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Own your share of the "Caravel of the Sky"

How to invest in space: the ultimate frontier market

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There's a hidden connection between technology, wealth and geography. Today I'm going to show you what it is and how you can profit from it for the next decade.

Take the discovery of the New World. Despite its small size, Portugal became a great trading nation with a vast network of contacts in Africa, Asia and South America because it was the first country to successfully sail to those destinations.

It was later unable to hold many of its richest possessions in Asia because it lacked the military capabilities of the Dutch, English or Spanish. Nevertheless, Henry the Navigator secured his place in history as the primary sponsor of that exploration for one important reason. He realised that if the Cape of Bojador in Western Sahara was ever to be overcome, Portugal was going to need a new kind of ship.

Henry funded the invention of the caravel, which was the first European ship that could sail into the wind. We might not think of ships as the height of cutting-edge technology today, but back then they most certainly were. Until the 1450s most ships in the Mediterranean used single large square sails, which meant they were not particularly manoeuvrable. Historic images of ranks of oarsmen pulling into the wind represented the brute force way of overcoming a headwind. Portugal probably first witnessed triangular or lanteen sails from the ships of Muslim sailors in Spain and adapted the design to create the caravel.

That breakthrough in technology opened up a world of new wealth and opportunity.

Caravels were not very large, carrying only about 50-200 tonnes, but they had a shallow beam so they could explore up rivers, they were highly manoeuvrable so they could sail just about anywhere and most

important of all they could sail against the wind by employing a zig-zag trajectory.

The primary reason Portuguese sailors had always been so frightened to sail further south than Cape Bojador was because the winds blow hard from the north-east in that area and pushed them out to sea. With their original boat designs they had to sail close to shore, but with the caravel they could finally take the risk of allowing the wind to take them offshore and out of sight of land.

It turns out that once you get offshore from Cape Bojador, the north-easterlies abate and more favourable winds appear which allow ships to continue further south. In fact, it was the willingness to be taken by the wind from Cape Bajador that allowed the Portuguese to discover the Azores, Madeira and even Brazil. They would never have taken that risk if they had not first figured out how to sail into the wind, so they could come back if it didn't work out.

Why the history lesson?

Because we're seeing the same thing happen again today. New transportation technology is opening up new worlds. It's smashing the barriers of geography. And it's presenting an enormous opportunity for investors to build wealth, just as the Spanish, Portuguese, English and Dutch had when seafaring technology opened the New World to the West.

Yes, I'm talking about investing in the modern-day New World: space.

The new frontier: off-world investing

The border of space is referred to as the "Karman line".

It stands at an altitude of 100km. In 1961 Yuri Gagarin was the first person to cross it and since then 559 others have done the same in 300+ space missions. That's a total figure for all space agencies in the world.

Only 560 individuals have been in space, ever. Why? That's simple. Cost.

Just to put the cost of space travel in perspective, if we look at what space programmes have cost and divide the total by the number of people who have been in space, it works out at considerably more than $1 billion per person. I think most people would probably prefer the cash if given the choice. Therefore, the Karman line is today's Cape Bojador. It has been a barrier beyond which it has been hard for any of us to conceive ever passing.

The reason I'm writing to you now is because Jeff Bezos' Blue Origin delivered an innovation similar to the caravel in November 2015.

What is this modern-day caravel? It's the reusable rocket.

Think about that for a moment. Medieval sailors had to hug the shore because they could not risk losing sight of it. Shipwrecks were common because they ran into hidden shoals and the risk associated with trade was high. The caravel represented a powerful catalyst for change which led to Europeans traversing the globe in search of trading opportunities.

> "A jumbo jet costs about the same as one of our Falcon 9 rockets but airlines don't throw away a plane after a one-way trip from LA to New York" – Elon Musk

The reusable rocket is a similar innovation because it allows us to think of space on a cost-per-use basis rather than a one-shot and hope-for-the-best venture. It's going to have a profound effect on the global economy and will create whole new markets on asteroids, moons and planets throughout the solar system.

The costs of even getting into space on that basis are mind-blowing.

Until just the last 18 months, government-backed space agencies, depending on taxpayers' largesse, have always had to be very careful about space exploration because each launch meant blowing something up that could never be retrieved.

