

Longer Term Investments

Space

Chief Investment Office Americas, Wealth Management | 30 November 2018 10:24 am GMT
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- The space economy is reaching an inflection point and is poised to grow from USD 340bn currently to almost USD 1trn in the next couple of decades, in our view.
- Key catalysts are the deep pockets and sustained capital investment by new economy billionaires and technological advances in rocket and satellite technology.
- Investment exposure at this early stage is best gained via existing listed companies in aerospace, satellite and communications segments. New space start-ups may offer investment opportunities in private markets.

"Human beings aren't heading to the stars to become poor."

Takeshi Hakamada, CEO of iSpace

Our view

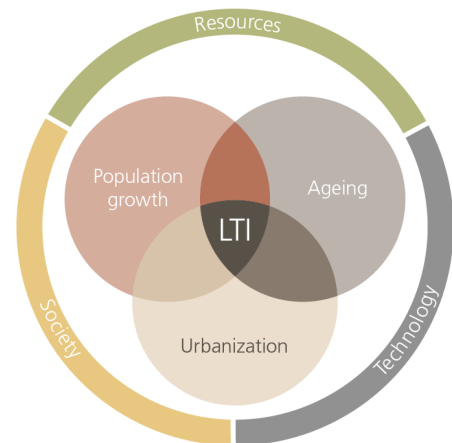
In the last decade, several factors have converged to bring us closer to an inflection point in the business of space than at any other time. These include a surge in private sector investment, evident from a proliferation of new space start-ups, as well as major advances in both rocket and satellite technology. We see parallels here with how the global internet, coupled with advances in processing power, opened up vast and disruptive business opportunities at the turn of the century. Mainstream financial markets are only just starting to awaken to the commercial and disruptive opportunities that space offers, as technology is starting to tear down the high entry barriers to access space.

We forecast that the combination of declining space launch costs and advances in satellite technology will raise the value of the space economy from USD 340bn currently to nearly USD 1trn over the next two decades. And while traditional satellite, government, and military applications in space will continue to grow, in our view, the space economy will start to have major spillovers across several industries. The emergence of satellite broadband internet is one such example.

In the next two years, we will likely witness the first commercial space tourism flights to low orbit space by Virgin Galactic and Blue Origin and the launch of the first satellite internet service by Space X. These will be important catalysts for the space economy, awakening consumers and investors to the commercial possibilities of space, and creating demand for new applications, not unlike the trajectory of the online economy over the last 20 years.

Introduction to the Longer Term Investments (LTI) series

- **The Longer Term Investments (LTI)** series contains thematic investment ideas based on long term structural developments.
- Secular trends such as population growth, ageing, and increased urbanization create a variety of longer term investment opportunities.
- These investment opportunities are influenced by the interplay of technological advancement, resource scarcity, and the societal changes.
- Investors willing to invest over multiple business cycles can benefit from potential mispricings created by the typically shorter term focus of stock markets.



Framework

The investment theme of "Space" falls into our new Long Term Investment (LTI) framework because of the role that technology, one of the three "known unknowns," plays in shaping the investment case for space over the long term (1). Technology is lowering the entry barriers to space, creating new business opportunities as well as potentially disruptive trends. The opening of the space economy can provide solutions to address environmental and resource scarcity issues arising from urbanization and population growth, two key long-term drivers, or "known knowns," of our LTI themes.

Falling satellite launch costs to shape space commercialization opportunities

Advances in rocket technology are producing smaller, lighter and more powerful rockets, which have lowered the cost of launch to low Earth orbit (LEO) more in the last decade than in the entire history of space exploration. A new generation of low-cost light rockets have emerged to deliver light payloads to LEO. Priced at just a few million dollars, light rockets can carry payloads of under half a ton and are viable for small satellite launches. However, not all launch cost savings are due to rocket technology. Manufacturing supply chain consolidation has cut launch costs, particularly in Europe, as has greater human capital productivity; almost 90% of the cost of a rocket is manpower. Before 2000, launch costs frequently surpassed USD 20,000/kg. Currently, Space X's Falcon 9 offers payloads per kilogram to LEO of just USD 2,684, a discount of almost 70% to Europe's Ariana 5, which charges USD 8,476/kg (see Fig. 2). This is significant for satellite launches, as the cost of launch can comprise one-third of the total cost of a satellite, versus around half for the hardware.

