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The £1tn frontier

How can we profit from the new age of space exploration?

Eoin Treacy, Investment Director



Dear reader,

"It's human nature to stretch, to go, to see, to understand. Exploration

is not a choice, really; it's an imperative."

– Michael Collins, Gemini and Apollo astronaut

It's time to think bigger.

A permanent colony on the Moon... and then Mars.

Extra-terrestrial energy production.

Mining exponential resources, off-world.

A new space age has just

begun... an era of interplanetary commerce that will generate new technologies and vast new fortunes. In this month's issue, we look beyond the turmoil of *terra firma* and focus on the huge opportunities being forged at the "final frontier".

On Saturday, SpaceX, a private company, delivered astronauts to the International Space Station. Morgan Stanley estimates the space sector will be worth \$1 trillion in revenue within 20 years.

We are truly on the cusp of a new investment sector that is going to revolutionise the global economy and create an interplanetary economy at the same time.

What I am particularly enthused by is the opportunity for profits

this provides and also the fact it is a perfect example of how private enterprise beats governments every time.

In 1961, John F Kennedy took up the baton and announced that within a decade the US would have people on the moon. It cost about \$700 billion in today's money to do it. That massive cost hobbled the space programme because it was difficult to justify the cost of space exploration.

In 2011 the US flew its last astronaut to space and retired the space shuttle programme. It's been an embarrassing nine years where the world's only true superpower has been hitching rides with Russia's space programme to the International Space Station.



I am reminded of the success Craig Venter had in sequencing the human genome in 2003. The government-sponsored programme was split up between about 20 international universities and was expected to take 15 years to complete, at a cost of \$3 billion. At the time it was one of the most ambitious and expensive projects in history.

Because it was a government-funded venture, it was also subject to crippling bureaucracy. There was no urgency to achieving the goal because none of the participants had an incentive to go quickly. In fact, it was quite the opposite, they were

and their militaries. That is going to eventually unlock a massive new source of profits for equity investors. None of this would be possible were it not for the ingenuity of private investment.

Elon's Exponential Enterprise

Elon Musk has done the same thing with launch costs. He rightfully pointed out that making single-use rockets was an extraordinary waste of money. To solve the problem, he pioneered reusable rockets. That has massively reduced the cost of lifting payloads into space.

only \$20,000 per person. Looking at that kind of cost compression from \$214 million to \$20,000, you can see how the parallels with the cost of genetic sequencing are comparable.

This is exponential cost compression and it is the kind of innovation that will put space travel within reach for millions of people.

The US space sector has been dominated by government agencies and private contractors with no incentive to come in below budget. It's been that way for decades and that lack of imagination succeeded in almost extinguishing the sector.

I believe privately run space travel is a similar positive catalyst for the evolving space sector. The catalyst for cascading innovation and opportunity.

Sequencing the genome was a massive catalyst for the biotech sector and it is the reason we are going to have a vaccine for coronavirus inside of a year. Previously, it would have taken more than three years under an optimistic scenario.

incentivised to go slowly because of the abundant funding.

Venter came along and believed he could get the job done faster and cheaper. He formed a company and delivered the human genome three years ahead of the government-backed human genome project and only spent a fraction of the money doing it.

It's a perfect example of how private enterprise, with a profit motivation, will beat lumbering government bureaucrats, without fail.

We are on the cusp of commercialising a segment of the global economy which was only ever the preserve of governments

Each space shuttle mission has been estimated to cost \$214 million. To hire Russia to send personnel to the Space Station cost about \$81 million per seat, which is up significantly from the \$25 million they used to charge back in 2006.

Each SpaceX launch costs about \$55 million per passenger. However, that's for the first flight. SpaceX is an incredibly innovative company which is not afraid to blow up prototypes in its rush to get new products to market.

Elon Musk was quoted last year saying he expects seats on the 100-seat Starship vehicle to cost about \$2 million per flight. That's

I believe privately run space travel is a similar positive catalyst for the evolving space sector. The catalyst for cascading innovation and opportunity. Now that it has been proven possible for a company to deliver astronauts to space, we are likely to see an explosion of new activity which will open up a whole new tourism sector for the well-heeled.

