Deloitte.

Space

The Commercialization of Low Earth Orbit

The promise of human spaceflight stands to transform our economy by leveraging the untapped power of LEO

Volume 2: An Orbit for Everyone

Spring 2022

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This is the second volume in a series of Deloitte Consulting publications on the commercialization of low Earth orbit (LEO) and its associated economic impact. In Volume 2 (this document), we expand upon our vision for the future of the industry by summarizing the key market segments in the LEO economy, and then charting several potential future scenarios for LEO Commercialization by 2035. Subsequent volumes in the series will explore the key market forces, barriers, and future scenarios for each individual market segment.

Introduction

All systems go: A note on our analysis and methods

We begin our analysis with a structured approach to understanding the current-day market, and subsequently, to anticipating development scenarios. To reach our conclusions on potential growth and market size for the LEO human spaceflight industry, we first developed a comprehensive LEO value chain segmentation that collectively identifies the presence of humans on orbit.

Based on our analysis of the LEO Economy, we believe the industry can be dissected into six broad market segments that encompass specific commercial activities, which we will expand upon within this volume. Within each segment, we analyzed existing, emerging, and exemplary use cases to design quantitative economic models that allow us to estimate potential future market sizes across various scenarios.

Beyond modeling market value, our scenario analysis across the market segments illuminates the market structure, including limiting factors, external forces on supply and demand, overall segment attractiveness, and limiting growth factors for increased commercial human spaceflight in LEO. This approach identifies impacts and opportunities for market development, and therefore economic development in LEO, by identifying decisions that can be made to remove limiting factors and incentivize desired market outcomes.

Our analysis indicates that significant untapped demand exists for LEO human spaceflight operations, but such demand is currently inhibited by dated industry perceptions of what is possible. Industry broadly does not consider commercial LEO operations because such operations are perceived to be prohibitively expensive or unlikely to achieve a return on investment within a desirable timeframe. Given our large professional network, which spans 85% of the Fortune 500 corporations and includes a broad footprint in the startup community, Deloitte is aware of the perception that a LEO commercial market is "too hard," "too expensive," "too risky," or "too futurist". Thanks to our 175 years of experience as a leading commercial company, however, we also understand the fact that perception isn't always reality and that the best way to overcome unsupported perceptions is exhaustive business case analysis.

Deloitte's approach to stimulating transformation in the commercial LEO economy

Realizing a vibrant future for a commercialized LEO requires seeing, doing, and delivering differently

In today's changing market, ambition needs to be delivered rapidly and with agility in order to win. We leverage Deloitte's Zoom-In / Zoom-Out framework to derive strategies for commercializing LEO in a world that defies prediction.

Imagine

ZOOM-OUT: ENVISION THE FUTURE & FOCUS ON SUCCESS

We zoom out to envision, frame, and focus on the art of the possible for an extensively commercialized low Earth orbit (LEO) economy within the next 10 to 20 years. We ground this vision for the future through industry engagement, extensive technology sensing, and horizon scanning. We frame this vision through a value chain view of the market, and we define what success looks like from a capability and mission standpoint.

We develop economic scenarios from the vision for the future by conducting extensive scenario planning and leveraging the *Deloitte Space Mission and Payload Planning Tool* to assess the financial viability of specific mission designs and therefore their commercialization potential and economic impact. We refine these scenarios into economic outlooks across the zoomed-out time horizon.

Deliver

ZOOM-IN: DESIGN THE PLAN AND MOBILIZE

We zoom in to define high-impact initiatives and recommendations to mobilize for action in the next six to 12 months. We focus on efforts that are scalable and sustainable with an ability to quantify progress on key outcomes and metrics to ensure that commercialization and industry transformation is robust over time.

Realize

SCALE THE INDUSTRY & SUSTAIN GROWTH

We prepare leaders and industry to initiate broader scale change by identifying the incentivization, stimulation, and enabling efforts required to implement, scale, and sustain growth pathways towards the future. We identify the levers, policies, and efforts required to create value-driven outcomes and propose adaptations to business, operating, and economic models in the face of deep industry insights and external technology pressures.

An orbit for everyone

Market segmentation overview

In our modeling and analysis, we divide the LEO human spaceflight industry into the following value chain segments:

1. Infrastructure
2. Services
3. On-Orbit Research & Development (R&D)
4. On-Orbit Manufacturing
5. Space Tourism
6. Media, Entertainment, & Advertising

Figure 1 details the end-to-end value chain segments and key activities and use-cases – both terrestrial and on-orbit – which are of interest to the LEO human spaceflight industry.

Based on this segmentation, Deloitte examined multiple forces and factors driving value creation within each segment of the LEO spaceflight economy and forecasted each segment individually to arrive at a cumulative 'sum of the parts' market size and resulting overall industry annual growth rates.

Launch services (including crew and cargo transport), satellite remote sensing, R&D, and media have already demonstrated the ability to support commercial enterprise activity and allow companies to capture meaningful value. Conversely, some segments within the value chain that are not currently generating high market value could become sources of commercial activity as LEO grows to outsize NASA's demand. Our team anticipates activity in these segments will accelerate after more advanced infrastructure is established in satellite and launch services since these segments are critical economic and operational enablers for the industry at large.

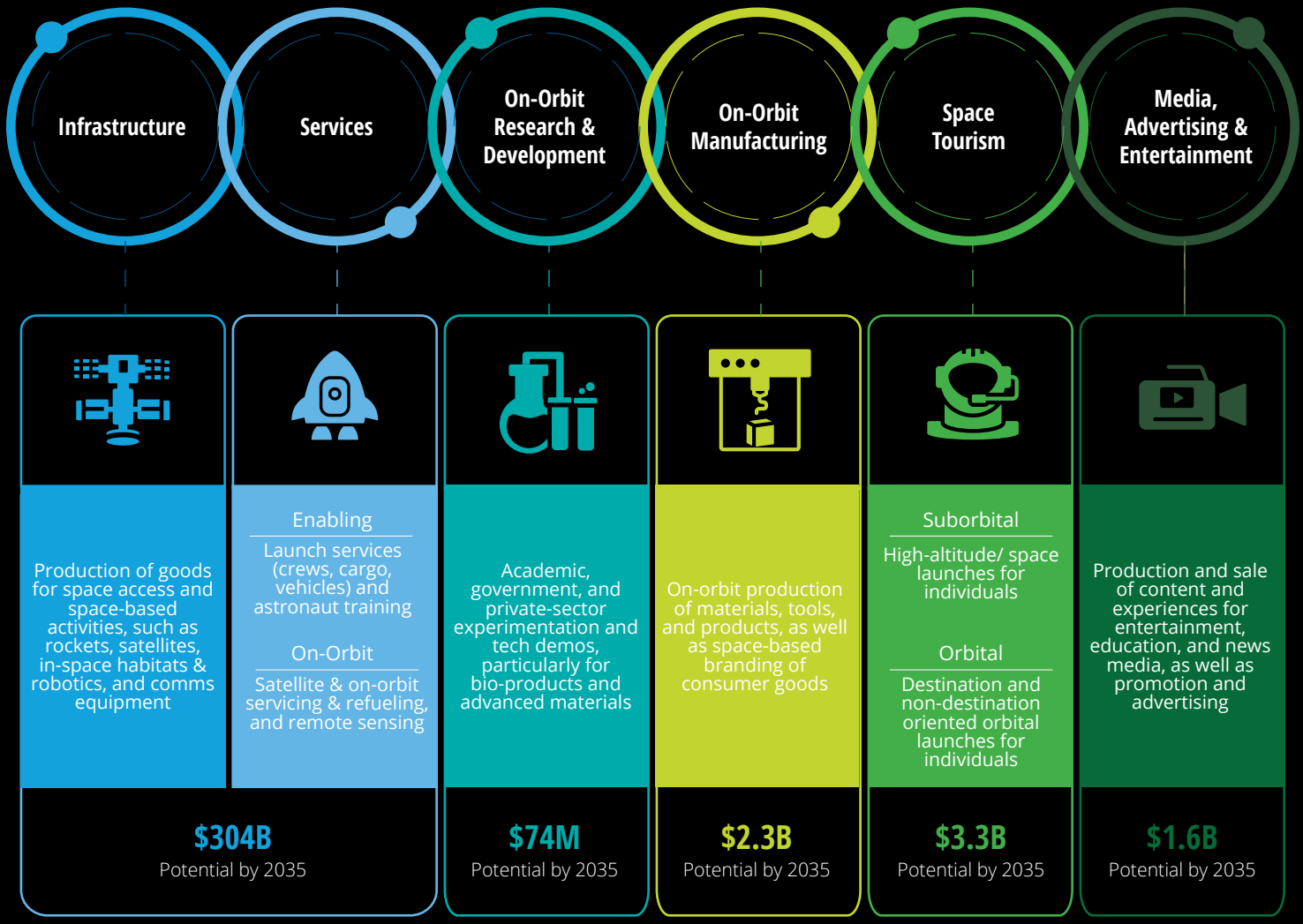
As shown in Figure 1, by the end of the 2022-2035 forecast period, the infrastructure and services markets will likely retain the majority share of the collective LEO economy, reflecting satellite remote sensing and launch activities as the primary driver and enabler of LEO economic activity. Additionally, manufacturing and tourism segments could begin generating value at earliest by 2023 and 2024, respectively, and expand thereafter through 2035.