Falling costs draw investors: new economy private investment as key catalyst for space economy growth

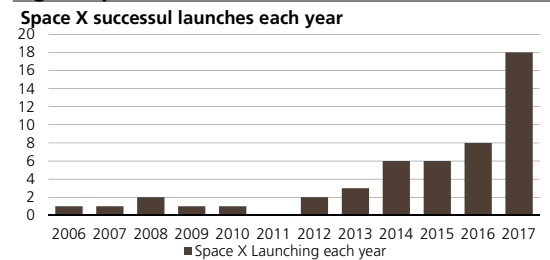
Declining costs are lowering the barrier to investing in space. The key growth catalyst for the space industry in the last two decades has come from the private sector. According to Goldman Sachs, USD 13.3bn alone has been spent on new space start-ups since 2000. The world's most successful new economy billionaires, including e-retailer Jeff Bezos (Blue origin), electric car mogul Elon Musk (Space X), as well as airline magnate Richard Branson (Virgin Galactic), are investing heavily in reusable rocket technology for low-cost launching services and sub-orbital space travel. Bezos has invested USD 500m in Blue Origin, and Elon Musk an estimated USD 100m in SpaceX, with a USD 1bn investment from Fidelity and Google to invest in a satellite internet network (see boxes on Space X and Blue Origin for more). Richard Branson received a USD 1.0bn capital injection in Virgin Galactic from the Abu Dhabi Sovereign Wealth Fund in 2017 on top of an original seed investment of USD 280m.

(1) Refer to CIO Publication "Long Term Investments: The Economics behind long-term themes" published 20 February 2018.

Box 1: Space X

Elon Musk's Space X both represents and drives the new paradigm of space commercialization by new economy billionaires. Space X has revolutionized space technology through the manufacture and launch of advanced rockets and spacecraft. Focusing its business model on providing low cost satellite launch services to customers such as Immarsat and Viasat, Space X currently enjoys a mission backlog of 100 missions worth over USD 12bn (Gwynne Shotwell, President of Space X, 2018). It has reduced the cost of satellite launches to USD 60m vs. USD 200m for its main rival United Launch Alliance, a JV between Lockheed Martin and Boeing. Estimated breakeven for the company requires 10–12 launches per year. The company achieved a record 18 launches in 2017. In March 2018, Space X was granted a license from the Federal Communications Commission to operate an array of broadband internet satellites, the first step of its ambitious Starlink project to deploy 4,425 broadband satellites to provide internet to underserved areas of the planet.

Fig. 1: Space X sets a record 18 launches in 2018



Source: Space X, as of November 2018

Box 2: Blue Origin

In 2014, Jeff Bezos, founder of e-retailer Amazon, invested over USD 500m to found Blue Origin, a business dedicated to creating reusable rockets for space tourism. In 2017, Bezos claimed he was selling down USD 1bn a year in Amazon stock to finance Blue Origin (Reuters, April 2017). As of August 2018, Bezos held around 16% of Amazon shares worth around USD 123bn (based on the share price as of 28 November 2018). Blue Origin plans its first crewed launch of its New Shepard reusable rocket vehicle in 1H19. Future commercial space launches plan to carry six passengers, 62 miles above the Earth for an 11 minute ride. Ticket prices are expected to be in the six figure range based on Virgin Galactic space ticket price of USD 250,000 in 2014.

Rising private sector investment is diversifying the traditional focus of space away from government/military use and into areas as diverse as satellite internet, space tourism, space mining, etc. Moreover, increasingly affordable private satellites will provide data on weather, floods and pollution that could have a huge impact on the development of agriculture and urbanization. Government spending in space programs totaled USD 62.2bn in 2016 and is expected to increase to USD 79bn annually by 2026 (Source: Euroconsult). But much of the incremental investment in the space economy will likely come from the private sector, with start-ups opening a new era of opportunities for investors.