It will open up mining operations on the moon and asteroids. It will allow for settlements to be created on the moon and Mars. In just the same way that ocean liners were once the epitome of luxury travel and now represent



vacation options for millions of people, space travel will probably evolve in a similar fashion.

Let's break down the opportunities into three broad sectors. The first is tourism and colonisation, mining and military applications.

Off-world resource boom

SpaceX's proposed Starliner and Virgin Galactic's prototype all point towards affording consumers the opportunities to reach low earth orbit for a brief time. That is something that will appeal to a lot of people and it will be the primary vector for raising capital to spur further innovation in rocket engines, and much bigger vehicles with higher payloads.

Within the next 20 years we are likely to see a permanent colony on the moon and Mars. Think about it this way. A country like Russia has a small population relative to its size, it is rich in resources but there are vast swathes of the country that are inhospitable for significant portions of the year. Australia also has a vast area but major habitation zones are limited to relatively small areas on the coasts.

Mars or the moon will greatly exaggerate that kind of isolation but with massive resource availability, the emergence of interplanetary commerce is inevitable.

The reason I am so enthusiastic about this opportunity is because

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of J. Paul Getty. This one-time richest man in the world built his fortune following the successful negotiation of oil leases in Saudi Arabia and Kuwait in 1949. He deployed newly designed supertankers to transport the oil to overseas markets.

Prior to that moment, everyone knew Saudi Arabia and Kuwait had oil, but no one had been able to successfully transport it over long distances. Much cheaper and larger space tankers ensure whatever resources are found can easily be returned to Earth.

To date, voyages to asteroids have primarily focused on scientific curiosity. For example, the recent Japanese venture to retrieve a core sample from the Hayabusa asteroid was aimed at answering questions about the origins of the universe.

The rocket was launched in December 2014 and arrived at the asteroid in June 2018. It stayed here for 17 months and collected samples from the interior of the asteroid before leaving in late 2019. The return journey is only going to take a year. This is the second Japanese sample return mission from an asteroid and it represents the dawn of off-world mining.

The proposed voyage to 16 Psyche, which astronomers believe is similar to an exposed planetary core, is also aimed at

satisfying scientific curiosity. Although in 16 Psyche's case it might also be aimed at finding out if it does in fact contain vast quantities of gold.

The parallels we see today, with the early days of exploration of the Americas, are very compelling. Voyages to the Americas were initially aimed at finding a quicker route to India, which was the origin of the spice trade.

Spain's demand for gold spurred massive mining operations and created the legend of El Dorado, the city of gold. The return of silver and gold to Europe spurred inflation as more money chased limited goods and services.

It spurred massive innovation, building and was the basis for the excess capital to drive the Industrial Revolution. The evolution of interplanetary economics is likely to have a similar effect.

Of course, we also know that the original colonies have all become individual countries once the population achieves critical mass. Therefore, we can expect the exploration of the moon, Mars and the asteroid belt to follow a similar trajectory.

They will be theatres of war between the great powers of our



day, and will eventually become independent countries in their own right. That will all probably occur in the next 50 years.

The race could easily be about securing supplies of helium-3 to fuel fusion reactors. Russia and China have both already stated they are developing plans to mine the precious resource on the moon. It is extremely rare on Earth, but it is estimated that 1.1 million tonnes of helium-3 have been deposited by solar winds on the moon.

Twenty-five tonnes of the resource would power the entire US for a year and would be

One possibility is deep ocean mining, which is enormously polluting. Another would be planetary or lunar mining operations.

The Human Genome Project was publicly funded but overtaken by private enterprise. Government-sponsored space programmes pioneered space travel, but have now been overtaken by private enterprise. There is one other massive publicly funded project which is now receiving a lot of competition from the private sector. It's fusion energy.