When mistakes are made it not only costs lives but destroys

confidence in the value to be gained from space exploration. After all, there is always something else that the public would like their money spent on. That has meant timelines have slowed to decades rather than months or years.

But with reusable rockets the economics of space travel has become not only attractive but we are also already approaching commercial viability. The Karman line is going to be crossed by thousands of people, just like Cape Bojador was when the caravel was invented.

Reusable rockets shift the cost of getting into space so dramatically that they are ushering in a new era of exploration the world has not seen in 400 years.

There's one major reason for that. It's the same reason so many other technologies have changed the world in recent years. Exponential growth and the collapsing cost of getting into space.

Falling costs make space exploration the next big "New World" opportunity

The cost of getting satellites, weapons, people and materiel into space is falling at a rapid rate. Therefore it is only reasonable to expect the number of people travelling with them to increase and at a much quicker pace than any of us ever imagined.

The impending start of space tourism is being driven by a collapse in the cost of launching payloads into space.

The collapsing cost of launching payloads into orbit is what is behind the impending exponential growth of the space sector. In 1967 the average cost of lifting 1kg into space on the Saturn V rocket was $10,000. SpaceX successfully achieved the same feat with its Falcon 9 v1.2 Full Thrust at $2,600. In fact, SpaceX achieved an equally impressive record in 2013 when it successfully completed the cheapest ever launch of a space vehicle for $57 million.

SpaceX is scheduled to deliver its Falcon Heavy rocket by the end of this year and anticipates it will reduce the cost to $1,400 of lifting a kilogram in low Earth orbit (LEO). That's almost a reduction of 10x from the original flight in 1967. Elon Musk opines that "when upper/second stage & fairing are also reusable launch costs will drop by a factor of more than 100x".

Boeing's X-37B space plane prototype has spent 700 days in space in fully autonomous mode and is designed to be reused. Its existence confirms that new private ventures are not the only game in town. Traditional defence contractors have decades of experience in the space sector and are also active participants on behalf of their client governments in developing low-cost high-efficiency space vehicles.

Economics 101 states when the price of goods or services goes down, demand rises. That's exactly what is happening now. It's why tourism is going to be a big enabler for profitability for companies like SpaceX, Virgin Galactic and Blue Origin. The falling barriers to entry mean that companies will be able to launch satellites much more cost-effectively so the number will grow; and while it may sound farfetched, there are plans to mine asteroids.

Falling costs + increasing investment = a revolution in space

On top of that, there's an additional aspect to this story that is worth considering and which virtually ensures the capital required to drive the evolution of the space economy is going to happen. Defence.

Today both North Korea and Iran have space launching capabilities. According to Dr William R Graham of the US Congress EMP Commission, North Korea has developed an electromagnetic pulse weapon it could conceivably detonate in the atmosphere above the US which could disrupt the power grid for up to a year and affect the lives of 90% of the population. Iran might

Falling costs make space exploration the next big "New World" opportunity

have entered into an agreement to slow down its development of nuclear weapons but it is still developing rockets with ballistic capabilities.

Therefore, the major space nations such as the US, Russia and China have little choice but to develop counter measures, first-strike capabilities, anti-satellite weapons and satellite defence weapons, as well as monitoring and measuring devices.

The US armed forces are in the process of creating a sixth arm of the military, the US Space Corps. The US military also have a "Space Aggressor Squadron" with the express aim of replicating and combating the threats posed by all other actors by employing global positioning system (GPS) and satellite communications (SATCOM) jamming techniques.

For Europe, Russia and China that means they will have to follow suit lest they lose in the initiative in ceding the ultimate high ground to the US. In that aim the US, China and Russia have all successfully tested anti-satellite weapons over the last few years.

Under President Donald Trump, the US's military budget is expected to rise by about a 5% compound annual growth rate between 2017 and 2021, suggesting that the Obama administration's attempts to rein in military spending are over. The US defence budget for 2018 will likely be over $620 billion with $9.8 billion allocated to space-based systems.

In total, NASA's budget will potentially increase to $19.5 billion annually.

