizations and policymakers. In addition to an in-depth exploration of the evolution at NASA that led to the success of SpaceX and the birth of the Space Economy, chapter 6 offers an insider look at the current rules around space and how they are likely to evolve in the near future. If your company operates in space or plans to do so, this chapter is required reading.

Chapter 7 offers practical guidance and useful insights on separating fact from fiction when it comes to space-based tech and making the best possible use of your funds

to generate robust, resilient, long-term growth in any portfolio with a space-aware investment philosophy.

If the idea of working within the Space Economy excites you, you're in luck. The opportunities out there go far beyond specialized areas like physics and engineering. In chapter 8, I walk through the most in-demand skills, traits, and attributes of space professionals and offer guidance on the most promising career paths. There's room for everybody, and best of all, the Space Economy will be incredibly resistant to downturns.

In the aftermath of COVID-19 and the Great Resignation, talent has become the most pressing challenge for nearly every organization. This is doubly true within the Space Economy, where the competition for talent is even more fierce than in the tech industry as a whole. On the bright side, great employees are drawn to ambitious companies with inspiring missions. Space Economy businesses are the most ambitious on the planet. In chapter 9, I cover what the smartest organizations are doing to attract, develop, and retain world-class talent.

Most of this book is devoted to the here and now: The Space Economy as it currently stands and the opportunity currently on the table for anyone smart and ambitious enough to seize it. That said, there is always value in looking a little further ahead, in this case at the Emerging Industries of the Space Economy. Lunar bases and crewed missions to Mars really aren't as far off as you might think, and those possibilities represent just a fraction of the potential that some very smart and highly pragmatic leaders have in mind for the next few decades. In chapter 10, I offer a down-to-Earth, hype-free, reality-based overview of what is likely to come next, as well as the far-

fetched ideas you can safely dismiss as impossible. I'll also look at two existential threats—climate change and military conflict—and explore the dangers and, more important, the hopes offered by the Space Economy.

In highlighting the exciting potential of the Space Economy to change the world for the better, my hope is that people on both sides of every political divide can come together and work toward a vision for a healthier and more resilient world. Elon Musk may be planning humanity's exit strategy via Mars, but until then there's plenty worth saving here on Earth. We finally have tools that offer the promise of a way forward.

It's with all this in mind I say this is the most important book you can be reading right now. It will serve as a crucial primer for understanding where things are really headed—not just in the United States, not just across the satellite industry, but throughout the economy as a whole—and positioning yourself within it as an investor, an entrepreneur, or a career professional.

Wherever you stand, this story affects you. Are you going to learn more about this new reality and seize the opportunity for everything it's worth? Or will you play it "safe" and stick your head in the sand? A new world isn't just coming. It is literally on the launchpad. Take-off is imminent. Are you ready to board?

Chapter 1. To See the Future of Your Job, Your Investments, and the Economy, Look Up: Space is the Next Big Thing

If you've ever wished that someone from the future had tapped you on the shoulder and told you to invest in Apple Computer in 1983, found an e-commerce company in 1996, or take a risk on that Google gig in 2002 instead of playing it safe at Bear Stearns, you understand the importance of distinguishing signal from noise. It's as crucial for personal success as it is for commercial satellites.

The pattern repeats throughout history: As a new wave of opportunity builds, a handful of people position themselves to ride that wave to its crest and prosper. The rest of us watch them rise and wish for time machines.

No one is born with the ability to see through the hype and zero in on what's really next. The winners earn their edge through the accumulation of knowledge and insight. Read on to join their ranks.

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To understand the scope and potential of the Space Economy, look at the rise of a now-ubiquitous space-based technology: the Global Positioning System (GPS). The story of GPS and how it has fundamentally changed the world will help you grasp the far greater potential of the Space Economy as a whole.

On September 1, 1983, a Soviet fighter plane shot down Korean Airlines Flight 007 en route from New York City to Seoul, South Korea. A navigational error had sent the Boeing 747 passenger plane into Soviet airspace at a moment of peak Cold War paranoia. Within minutes, missiles had been fired at what the Soviets believed to be a reconnaissance aircraft for the West. In all, 269 civilians were killed.

In the wake of the tragedy, Ronald Reagan declared that GPS, a technology being developed for military use, would be made available to all as a public good. Whether or not the KAL 007 tragedy spurred this move or simply offered Reagan a timely moment to announce a decision that he'd already made, a technology that had been created for warfare would soon allow everyone to more easily find their way. The world would never be the same.