The International Thermonuclear Experimental Reactor (ITER) is

This is another great example of how the only way to get academics to work for a living is to take away their funding. That's just what happened to the particle physics team at MIT. It had been working on fusion for decades with no progress. Then it lost its funding. Shortly afterwards, the team left MIT, founded a company and estimates it can build a miniature fusion reactor.

That company, Commonwealth Fusion Systems, announced it has sourced \$84 million in funding on Wednesday. That brings its fund raising to \$200 million since 2018. I don't know if it will be the company to eventually deliver cheap abundant clean energy, but I am pretty sure the private sector will get it done before governments do.

Therefore, we can expect major developments in fusion within the decade. I remain regretful that our investment in this sector did not pan out, but my enthusiasm for fusion remains just as high as it was when I first brought this question to your attention.

UK leading the way

What I want to concentrate on now is the confluence of technologies that are driving the pace of innovation in the space sector. Reusable rockets have greatly reduced lift costs. The innovations being announced weekly in fusion will eventually climax in a massive new source of energy, that will create a demand factor for interplanetary commerce.

However, there is one more

... my enthusiasm for fusion remains just as high as it was when I first brought this question to your attention.

worth about \$75 billion. Mining the resource on the face of the moon is not likely to be easy and fusion reactors do not yet exist today, but if we play the trend of exponential growth forward, these are likely to be major future industrial trends.

Additionally, one of the most technologically advanced sectors in the world today is deep sea oil drilling. These operations are performed under incredible pressure, at massive depths, and are heavily mechanised.

The problem for the sector today is that deep sea drilling is uneconomic with oil prices so low. They are looking for additional outlets for their talents.

being built in France. It's one of the biggest science experiments in history and is costing tens of billions. It's not expected to generate power until 2035 but when it does, it will provide a tenfold gain over the energy used to generate the reaction.

In the time since the project was conceived, there have been massive advances in bringing together superconducting technology. Huge magnets are required to contain super-hot plasma, so the ITER project is taking so long to build because of the size of the structure required to house the apparatus. With modern superconductors the experiment could fit on the back of a truck.



additional piece of the puzzle that will greatly assist the evolution of space travel. That is advanced rocket technology. The good news is that this is a sector the UK is well placed to lead in.

Reaction Engines is a UK company which has been developing a Synergetic Air Breathing Rocket Engine (SABRE) for the last 30 years. In that time, it has received funding from the UK government, the US Defense Advanced Research Projects Agency (DARPA), BAE Systems, Boeing and Rolls-Royce.

The company provided plans to an EU-funded study in 2008 for a vehicle with cruise speeds of Mach 5. That offered a first opportunity to demonstrate the company's bleeding-edge heat exchanger design.

In 2012, the company manufactured its first fully operation precooler and through exhaustive testing demonstrated its frost control systems beyond doubt. With that success, the UK government committed an additional £60 million through the UK Space Agency and European Space Agency.

2015 represented the transition from a research and development company to active efforts to commercialise its invention of an air-breathing engine capable of Mach 5 speeds to altitudes of 25 kilometres. Speeds of Mach 25 are envisioned for space flight.

In 2019, Reaction Engines in conjunction with DARPA conducted a ground-based high temperature airflow testing of its

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precooler. The modular nature of the company's design means each of the individual components can be individually tested before they are eventually assembled. That greatly reduces the cost of testing because flight tests can be avoided until the end of the process. Here is what Reactions Engines' chief executive, Mark Thomas, had to say following the successful test:

"This is a major moment in the development of a breakthrough aerospace technology which has seen Reaction Engines' precooler tested at Mach 5 airflow temperature conditions, smashing through previous achievements at Mach 3.3 temperatures and paving the way for hypersonic flight. In addition to its use in our SABRE class of air breathing rocket engines, there are numerous exciting commercial applications for our precooler technology, which delivers world-leading heat transfer capabilities at low weight and compact size, and we are seeing significant interest from a range of potential customers and technology partners."