Then there's Britain. The UK generates about £13.7 billion from the space sector per annum, which is around 6.5% of the global space economy, while the government has ambitions of increasing that to 10% over the last 13 years. To achieve that goal the government is building the first commercial extreme environment test centre (Blue Abyss) at the RAF Henlow base at a cost of £100 million, which is due to open in 2019.

The UK generates about £13.7 billion from the space sector per annum

Quite apart from what governments are expected to spend, the private sector is investing heavily in space. For billionaires, mega yachts are passé; now they buy rockets.

Consider...

- Jeff Bezos anticipates liquidating $1 billion of Amazon stock per annum to fund Blue Origin.
- Elon Musk is spending his PayPal fortune to fund SpaceX.
- Fidelity teamed up with Google to invest $1 billion in the company.
- SoftBank's Vision Fund invested $1.2 billion in OneWeb to help drive development of a global broadband network.
- Tencent has invested in Luxembourg-based Planetary Resources with the aim of funding asteroid mining.
- In 2009 Richard Branson secured an investment of $280 billion for Virgin Galactic from the Abu Dhabi sovereign wealth fund and followed that up last month with another $1 billion from Saudi Arabia for investment in all his space-related companies.

For Branson it's all about tourism. Virgin Galactic was initially designed to provide space travel to the well-heeled masses. At the Nordic Business Forum last month, he had this to say: "We are hopefully about three months before we are in space, maybe six months before I'm in space."

That helps to emphasise that space is no longer some pipe dream but in fact represents the evolution of what is in my opinion a totally new avenue for investment. Space is truly the last investment frontier.

New worlds, new opportunities

All this excitement has a commercial side to it, too.

Bank of America Merrill Lynch recently announced its forecast that the space market will increase from approximately $339 billion today to about $2.7 trillion in 2045 or just 28 years from now.

Bezos compares space today to the early days of the internet, seeing a "dynamic, entrepreneurial explosion in space just as we witnessed over the last 20 years on the internet – thousands of companies and tens of thousands of startups doing interesting things online... this is underpinned by much lower cost access to space."

If the falling cost of launching was not a compelling enough catalyst, the revolution in satellite size, design and capabilities is truly profound.

The first mass-production line has been started by OneWeb. It plans on producing 650 initially and ramping up to capacity of 2,000 more. SpaceX is also building satellites with aims of building 4,500. Mass production has reduced costs of building satellites by 100x, which means that the primary cost is now centred on launch and as discussed above that is also collapsing.

These new mass-produced satellites are going into low Earth orbit, which is designed to deliver internet access to everyone everywhere on Earth at gigabit speeds and capable of delivering voice-over-IP (VoIP) services. Previously the kinds of satellites which deliver TV, etc, have been orbiting at much higher levels, which create latency in the system and therefore are inappropriate for internet use.

The older designs you've probably seen pictures of have useful lives of approximately 15 years on average. As they come up for replacement in the coming decade, they are going to be replaced by much more technologically advanced versions. However, even those are likely to be cannibalised by the newest technology on the horizon: CubeSats.

A CubeSat looks exactly like it sounds. They mostly measure 10X10X10cm, weigh less than 1.5kg, cost about 1/10th of even the cheapest conventional satellite and are equally capable of low Earth orbit. They are generally manufactured from off-the-shelf items, which keeps the cost down. The drawback right now is that they only last for about five years. That lifespan means they need to be replaced more often, which increases costs but also allows them to be updated with the most up-to-date hardware.

The UK is one of the world's largest manufacturers of CubeSats, at 40% of the total per annum with Glasgow driving innovation as the "space capital city" of Europe.

When we combine the economics of launch with satellites we get some interesting statistics that are worth considering. A satellite usually costs about $1 billion to build and launch, but with CubeSats that cost has now fallen to around $5 million. Because CubeSats are smaller, simpler and use current technology they can be built much quicker than the hulking masses we are accustomed to seeing. For example, Planet Labs built two in only nine days in 2015.

The technology underlying CubeSats is dependent on having powerful enough transponders to deliver communications to Earth. They are close to commercial viability right now but it will likely take another few years before they are truly competitive.