Reusable rocket technology – the next game changer

Over the next decade, launch costs are predicted to decline 10-fold. Part of this decline will be driven by the mainstream adoption of reusable rocket technology. Since the early days of the space shuttle, reusable rocket technology has been seen as a key solution to achieving economic and sustainable access to low orbit space. While fuel accounts for most of the weight of a rocket, most of the cost is in the hardware. This argues for substantial cost savings from reusability. Both Space X and Blue Origin (see boxes) are betting on reusable rocket technology for sending medium-to-heavy loads to geostationary orbit (GEO) with their Falcon 9 and New Shepard rocket models, respectively. Space X achieved a major breakthrough in December 2017 when it reused a Falcon 9 rocket for the first time for a NASA launch. Blue Origin has successfully reused its New Shepard rockets in test flights in preparation for commercial space passenger launches in 2019.

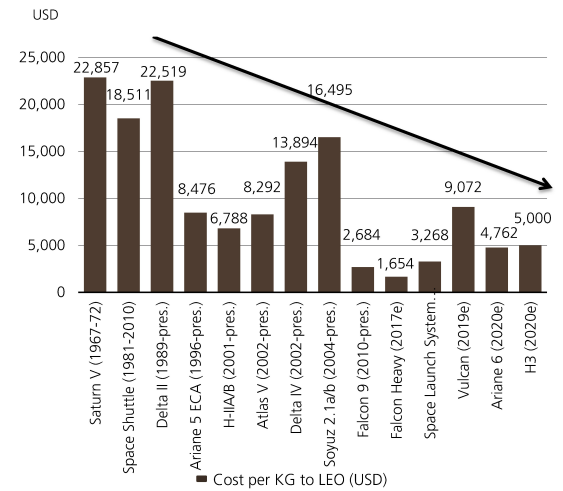
Disruption and opportunities in the satellite industry

Advances in satellite technology, including miniature satellites, high throughput satellites and constellation satellites, are disrupting the traditional satellite operating market (see box for definitions). Cubesats can now be as small as 10cmx10cmx10cm and as light as 1kg, and can be launched for as little as USD 40,000. A single high throughput (HTS) satellite can offer more internet bandwidth than the sum of everything currently in orbit. Meanwhile, "constellations" of small satellites can grow orbit bandwidth by a factor of 10x at rapidly falling costs (source: GS). Greater satellite capacity and smaller sizes imply lower launch costs augurs, spurring a substantial rise in satellite supply and a rapid decline in prices. The situation is further exacerbated by weakening demand from traditional end markets such as satellite video and TV due to competition, further pressuring prices down. However, the flip side to the new low costs of satellites is new demand creation from end applications in communications, surveillance and other new areas. Many of these will dovetail as major disruptive trends unfold over the next three decades. The area of greatest commercial potential here, in our view, will come from satellite broadband internet.

Satellite broadband internet

According to Nielsen Online, there are currently 4 billion internet users worldwide – a global internet penetration rate of 52%. Three-quarters of the remaining unconnected population are located in just 20 countries. With the falling costs of satellite launches, the potential

Fig 2: Falling costs of launch to space



Source: Company data, FAA, UBS as of 2017

Box 3: Definition of satellite types

High throughput satellites

High throughput satellites (HTS) can deliver much higher capacity than traditional satellites at a fraction of the cost. Thanks to spot beam technology today's HTS can offer speeds of 100GBpS, more than 100x that of conventional satellites. Total throughput of planned HTS capacity over the next two years could reach 800GBpS, which would triple global bandwidth in Space. (Vizocom) HTS will play a pivotal role in offering broadband internet to underserved regions of the globe as well as broadband backhaul to cellular network operators.

Cubesats

Cubesats, also known as nanosatellites, are miniature satellites measuring 10cmx10cmx10cm, roughly the size of a Rubik's cube. Their key advantages are low cost, flexibility (they are custom built) and the fact they do not create debris as they burn upon re-entry. Their key limitations are their life cycles (up to 12 months) and limited capacity to carry instruments. Typical commercial applications might be beaming high-resolution images to earth for agriculture or cityplanning.