2020 will see the first full system testing with the ambition to deliver a product to market in the coming years.

The SABRE system design has a number of advantages. The first is it is an air-breathing design,

which means it does not need to carry additional fuel because it uses the heat generated from the incoming air to drive the engine.

The precooler rapidly cools the incoming air, which has been heated through aerodynamic heating, from 1,000 degrees Celsius to ambient temperatures. That allows the engine to operate at much higher speeds than existing engines.

During air-breathing flight, heat absorbed by the precooler is recycled to power the engine. Additionally, a ramjet system improves overall efficiency by using surplus air to generate extra thrust. When it goes to rocket mode at altitudes above 25 kilometres, it uses liquid oxygen to fuel its additional ascent.

The next question is how do we invest in the sector?

This month's *Frontier Tech Investor* recommendation

Reaction Engines is a private company and it is likely to stay that way for the foreseeable future. Therefore, the only way to invest in the SABRE engine is through a tangential play.

This is a particularly interesting time to look at the aeronautics sector because it has been beaten down during the coronavirus



lockdown sell-off. With the number of people taking flights down by at least 90%, and airlines seeking multi-billion-pound bailouts from their respective governments, there is little demand for new aircraft. That has resulted in significant declines in the prices of major aeronautics suppliers.

The main piece of information that came out last week about coronavirus is that the mortality rate has been downgraded from 3-4% to 0.4% by the US Centres for Disease Control. That amounts to a 90% downgrade in the potential mortality from the disease and brings it a lot closer to the “bad

unrest across the US and in other isolated areas, suggests the public pressure to ease lockdowns will increase further. That will lend ever more urgency to the drive to create a vaccine.

It's hard to imagine today but I am strongly of the opinion Covid-19 is this generation's Y2K. A year from now, we will be wondering what we were so worried about. At the very minimum, it is likely a vaccine will be approved by November or December so that everyone will be thinking of travelling again in 2021.

Therefore, I believe the aeronautics sector now presents

million to implement over two years but will save £1.3 billion in expenditure. Its bonds are all now trading below par, which is a reflection of higher borrowing costs the downgrade represents.

The defence sector has so far been immune to the ravages of coronavirus and there is no need for downsizing in that division. That means most of the headcount reduction will take place in the commercial aviation sector.

Rolls-Royce has customers in more than 150 countries, comprising more than 400 airlines and leasing customers, 160 armed forces, 70 navies, and more than 5,000 power and nuclear customers. It is worth reminding ourselves that none of Rolls-Royce's agreements with airlines contain credit-triggers of covenants that require early repayment. In other words, it does not have immediate calls on capital in the form of debt repayments.

One of the reasons for the negative credit outlook is about half of the company's business is based on service contracts which are dependent on the number of hours an engine is flies. With global passenger traffic down 50% this year but 90% fewer flying hours in May, there is potential for significantly lower earnings. Since the company has a clear focus on supplying engines to the long-haul travel segment, it is significantly exposed to the downturn in the global travel segment.

However, despite the challenge

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flu” range of possibilities.

It's still not something anyone wants to get. Covid-19 can lead to significant long-term lung damage and a lengthy period of convalescence. However, it does not represent the kind of threat many envisioned when lockdown orders were put in place.

The plans we are looking at today for reopening were formulated during the lockdowns and probably do not take this new reality into account. That suggests while we are likely to be wearing masks for a while longer, the absolute need for total lockdowns is ebbing quickly.

Meanwhile, the outbreak of civil

value. My esteemed colleague, Sam Volkering, has introduced a new buy-up-to level on Meggitt last week, and **this month I am also recommending you buy Rolls-Royce.**

The case for Rolls-Royce

It has been a dismal run of events for Rolls-Royce over the last few months with the shares of major customers like Boeing and Airbus cratering. The company's debt was also downgraded last week to junk status by S&P in a reflection of the wider difficulty being experienced by the aviation industry.