Google and Facebook have both been experimenting with ways of delivering internet to the globe for the last few years. They have tried everything from radio waves to balloons to gliders, but a constellation of satellites is the most likely solution to the question of how to get internet to the globe at a price even the poorest people can afford. The reason big search and social media companies are so interested in blanketing the world with internet access is very simple. It's where their organic

Bezos compares space today to the early days of the internet

growth is going to come from.

The global population is estimated to grow by billions over the coming decades, but a lot of that growth is going to occur in Africa and Asia where internet access is spotty and slow where it exists at all. If companies like Facebook, Google or Tencent hope to growth their subscriber bases, they need to reach out to these billions of people who do not yet have access to the internet. Therefore, satellites are an invaluable resource to achieve their long-term goals.

That virtually ensures continued growth for the sector. The other side of that coin is that fast, cheap internet represents a death knell for satellite TV services. Why pay the subscription when streaming is so much cheaper?

Planet Labs, on the other hand, employs a different business model. At any time it has a bird's eye view of everywhere on Earth and takes millions of high-resolution images on a daily basis, generating terabytes of information. It then sells that information to anyone looking to run quantitative analysis or big data applications based on geography, whether shipping companies or traders, farmers, fishermen or those counting the number of cars in parking lots to gauge footfall at malls. Space represents the perfect bird's eye view of the world and big data is a major beneficiary.

So how do we invest?

The falling cost of launch and satellites is proving to be incredibly disruptive to the space sector, and the fact that the vast majority of new entrants are privately held is a challenge from the perspective of a stockmarket investor.

For example, SpaceX is the sixth-largest company predicted to become a unicorn in the world with a value in the order of $20 billion but has no plans, which I have heard of, for listing. So how do we gain access?

The easy answer for right now is through the defence sector. More than half of all satellites are used for military purposes and the next major war is almost certainly going to have a space component to it.

For decades the US has shared its GPS with the world for free. However, now the Europeans, Russians and Chinese are building proprietary GPS networks. That is because, with the advent of satellite-killing missiles, the US's network is now considered a legitimate target in future conflagrations.

That is particularly true because the US's war machine is more reliant on space than any other country. If some future enemy wishes to hit the US where it hurts, it is likely to target space first.

Everything from ship navigation to cars and mapping apps on our phones rely on GPS to let us know where we are and how to get where we want to be. Knocking it out would represent a catastrophic loss for the US military apparatus. It would disable all cruise missiles, planes would be flying blind and soldiers would have to go back to reading maps. Drones are controlled by satellite uplink and could be completely disabled by taking out the satellites they use for communication.

In short, space is an incredibly important piece of infrastructure and for all intents and purposes it is largely unprotected.

But there are ways to protect satellites. The first would be to give them some manoeuvrability so they could slow their velocity in orbit and avoid an incoming missile. The second would be to build redundancy into the system and have more satellites than you need. The third would be to arm them directly for shoot-back capability. Fourth, CubeSats because of their relative cost could blanket the sky and would represent a difficult target to knock out. Whichever way you look at it, there is going have to be investment in boosting the defence of the satellite sector.

> *The Department of Defense has finally awoken to the reality that we must invest in the next generation of space capabilities, and recent budgets have begun to arrest the decline in those investments. Over the next five years, space must be a priority for additional funding to ensure that the United States maintains its space superiority and has the capabilities and capacity to deter and defend our critical space assets in future conflicts.*
>
> Senator John McCain, chairman of the Senate Armed Services Committee

This month's pick

In selecting one of the myriad potential investments in space, there is one which ticks all the boxes. It is instrumental in the measures being put in place to defend satellites.

It has already put in the place the Geosynchronous Space Situational Awareness Program, which is a network of satellites monitoring threats to the entire network from land-based entities.

Meanwhile, it has also built the Space Tracking and Surveillance System Demonstrator, which tracks not only satellites but space junk, of which there is an increasingly large quantity. The movie *Gravity* explored the impact space junk can have when it collides with other objects in space and as the number of satellites multiplies over the next few decades, monitoring it all is going to be a major endeavour.

It also has a range of launch capabilities from small to medium-sized payloads. Its Pegasus and Minotaur rockets have been launching satellites for decades and at some of the most attractive price points of any provider.