A 2019 report commissioned by the United States Commerce Department estimated that GPS has created $1.4 *trillion* in economic benefits in the U.S. alone since the system became publicly available in the 1980s.[1] Today, this crucial layer of infrastructure continues to enable new technological applications. As of 2020, free access to location data has driven exponential business growth around the world, creating nearly eight hundred companies with a combined equity value of over half a trillion dollars.

The importance to the global economy of this invisible signal cannot be overstated. The world relies on GPS and other global navigation satellite systems (GNSS) for everything from plotting local driving routes to coordinating the supply chain. Uber, Yelp, and Niantic, creator of Pokémon GO, rely on GPS to function and together represent some of the largest venture outcomes in history. According to the PitchBook financial database, the top twenty-five exits through 2020 for GPS-based companies have generated an average exit multiple for early investors of 690x. Even if you aren't an experienced investor yourself, you can surely appreciate a return of 690x on an investment.

For all its importance and still-untapped potential, GPS is only part of the story. GPS is one of three space-based technology stacks in the Satellites industry that unleash extraordinary

[1] "Economic Benefits of the Global Positioning System (GPS)" (RTI International, June 2019).

value every day. These three stacks represent the next-generation digital infrastructure that underpins multi-trillion-dollar global industries today. (More on the three stacks below.) The story of GPS helps frame the discussion to come because GPS itself is familiar, undeniably valuable, and yet so ubiquitous as to be almost invisible. The lens that brings GPS into focus will help you see the potential of the Space Economy as a whole.

The birth of a market

In 2012, as the commercialization of space was getting underway, the Space Economy exhibited all the key characteristics of a nascent market on the verge of dramatic growth. SpaceX, Elon Musk's California-based manufacturer and launch provider, had sent its Dragon capsule to the ISS, where it delivered cargo and supplies before returning safely to Earth. Previously, only three government superpowers—Russia, China, and the United States—had berthed a spacecraft at the ISS and brought it back successfully. That year, a private company joined their ranks, and in a way that would quickly enable the entrepreneurial ambitions of others. Classic market liftoff.

In business-school speak, technological innovation follows an S-curve. At first, progress is incremental and haphazard as innovators drive a new idea forward in fits and starts. As marketing expert and author Geoffrey A. Moore put it in his book of the same name, "crossing the chasm"—spreading an innovation from the early adopters to the mainstream—is extraordinarily difficult, even in the best of cases, when the new thing is inarguably superior to the old one. Many promising technologies fail to make it across the chasm or take an extraordinarily long time to do so.

From unexpectedly high costs to regulatory roadblocks to the defensive maneuvers of entrenched incumbents, there are many factors that can slow the spread of an idea before its

value becomes apparent to everyone. A piece may be missing from the process. Or there might be a small but pivotal flaw in the initial approach just waiting to be noticed by a subsequent entrepreneur. Sometimes, the obstacle is just cultural inertia, and all that's missing is a tenacious entrepreneur to deliver the needed push.

Whatever the barrier might be, the fall of that final obstacle spurs a rush of early adopters to take the plunge. If the new idea rewards their enthusiasm, they spread the word and a market is born, unleashing a wave of subsequent entrepreneurship and innovation that leads to exponential growth. The S-curve heads upward.

Eventually, the pent-up potential of an idea diffuses into the marketplace in the form of world-changing products and services. Once the late majority and laggards—i.e. your parents—are on board, growth plateaus once more. An "S." Eventually, the once-revolutionary innovation reaches the limit of its usefulness or competitive advantage. As newer ideas arise, one of them crosses the chasm, too, rendering the previous innovation obsolete in the process. Goodbye vacuum tubes, hello transistors.

In the case of the Space Economy, several factors throttled progress prior to 2012. Before SpaceX, the process of getting something into orbit was not only difficult and dangerous but also convoluted, expensive, and opaque. This made satellite launches a bespoke, low-volume business. As a satellite manufacturer, you would fly halfway across the world to meet with a Russian launch provider for several days to discuss requirements. Then, you'd go home and wait. Eventually, you'd be summarily informed of the cost of your launch: $130 million. Or $90 million. Or $300 million. Why that number and not another? Who knows? Pricing was essentially a black box. Getting an object into space meant that money had to be, well, no object. That meant you were either a government agency, a major telecom, or a defense contractor. The

opacity alone was a formidable barrier to entry—how do you raise capital when you don't know how much capital you need to raise?—and it was only one of several barriers that needed to come down to let the Space Economy flourish.

Iterating with software is relatively fast and cheap. Speedy iteration isn't possible with mega-infrastructure projects led by government agencies, defense contractors, and telecoms. Roughly a decade ago, getting to space wasn't feasible for the average Fortune 500 company, let alone aspiring entrepreneurs. The market was essentially closed to new entrants, which meant that the big, ambitious ideas that newcomers bring were few and far between. As an innovator, why would you bother pursuing an idea with no affordable way to test and iterate on it? Just focus your energy and creativity elsewhere.