Satellite constellations

Satellite constellations refer to a group of satellites working in concert, synchronized and under shared ground control. They are typically used in low earth orbit (LEO) because proximity to earth means satellite coverage is limited to a smaller area hence the advantages of multiple coordinated satellites. Global positioning services (GPS) and satellite telephony services, like Iridium, rely on satellite constellations. Satellite constellations are increasingly favored over expensive and more distant geo-stationary earth orbit (GEO) satellites because of low latency advantages for two-way transmission.

to offer affordable and competitive internet access via satellite is becoming a real prospect. According to Ibis World, the provision of internet services currently has a global value of USD 620bn. Based on the simplistic premise of doubling the existing number of internet users, halving the current cost of access suggests a market worth at least USD 300bn. This does not factor in the additional USD 720bn in revenues from internet advertising, e-commerce, social media and others.

Compared to the current estimated value of USD 340bn for the space industry, according to the Satellite Industry Association (see Fig. 3), the enormity of the business opportunity for satellite internet becomes apparent. And while low bandwidth and latency issues (the time it takes for a radio wave to reach orbit and back) are normally cited as the main existing drawbacks of satellite internet, this is changing with the newer satellite constellations. US-based OneWeb, which plans to provide internet via 720 low Earth orbiting satellites, will offer up to 50Mbps download speeds at a latency of just 50 milliseconds. It has received funding from Softbank (USD 1bn) and an assortment of US blue chips (USD 700m). Elon Musk's Space X also plans a much larger scale global internet network, employing 4,425 satellites in LEO, almost three times the number of operational satellites currently in orbit. Its broadband service aims to offer latency of just 20–30ms and broadband speeds up to 1Gbps.

Other new markets for satellite internet

While new unconnected geographies are obvious markets where satellite internet can be competitive versus terrestrial services, other new areas are emerging. One potential growth market for satellite networks is mobile backhaul: the transfer of digital data from mobile cell sites to data centers. According to Vizcom, the cost of Mbps over satellite will fall six-fold over the next two years while traffic will double due to high throughput satellites. Backhaul by satellite will be especially cost effective for mobile operators in areas where terrestrial backhaul over fiber or cable becomes too expensive.

The rising demand for bandwidth over the next couple of decades, due to new applications like the Internet of Things (IoT) and automated cars, suggests to us a wider role for satellite broadband, particularly as connectivity costs fall. According to UBS, digital data doubles every two years, with the size of the global digital universe set to reach around 44 zettabytes (ZB) by 2020, a 50-fold increase from 2010. Mobile data traffic, in particular, will witness exponential growth from the sensors, cameras and navigation of autonomous cars, especially when 5G download speeds become standard.

Rising satellite data for end-user applications

As we become increasingly reliant on satellites for collecting data, we also see a proliferation of applications for data analysis in logistics, agriculture, maritime and retail (e.g. supermarkets tracking produce to ensure it is organically sourced, or fishing boats being monitored to ensure they are fishing legally). We also believe satellite networks will become an increasingly versatile and cost-effective solution to address the connectivity needs of the IoT industry.

Box 4: New space start-ups offer innovative B2B and B2C applications

Two recent space start-ups from Japan offer insight to the variety of "new applications" in space, which could experience high demand growth as entry barriers to space decline sharply

iSpace, whose CEO, Takeshi Hakamada, is quoted on the front page of this report, raised USD 90m in Series A funding from Japanese corporations in late 2017 to focus on a space marketing venture which will offer corporate logos on its spacecraft and rovers. The company also aims to erect high tech billboards on the moon where corporations can show logos with Earth in the background. However, iSpace's ultimate goal is to use its rovers and lunar craft to map and identify water and other natural resources on the moon.

ALE is another Japanese space start-up, which raised USD 7.3m in Series A funding in 2017 and aims to offer on-demand meteor showers which will be ejected as pellets from slow-orbiting satellites. Each satellite will carry 300–500 man-made meteors. Demand for "shooting starts" might be driven by important personal life events including marriages and other ceremonies. By early 2020 ALE plans to have two satellites orbiting in space with capacity for 30–60 events. The Tokyo Olympics may employ ALE's services for its opening ceremony in July 2020.