Right now, it is developing solid fuel stages for NASA. There is an ongoing debate about whether rockets should use liquid or solid fuel. The former represents more difficult and volatile chemistry but provides a smoother ride into orbit. Solid fuel is basically gunpowder in a tube and until now has provided a bumpy ride, which has made it inappropriate for launching sensitive military or scientific equipment. The company I am looking at for this month's investment has solved the problem with the bumpy ride, suggesting that the inherent safety of solid fuel is about to become available for military applications.

That is allowing it to compete for the lucrative business of ferrying US military hardware into space, which is a sector largely dominated by SpaceX and United Launch Alliance (ULA, a joint venture between Boeing and Lockheed Martin) today. Its Next Generation Launch System fits into a comfortable niche between the lifting payloads that are too small for large rockets, like the Atlas V, and too large for small rockets. It has also achieved more launches over its history than SpaceX and ULA combined, and above all solid fuel is cheaper.

There is an additional point that is very much in favour of solid fuel when we want to think about getting tourists into space. It is safer. NASA estimated that the failure rate for solid fuel is 0.001% while liquid fuel is 6%. More than a 1 in 20 chance of failure could scupper plans for space tourism for decades, so safety has to be a priority.

That represents a challenge for reusable rockets to gain market share with strategic assets because right now its safety record is just not long enough. That will change in future but solid fuel is going to be around for the foreseeable future.

The company I am talking about is **Orbital ATK** and it has been at the forefront of launching and building satellites for decades. **It was acquired by Northrup Grumman in September** and the combined company now represents both a play on the continued growth of the military drone market as well as the evolution of next-generation space ventures, which offers obvious synergies.

It has also achieved more launches over its history than SpaceX and ULA combined

The share has been trending higher in a consistent manner since 2011 and as military budgets are set to expand, it has ample potential to continue on an upward trajectory. The share is trading on an estimated price/earnings (P/E) for year-end of 23.49 and pays a dividend of 1.32% with a 12.59% five-year annual dividend growth rate. What these numbers confirm is that the share has done well but is well supported by revenues which are growing.

The risk with Northrup Grumman is that the space sector is becoming increasingly competitive and the capacity of technological innovation is

increasing as money flows into the sector. The additional risk is that peace could break out or that military budgets do not grow as expected.

My 12-month target is $400 with a five-year target of $700 assuming the trajectory of spending on defence and space continues to trend higher as I expect.

Name:	**Northrup Grumman**
Ticker:	**NOC US**
Closing price as of 06.11.2017:	**$301.66**
Market cap:	**$52.5 billion**
52-week high/low:	**$306.61/$220.72**

figures accurate as of last market close: 06.11.2017

Five-year performance:
2012 +14% | 2013 +69.90% | 2014 +39.11% | 2015 +37.75%| 2016 +49.14% | 2017 (HY) +19.39%

Who can talk about space without at least thinking about aliens?

It's an awfully big sky out there. To me at least, the thought that we are the only species to have evolved to the point of looking upwards and wondering borders on gross hubris. But how do you go about proving something exists when you can't just reach out and touch it? Well the easy answer is you start looking around.

On Earth, water and life go hand in hand. Therefore, looking for extraterrestrial life, at least any we can recognise, is mostly about looking for water. That's why you hear scientists get excited every time there is news about finding sources of liquid water on Mars; or vast oceans under the ice on Titan, one of Saturn's moons.

The ocean under Titan's ice is very salty, like the Dead Sea, so it's possibly not the most clement place for life to evolve. Nevertheless, even bacteria would represent a win for life so that's potentially not a very high bar to reach.

So, what about little green men? The thought of sentient beings has both excited, delighted and been a source of dread for moviegoers for decades. That's a much higher bar to meet. However, Adam Frank from the University of Rochester and Woody Sullivan from the University of Washington have modified the Drake Equation (used to estimate the number of technologically advanced species in the universe) to suggest the odds of being the only technologically advanced civilisation are 1 in 60 billion for the Milky Way.