Then, SpaceX made the process of accessing orbit not only more affordable but also more transparent, publishing their pricing for all to see. Once entrepreneurs could develop business plans based on real launch costs, they could use those plans to raise capital. No more hazy estimates from close-door committees in a Russian conference room. Today, if you have a solid founding team and a promising idea that leverages launch, you've got a good shot at getting your money. As we'll see, SpaceX's next launch vehicle, Starship, will make getting to orbit even more accessible and affordable in the near future. However, its Falcon 9 started the snowball rolling by fundamentally changing the economics of space.

Thanks to economies of scale, smartphones have drastically lowered the cost and increased the quality of processors, sensors, and other electronic components. Prior to SpaceX, however, satellites engineers were restricted to using flight-proven components with "space heritage": tech that had been proven in the sky even if it was obsolete by consumer standards. Meanwhile, as nearly every industry took advantage of storing and processing data in the cloud,

satellite data remained locked in private server farms, accessible only through expensive, manual, and frustratingly bureaucratic processes.

Once SpaceX tipped the first domino by bringing the costs of launch down and making those prices transparent, it became feasible to send a bunch of smaller, cheaper, and more sophisticated satellites instead of one big one. If a single satellite failed, you had several others as a backup. This had the effect of releasing decades of tech innovation in one go. For new satellite operators entering the market this way, it made sense to store data in the cloud rather than invest in new servers. This spurred the incumbents to follow suit, opening up a vast trove of satellite data to new technological applications.

The final barrier blocking growth in the Space Economy was access to capital. That's where Space Capital and its peers entered the picture. When I founded the firm, there was essentially no venture capital activity focused on the Space Economy. Once the market opened up to new entrants that had viable shots at growth, the equity investment started flowing. See Figure 1.1.

INSERT FIGURE 1.1 - Private Market Equity Investment in the Space Economy

How did we get here?

The Moon landing was the greatest technological feat of the 20th century. Fifty years later, the United States was the dominant world power and yet it lacked any launch capacity of its own. With the retirement of the troubled Space Shuttle program in 2011, America was forced in a twist of historical irony to rely on the Russians to get its own astronauts to the ISS. It was a humiliating nadir for the "winner" of the so-called Space Race to rely on the "loser."

Equally surprising, it fell to a prickly South African tech entrepreneur to execute one of the most dramatic technological turnarounds in history, dragging the United States from laggard to leader in the space sector in under two decades.

As someone who has observed SpaceX's trajectory closely, I can say that Elon Musk's success has felt anything like an overnight one. Yet he has persisted, and for one reason: "The future of humanity, it's going to fundamentally bifurcate in two directions," Musk said in an interview. "[Either] it's going to become multiplanetary, or it's going to be confined to one planet until some eventual extinction event."[2] Even when things go south—and SpaceX has dealt with its share of adversity—this mission keeps Musk going. "When something is important enough," Musk told *60 Minutes* not long after the last Space Shuttle was retired, "you do it even if the odds are not in your favor."[3] Today, SpaceX is tipping those odds.

Gauging the size of the opportunity

Inexpensive orbital access is a momentous change, but does it offer opportunities to ordinary investors, entrepreneurs, and aspiring professionals? Starting a space infrastructure company like SpaceX's Starlink is still more difficult and expensive than buying a cheap laptop and programming an Android app. As we'll see, however, most of the Space Economy's economic potential for today's entrepreneurs lies in leveraging the data provided by satellites

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[2] "First Comes an Electric Car. Next, a Trip to Mars.," Wall Street Journal, June 2, 2013, sec. Special, https://online.wsj.com/article/SB10001424127887323728204578515743066949964.html.

[3] 60 Minutes, 2012: SpaceX: Elon Musk's Race to Space, 60 Minutes Rewind, 2018, https://www.youtube.com/watch?v=23GzpbNUyI4.

with new software applications. Even solo entrepreneurs are successfully bootstrapping businesses in this way. No giant hangar required. The Space Economy is unquestionably open to all. The real question is, how can people identify and leverage the emerging opportunities being unlocked while staying cognizant of the risks of any new market?

Many factors contribute to success, and timing is chief among them. For example, Beal Aerospace was a well-capitalized private company that tried to do SpaceX before SpaceX. But, in addition to technical struggles we will learn about in chapter 6, Beal failed to break the defense contractors' stranglehold on government contracts. By the time SpaceX arrived on the scene, the political conditions were more favorable. Likewise, the Emerging Industries of the Space Economy—from Mars bases to asteroid mining—will have their day. But that day is not today. Don't let them distract you from the real-world opportunities that are viable right now.