We anticipate that each segment in the ecosystem will mature at different rates to reach a commercially driven future state.

Understanding both the evolutionary path of these market segments and their potential total addressable market (TAM) is crucial to identifying and overcoming critical barriers to broader commercialization of LEO.

FIGURE 1

The Low Earth Orbit Value Chain and Its Economic Potential by 2035



Providing the foundations for growth

A vibrant LEO economy is created and enabled when infrastructure and services are readily available, priced appropriately, and can serve the needs of many customers from individual tourists to corporations and government space agencies. Looking forward, NASA, which has been a key pillar for the industry, desires to be one of many customers in a vibrant LEO economy. This future goal would be enabled by commercial infrastructure and commercial services that are market (demand) driven.[i] We view infrastructure and services as highly coupled components that form the foundational and enabling capabilities for LEO market growth.

Infrastructure follows demand

The infrastructure segment comprises industry and upstream supply chain inputs such as satellite components, launch vehicles, ground systems infrastructure (such as launch pads and ground stations), and on-orbit habitats, among other assets and hardware that enable human spaceflight in LEO. Inputs from the infrastructure segment primarily fill demand for satellites, subsequent launch activities, and on-orbit activities. It is this infrastructure that enables space services, such as space operations like commercial crew and cargo transportation and space applications like remote sensing. Historically, infrastructure development has been heavily supply-side driven due to limited customer bases. However, over the last decade, rising private investment and additional commercial interest has resulted in significant market transformation as infrastructure development programs become more demand-driven and commercially viable.

While stand-alone commercial activity is relatively nascent when considered in the broader history of human spaceflight, we believe public-private efforts can function as a foundation from which stand-alone commercial activity can incrementally emerge. This is most recently exemplified with NASA's announcement to fund early-stage R&D for three proposed commercial LEO destinations, awarding over $100 million to each of the commercial space station projects.[ii] If successful, these projects could unlock significant commercial activity in LEO and accelerate timelines across markets, beginning with infrastructure and moving down the LEO economy value chain to more nascent markets.

Services enable broader growth

Spaceflight services encompass a wide range of LEO activity from enabling services, like launch and astronaut training, to on-orbit services, including satellite remote sensing and capsule servicing/resupply. Most significant among these segments is satellite remote sensing, which currently drives most of the space-based industrial activity. Satellite communication (satcom) is also expected to grow substantially over the next decade.[iii] Both remote sensing and satcom provide the foundational demand for launch providers.

Our analysis indicates that the remote sensing market will continue to grow from several catalysts. On the commercial side of the industry, a handful of remote sensing operators have recently achieved public market offerings after years of venture capital investment to expand operations; on the defense side, the growing shift toward "responsive space" – that is, operations involving more agile satellite operations and rapid space launch – is expected to create additional demand for small satellite technology and supporting launch infrastructure.

Due to this anticipated growth, launch services, which already represent a large share of the market, will likely command significant capital investment in the next decade. Given its importance, we provide a more granular analysis of this sub-segment of the broader spaceflight services market in the next section.

Launch continues to expand

Greater launch activity fuels improvements in technology and operations that directly enable economies of scale, driving per-kg launch costs down and proliferating more cost-effective access to space. As such, growth in launch services has the potential to produce synergistic effects on LEO market segments further downstream and enable more nascent markets to grow. This synergy will most directly support un-crewed activities and operations but may also support increased capacity for human spaceflight – especially if the trend towards dual-use launch hardware continues among commercial launch services providers.

The current supply of both crew and cargo launch services to the ISS is meeting demand from NASA but will need to be reassessed to meet the demand of industry. Supply of cargo transport has shown rapid growth in recent years and satisfies demand from NASA's Commercial Resupply Services (CRS) contracts, which account for most current market needs. The market will likely become more attractive to new entrants in the mid-2020s once commercial modules on the ISS and free-flyer stations come online. Until such time, there are few incentives for new entrants to service the human-rated launch services market, particularly given the high capital and regulatory barriers to entry. Still, the market introduction of commercial crewed launch is a critical step toward increasing the number of humans in LEO and beyond.

Bringing Earth to space: the industrialization of low Earth orbit

R&D demonstrates consistent annual demand, but faces hard constraints

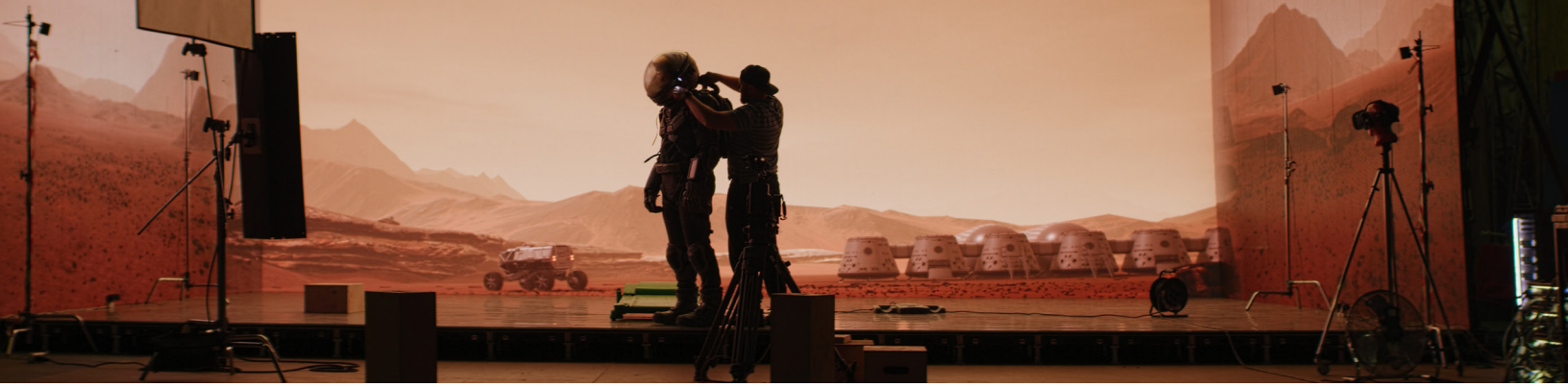
Historically, academic, government, and corporate experiments conducted on-orbit have focused on life sciences, physical sciences, technology development, remote sensing, and education. Common areas of life and physical sciences research conducted in microgravity include tissue engineering, regenerative medicine, biomanufacturing, pharmacology, advanced materials, protein crystallization, and environmental sustainability. Over the last decade, nearly all on-orbit R&D has utilized the unique microgravity research environment provided by the ISS US National Laboratory (ISSNL). The finite capacity of ISSNL and the astronauts who support it places a hard constraint on the upper limit of the R&D segment today but planned free-flyer stations and other on-orbit infrastructure have the potential to unlock demand in the future.