Space tourism, asteroid mining and space-based manufacturing

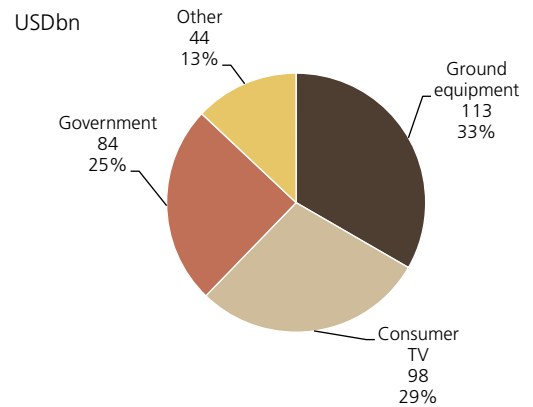
Space tourism

Since the advent of space travel in the latter half of the last century, 550 people have been to space and 35 have been in the last three and a half years. In addition, the International Space Station (ISS) has enjoyed continuous human habitation for several decades. The cost of accessing space for individuals has fallen from USD 20m, paid by Dennis Tito in 2001 to fly to the ISS, to USD 250,000, the prepaid cost of a ticket to sub-orbital space with Virgin Galactic. The key to successful space tourism, in our view, will be rocket reusability. The two key players, Virgin Galactic and Blue Origin, are pursuing this route through their respective SpaceShipTwo and New Shepard rocket models. Because it will be some time before these companies can achieve payback on their initial investments, we believe ticket costs for sub-orbital space travel will remain expensive and out of range for most individuals. A typical space flight on Virgin Galactic's SpaceShipTwo will take six passengers, fly 110km into sub-orbital space and offer four minutes of weightlessness. After a number of setbacks in recent years, Virgin Galactic expects to launch its maiden commercial passenger service to sub-orbital space in early 2019. Blue Origin plans the first crewed launch into space of its New Shepard Rocket in 1H19. If the launches by both companies prove successful, they will act as catalysts for space economy investment as well as the share prices of stocks exposed to the space economy, in our view.

Asteroid mining

According to Goldman Sachs, "a single asteroid the size of a football field could contain USD 25–50bn worth of platinum." Asteroid mining could help eliminate the scarcity of several resources on Earth, as well as transfer the pollutive aspects of mineral extraction off-planet. Some asteroids contain large quantities of water, carbon and phosphorus, while others have an abundance of precious metals like platinum. Asteroid mining could potentially redefine the concept of natural resources on Earth. According to Planetary Resources, around two trillion tons of water are available on near-Earth asteroids. The company is embarking on the world's first deep special exploration program with the objective of identifying and unlocking water resources in space. While the financial and technological barriers to asteroid mining are considerable, as the cost of manufacturing spacecraft declines, we believe the chances for exploration and extraction of resources should increase. And companies such as Planetary Resources are already collecting data for global hydration mapping that will help them build the first commercial mine in space.

Fig. 3: Global space industry revenue (2016)



Source: Satellite Industry Association, 2017

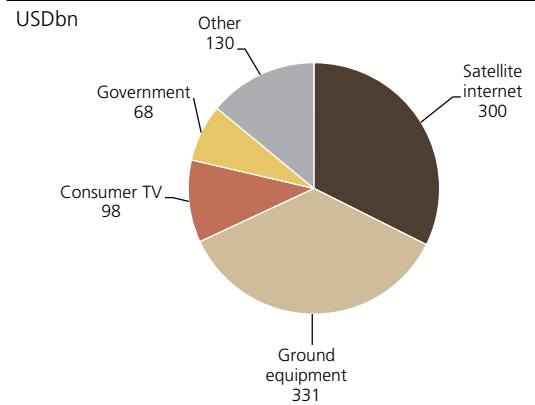
Space-based manufacturing

The idea of manufacturing in space is not a new one, as it already exists on a small scale as a necessary feature of long-duration space missions and exploration. Typically, it involves 3D printers, manufacturing tools and spare or replacement parts for use in space, as has been happening on the ISS. The employment of advanced robotics to build infrastructure and habitats on moons and planets for long-term missions ahead of manned space missions will also lay the foundations for future potential space-based manufacturing. The key challenge for manufacturing goods off-planet for use on Earth will be sourcing raw materials from other bodies in space and "the cost of freight" back to Earth. We believe scalable space-based manufacturing is several decades away but will likely be catalyzed by advances in robotics and artificial intelligence, as well as by the mainstream use of reusable rocket technology. Space manufacturing to meet the specific requirements of activities in space is likely to experience rapid growth in a short time frame, in our view.