Entrepreneurs pitch us all the time with ideas that are not just overambitious but flat-out physically impossible. We're pretty good at spotting these because, as discussed in the Introduction, Tom Ingersoll and other key experts at Space Capital have built rockets, satellites, and operating systems, founded companies with assets currently in space, and led multiple exits as operators. Our track record and accumulated expertise are the main reasons why Space Capital remains a trusted source of operational guidance for top-tier venture capital and private equity firms.

Nascent markets like the Space Economy are exciting, dynamic, and fast-moving. This makes them prime breeding grounds for hucksters and bottom-feeders. Simply doing your homework—in part, by reading this book—will inoculate you against many of the hazards. With the benefit of hindsight, it's clear people almost always get swept away by something obviously too good to be true because of willful blindness, the unwillingness to look a gift horse in the

mouth. All of us want in on the Next Big Thing, whether we're choosing a career, an investment opportunity, or an entrepreneurial niche to explore. Just be cautious. Anyone can make a prediction, but if someone can't give you a clear and reasonable explanation *why* a given opportunity is worthy of your time, money, and attention, ignore their advice or gamble with all three.

This book offers a way of thinking about the opportunities currently orbiting above us. Think of it as a map for understanding this chaotic landscape of innovation and opportunity, one that, as we'll see, encompasses areas as varied as AI and climate tech. My goal in writing it is to convince you that the Space Economy is the right lens for bringing the greatest opportunities of our era into focus and showing you how to seize them. Today, several space technologies sit in the same part of the S curve as GPS did back in the 1980s when far-sighted companies like Trimble, Magellan, and Garmin brought an obscure, satellite-based positioning system from the military to the mainstream.

People always get the pace of technological progress wrong in the same way. When a new innovation arrives, we all imagine wild possibilities just around the corner. When those breakthroughs don't arrive as quickly as expected, we immediately become cynical and stop paying attention. Then, out of the public eye, the nascent innovation keeps evolving, faster and faster, until progress not only meets those wild early expectations but wildly exceeds them. We've reached this inflection point with the Space Economy.

Why now is the right time to launch

The Space Economy saw record-breaking levels of investment in 2021. Then came headwinds: the lingering effects of COVID-19, the war in Ukraine, the changing climate and its consequences—mass migration, disease, famine—and the end of the longest market bull run in

history. This is to name just a few of the calamities keeping business leaders (and everyone else) up at night. Global challenges like these require global solutions.

In times of uncertainty, information becomes even more important. Even as the sky falls, businesses and governments only increase their investment in space-based data. Earth's orbit offers an unparalleled vantage point to gather and transmit data about the state of the world. There is no substitute for a view from above. Today's space technologies constitute a global, digital infrastructure, an invisible backbone powering the world's economy. GPS, as well as two other satellite technology stacks—Geospatial Intelligence (GEOINT) and Satellite Communications (SatCom)—play a crucial role in most major industries, doing everything from tracking fugitive methane emissions to optimizing global shipping routes.

It's for these reasons and more that the Space Economy is counter-cyclical. In boom times, space-based data helps businesses expand. In times of crisis, it keeps them resilient.

The term "Space Economy" may suggest the "space tourism" of companies like Blue Origin and Virgin Galactic, companies launching "cashtronauts" to the edge of space. The near-term, hold-it-in-your-hands potential of space-based technology, however, is far better illustrated by Planet Labs. Planet was started in 2010 by a group of former NASA engineers who realized that NASA's quintuple-redundant, ultra-resilient approach to satellite design no longer made sense in the era of SpaceX. Why spend enormous amounts of time and money on a single, infallible satellite when you could launch a swarm of relatively cheap and tiny ones that could operate as a distributed network? If a few satellites failed, so what? There would still be plenty more keeping the network operational. Advances in consumer electronics meant that low-cost, off-the-shelf components originally developed for cars and phones could be used to build satellites with capabilities in excess of the most sophisticated bespoke options.

Planet Labs was one of the first pioneering companies to recognize and take advantage of more affordable launch. It was also our first investment at Space Capital, though by the time we got our fund up and running in 2015, the company was already raising Series C growth capital. Since 2017, Planet Labs has had a network of small satellites imaging the entire planet on a daily basis. Its stock is now traded on the New York Stock Exchange.

Planet Labs is just one example of what is now possible. As major innovations—the steam engine, the transistor, the laser—have always done, SpaceX has spawned an entire ecosystem of start-ups. Opening up orbit is unlocking our future.