Our analysis shows that R&D, though constrained, provides important synergistic value to nascent LEO markets, such as manufacturing. This makes the R&D market a relatively small but nonetheless important contributor to the broader LEO economy, as it allows for the exploration of on-orbit and terrestrial products and applications which can lead to much larger business cases.

Manufacturing could reinforce markets and create new opportunities

Manufacturing includes the on-orbit production of goods and services, encompassing several potential scenarios. These include 1) production of goods for terrestrial industrial applications; 2) production of goods for on-orbit applications; and 3) transportation of goods to space for novel branding in terrestrial consumer markets. To date, sustainable business cases for on-orbit manufacturing for terrestrial consumption have been elusive, with incremental costs of on-orbit production being too high for many business cases to close. However, our research indicates that manufacturing could become the final frontier of value creation in LEO, with significant long-term potential if possible near-term demand is appropriately targeted. Ultimately, LEO manufacturing could serve as a noteworthy future contributor to the space industrial complex of the U.S. and other nations.

Asteroid mining, or capturing near-earth asteroids to extract valuable resources, has long been discussed as a potential prospect for the LEO economy. Market-value estimates of asteroids with high concentrations of precious metals like platinum have ranged well into multiple billions of US dollars or more.[iv] Our team does not disregard the noteworthy value proposition of space-based mining operations. However, given the wide range of undeveloped technology and infrastructure necessary, and current lack of investment to develop it, we view very limited potential to realize this market within our 2035 forecast horizon.



Bringing space to Earth for everyone

Since the beginning of space exploration, a wide range of consumers from media influencers to business executives has been interested in experiencing space firsthand, yet in-space experiences have historically been limited to astronauts due to prohibitive overhead costs and launch availability. The most likely benefactors of the growing infrastructure and services segments are tourism and, subsequently, media and entertainment.

Space tourism emerges to boldly go where few have gone before

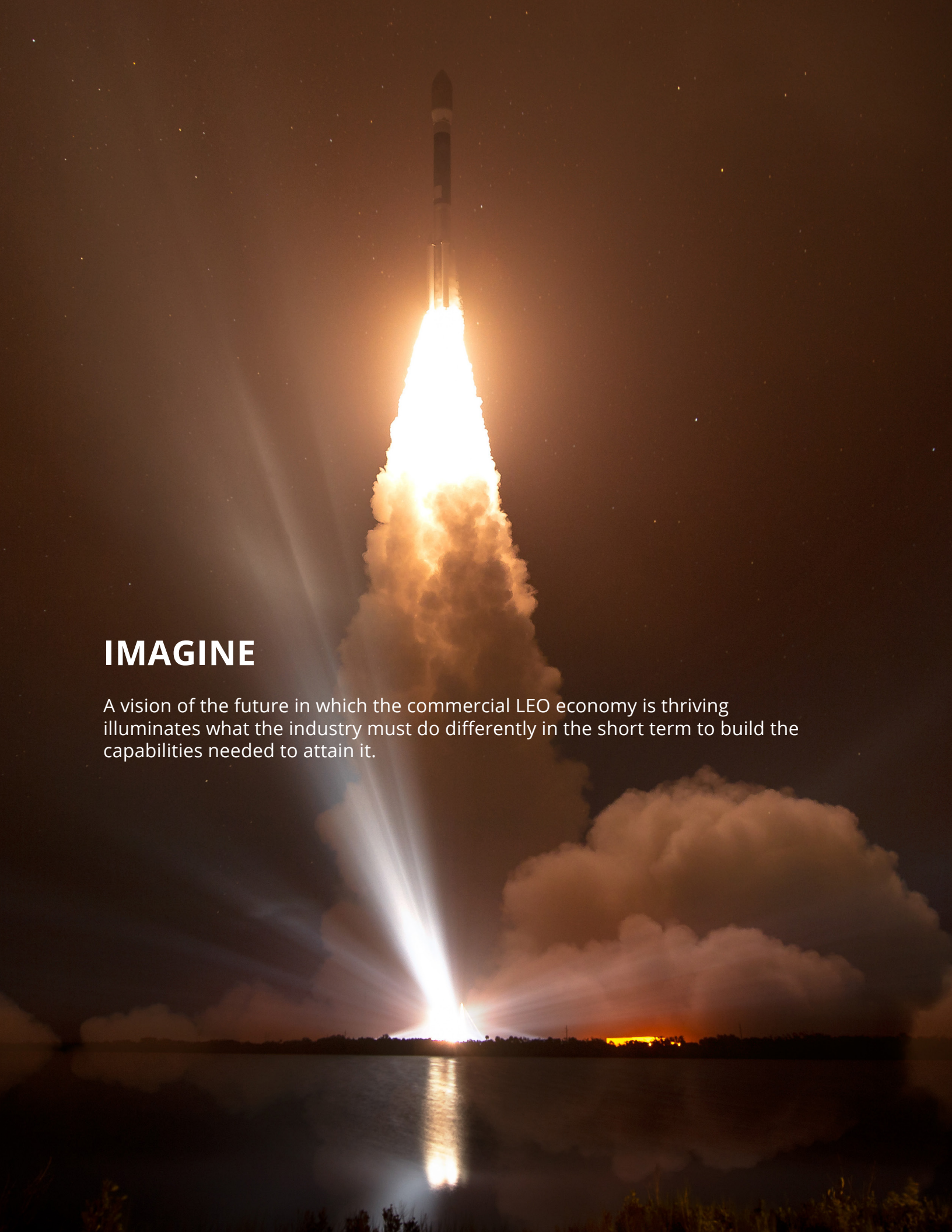
Historically, space tourism comprises all the activities that support leisure travel to space. The space tourism market can be divided into sub-orbital tourism, orbital tourism, and destination-oriented tourism. **Sub-orbital tourism** enables human spaceflight to the edge of space without sending the vehicle into orbit, whereas **orbital tourism** enables travelers to experience orbital spaceflight. **Destination-oriented tourism** encompasses any trip into space that includes destination, such as docking with ISS. **Non-destination orbital flights** exist as well, where travelers experience orbit without ever leaving their vehicle. Our tourism market projections cover LEO-based activities, which include destination-oriented and non-destination orbital flight segments on our value chain but exclude sub-orbital trips.

In recent years, key demand from the remote sensing market and NASA's Commercial Crew program have allowed select organizations to achieve significant technological breakthroughs needed to proliferate access to space. The recently completed Inspiration4 mission (September 2021) became the world's first all-civilian mission to orbit[v] and the upcoming Ax-1 mission will be the first private mission to the ISS[vi]. Both missions are historic milestones and, coupled with private sub-orbital spaceflights already completed, demonstrate the viability of two unique sub-segments for tourism: orbital destination, and orbital non-destination. Over the next decade, our analysis suggests space tourism could continue to grow and become a viable and consumer-driven market.

The story of space remains strong: Media, entertainment, and advertising

The story of space and the desire for consumers to engage with storytelling, brands, and experiences related to space has never been stronger. Consumer engagement has expanded due to the increase in visible space industry activities, the proliferation of wide-reaching social media platforms and services, and the adoption of space as a branding play by celebrities, recording artists, and luxury brands. Furthermore, the story of space has found its way into Super Bowl commercials, Hollywood blockbuster movies, and wide-ranging advertising campaigns – many of which include stories told on the ISS, Lunar surface, or in deep space. We see the story of space driving media, entertainment, and advertising (MEA) activities, thereby creating substantial market value for the storytellers, sellers, and commercial spaceflight companies. Ultimately, we see MEA activities occurring both terrestrially and on-orbit.