It announced 9,000 jobs will be cut in May. That will cost £800



being experienced by air travel, Rolls-Royce has other business units. The company's strategic vision is focused on green power, which is a euphemism for efficiency gains, electrification and digitalisation.

In 2019, outside of the commercial aviation space, Rolls-Royce announced a new Pearl 700 engine for the Gulfstream corporate aviation sector. It also received a ten-year service agreement with Svitzer for marine engines and a new agreement to supply MTU engines to Sunseeker luxury yachts.

In defence, it completed early engine test for new engines for the B-52 bomber. The contract awarded by the UK's Ministry of Defence to develop hypersonic propulsion is in conjunction with the technology Reaction Engines is designing. The primary crossover between Reaction Engines and Rolls-Royce is in the development of the Skylon hypersonic space vehicle, which has already received £10 million in support from the UK government.

Then in the US, the Bell Boeing V-22 Osprey and RR300 engines on the Robinson R66 helicopter exceeded one million hours. The development of Boeing's MQ-25 stingray autonomous refueling drone will use a Rolls-Royce engine.

The company's efforts to drive electrification have been focused in providing rolling stocks to the railroad sector. It secured deals in 2019 with Irish Rail and Porterbrook, which is the UK's

I am confident Rolls-Royce will come through this crisis in a healthier position and not least because the management team will need to be innovative to prosper.

largest leasing firm for trains and carriages.

It also successfully completed ground tests for hybrid gas systems, which have been sold to the German State of Brandenburg. Rolls-Royce has also had a long-term relationship with the UK government to develop hybrid-electric flight demonstrator aircraft.

In the digitalisation sector, the company is developing an electronic monitoring system for engine systems while in action at sea or in the air. The long-term ambition of Rolls-Royce is to develop a balanced portfolio. The acquisition of Siemens' eAircraft business last year is a big part of that ambition.

I believe Rolls-Royce is a value proposition at today's price. The share is down 75% from the 2018 peak and is back testing the 2008 lows. The reason to be more optimistic over a 12- to 60-month timeframe is because of the investments it has already made in new engine technology.

The company owns a significant piece of Reaction Engines. It will be among a small number of companies to have access to UK-designed and built hypersonic engines when they are commercially viable.

The company's current valuation was based on long-haul flights. The company's future is in hypersonic earthbound travel and space flight. It's in the increasing geopolitical tensions arising between the West and China, and in its desire for more efficient engines.

The beginning of the private sector-led growth of the space sector is a major catalyst. Coronavirus is, in my view, presenting us with an opportunity to pick up undervalued stocks while they are still trading at discounts.

The big point is that the defence sector took in £5.3 billion in 2019, which is unlikely to be affected by coronavirus. The revenue from that sector alone accounts for the entire market cap of the company today, which is £5.80 billion.

Nevertheless, I cannot say with confidence that the share is done declining. I am confident it now represents much better value today than it did a year ago. Rolls-Royce had £4.44 billion in cash at the end of 2019. It is probably going to need every penny of that to weather the current crisis.

However, I am confident it will come through this crisis in a healthier position and not least because the management team



will need to be innovative to prosper. These kinds of metrics suggest to me a lot of the bad news has already been priced into the share.

With the uncertainty as a background, I am going to place a

buy-up-to level quite close to the current price. I believe a half-sized position is warranted at this stage, which leaves the option open to buy more in the event of additional weakness.

My buy-up-to level is 350p but if

this is in fact the low, there is a clear argument for raising that level soon after it is penetrated. My 12-month target is 400p and my 3-year target is 800p.

The risks as I have laid out above are that the travel hiatus lasts longer than is currently envisaged, that a number of airlines go bust and/or that demand for new engines remains muted for a lengthy period.

All the best,

Eoin Treacy
Investment Director, *Frontier Tech Investor*

Action to take:

Ticker:

Price as of 02.06.20:

Buy up to:

Market cap:

52-week high/low:

Buy Rolls-Royce Holdings PLC

RR/ LN

304.40 GBp

350p

£5.80 billion

924.31p/235.50p



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