Just how big is space?

On November 15, 2021, the seven astronauts on the ISS were warned to seek shelter in case the station was damaged by a cloud of debris in its path.[4] Without warning, Russia had tested an anti-satellite weapon (ASAT) by blowing up a defunct Soviet satellite weighing nearly five thousand pounds, releasing hundreds of thousands of pieces debris into Earth's orbit in the process and endangering everyone onboard the station—including two cosmonauts. One of the more surprising parts of all this was that private companies in our portfolio did a better job of tracking the incident than the U.S. government itself.

After it began its invasion of Ukraine, Russia rumbled threats about shooting down GPS satellites. Meanwhile, civilians around the world were tracking the progress of invading troops

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[4] Nadia Drake, "Russia Just Blew up a Satellite—Here's Why That Spells Trouble for Spaceflight," National Geographic (blog), November 16, 2021, https://www.nationalgeographic.com/science/article/russia-just-blew-up-a-satellite-heres-why-that-spells-trouble-for-spaceflight.

through traffic reports on Google Maps. Russian efforts to shut off communications and control the narrative through propaganda became even harder when SpaceX shipped Starlink terminals to Ukraine to help its people stay connected and coordinate military operations.

Just as America's Operation Desert Storm was the GPS war, the invasion of Ukraine is the first space war. The economic, political, and now strategic importance of the Space Economy can no longer be denied. This is why we are seeing such exponential growth. In the first quarter of 2022 alone, more than $7 billion was invested into 118 space companies, bringing total private capital investment past the quarter trillion mark. Three-quarters of the action is taking place in the United States and China, but activity is rising nearly everywhere else, from New Zealand (Rocket Lab) to Japan (iSpace) to Finland (ICEYE*). The Space Economy is increasingly international. The arena is open to all.

Between 2012 and 2021, almost a quarter of a trillion dollars in private capital fueled innovation across almost two thousand unique companies that span the three satellite technology stacks—GPS, GEOINT, and SatCom. Each of these stacks comprises three layers: Infrastructure, Distribution, and Applications.

The Infrastructure layer is the hardware and software involved in building, launching, and operating space-based assets. The Distribution layer is the hardware and software involved in accessing, processing, and managing the data from those assets. The Applications layer is the hardware and software that uses this data to deliver products and services to customers. For example, Lockheed Martin launches GPS satellites (Infrastructure) that generate positioning and timing data. Companies like Trimble and Garmin make the terminals (Distribution) that receive the GPS signals from satellites. Software developers like Uber, Yelp, and Niantic build software

Applications that leverage GPS data. Companies like Garmin and Uber are a key part of the GPS stack even though they play no role in the operation of the GPS satellites themselves.

GPS provides a clear model for how the other satellite technology stacks—SatCom and GEOINT—create new investment opportunities.

Much of the growth in the Space Economy we've witnessed over the past decade has been based on a ten-year-old launch paradigm. With the arrival of SpaceX's enormous, fully reusable Starship—more later on the significance of this revolutionary launch vehicle—we are entering a new phase of Infrastructure development that will take all the growth we've seen to a greater level, enabling entirely new industries. The Space Economy promises solutions to the most pressing and urgent problems of our time, from resource scarcity to climate change.

The rise and fall of America's space ambitions

The Germans' V-2 was the first long-range, guided, ballistic missile, as well as the first human-made object to enter space. In 1944, a V-2 crossed the so-called Kármán line, an altitude still roughly considered to be the boundary between Earth's atmosphere and outer space. One hundred kilometers above mean sea level, the Kármán line is, by definition, one that no propellor craft can ever cross. It's the point beyond which the air is too thin to generate lift.

After World War II, the German engineer Wernher Von Braun and a small army of his fellow experts were brought to the United States as part of Operation Paperclip. There, they helped the U.S. develop its own rockets and, in 1958, helped it launch its first satellite: Explorer 1. Eventually, Von Braun, a former SS officer, became director of the new Marshall Space Flight Center, where he led the development of the Saturn V vehicle that sent the Apollo missions to the Moon. America saw the quest to dominate space as so important that it welcomed Von Braun and his colleagues and gave them access to the country's most secret sites and projects.

Looking back, the Space Race between the United States and the Soviet Union can't be understood along economic lines alone. Likewise, the idea that the Apollo program was crucial to America's national security feels like a thin justification when you consider what that money and effort might have accomplished if invested directly in, for example, more sophisticated nuclear weapons. Both countries bent all their efforts on chasing each first, from first satellite in orbit to first human on the Moon. Unfortunately, less thought was given to what would come after those momentous firsts had been achieved.