Looking ahead, we also recognize that an increase in space tourism demand can significantly increase the potential for on-orbit MEA activities as many production related activities will require humans-in-the-loop on-orbit. In the short term, media applications likely have the greatest potential of the three MEA activities to generate revenue and value directly associated with the human spaceflight mission and the commercialization of LEO. Long-term growth of the MEA segment will also require investment in new infrastructure, from cameras to telecommunications, and the adaptation of business models to support the breadth of possible MEA use cases that leverage the LEO environment.



IMAGINE

A vision of the future in which the commercial LEO economy is thriving illuminates what the industry must do differently in the short term to build the capabilities needed to attain it.

Envisioning future scenarios and what it will take to launch the new economy

Identifying opportunities to enable rapid growth across our identified market segments begins with mapping potential trajectories for the LEO economy as a whole. From this framework, we can cascade potential future scenarios through each market segment with empirical approaches to market sizing and business case analysis.

As we look toward the future of LEO, we recognize that the commercial potential of human spaceflight and on-orbit servicing has yet to be realized. However, many of the foundational components for sustainable commercial human spaceflight are in development or entering the market today. This demonstrated progress and continued investment in the sector allows us to imagine the pathway from today to tomorrow through a variety of scenarios.

Scenarios are powerful planning tools precisely because the future is unpredictable. Using scenarios is like rehearsing the future, and by recognizing the warning signs that are unfolding, one can avoid surprises, adapt, and act effectively. However, alternative approaches to strategy are required in a world that defies prediction. Imagining and planning for a future, vibrant economy in low Earth orbit is no different.

Zoom-Out: Imagining the LEO economy in 2035

To envision the long-term future of the LEO economy, we began with a focal question: what could the commercial LEO economy look like in 2035? From there, we focused on identifying the driving forces (trends and uncertainties) and critical limiting factors such as technology readiness and market structure that could impact the industry between now and 2035. Next, we conducted a series of scenario planning activities that ultimately fed into our market outlooks.

We leveraged our customized Space Mission and Payload Planning Tool (SMPPT) to create market scenarios across the six identified market segments. The Deloitte SMPPT allows for the aggregation of multiple market scenarios based on a top-down annualized growth approach or a bottoms-up formulation of individual missions and use cases for each segment. Our scenario planning tool allows us to create market outlooks based on factors that may constrain, support, or fundamentally transform the commercial LEO economy. The outlooks we produced are driven specifically by our view of what a vibrant LEO economy could be in 10 to 20 years, coupled with interconnected technical, operational, and economic constraints present within the value chain segments today.

Aggregated, the outputs of our scenario planning efforts resulted in three macro LEO economy outlooks defined as the high growth case (optimistic growth potential with multiple market barriers removed), steady growth case (consistent growth potential from today's industry outlook with some market barriers removed), and constrained case (low growth potential from today's industry outlook with multiple market barriers remaining).

An Introduction to our Zoom-Out / Zoom-In Framework

Our approach is based on what some of the most successful technology companies have pursued over the past several decades. It goes by various names; we call it Zoom-Out / Zoom-In. This approach focuses on two very different time horizons in parallel and iterates between them. One is 10 to 20 years: the zoom-out horizon. The other is six to 12 months: the zoom-in horizon. A desire to learn faster is what drives this approach to strategy: constantly reflect on what we can learn from both time horizons and refine our approaches to achieve more impact in a less predictable world.

Applying Zoom-Out / Zoom-In to the Commercialization of LEO

Key Questions Across Two Time Horizons

Zoom-Out	Zoom-In
What could the commercial LEO market look like 10 to 20 years from now?	What actions can we as industry or government take in the next six to 12 months that would have the greatest impact on accelerating movement towards that end-state economic destination?
What kind of activities will need to occur on-orbit to create a sustainable LEO economy?	What is the role of government and industry in creating high-impact initiatives that can be executed today?
What does success look like for government and industry in each segment of the LEO value chain?	

Read more about the Zoom-Out / Zoom-In framework in Deloitte Insights.

An Introduction to our Space Mission and Payload Planning Tool

The Deloitte Space Mission and Payload Planning Tool (SMPPT) was designed from the start to leverage our global reach across all industries and sectors. The tool was built using the same approach that Deloitte has used to guide digital transformation, emerging market growth, and disruptive technology adoption. At the heart of the tool is a series of modules that allow us to explore our vision for the future over a defined time horizon (zoom-out) and assess what we must do to begin the journey towards that future today (zoom-in).

THE BUILDING BLOCKS: Designing the Tool

3+ Years of Research

10+ Countries Represented

75+ Industry Leaders Consulted

100+ Unique Data Sources Used

40+ Commercial Sectors Analyzed

3,000+ Individuals Surveyed

ZOOM-OUT
A Vision for 2035

- What does a sustainable space tourism market look like?
- What kinds of goods should be manufactured on orbit?
- What do the segments look like under multiple growth scenarios?
- What are the limiting factors to closing various business cases before 2035?
- What other economic value can be extracted from a presence in LEO?

ZOOM-IN
What to Know Today

- What transportation costs will open up what market segments
- What goods can be economically manufactured on orbit
- What premiums terrestrial goods can bear when made on orbit
- What segments we can stimulate to enable our 2035 vision
- What incentivization levers can be applied to grow the market

THE CORE OF OUR VISION FOR 2035

SPACE MISSION & PAYLOAD PLANNING TOOL

Market Segment Configuration
Mission Buildup
Scenario Design
Market Dynamics
Market Forecasting

THE PROCESS: Using the Tool

Configure

Scenario planning is conducted by configuring multiple input variables and calculating market, segment, and mission economic impacts using global market and demand elasticity data.

Compute

The tool outputs economic value and market sizing in a top-down segment growth projection or a bottom-up mission buildup model.

Aggregate

Aggregate the growth projections as constrained, steady growth, high-growth, and transformative projections to create a complete market picture for the low Earth orbit economy.

Analyze

Projections identify market structure, dynamics, and barriers to growth to inform what actions may stimulate demand and grow the LEO economy.

Imagining the future

A high growth view: the commercialization of LEO takes off

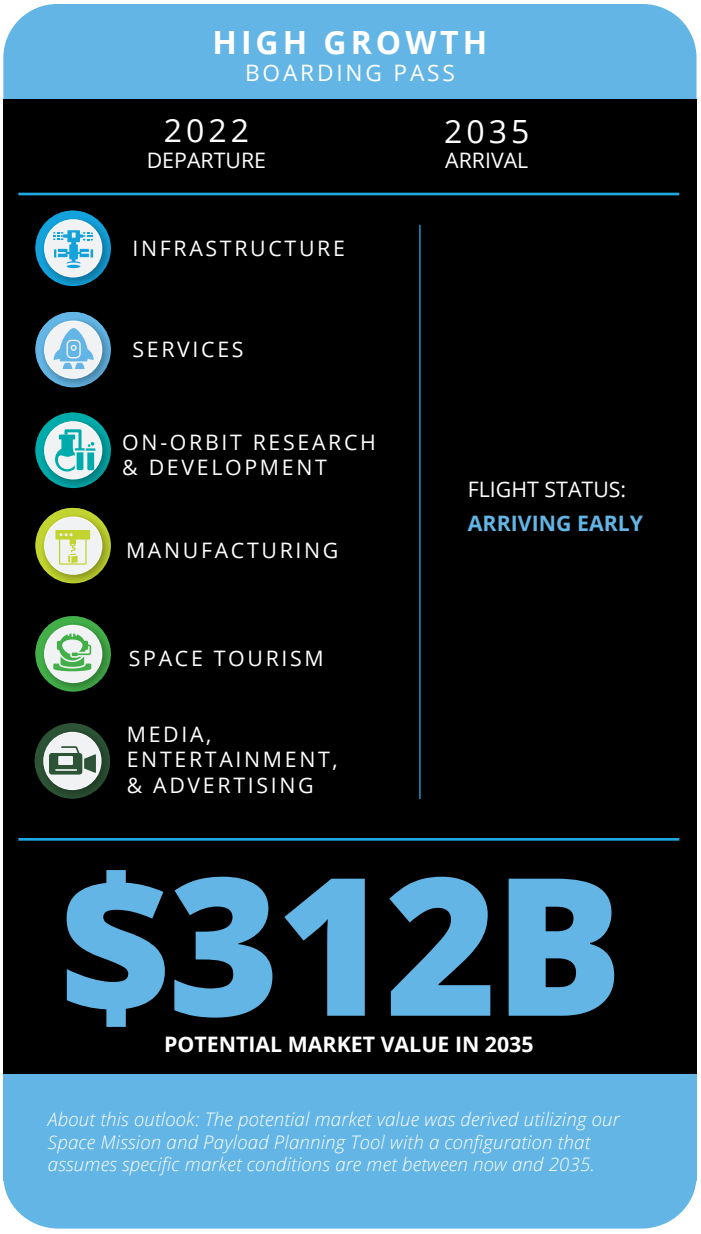
In a high-growth outlook, access to space rapidly expands due to accelerating demand as well as technological innovation driving supply-side economies of scale. These market forces then catalyze faster growth and maturation timelines for nascent markets outside of the core space services market (including launch and satellites). In this scenario, we envision multiple simultaneous infrastructure projects in LEO with on-orbit lodging capabilities, as well as industrial capabilities to enable the tourism and manufacturing markets, respectively. Terrestrially, publicity around space accelerates and drives strong growth across MEA outlets, such as film and television, social media, and journalism projects all involving space-based activities.

