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Equity investment reached another record level and with the space economy forecast to grow rapidly, potentially trebling in size to more than $1trn by 2030, there are a vast array of potential investment opportunities. Not all of these are likely to be winners, but with satellite deployments increasing sharply and space-based data demand rising inexorably, those that do could deliver an exciting ride.

New space economy driving growth

Over the last 25 years the 'New Space' economy has been planning a revolution in space. The plans are now being enacted with commercial operators launching crewed spaceflights and an increasing number of satellites primarily into Low Earth Orbit (LEO). A data hungry world is seeking space services to address issues such as connectivity, communications, security, climate change, resource management and disaster response. The traditional backbone of data provision has been the Geostationary Equatorial Orbit (GEO) satellite networks with high cost and persistent high capacity. Their position is now being challenged as the growth in data and connectivity demand has driven the New Space segment to develop cheaper access for customers. The launch segment has reduced cost per kg to less than $1,000, while the capital cost of LEO small satellite networks has fallen with increasing payload capabilities as technology develops for sensors, controls and power. With only around 4,000 satellites in operation today – and potentially 100,000 to be launched over the next decade – growth should accelerate.

Sorting the space debris from the stars

The opportunity is clear, and while the incumbent operators are challenged, they are also involved in the new developments. However, the number and variety of New Space business models is substantial covering all aspect of space missions, from design, development and manufacture of spacecraft (including satellites) and their subsystems, through launch, deployment, operation and data sales. The dozen space-related SPAC (special purpose acquisition companies) listings since Virgin Galactic in October 2019 reflect the variety of ambitions and technologies. In reality, there are potentially several thousand other companies seeking a flightpath to commercial success. Not all will win and at this stage clear winners are hard to identify as the recent performances of the SPAC listings suggest. Those that do should provide an exciting ride, but investors should pick their space vehicle with care.

Geopolitical tensions could disrupt growth

The recent increase in geopolitical tensions has the potential to impact these growth plans. In recent decades space has been a relatively collaborative environment, especially on the commercial side. With at least one major nation involved in conflicts likely to face sanctions for some time, the benign operating environment could become more hostile. Some launches appear to have been disrupted already and greater operational obstacles could appear.

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Companies mentioned in this report

AAC Clyde Space*
Mynaric*
Seraphim Space Investment Trust*
Creotech Instruments
Exos Aerospace

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Space: Enabling the next Industrial Revolution

Introduction

The global space industry has revenues approaching $400bn, of which almost three quarters relate to the satellite industry, with the balance split between projects funded by government space budgets and commercial human spaceflight. Innovative new technologies and increases in demand for connectivity along with the acquisition and transmission of space data are driving a surge in space activity.

Historically the market has been dominated by large satellites weighing several tonnes and costing hundreds of millions of dollars placed in GEO orbit, providing operators with long-term security of operational rights and significant barriers to entry. However, the last 20 years has seen the emergence of a large number of space-related start-ups seeking to lower the cost of access to space. The recent headline makers have been the first commercial manned space flights. However, an acceleration of small satellite constellation deployments in LEO (up to 2,000km), which have been in the planning stage, is underway, with over 1,000 launches in each of the last two years compared to below 250 per year on average in the previous decade. As a result, there are around 4,230 satellites in operation today and potentially another 100,000 could be launched over the next decade, dominated by the megaconstellations of SpaceX and OneWeb, with a significant and growing number of smaller networks also planned. As functionality increases so will the number of applications and data service revenues. New technologies continue to be developed to increase the control and capabilities of payloads to reduce the cost and timeliness of high quality data. In addition, many satellites can now be deployed on a single launch mission and consequently, the costs have dropped massively. New participants continue to emerge and many projects are still in the early phase, for example Amazon's Kuiper Project.

As part of its National Space Strategy released in September 2021 the UK's department for Business, Energy & Industrial Strategy (BEIS) constructed a Space Sector Market Model developed by Bain & Company in April 2021. The model suggests that the global space economy could grow from £270bn ($346bn) in 2019 to £470bn ($603bn) by 2030, a CAGR of 5.5%. Other estimates suggest the space economy could more than treble to over $1tn by 2030. The opportunity is therefore substantial and picking winners could be an exciting ride as new technologies and applications drive further commercialisation and industrialisation of space.