Value of global space economy to grow almost three-fold by 2040

We forecast the global space economy can grow to USD 926bn by 2040, an almost three-fold rise from a current value of USD 340bn. This translates to a compound annual growth rate (CAGR) of 4.6%. Assessing the future value of the space economy is fraught with forecast risk, evident in the wide dispersion of third-party estimates. Current forecasts for the value of the space economy in 2040–45 range from USD 600bn to over USD 2trn. Launch execution risks are considerable, as multi-year delays are not uncommon. Most forecasts are contingent upon reusable rockets being commercially operational in the next couple of years and satellite broadband being a success. In this sense, our forecasts are no different. The key growth delta in our forecasts is derived from satellite broadband internet, which we forecast will grow into a USD 300bn market by 2040 from virtually nothing currently. This figure does not factor in internet revenues generated from internet advertising, e-commerce and other traditional internet revenue sources. The ground equipment market, namely satellite observation stations, will need to grow alongside the number of new satellites launched, which will be determined by reusable rocket technology producing lower launch price points. We forecast a 5% CAGR in annual satellite launches over the next 22 years, and forecast this will grow the ground equipment market to USD 331bn by 2040. We conservatively forecast other segments of the space economy, namely "government" and "other," to grow at a low-single-digit annual growth rate with respective forecast values of USD 130bn and USD 68bn by 2040; growth risk forecast is much lower in these segments. We anticipate little further growth to the satellite consumer TV market, which we maintain at USD 98bn. While our forecasts are subject to the same downside risks as others, assuming space technology delivers, we believe the upside risk to our forecasts are considerable. We do not address the value of potential new space businesses mentioned above, including mobile backhaul, end satellite data applications, etc.

Fig. 4: Global space economy value by 2040



Source: Satellite Industry Association, UBS, as of March 2018

Box 5: Space and sustainability

Currently, government spending in space makes up over one quarter of the space economy at just over USD84bn (Satellite Industry association). Most publicly listed aerospace companies are exposed to government and military contracts. This is reflected in the fact that one quarter of the 1500 satellites orbiting the planet have military applications while three quarters of space spending is currently driven by military or related surveillance applications. As a result it is hard to attribute "sustainability" to space investment. Still, based on our thesis that the growth delta of the space economy will be driven by non-military spending over the next two decades we see high potential for space to acquire a sustainability direction. For example the United Nations Office for Outer Space Affairs describes the potential uses for space technology in improving access to communications among underserved populations, and obtaining data to better manage natural resources and improve agricultural yield. Over the longer term the potential to migrate polluting mineral extracting and manufacturing activities off planet could also be viewed as providing 'sustainable' solutions to planetary environmental and resource scarcity issues. Longer term "human colonization" of space may also be viewed as a solution to terrestrial over-population. However, we believe it may still be too early to overstate the "sustainable direction" of our investment case for space.

How to invest in space?

Investors can gain exposure to space via public stocks already engaged in rocket development and launch services, satellite manufacturing, satellite services and communications. Due to considerable consolidation in the satellite launch asset market, leading players often share exposure to the same asset.

The number of investments in space has increased from eight in 2000–2004 to an average of 93 in the last five years, with the reported involvement of at least 16 of the world's richest billionaires. Because space investment is still in its early stages, we foresee rising private investment as costs/entry barriers decline and new public listings of private space ventures increase. Many new private space ventures are likely to become profitable in the coming years, and we would be surprised to not see some of these new start-ups IPO given their capital intensity.

We also expect to see a rise in internet providers and communications companies investing in space, given the huge growth of this market. We think there is an ample spectrum of companies across new sectors that will benefit from space in the coming years, some by raising existing investments and others by investing for the first time.

For investors interested in private companies exposed to space, please refer to Table 1 on page 8. Because private companies offer more focused exposure, we would expect more aggressive growth as well as higher investment risk as the space economy develops.