Scenario catalysts

Demand strength: Annual satellite demand in aggregate grows across all orbital categories (LEO, GEO, etc.), driven by new market entrants and increased demand among existing players. Meanwhile, satellite, cargo, and human launch prices drop significantly, reaching inflection points that unlock new viable business cases. Proposed Lunar (Artemis) and Mars mission programs unfold on an accelerated timeline, driving new sources of demand for human activity in LEO.

Technology and innovation: New major smallsat constellations outperform projected lifespans, prompting improved economics for remote sensing and telecom infrastructure, while continued innovation in the launch sector continues to improve transportation costs.

Geopolitical and regulatory: Rising competition among nation-states in the space domain leads to increasing government investment in the commercial spaceflight market while avoiding major conflict and negative effects. US regulation of spaceflight reflects consensus standards from industry and supports a thriving competitive market.



Imagining the Future

A steady growth view: systems nominal with gradual climb

In a steady growth scenario, we envision an industry that progresses on the trajectory we've seen from the past decade. Satellite demand remains consistent, supporting a healthy launch services market. Major innovations in the industry continue to generate sustained media coverage and occasionally reach broad audiences, but firms encounter limits to growing audience sizes. Non-orbital space tourism emerges from a handful of industry pioneers, fueling interest in other nascent LEO markets such as space branded novelty products.

Scenario catalysts

Demand strength: Annual satellite demand in aggregate remains consistent across all orbital categories, with minimal disruption to the industry. Launch pricing moves back from NASA's $20k/kg announcement, reaching $3-6k per past performance. Cost stability, above all, maintains past performance. Proposed Lunar (Artemis) and Mars mission programs unfold on schedule.

Technology and innovation: Small-sat constellations perform on-par with expected lifespans, causing no major disruptions that would unexpectedly shift supply and demand, while advancements in terrestrial telecommunications infrastructure (e.g., 5G) limit the upper boundary of the satcom market. Applications of R&D and manufacturing in microgravity continue in nascent stages but are supported at greater levels through emerging capacity on the ISS and free-flyer stations.

Geopolitical and regulatory: Responsive space and great power competition continues at current pace without major acceleration or catalytic events that would produce a shock to the industry. Additionally, space traffic management efforts are successful, allowing industry to effectively manage increasingly saturated launch schedules and orbital debris.

STEADY GROWTH
BOARDING PASS

2022 DEPARTURE	2035 ARRIVAL
INFRASTRUCTURE	FLIGHT STATUS: ON-TIME
SERVICES	
ON-ORBIT RESEARCH & DEVELOPMENT	
MANUFACTURING	
SPACE TOURISM	
MEDIA, ENTERTAINMENT, & ADVERTISING	

$231B
POTENTIAL MARKET VALUE IN 2035

About this outlook: The potential market value was derived utilizing our Space Mission and Payload Planning Tool with a configuration that assumes specific market conditions are met between now and 2035.

Imagining the future

A constrained view: the countdown is paused

In a constrained outlook, we observe a broad trend of stagnation across markets in the industry, driven by struggling return on investment (ROI) performance from existing LEO businesses and tapered government investment. Launch costs largely stagnate, with minimal reduction in the long-term due to slowing growth in satellite demand and launch cadence. Promising, nascent LEO markets suffer as lower corporate and government R&D investment limits technological innovation. Fewer major events generate smaller media audiences and public interest shifts away from space. The technological achievements of the 2010s, such as reusable launch vehicles and small satellites, maintain their status as the major industrial milestones for the modern LEO infrastructure and services segments through the 2020s.

Scenario catalysts

Demand strength: Current market saturation across the launch and satellite remote sensing markets results in high levels of attrition. In result, annual satellite demand underperforms growth forecasts, causing a negative shock to the industry. Early signals of demand for space tourism prove fleeting due to unfavorable price conditions.

Technology and innovation: New major smallsat constellations underperform their projected lifespans, requiring commercial entities to outlay additional capital to maintain constellations. Capital reallocation towards maintenance and operations limits the investment funding available for innovation and increased capacity.

Public sentiment: Launch anomalies and other negative events dampen progress in the market, resulting in waning investment interest and a massive disruption to prospective tourism activity. Negative publicity over unequal access to – and pollution from – space launch activity drives down public interest.

Geopolitical and regulatory: Great power competition fractures collaboration and interferes with space infrastructure (anti-sat missiles, etc.), increasing costs and business risk for commercial operators, thereby forcing negative supply and demand shocks on the market. Stagnation or new restrictive measures in the regulatory environment constrain existing ventures and raise barriers for new entrants. The complexity of increasingly global participation in a crowded orbital environment presents logistical complications for launch and satellite services providers.

CONSTRAINED
BOARDING PASS

2022 DEPARTURE	2035 ARRIVAL
INFRASTRUCTURE	FLIGHT STATUS: **DELAYED**
SERVICES	
ON-ORBIT RESEARCH & DEVELOPMENT	
MANUFACTURING	
SPACE TOURISM	
MEDIA, ENTERTAINMENT, & ADVERTISING	

$151B

POTENTIAL MARKET VALUE IN 2035

About this outlook: The potential market value was derived utilizing our Space Mission and Payload Planning Tool with a configuration that assumes specific market conditions are met between now and 2035.