There has been a progressive increase in the amount of equity investment in space infrastructure companies, reaching a record of just under $15bn in 2021. To date, 13 companies have been listed on the NYSE and Nasdaq markets using SPAC partners since Virgin Galactic in October 2019. D-Orbit is expected to increase the total to 14 during the summer. Alongside incumbent space operators, major aerospace and defence groups with space interests and a number of listed New Space companies, the choice of investment is increasing.

However, with such an array of opportunities to invest in, the challenge is to identify the opportunities to participate profitably. An alternative is to look at specialist investment funds that qualify and select potential investments. Included are some space-related exchange traded funds (ETFs), although some of the investment decisions appear to dilute the direct space exposure. An interesting new addition is Seraphim Space Investment Trust, which listed in London in September 2021 and has so far invested £170m in 23 opportunities, after considering a huge number and variety of New Space companies.

Why Space is relevant

Even before the current increase in geopolitical tensions, which appears likely to diminish future international collaboration, the world faced a number of challenges such as resource planning, energy management, optimising agriculture, climate change, weather forecasting and disaster response. Governmental attitudes permitting, space appears likely to play an increasingly important part in addressing these and helping to secure the future of our planet. As the fundamental driver of a data hungry world increases, enhancing global connectivity and communication should drive operational efficiency, and increasingly advanced earth observation sensors are allowing data acquisition and analysis to identify and manage major issues.

The next phase seems likely to be exporting processes to be performed in space, creating microgravity factories, research laboratories, solar power generation systems and other innovative processes.

In our view the most interesting aspects for investors at present tend to exclude the human spaceflight area as well as beyond earth exploration, although these are clearly areas of interest for some of the large corporations such as SpaceX and Virgin Galactic. Timelines for these developments are extended and sustainable business models have yet to be validated. As a result, we focus on the satellite industry and its development, which accounts for the bulk of the revenue opportunity.

We will often need to generalise when describing the space industry in an effort to keep it simple, but please bear in mind, that as someone once said, it is more complicated than that.

Background

The Space Age is now 65 years old with Sputnik launched by the Russians in 1957 and the first US satellite, Explorer 1, launched the following year. NASA was created in 1958 by President Eisenhower, who also launched military space programmes that year. Manned flight by NASA began in 1961 and concluded with the final Space Shuttle Atlantis mission in July 2011.

Since these early government sponsored programmes commenced the commercialisation of space was significant but highly regulated. The primary applications were for broadcasting, communications, navigation and earth observation using tightly regulated GEO satellites. The number of satellite slots in the very high altitude orbit is limited to control interference and protect operational frequency rights. Since the end of the Cold War the development of space has been undertaken in a largely collaborative environment, epitomised by the International Space Station, which has been operating since its launch in 1998.

GEO satellites have historically been large, expensive to build (costing several hundred million dollars), with long lead times and historically high launch costs (further tens of million dollars). The number of satellites launched on a single flight was generally limited to one or two and the operational life on orbit was around 15–20 years. The opportunity to adopt new technologies was thus limited as replacements with upgrades were not required for that extended period.

The emergence of New Space

Defining New Space is not clear cut as the sector has emerged over the last 25 plus years. We would regard New Space as a shorthand for the emergence of entrepreneurial, commercial companies seeking to disrupt the historic norm across the technologies and missions traditionally undertaken by commercial Fixed Satellite Services (FSS) and Mobile Satellite Services (MSS) operators using GEO or medium earth orbit (MEO) networks. Seeking lower cost of space access for clients – be it for space tourism, earth observation, or communication – drove technology innovation and investment deployed across all aspects of space missions from development through design, manufacture, launch, operation and data acquisition and transfer.

While commercialisation of space away from government and institutional operations began earlier, the emergence of these new companies began to gather pace in the late 1990s. Despite a long learning curve, the sector is now coming of age, with commercial manned flights, the development of LEO small satellite markets and the pace of deployment of constellations accelerating.

