The business of space

Commercial players aim for the stars, ground themselves on Earth, and make big bet on small satellites

by Betsy Loeff

All you star-gazing souls who look skyward and mourn NASA's small 0.47 percent share of the federal budget, take heart: More than three-fourths of the global economic activity related to space — some $323 billion in 2015 — came from commercial sectors. Broadcasting, telecommunications, and Earth-observation spending made up the biggest piece of this moon pie: $126 billion. But infrastructure was another big slice. Things like launch services, in-space platforms, ground equipment, and even insurance to cover it all totaled more than $120 billion.

No, it's not your standard-issue, government-backed space race anymore. Space is serious business and these days that business is booming.

To boldly fund what no one has funded before

"Access to space has historically been dominated by governments and a few select large contractors," says **Eric Matteson** (*MBA '03*), a space launch program manager for Orbital ATK's Launch Vehicles Division in Arizona. "Orbital ATK built the first purely commercial rocket, called Pegasus, and in recent times there have been more startups joining in with their own designs," he adds, pointing to firms like Elon Musk's SpaceX, which is now 15 years old, and the 11-year-old Rocket Lab as examples.

All of these companies are part of what's now called NewSpace, which Wikipedia defines as a "highly visible, globally emerging private spaceflight industry" that is characterized by "commercially minded aerospace companies and ventures working to independently develop faster, better, and cheaper access to space and spaceflight technologies."

What's more, investment in NewSpace is on the rise.

"One of the big differences from the past is now venture capital markets are willing to invest in space," says **Barry Matsumori** (*BS Management '78*), CEO of satellite company BridgeSat and former senior vice president of both Virgin Galactic and SpaceX. "They never did that before."

Venture capitalists traditionally view space business as too risky and slow to deliver a return on investment. However, according to a report produced by analysts at The Tauri Group, "more than 50 venture capital firms invested in space deals in 2015, the most in any year." The venture capitalists pumped some $1.8 billion into commercial startups with space-related products and services, which was more than venture capitalists chipped in during the previous 15 years combined.

Venture capitalists are putting in big bucks, too. As a case in point, Rocket Lab, a privately owned startup that plans to offer small-satellite launch services, made news in March 2017 by closing a $75 million financing round. The startup launched its experimental rocket for the first time in May 2017.

Along with venture capitalists, there's the billionaires club, a small number of headline-grabbing innovators who are financing space-related businesses. This club includes Amazon founder Jeff Bezos, who started Blue Origin to provide private access to space, and Tesla CEO Musk, whose SpaceX was launched in 2002 to offer space transport services, among other things. Virgin Galactic's founder, Richard Branson, aims to provide suborbital spaceflight for tourists through SpaceShipTwo, as well as space transport services via LauncherOne.

Other billionaires involved in space include the co-founder of Microsoft, Paul Allen, who established Vulcan Aerospace, and Facebook's Mark Zuckerberg, who joined British physicist and mathematician Stephen Hawking and Russian millionaire, scientist, and philanthropist Yuri Milner in a $100 million space exploration project called Breakthrough Starshot, which aims to reach the nearest star system.

For those who want to initiate a space-related startup but don't have billions to invest, the Founder Institute, a California-based business incubator, may be able to help. It has earmarked financial incentives and mentorship support from industry veterans to help space-related startups get off the ground.

"This is an international call for anyone working in space or passionate about space to launch a company," Adeo Ressi, co-founder and chief executive of the Founder Institute, told *Space News*. "Our goal, which admittedly might be a bit of a stretch goal, is to have 500 new space and space exploration companies launched by 2025."

Ressi's dream may not be entirely out of reach, although it may remind some of that old industry analyst joke: "The numbers are right. The years are wrong."

NewSpace Global, an analyst firm that covers the space industry, has gone from tracking 125 space companies six years ago to more than 1,000 today. Richard M. Rocket, NewSpace Global's CEO, told SatelliteToday.com that, "We will get to 10,000 businesses in the next 10 years. Every single company that's in the satellite and launch market – regardless of size, whether or not they are public or privately held, whether based in Seattle, Denver, or Nigeria, it doesn't make a difference – everything is going to flip upside down in the next 10 years."

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Out-of-this-world ideas

There are many new ways to commercialize space technology, data, and access.