The Kepler Space Telescope was launched in 2009 and has so far discovered 2,337 "exoplanets", 30 of which have small habitable zones or which exist in a sweet spot for Earth-like conditions to exist. That's 30 reasonably high-probability targets for life in eight years of searching. That success has led to much greater enthusiasm for building ambitious space telescopes. In August the Transiting Exoplanet Survey Satellite was launched on a two-year mission to examine light patterns for 200,000 stars to build on Kepler's success. By the end of 2019 we could have hundreds of high-value targets to examine further.

The Hubble Space Telescope has a mirror about 2.4 metres in diameter and was launched in 1990 when mobile phones looked like bricks. Since then miniaturisation, computing power and data analysis have multiplied in power many times so when the James Webb Space Telescope is launched next year it will have a mirror three times larger than Hubble's. Its primary aim is to look back 13.5 billion years to examine how the first galaxies formed.

The Wide Field Infrared Survey Telescope (WFIRST) is expected to enter service in 2023 and is designed to give astronomers 100 times more viewing space than Hubble. Its aim is to answer fundamental questions about dark matter and dark energy and is expected to find

an additional 2,500 exoplanets.

These are impressive, but things will get really interesting sometime after 2025. The Advanced Technology Large-Aperture Space Telescope (ATLAST) is expected to have a mirror in the order of 16 metres in diameter and resolution up to ten times better than James Webb, making it 2,000 times more sensitive than Hubble. It would be powerful enough to hunt for biosignatures in the atmosphere of exoplanets.

So, the chances are we will "see" aliens way before we meet aliens. However, there is one very important consideration that is worth considering. Telescopes look back in time. When a telescope looks at a star 100 light years away, it shows us what happened millions of years ago. If we find biosignatures on a planet that far away that would be like finding life on Earth before the dinosaurs evolved. Even if we see life, it will not tell us how technologically advanced anything that evolved on the planet has become. On the other hand, if a future telescope sees a telescope looking back at us that would show us a technology from millions of years ago and tell us in no uncertain terms we are not alone but also how unevolved we are.

Data as of 06/11/2017

Energy

Company	Ticker	Rec Date	Price Then	Price Now	Gain/ loss %
Orocobre Ltd	ORE. AX	07/04/16	A$ 2.92	A$ 5.57	96.92
Ormat Technologies	ORA on NYSE	06/06/17	$58.79	$65.05	10.65
Smart Meter-ing Systems	SMS LN	03/10/17	735.5p	820p	11.49

Technology

Company	Ticker	Rec Date	Price Then	Price Now	Gain/ loss %
Cyberdyne	7779	30/05/16	JPY 2,353	JPY 1,475	-37.31
IBM	IBM LN	07/06/16	$153.33	$150.84	-1.62
SAIC	SAIC US	05/07/16	$58.20	$70.40	20.96
Garmin	GRMN US	02/08/16	$55.75	$59.30	6.37
2U INC	TWOU: US	06/02/17	$33.25	$63.96	92.36
Cisco Systems Inc.	CSCO: US	03/04/17	$33.80	$34.41	1.8
Advanced Micro Devices	AMD US	26/07/17	$14.76	$11.93	-19.17
Microsoft	MSFT	31/07/17	$73.04	$84.47	15.65
Northrup Grumman	NOC US	06/07/17	$301.66	$301.66	0

Medical

Company	Ticker	Rec Date	Price Then	Price Now	Gain/ loss %
Terra Tech Corp	TRTC	11/10/16	$0.41	$0.24	-42.23
Autodesk	ADSK	19/07/17	$108.83	$123.82	13.77
Abcam	ABC	07/03/17	907.5p	1045p	15.15
Zynerba Phar-maceuticals Inc	ZYNE: US	03/04/17	$20.10	$11.19	-44.33
Illumina	ILMN	04/09/17	$207.15	$209.19	0.95

Moonshot

Company	Ticker	Rec Date	Price Then	Price Now	Gain/ loss %
SolarWindow	WNDW	07/04/16	$3.96	$4.30	8.59
Alkane Resources Ltd	ALK: AU	05/09/16	AU$ 0.31	AU$ 0.31	0
Editas	EDIT: US	07/03/17	$21.02	$24.02	12.88
Haydale Graphene Industries	HAYD	02/5/17	178.5p	123.00p	-31.09

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