According to the Satellite Industry Association in the United States, the overall space market had revenues of $371bn in 2020, of which governmental budgets and human spaceflight account for just over 25% with the balance relating to the commercial satellite industry. We note that governments and national space agencies provide important funding resources for research and development projects and thus the companies involved, including smaller start-ups, often emerging from academia. While the pandemic has seen growth levelling off in part due to supply chain delays, we expect it to resume in 2022. The closing off of international collaboration due to heightened geopolitical tensions could impact on some opportunities. However, the global megatrends of sustainability, climate change, communication, connectivity, mobility and asset tracking drive increasing demand for the timely acquisition and transmission of space data, facilitated by the increasing capability of payloads and falling costs of participation.

The satellite market can be broadly split into segments depending on activity. In sequence these are:

- satellite manufacturing
- launch
- satellite services
- ground equipment

Space missions are conceived and planned, then satellites, vehicles and payloads are designed and manufactured supported by a supply chain of subsystems and components technology companies, which provide the specialist equipment such as controls, sensors and power. Payload sensors can be used for image capture, communication and connectivity while controls can include navigation tools, attitude sensors and on board computers. Power includes batteries and solar arrays as well as propulsion.

When built the satellites are deployed normally by an independent launch provider (although SpaceX launches its own satellites and transport vehicles). Once in orbit, assuming successful deployment and commissioning, the satellites start to acquire and transmit data as designed to ground stations and other receivers down to consumer level depending on the application (communication, connectivity, GPS, asset tracking, earth observation, broadcast, defence etc). When a satellite reaches the end of its operational life it is usually deorbited and replaced.

It is useful to note the three main orbits involved (all heights from the earth's surface):

- Geosynchronous Orbit (GSO) (>35.780km). Satellites match the speed of the rotation of the Earth. It includes GEO satellites that sit in a fixed location above the equator travelling at around 11,100km an hour where the large incumbent FSS companies operate in a highly regulated and slot constrained orbit.
- MEO (2,000–35,780km) includes GPS satellites at 20,200km in a semi-synchronous orbit completing two orbits a day over the same locations.
- LEO (180km up to 2000km), the main area for application of the New Space companies' satellites and technologies and includes asynchronous orbits, which are useful for observing change over time.

We would split today's space operators into three broad categories: incumbents, and in New Space, large well capitalised corporations and smaller start-ups. All tend to be at varying stages of development, but it should be noted that the disruptive impact of New Space is being embraced by incumbent operators as well as the new entrants to see how it can improve their operations and economics.

Traditionally the incumbents tended to operate in one segment of the space market. The newer entrants are often more vertically integrated covering several segments, with SpaceX operating in almost all areas of the commercial market.

In addition, an increasing number of nations are seeing the advantages of securing their own space operations that can supply data across all aspects of space applications including national security, weather forecasting, resource planning and communication. Most importantly, the cost of access is no longer prohibitive and commercial space start-ups are appearing around the world, often the evolution of academic or institutional programmes.

What are the drivers for the space economy?

The primary driver of commercial space-based activity remains the increasing amount of global data being acquired and transferred for connectivity, communication and broadcast purposes. The ability to use space-based resources to improve connectivity continues to drive technology development across the board with high throughput satellite technologies helping to provide the infrastructure for FSS and MSS operators. The services provide an alternative to ground-based infrastructure where build out costs are not economically viable, for example mobile phone connectivity in large areas of Africa where around 30% of the rural population still lack broadband coverage.

The International Telecommunication Union, which regulates space spectrum allocations, estimates that in 2021 an estimated 4.9 billion people were connected to the internet, up 17% on 2020 and representing around 63% of the world population. Of the c 2.9 billion people yet to connect most live in the developing world, which provides an opportunity for space-based solutions if the economics are correct. Broadband usage has increased from 152 terrabits per second (Tbit/s) in 2015 to 932Tbit/s in 2021, up 30% on 2020 as the number of connected devices continues to rise.

In addition to the inexorable growth in data demand, there have been two other key drivers of the New Space market.