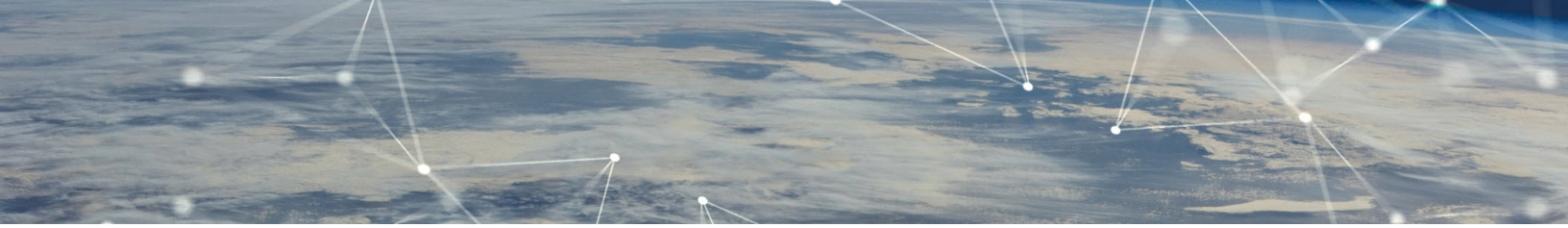
Imagining the future

A transformative view: changing the game

In addition to developing high growth, steady growth, and constrained outlooks, we can also envision a future where the industry has transformed through the introduction of breakthrough technologies or significant market structure transformation (e.g., drastic changes in launch costs). Predicting the adoption of breakthrough technologies or the enablement of structural change is not an easy task and such predictions are often overly optimistic in the short term and miss the mark for the long term. We have observed this trend with early predictions about the Internet, smart phones, social media, and more. As such, we recognize the importance of acknowledging that a large-scale transformative outlook is possible to achieve. However, this transformative structural change is just as likely to occur in a single segment (i.e., a significant reduction in the price per seat for space tourism) as it is across the entire value chain (i.e., significant additional reductions in price per kg to LEO).

In some cases, such as orbital space tourism, it is easy to imagine a robust, sustainable high growth outlook as we can see direct pathways to the market structural changes needed – significantly lower cost human transportation services. In other cases, such as on-orbit research and development, we recognize the significant economic potential of microgravity research conducted on orbit, but the pathway to unlocking that value is more nuanced and complex, thereby leading to a significantly constrained outlook.

We explore transformative outlooks for subsegments (e.g., orbital space tourism) where we can model the impact of significant structure change or breakthrough technologies based on market or technical analysis. These transformative outlooks are detailed in subsequent volumes where applicable.



Imagining the future

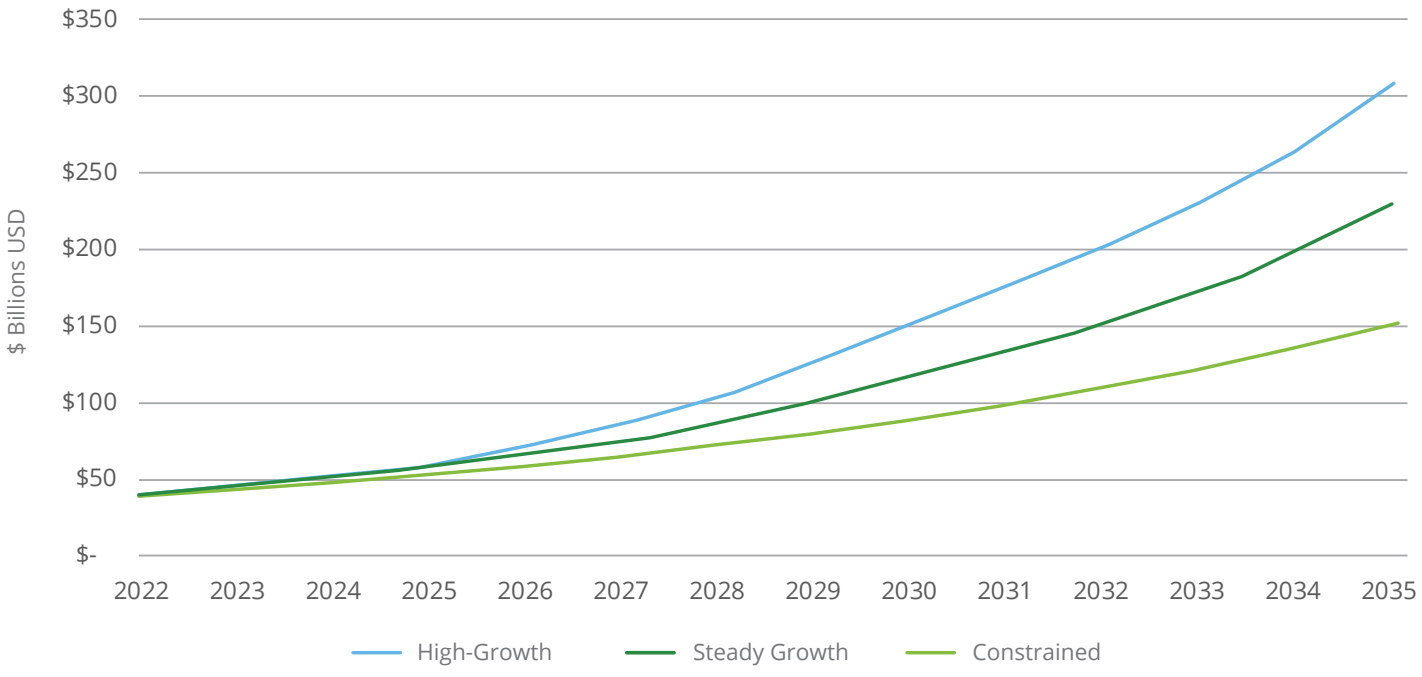
A view of the market in 2035

By 2035, we can envision a vibrant LEO economy driven by multiple on-orbit destinations, regular human-rated access to space, the industrialization of on-orbit manufacturing, and robust on-orbit services. We recognize that this vision can play out in multiple ways with varying economic development and impact. Our modeling efforts suggest that the low Earth orbit space economy of 2035 can deliver annual economic value ranging from $151B (constrained outlook) to $312B (high growth outlook), reaching the upper end of this range if key structural barriers are addressed through properly coordinated investment and incentivization. In Figure 2 below, we aggregate the potential for market growth across the LEO value chain.

This range is driven largely by the strong historic and projected performance of the infrastructure and services market segments, which together provide most of the annual value for the LEO economy. Despite the outsized economic impact of infrastructure and services, we remain optimistic in the potential for currently nascent market segments such as manufacturing, orbital space tourism, and media. Zooming out, we can envision a 2035 where these three segments advance from serving innovators and early adopters towards global customers and mass markets.