If Operation Paperclip were the only game in town, progress would have run much more slowly. In fact, we might still be working toward that first Lunar visit. However, the 1,600 or so German ex-pats who swore allegiance to America were solidly outnumbered by the 2,200 that the Soviet Union quietly relocated themselves. Once the two great powers were chasing the same prize with their own secret reserves of German rocket scientists, every space-related brass ring carried the weight of national pride. Every milestone became an argument for an economic system and a political worldview. Which model drove progress faster: capitalism or communism?

The Soviets took an early lead in this game of orbital one-upmanship, spurred by the Americans' stated intention to launch a satellite in 1955. The Soviets launched Sputnik 1 in 1957, stunning the globe. Explorer 1, the Americans' first satellite, launched the following year, but in this race, there were no silver medals. More firsts followed for the Soviet Union: Laika, first mammal in space (1957), Luna 1, first spacecraft to leave Earth's orbit (1959), Luna 2, first spacecraft to land on the Moon (1959), Yuri Gagarin, first human in space (1961). Maybe it came down to the six hundred additional German experts. Regardless, the Soviets left the Americans scrambling over and over. Their brutal, no-holds-barred approach to scientific

progress seemed justified by their results. Something dramatic would have to happen to make the case for the American way.

In 1962, John F. Kennedy addressed a nation set back on its heels. Speaking in front of forty thousand people at Rice University, JFK made the case for landing Americans on the Moon among other space-related feats "not because they are easy, but because they are hard." By that point, Kennedy had already told Congress of his intention to fund a Moon landing—Von Braun said this was the brass ring to chase next—but the reception from lawmakers had been chilly.

It wasn't hard to see why. Polls showed a majority of Americans against the idea: Too expensive. Too risky. The government ought to focus on Earth's problems instead. Former President Eisenhower even called the idea "nuts."

Kennedy's impassioned speech at Rice, addressed directly at America's image of itself, turned the tide. One forgotten element of Kennedy's plan was the fact that he sought international cooperation. Nikita Khrushchev even warmed to the idea of working with the Americans on a Lunar landing.[5] For one, it might offer Russia a valuable glimpse at the latest American technology. Unfortunately, Kennedy was assassinated before Russia's cooperation could be secured, and the idea was swiftly dropped by the next administration. America would capture this ring—or fail to do so—on its own. And America did capture it, on July 20, 1969, when the Eagle touched down on the surface of the Moon, and Neil Armstrong and Buzz Aldrin became the first humans to step foot on our nearest celestial neighbor. Five similar missions followed. The last, Apollo 17, put Eugene Cernan and Jack Schmitt on the Lunar surface.

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[5] Roger D. Launius, "First Moon Landing Was Nearly a US–Soviet Mission," Nature 571, no. 7764 (July 2019): 167–68, https://doi.org/10.1038/d41586-019-02088-4.

It's been more than fifty years since Cernan and Schmitt re-entered the lander and ascended from the Moon's surface. No human has returned since.

If you want to understand why the United States was able to accomplish this extraordinary feat only to gradually turn its back not just on the Moon but on space exploration in general over the following decades, you can point to a number of important factors: Economic turbulence. The 1986 *Challenger* disaster. Systemic problems with the way NASA paid its contractors. All these factors and more will be discussed in detail in chapter 6, but perhaps the underlying reason was the assassination of JFK in Dallas on November 22, 1963.

Kennedy's life, and his Presidency, were cut short before he had the opportunity to architect a long-term vision for America's space program. Once the narrowly defined goal of a crewed Lunar mission was achieved with Apollo 11, there was no leadership at a national level in terms of where America should go from there. As the post-War boom faded and the American economy began to sputter in the 1970s, investing in space seemed less like an engine of economic growth and innovation than a distraction from urgent concerns "down here." In retrospect, it's hard to imagine a more flawed and damaging misconception.

Emblematic of America's cooling space ambitions was the Space Shuttle program. In a matter of years, the country lurched from running ambitious missions named after Roman gods like Apollo and Mercury to operating a "shuttle" to LEO. In the national imagination, NASA became a glorified Port Authority. That impression of obsolescence and irrelevance was only calcified by ballooning budgets, sporadic public accomplishments, and an increasingly problematic record of failures and accidents. When NASA retired the troubled Shuttle program in 2011 without a replacement, it left the country with a major gap of capability. In the press,

however, this registered as little more than a historical footnote, a faint reminder of a more impressive age.