Microtechnology development driving capabilities

The continuing pace of innovation of microelectronics has allowed the development of increasingly capable smaller payloads comprising data sensors and communications systems along with supporting control, navigation, power and propulsion units. Rapid technology developments in key areas such as solar arrays, batteries, optical satellite links, propulsion, communications technologies, antenna and sensors continues. As a result, the deployment of satellites and constellations for an increasing number of applications is accelerating. The bulk of anticipated launches in the small satellite market over the coming decade will be for communication and connectivity purposes, including the megaconstellations of SpaceX's Starlink and OneWeb (see our commentary), which will account for the vast majority of satellites to be deployed over the next decade.

When considered with the shorter operational lifetimes in LEO of around five to six years there is a clear opportunity to deploy enhanced capabilities more rapidly as constellations are progressively and continuously replenished. LEO models thus build further recurring revenue elements in them in addition to data sales. GEO satellites will not be replaced for generally around 15 years, which can allow step changes in capabilities but not necessarily as timely due to the long development, build and deployment lead times.

The result has been the boom in the small satellite (<500kg) segment designed for operation in LEO constellations. Whereas GEO satellites can provide global continuous coverage with just three spacecraft, LEO operations require at least 40–70 to provide global coverage and a lot more to provide constant connectivity and high-quality real-time data.

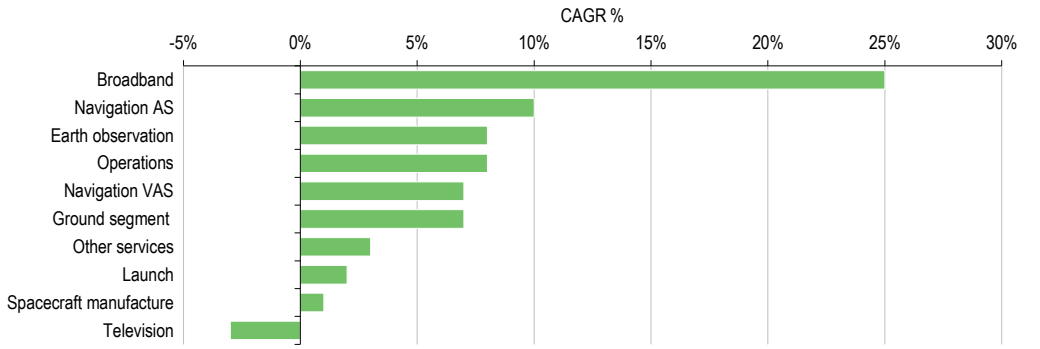
Launch costs declined as options increased

In addition, there has been a significant addition to the heavy lift capabilities of Arianespace and ULA, as well as other nations. In its launch provider database, SpaceFund Venture Capital identifies over 100 launch providers with a wide range of lift capabilities at various stages of development and funding. Of these, well over a dozen offerings, including several reusable vehicles, are operational. The increase in the number of launch options, together with innovative methods of small satellite deployment systems, have driven a substantial reduction in cost per kg to approaching $1,000, allowing network satellites to be deployed at highly competitive overall costs. For satellite operators R&D, manufacturing and launch costs define the returns that can be made from the operational phase revenues once deployed.

The scale of the opportunity

According to the BEIS Space Market Model used in developing the UK National Space Plan released in September 2021 the segmental growth rates are as follows as the market grows to $630bn in 2030.

Exhibit 1: Space market CAGR (2019 to 2030)



Source: BEIS Space Market Model. Note: AS=autonomous services. VAS=value added services.

While the BEIS model could prove conservative as other forecasters suggest the market could more than treble by 2030, we feel it provides useful trend information. As can be seen the broadband, global navigation satellite system (GNSS) and earth observation (EO) segments are expected to show the strongest growth. While the number of satellites to be launched increases substantially the average value per satellite has fallen as the smallsat segment expands. The number of traditional high value GEO satellites is not expected to change dramatically meaning overall market growth for spacecraft manufacture is subdued. The fall in satellite TV revenues appears to be a function of the way television is increasingly consumed via internet connection.