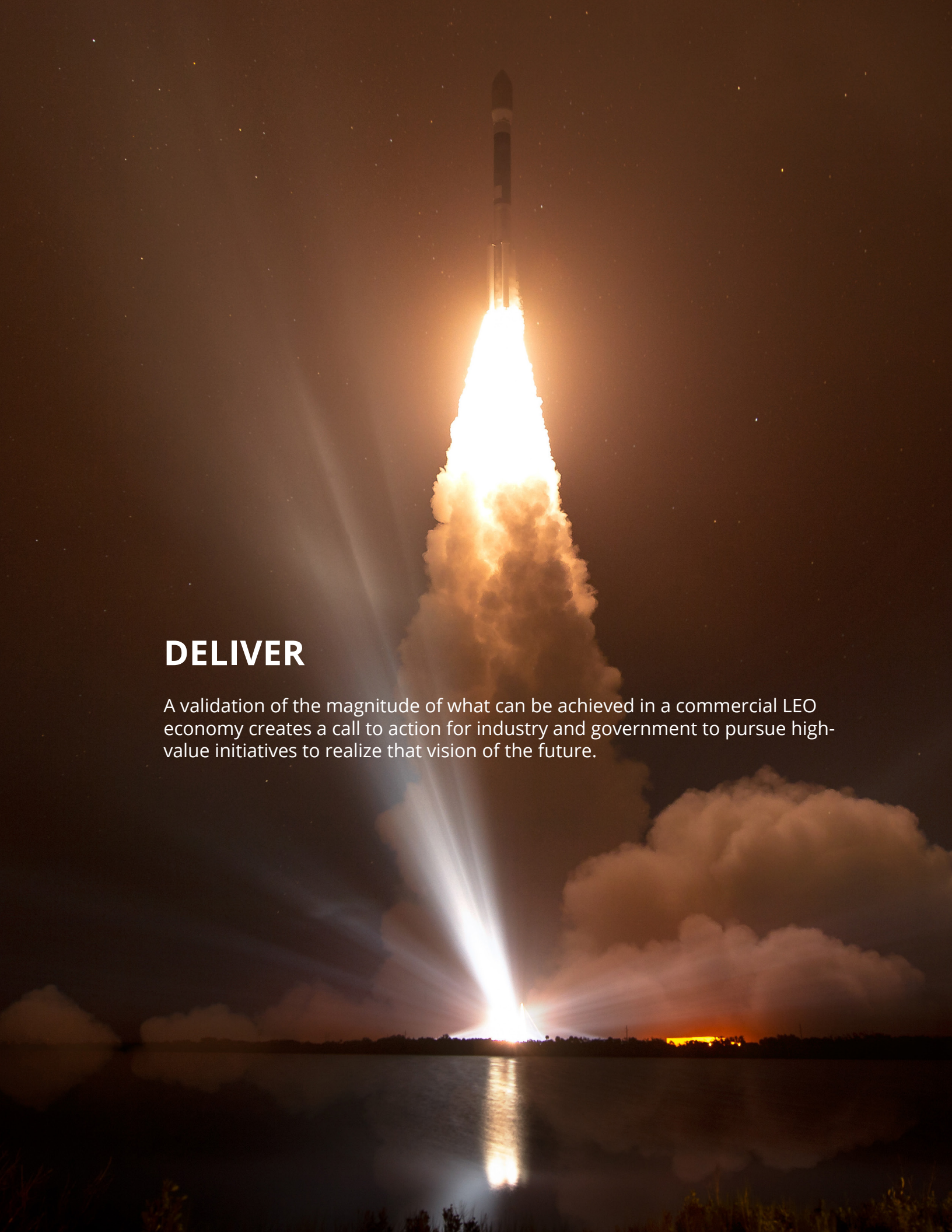
FIGURE 2

Total Addressable Market Projections for LEO Economy (2022-2035) in $B USD



Focus on Success

With a broad vision of the future and a desire to incentivize transformation towards the high growth outlook, we now turn our focus to what success looks like in the form of where to play and how to win for each of the market segments.



DELIVER

A validation of the magnitude of what can be achieved in a commercial LEO economy creates a call to action for industry and government to pursue high-value initiatives to realize that vision of the future.

What is it going to take to achieve the vision for 2035?

Realizing any of the market outlooks from high growth to constrained will depend on action or inaction on a variety of limiting and enabling factors. To determine where to start, we asked a series of focal questions based on our scenario planning and market outlooks:

- What are the most significant market dynamics that will influence the growth trajectory of each segment of the LEO economy?
- What can industry or government do in the next six to 12 months that would have the greatest impact in accelerating our movement towards that longer-term economic destination?
- What is the role of government and industry in creating high-impact initiatives that can be executed today?

Answering these questions leads to a series of growth imperatives, high value initiatives, and a call to action to guide the commercial LEO market towards a high-growth future and potentially large-scale transformation.

Imperatives to bridge the gap

Our scenario planning produced clear implications for what needs to change in the short term to build critical capabilities for the future. Broadly speaking, unlocking the vision for 2035 requires concerted efforts to:

- Deliver lower cost, higher cadence human-rated access to space
- Significantly increase up-mass capacity to support on-orbit logistical needs and, more importantly, increase the almost non-existent current down-mass capacity to enable manufacturing operations
- Establish multiple on-orbit destinations for human-rated, depot-centric, and other mission specific activities
- Better align the resources and complementary technical capabilities of public and private sector players – including those who haven't yet considered the value of space-based operations – to develop winning strategies
- Enable access to LEO in a manner that allows missions to move at the speed of business

High-value initiatives

Guided by a series of growth imperatives, we then focused on defining high-impact initiatives that government and industry, collectively, can do over the next six to 12 months to accelerate the path forward. Key growth initiatives are summarized below for segments across the commercial LEO value chain.

To create an orbit for everyone, we suggest focusing on creating infrastructure that provides foundations for growth to a future that includes multiple on-orbit destinations; a scalable, agile, and responsive launch architecture that can respond to market and government needs; and regular, sustained human-rated access to LEO. In the near-term, we must enable additional economically viable and sustainable business cases for commercial LEO destinations through a focused assessment of accelerating technologies and enabling investments.

To bring Earth to space, otherwise framed as the industrialization of low Earth orbit via R&D and manufacturing activities, we must determine why the Fortune 500 inconsistently invested in microgravity R&D and manufacturing operations on a continual basis and build pathways to stimulate R&D demand across multiple LEO destinations. Specifically, focus on ways to shorten lead-times for R&D pursuits on orbit, consistent with the technology development lifecycle. For manufacturing, we suggest stronger incentivization of business cases that close at scale for products/technologies that intrinsically benefit from microgravity (e.g., making materials with superior properties). In parallel, we suggest increased engagement with the consumer discretionary sector to facilitate the production of luxury and novelty goods that command a premium from a trip to space. Even in limited-run production scenarios, this initiative can strengthen demand for the foundational infrastructure and services needed to support broader commercial activity in LEO.

To make the dream of space travel a reality for private citizens, we must determine how to open the market beyond just ultra-high-net-worth individuals by determining the market inflection points for prices that will enable greater participation in orbital space tourism. We envision a combined portfolio of subsidies, incentives, and hybrid mission architectures as the means to offset the cost per seat and reach target inflection points that will swell demand.

For media, entertainment, and advertising, we suggest focusing on bringing space down to Earth by capitalizing on the appeal of space and its associated story, brand, and affinity value. First, we must assess the brand value of space across a variety of engagement mechanisms, focusing on aspirational affinity with space that is accessible to the masses, not just ultra-high-net-worth individuals. To capture the value of the story of space, create tangible and profitable campaigns involving real-world human spaceflight while maximizing ancillary revenue streams from advertising and product placement. We also suggest telling the story of Earth from space: amplify the impact of story-telling on Earth using space-based imaging and other services.