Table 1: List of major private US space start-ups

Name	Business	Ownership	Bbg ticker	Description	Headquarters	Founded
Blue Origin	Space flight/ launch providers	Private	5043517Z US Equity	Blue Origin manufactures reusable rockets for space tourism, guided missiles and space vehicles.	Kent, WA	2000
Deep Space industries	Asteroid mining	Private	1073069D US Equity	DSI is an American company with global operations, developing spacecraft technologies that are needed for asteroid mining, and is selling satellites that use these technologies. The company expects to make in-space materials, extracted from asteroids, commercially available in 2020s.	Mountain View, CA	2013
DigitalGlobe	Satellite operators	Acquired by Maxar technologies (MAXR CN)	DGI US Equity	High-resolution space imagery and geospatial company. DigitalGlobe has a commercial satellite constellation in orbit that provides high-resolution earth imagery, data and analysis.	Westminster, CO	1992
International launch services	Space flight/ launch providers	Acquired	790790Z US Equity	ILS provides launch services (sales, marketing and management) for global satellite operators. It is based in Virginia, US and is an American-Russian venture with exclusive rights of the commercial Angara and Proton rocket launch services.	Virginia, US	1995
MacDonald Dettwiler & Associates	Satellites Manufacturers	Private	7668687Z CN Equity	MDA is an international space technology company that specializes in global communications, surveillance and intelligence.	Richmond, Canada	1969
OneWeb	Satellite operators		1372330D FP Equity	OneWeb is a global communications company. In partner with OneWeb Satellites, the company is planning to launch 900 satellites into low Earth orbit to deliver internet access globally.	Arlington, VA	2012
Planet Labs	Satellite operators	Private	0862083D US Equity	Planet Labs specializes in Earth imaging. The company designs and manufactures a fleet of satellites that will map the entire Earth.	San Francisco, CA	2010
Planetary Resources	Asteroid mining	Private	1410865D US Equity	The company specializes in the exploration and utilization of resources from asteroids. Recently engaged in an extensive data-gathering series of missions in deep space that will visit multiple near-Earth asteroids.	Redmond, WA	2012
Rocket Lab	Space flight/ launch providers	Private	1051875D US Equity	Rocket Lab is an aerospace manufacturers with a mission to reduce barriers to commercial space by providing high-frequency, low-cost launches.	Huntington Beach, CA	2006
SpaceX	Space flight/ launch providers	Private	1398495D US Equity	SpaceX designs, manufactures and launches advanced rockets and spacecrafts. The company's mission is to enable people to live on other planets and promote space tourism.	Hawthorne, CA	2002
Stratolaunch	Space flight/ launch providers	Private	1066773D US Equity	Provides solution to space transportation. It was founded by Paul Allen to develop Stratolaunch System project, which is an air launch system capable of transporting payloads to low Earth orbit using a large carrier aircraft.	Seattle, WA	2011
Virgin Galactic	Space flight/ launch providers	Private	0612376D US Equity	A spaceship company within Virgin Group, developing commercial spaceflight and aims to provide suborbital spaceflights to space tourists and suborbital launches for space science missions.	Las Cruces, NM	2004
Xcor Aerospace	Space flight/ launch providers	Private	0046974D US Equity	Xcor aerospace specializes in private spaceflight and rocket engine development.	Midland, TX	1999
Bigelow Aerospace	Space accomodation	Private	0562539D US Equity	The company manufactures and develops expandable space station module.	Las Vegas, NV	1999

Source: Company docs, UBS as of November 2018

Appendix

Terms and Abbreviations

Term / Abbreviation	Description / Definition	Term / Abbreviation	Description / Definition
1H, 2H, etc. or 1H11, 2H11, etc.	First half, second half, etc. or first half 2011, second half 2011, etc.	A	actual i.e. 2010A
CAGR	Compound annual growth rate	COM	Common shares
E	expected i.e. 2011E	Shares o/s	Shares outstanding
UP	Underperform: The stock is expected to underperform the sector benchmark	CIO	UBS WM Chief Investment Office
x	multiple / multiplier		

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