The space-based data services for the EO and GNSS segments account for almost 40% of the current space economy and this is expected to increase to almost 50% by the end of the decade. The segments cover a vast array of data hungry domains including air, sea and land navigation, asset tracking, climate, meteorology, natural resource planning, agricultural optimisation and urban development amongst others. Customers can be commercial, institutional or governmental.

Overall, the proportion of space-based data services versus infrastructure (spacecraft, launch, ground equipment and operations) revenues (69%:31%) in 2019 does not vary substantially in the model by 2030 (67%:33%), although we suspect the data demand will exceed expectations. For example, in the recent release by the European Union Agency for the Space Programme (EUSPA) of its GNSS and EO market report suggests that data services revenues for those segments could be around $100bn higher by 2030 than the UK model which referenced an earlier EUSPA GNSS report. The same applies to the supporting ground-based connectivity infrastructure.

We expect the bulk of the growth to come from LEO operations although technology and capacity upgrades in GEO should also add to services revenues. It should be noted that in absolute dollar terms a low percentage growth rate in GEO revenues is equivalent to substantial growth in New Space revenues.

Turning future dreams into reality

The recent increase in geopolitical tensions has the potential to impact these growth plans. In recent decades space has been a relatively collaborative environment especially on the commercial side. With at least one major nation involved in conflicts likely to face sanctions for some time, the benign operating environment could become more hostile. Already, some launches appear to have been disrupted and greater operational obstacles could appear.

However, given a favourable international environment and as discussed, space appears likely to play an increasingly important part in securing the future of our planet. As well as the fundamental driver of increasing connectivity for the globe, which should drive operational efficiency as asset utilisation and communication improves, increasingly advanced earth observation sensors are allowing data acquisition and analysis to identify and manage issues such as resource planning, energy management, agriculture, climate change, weather forecasting and disaster response.

The next phase seems likely to be exporting processes to be performed in space, creating microgravity factories, solar power generation facilities and other innovative processes.

Companies such as Cardiff based start-up Space Forge are seeking to create a model for the manufacture of revolutionary products and materials utilising the unique conditions offered in space. Others such as D-Orbit and Astroscale are offering in orbit services, including end-of-life management services, which should help to manage issues such as space debris.

Of course, the natural curiosity of beyond-earth human exploration could be supported by staging facilities constructed in space with the prospect of a return to the Moon and potentially to Mars back in people's visions.

Space investment growing, as opportunities increase

What has been apparent over the last decade has been an increasing amount of investment in space markets, and the popularity of listing via SPACs underlines that. A SPAC is a listed vehicle that raises funds to invest in acquisition opportunities, normally via a merger that provides an identified partner with funding and a listing.

Exhibit 2: Recent space-related SPAC deals

Company	Ticker	SPAC partner	Listed	Share price ($)	Mkt cap ($bn)	Segment
Virgin Galactic	(NYS: SPCE)	Social Capital Hedosophia	25-Oct-19	8.72	2.25	Launch & Transportation
AST SpaceMobile	(NAS: ASTS)	New Providence Acquisition Corp.	06-Apr-21	9.92	1.80	Space infrastructure
Astra	(NAS: ASTR)	Holicity, Inc.	30-Jun-21	3.67	0.97	Launch & Transportation
Momentus	(NAS: MNTS)	Stable Road Acquisition Corp.	12-Aug-21	3.94	0.32	Launch & Transportation
Spire	(NYS: SPIR)	NavSight Holdings, Inc.	16-Aug-21	1.89	0.88	Space infrastructure
Rocket Lab	(NAS: RKLB)	Vector Acquisition Corporation	25-Aug-21	7.83	1.19	Launch & Transportation
Redwire	(NYS: RDW)	Genesis Park Acquisition Corp.	02-Sep-21	6.16	0.39	Space infrastructure
Arqit	(NAS: ARQQ)	Centricus Acquisition Corp.	03-Sep-21	13.08	1.57	Information Technology
BlackSky	(NYS: BKSY)	Osprey Technology Acquisition Corp.	09-Sep-21	1.89	0.23	Space infrastructure
Planet Labs	(NYS: PL)	dMY Technology Group, Inc. IV	07-Dec-21	5.03	1.32	Space infrastructure
Virgin Orbit	(NAS: VORB)	NextGen Acquisition Corp. II	28-Dec-21	6.43	2.15	Launch & Transportation
Satellogic	(NAS: SATL)	CF Acquisition Corp. V	26-Jan-22	8.58	0.78	Space infrastructure
Terran Orbital	(NYS: LLAP)	Tailwind Two Acquisition Corp.	28-Mar-22	5.15	0.22	Space infrastructure
D-Orbit	(NAS: DOBT)	Breeze Holdings Acquisition Corp	Exp.Q2/Q3 22			Launch & Transportation