An unexpected resurgence

Not long ago, NASA operated under a system riddled with waste and failure driven by counter-productive, short-sighted incentives. In other words, pretty much like any other large American government bureaucracy. If NASA wanted a rocket or a satellite built, it went to a small group of defense contractors and paid one of them a vast sum of money to go build something according to a fixed set of specifications. These were known as "cost-plus" contracts.

The contractors figured out pretty quickly that they could make more money by delaying things than by getting the job done on time and under budget. If they spent years and billions working toward a critical objective without making much progress, they could then go back to the trough: "This engineering stuff is tougher than we'd expected," they'd tell the bureaucrats. "We'll need two more years and X billion dollars to finish the job." Under a cost-plus system, NASA was left with little choice. It could pay more and get what it needed, however behind schedule and over-budget, or it could scrap the mission. Often, NASA's ability to negotiate was further restricted by planetary launch windows that came around only periodically.

If you're wondering why American space innovation stagnated in the eighties and nineties, look no further than cost-plus. The government wasn't a customer of the defense contractors. It was their benefactor. Ultimately, these companies weren't funded to get the job done efficiently but to keep large numbers of constituents employed.

Thanks to some very smart leaders at NASA that we'll meet in chapter 6, a new, more robust system was established in the 2000s. Under a "fixed-price" system, NASA identifies the service it wants: "Develop the capacity to get this many people and this much cargo to the ISS on

this schedule. If you can do it within this price range, you are guaranteed payment." If a contractor can meet NASA's requirements, it can count on a guaranteed revenue stream. If it goes over its budget, that's its problem. This new system of incentives made genuine competition possible. A 2020 report from the U.S. Government Accountability Office to Congress concluded that "a firm-fixed-price contract…provides maximum incentive for the contractor to control costs and perform effectively and imposes a minimum administration burden upon the contracting parties."[6]

This was the kick the Space Economy needed. Competition cuts costs, increases efficiency, and drives innovation. When multiple providers compete under commercial terms, the customer—NASA—reaps the benefits: lower costs, faster development, more contractor accountability, and stronger mission assurance. By fixing its incentives, NASA made it possible for SpaceX and other new entrants to flourish.

The full story of SpaceX lies outside the scope of this book, although we will touch on elements of the narrative later on. For now, it's enough to talk about what makes the company and its launch vehicles so important to the Space Economy. We've already looked at how price transparency allows smaller businesses and start-ups to calculate costs, draw up realistic business plans, and secure funding for space-based projects. This has had dramatic effects, the success of Planet Labs being one early example.

SpaceX's Falcon rockets were a key development that brought the cost of launch down by an order of magnitude and opened the door to venture capital, in large part because their

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[6] "NASA Commercial Crew Program: Significant Work Remains to Begin Operational Missions to the Space Station" (United States Government Accountability Office, January 2020).

booster stage is reusable, with time and effort. As a consequence of lower prices, we've seen a tremendous amount of investment pour into the Space Economy. On the horizon, SpaceX's new launch vehicle, Starship, will take things to another level entirely. Built primarily from stainless steel and requiring few rare or expensive materials in its construction, Starship, for all its technological sophistication, exhibits a design philosophy more in line with commercial jets than NASA launch vehicles. It's intended to be cheap to produce, cheap to operate, and *quickly and completely reusable*. Imagine how high airfares would be in a world where, at the end of every flight, airline employees tossed the plane into the ocean and rolled a fresh one out of the hangar. Air travel would be restricted to big companies and the ultra-rich.

Capable of landing on and launching from not only Earth but the Moon and Mars, Starship opens up a vista of new possibilities. Think about what you might do with a pressurized box, 1,100 cubic meters in volume, that can be sent affordably to the Moon and back safely? Today we measure space cargo in kilograms. Starship can carry *one hundred metric tons*. That's about a hundred and fifty large, male elephants, a thousand-percent improvement over a Falcon 9, which is already the option to beat. Whereas one seat on a Falcon 9 rocket costs about $75 million today, Musk is confident that an entire Starship launch will cost less than $10 million.

Starship will change everything, but it'll take time for most of us to understand just how profound this change will be. For example, given the vehicle's performance and cost, optimizing for mass or size with price as no object will no longer make sense. Forget hugely complicated, inefficient, and ultra-redundant space stations. Theoretically, Starship can be refueled in orbit indefinitely—fill it with equipment and crew quarters and it's a DIY space station. Heck, throw in Egyptian cotton towels, some tasteful branding, and it's a Space Marriott. Load Starship up with machinery and it's a zero-gravity microchip factory. Want to do a Moon landing? No need

for bespoke Lunar equipment when you can tote along a few customized Humvees and some repair equipment. Roll them right out the back of the vehicle and start cruising to Copernicus crater. John Deere tractors could clear the plot for the first Moon base.