Delivering the future

A call to action

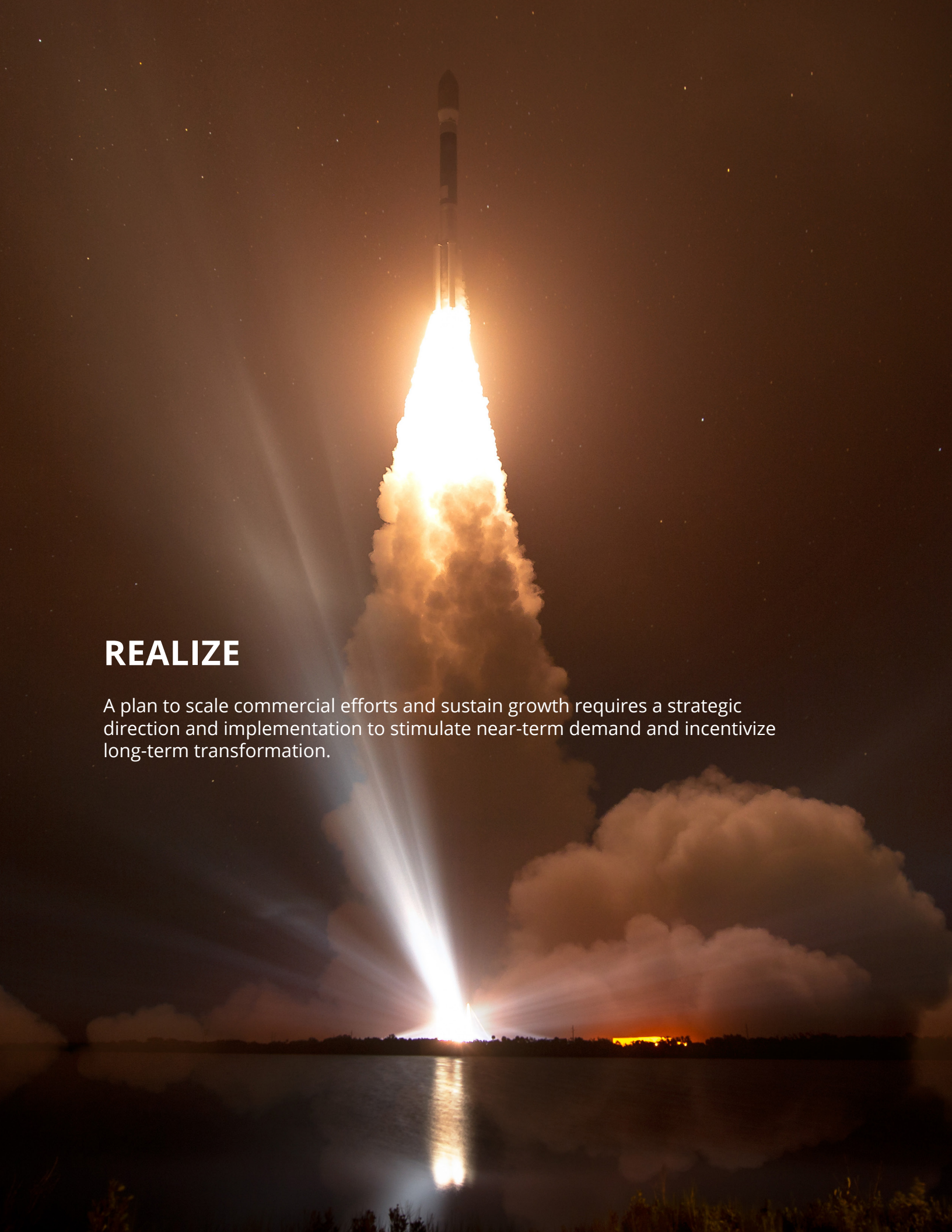
Getting to tomorrow will require action across a variety of sectors and the LEO market segments. What was once a theoretical exercise in imagining the future for the LEO economy has become very real and with clear implications for what needs to be done differently in the near term. In short, we need to drive greater commercial participation by non-traditional players from across the Fortune 500. To increase this participation, we need to identify what business cases could and should be addressed. This can be done through active engagement with industry and supported by continual systematic market analysis, emerging technology analysis, and robust economic modeling to identify and vet identified and attractive use cases. Additionally, differentiation between real and perceived barriers must be addressed through increased engagement, education, and focused discovery across both current players in the LEO market and those that have not yet realized the value they can capture.

There will be winners and losers on the trajectory to commercializing LEO. What differentiates them will not just be the ability to execute on a technical level, but the ability to successfully fuse technical, political, and financial, capabilities with far-reaching access to players across interrelated pathways. Initiatives and pathways that create "downhill" momentum from early-phase to later-phase opportunities are critical to success. Independent pathways exist and, while they do not lead to largest economic impact, they still have a crucial role in achieving the commercial LEO economy. Integrated, synergistic pathways will require either public-private or private-private partnerships (or both). Finding these pathways, aligning capital, and executing in a phased approach will lead to greatest growth in LEO economy.

FIGURE 3

Zoom-Out / Zoom-In Summary

SEGMENT	IMAGINE (Zoom-Out)	DELIVER (Zoom-In)
Infrastructure & Services	Ground- and space-based capabilities ***create an orbit for everyone***	• Create infrastructure that provides foundations for growth across demand segments • Focus assessment of and investment in technologies to close more business cases • Pursue favorable regulatory conditions to stimulate competition
R&D & Manufacturing	The Fortune 500 ***brings Earth to space*** by industrializing LEO at scale	• Stimulate R&D demand across multiple LEO destinations, including free-flyer stations • Shorten lead-times for R&D pursuits on orbit, allowing industry to operate at the speed of business • Strengthen incentives for business cases that close at scale for products made in space • Increase engagement with the consumer discretionary market to produce space-based premium goods
Space Tourism	***Make the dream of space travel a reality*** for citizens beyond the ultra wealthy	• Continually refine market analysis to identify demand inflection points based on price • Establish hybrid portfolios of subsidies, incentives, and hybrid mission architectures to offset costs and attain target price points
Media, Entertainment, & Advertising	***Bring space down to Earth*** by capitalizing on the story and brand value of space	• Assess the brand value of space across a variety of engagement mechanisms • Focus on aspirational affinity with space that is accessible to the masses • Capture value through campaigns that combine real-world human spaceflight and ancillary revenue streams • Amplify the impact of story-telling on Earth with space-based infrastructure and services



REALIZE

A plan to scale commercial efforts and sustain growth requires a strategic direction and implementation to stimulate near-term demand and incentivize long-term transformation.

The Deloitte game plan

We have heard the call to action and, since the founding of the Deloitte Space Group in 2017, have mobilized our resources to help accelerate the drive towards our vision for the future of LEO. We may not launch rockets or build space stations, but we are investing our resources into accelerating technology, mission, and economic development in space. From deploying digital engineering solutions to active cyber defense of space systems and the creation of modeling and simulation tools such as the Deloitte Space Mission and Planning Tool, Deloitte is committed to working with commercial and government institutions across the globe to grow capabilities and commercial opportunities in the space domain.

As such, and in support of our desire to realize our vision for a vibrant LEO economy in 2035, we believe that industry needs a grounded perspective on critical decision metrics such as technical feasibility, research, development, test & evaluation (RDT&E) that needs to be completed to enable broader commercial activity, and a dynamic forecast of near-term through long-term ROI potential. In our experience, this is best accomplished through extensive industry engagement, dynamic forecasting based on multidimensional scenarios, and a regular reexamination of assumptions and approaches.

Even in our positive outlook and aspirational goals, we recognize that the largest global industrial contributors are not investing in LEO operations at scale, so we continue to leverage our global presence and reach into the Fortune 500 to:

- Ask why they are not investing today;
- Listen to what they say is holding them back; and
- Identify potential LEO business cases that could be viable.

This provides us the necessary information to:

- Model the underlying economics of each potential business case;
- Forecast how large the LEO economy can be;
- Determine the price elasticity driven by investment/launch costs;
- Understand the market dynamics including what is holding back action today; and
- Suggest actions to remove barriers and stimulate the commercial space economy.

Given the rapid pace of change and investment within certain segments of the commercial space industry, we acknowledge that the outlook for 2035 will require continual analysis and reassessment. As we collect additional viewpoints and data on these critical questions, we will continue to incorporate these discoveries into our models by adapting the underlying assumptions of each potential business case. Throughout this journey, we will continue to share our macro conclusions and provide suggestions to industry, academia, and government. We believe that this is best done collaboratively and invite you to join us in imagining the future and incentivizing today.

This publication series is just the start. In succeeding volumes of the Commercialization of Low Earth Orbit series, we'll examine multiple market forces and potential catalysts driving value creation within each segment of the commercial LEO market.

Let's Talk.

Let's Talk

Deloitte Space is the world's first professional services practice devoted to supporting the entire space value-chain, from both the government and private sectors, from Fortune 500 companies and aerospace stalwarts to emerging space companies and start-ups who we are supporting today. We have space professionals in Washington, DC, Colorado, California, Texas and Alabama, as well as globally in the U.K., Australia, Canada, Japan, Luxembourg, New Zealand, and the United Arab Emirates. In addition, we are a premier provider of supporting capabilities such finance, cyber, technology, data, and other professional services for government space agencies, commercial aerospace companies, and academic entities focused on space science and systems.

Deloitte is confident that we have and will continue to demonstrate a strong understanding of the space enterprise. Our 360-degree perspective underscores our fresh and holistic thinking about challenges in space. We possess differentiated knowledge of New Space, as well as outside perspectives on the United States Department of Defense, Government, open architecture, and enterprise transformation. Our experts have launched rockets, deployed satellite remote sensing systems, implemented global telecom solutions leveraging commercial satcom, analyzed the commercial space economy, and secured private investment for space technology companies. An advantage we have over our competitors is the broad array of resources available at any given time, allowing us to leverage experience, expertise, eminence, skills, credentials, and – most importantly – perspectives that very few can match.

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