Source: Refinitiv, Edison Investment research. Note: Priced at 20 April 2022.

Since Virgin Galactic came to the market in October 2019 a further 12 space-related SPACs have listed on the NYSE and Nasdaq markets, with D-Orbit scheduled to enact its merger and listing in Q222 or Q322. The attraction of a SPAC listing for the space companies has been the ability to raise sufficient capital to fund both current capex requirements and those for the immediate future as satellite networks and other products are developed, built and deployed ahead of data revenues. In addition, a listing affords the ability to raise further capital via secondary offerings.

Share price performances to date have been generally underwhelming but the listed SPACs have a combined market capitalisation of $14.1bn.

We note that prior to Virgin Galactic, SPAC processes had been used elsewhere in the world. Avio SPA, the Italian rocket propulsion company, was listed on the Borsa Italiana in Milan using a SPAC in 2017. It joined a number of quoted space infrastructure companies.

There are a number of other quoted space tech companies around the globe, a selection of which we note below.

Exhibit 3: Selected listed space companies

Company	Ticker	Market	Description	CCY	Share price	Mkt cap	Mkt cap
					Local CCY	Local CCY	US$m
AAC Clyde Space	AAC	Nasdaq FirstNorth Stockholm	Smallsat and system manufacturer and data services	SEK	2.17	419	44
Avio Spa	AVIO	EuroNext STAR Milan	Launch – propulsion	EUR	11.24	302	279
Creotech	CRI	Warsaw New Connect	Smallsat and system manufacturer and data services	PLN	158	243	56
Gomspace	GOMX	Nasdaq FirstNorth Stockholm	Smallsat and system manufacturer and data services	SEK	11.42	716	75
Mynaric		Xetra, Nasdaq	Optical inter-satellite communications links	EUR	10.22	214	214
OHB SE	OHB	Xetra	Satellite manufacture and data services	EUR	34.3	588	542

Source: Company reports, Edison Investment Research. Note: Priced at 20 April 2022.

Of course, investing in space funds is a clear alternative to direct investment, and should help to manage risk. However, publicly available funds appear to be limited with the likes of London listed Seraphim Space Investment Trust (LSE: SSIT) apparently unique.

There are a number of space-related ETFs such as SPDR S&P Kensho Final Frontiers ETF (NYSE: ROKT), Procure Space ETF (Nasdaq: UFO), and ARK Space Exploration and Innovation ETF (Cboe BZX: ARKX). However, it is important to qualify the underlying investment entities, which in some cases are not necessarily as space related as may be desired.

Many of the large global aerospace and defence companies also have interests in various space segments but generally these account for a relatively small proportion of their revenues. Airbus, Boeing, L3Harris, Leonardo, Lockheed Martin, Northrop Grumman, Raytheon, Safran, Thales and many others all have some exposure.

In addition, there are a number of quoted incumbent satellite services providers such as Eutelsat, Inmarsat, Intelsat, Iridium Communications, SES and Viasat.

Many companies remain private and in various stages of development such as ABL Space Systems, Astroscale, Exos Aerospace, York Space Systems as well as OneWeb and SpaceX. These include a large number of start-ups around the globe as more nations seek to deploy their own scientific and technological expertise to create a national space presence. Ultimately these could go public, but of course there is also a possibility that the larger aerospace and defence corporations could buy them if the business model provides a compelling financial case. Raytheon's acquisition of Blue Canyon Technologies, a provider of turnkey small satellite solutions, for a reported c $350m in December 2020 is an example of such a move.

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