Starship will fundamentally change how we operate in space. On track for its first full-scale orbital test flight in late 2022, Starship will further remove the barriers to entry of the Space Economy and stimulate the development of entirely new applications. Space exploration has stagnated for decades. Today, commercial capabilities are quickly outpacing those of governments. NASA, American defense contractors, and other major players like China are being forced, at long last, to play catch-up.

Space is international

You may have noticed an American tilt to this narrative. This reflects the fact that the U.S. sparked the Space Economy and still dominates it. For now, anyway. We aren't privy to many details about China's space plans here in the West but, for one example, a Chinese national company, China SatNet, is building a 12,992-satellite internet constellation in LEO.[7] This is a large, serious effort to provide global broadband internet access for the Chinese, one they're going to need, since Starlink is prohibited in the country.

Together, America and China account for 75 percent of the action, but exciting things are happening elsewhere. New Zealand's Rocket Lab sends payloads to space regularly and manufactures its own spacecraft and satellites. Equatorial Launch Australia also sends payloads

[7] Larry Press, "Update on China SatNet's GuoWang Broadband Constellation – Can They Do It?," CircleID (blog), February 3, 2022, https://circleid.com/posts/20220203-update-on-china-satnets-guowang-broadband-constellation-can-they-do-it.

into orbit. When it comes to launch, location is incredibly important, and no single country has a monopoly on the ideal conditions. Australia's Arnhem Space Centre, for example, offers "excellent weather and stable upper atmospheric conditions; low aviation and maritime traffic, a stable geo-political environment and comprehensive logistics infrastructure."[8]

The Space Economy is increasingly international, and our investments at Space Capital reflect that. There are examples from all over the globe throughout this book. One reason I'm writing this book, in fact, is to inspire entrepreneurs, investors, and professionals in other countries to participate. There is no time like the present.

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In the same way that every company today is a technology company, every company of tomorrow will be a space company.

A major part of our investing thesis at Space Capital is how we define the Space Economy. We believe that any technological product or service that depends on orbital access belongs underneath this umbrella. Our definition causes consternation at first—what does Uber have to do with outer space?—but, as you'll see, the Space Economy is the only framework that fully captures all the potential that launch makes possible.

We've already learned about the Infrastructure, Distribution, and Application layers within the GPS tech stack. Where GPS blankets the world in positioning signals that help us navigate, Geospatial Intelligence, or GEOINT, shows us, via sensor-laden satellites, exactly what we'll find there, wherever "there" happens to be. GEOINT Infrastructure companies handle the

[8] "FAQ," Equatorial Launch Australia (ELA), accessed June 28, 2022, https://ela.space/faq/.

satellites, GEOINT Distribution companies process and serve the data, and GEOINT Applications use that data in increasingly useful and surprising ways.

Satellite Communications, or SatCom, encompasses the transfer of data from one place to another, embodied most visibly by the constellation of Starlink satellites that increasingly offer wireless, uninterruptible, high-speed data access to every point on Earth, from Death Valley to the peak of Mount Everest. Once SpaceX's Starship launch vehicle makes it possible to rapidly launch the remainder of Starlink's 4,000-satellite network, you will *always* have a good signal. No matter where you go, there you are…watching Netflix.

INSERT FIGURE 1.2 - Satellites: Largest of the Six Industries in the Space Economy

See Figure 1.2. This matrix, summing up today's Satellite industry, neatly encompasses more than 90 percent of the value in the Space Economy. Launch accounts for a few percentage points. Emerging Industries, discussed in Chapter 10, less than a percentage point. Both are important parts of the picture, but at Space Capital we believe this sturdy little three-by-three matrix will stand the test of time as a framework to understand the big picture of the Space Economy—and envision new possibilities within it. Models are powerful tools for thought.

It's ironic that the Launch industry itself barely registers as a blip relative to what launch makes possible. SpaceX's financial value isn't based on its launch operation, which amounts to a few billion dollars in annual revenue, but on the potential of its Starlink service. Likewise, the four Emerging Industries—Logistics, Stations, Lunar, and Industrials—are gaining steam on the horizon but are still small enough to consider a footnote. The big picture is what matters most, and that picture is getting very big indeed. In 2021, the Space Economy represented a solid 3 percent of *all* global venture capital investment. That figure is growing quickly.

I'll go into each of part of the satellite technology matrix in greater detail in the next chapter. Meanwhile, I hope it's clear that space-based technologies are on their way to becoming an intrinsic part of our technological infrastructure, a layer below all the other layers even as these satellites soar high above us in greater and greater numbers. The possibilities of space are vast, but they begin right here on the ground.