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The NewSpace sector includes launch organizations, firms with moon-mining goals, businesses that plan to provide satellite maintenance services, orbital debris removal companies, and much, much more.

"Businesses are even looking at providing entertainment from space," Matsumori notes. "One company in Japan plans to launch a nanosatellite into a very low orbit, and it will release, in a controlled fashion, pellets that will produce a light show. Different materials make up the pellets. As they enter the atmosphere, they oxidize, emitting light. Because the materials are different, each one oxidizes with a different color. Hence, you'll have a pattern and colors."

Another company, SpaceVR, plans to put virtual reality cameras on foot-long satellites to give the earthbound an astronaut's view of the planet.

Launch, rinse, repeat – and 3D print

Along with new ideas for products and services, NewSpace entrepreneurs "have entered the space business with a different approach," Matsumori says. Among the changes is a belief in reusability of rockets. "Early on, Elon Musk had the notion that throwing away a used rocket is kind of silly," Matsumori continues. "If you flew a 747 from Arizona to New York and then threw the plane away, that's not intelligent business. But, essentially, that's what's been done in the rocket and engine space business. Elon decided reusability is essential. Now SpaceX is not only recovering the first stage of a rocket; they're using that first stage over again."

Blue Origin has similar goals, and that company has already demonstrated that it can launch a rocket, disengage the crew capsule, and safely land the booster rocket in a vertical position by engaging its thrusters.

Besides recycling, NewSpace and established companies are joining the movement of additive manufacturing, or 3D printing, to help make commercial space endeavors low-cost and easier – from 3D printing rocket parts while on the ground to making astronauts' tools in space with the first 3D printer on the International Space Station. But there's more than economics driving such rocket-related sustainability endeavors. There's zeal.

"We needed somebody to launch our satellites, and we could have gone with NASA, but we bet on SpaceX. The price was right, and we believe in what they're doing."

Victor Einfeldt
(MSIM '06), manager of network security and infrastructure for satellite communications provider Iridium

"When I was at SpaceX, one of the things that I liked about being there was that if you ask anybody in the company, 'Why does the company exist? Why are you here?' the answer was simple: 'We're going to Mars.' That's what Elon wants. Everything that the company does is about supporting the mission to Mars," recalls Matsumori.

He must have fit right in. Early in Matsumori's career, he worked on space architecture as part of a NASA study. The researchers examined space vehicles, space stations, Mars habitats, and other details designed to answer the question, "How do we get to Mars and stay there?" says Matsumori, who shares his knowledge giving annual lectures to students of ASU's School of Earth and Space Exploration.

Even if people don't venture away from the planet, they could be customers for space travel, says Matteson. He thinks private space travel may be akin to where the airline industry was many years ago, where only the wealthy could afford to fly until economies of scale kicked in and prices came down. He sees "shades of the early airline industry in front of us now with space travel."

Plus, he sees applications beyond shelling out big cash for a chance to experience weightlessness on a Virgin Galactic suborbital flight. "It still takes too long to get to Japan, for instance. If you could do that in a couple of hours versus 15 hours, that would be transformational to world travel," he says.

What's old is new again

Newcomers aren't the only ones reusing space vehicles and innovating in the space business. Established giants are engaged in some recycling actions, too.

Matteson, for instance, has spent part of his Orbital ATK career repurposing used rocket motors. "It's a swords-to-plowshares application," he says. For years, the Minotaur program at Orbital ATK has been taking motors from old Minuteman and Peacekeeper land-based, intercontinental ballistic missiles and turning them into low-cost rockets that can launch government satellites or payloads on suborbital trajectories.

"These decommissioned motors were sitting in silos waiting on alert for launch against a nuclear attack," Matteson says. "They are inspected by the Air Force, and then we integrate modern avionics, structures, new upper stage propellant, and the payload for a complete launch vehicle solution."

Along with recycling, upgrades are underway. For example, Iridium, a satellite communications provider, is in the process of replacing their old and distant assets. "We have 66 satellites up there now," says **Victor Einfeldt** (*MSIM '06*), Iridium's manager of network security and infrastructure. "Satellites are not designed to last more than 20 years," he explains. "We have 75 satellites scheduled for launch, and six will be ground spares – a $3 billion investment. Sixty-six are going to be in the mission orbit, or servicing customers. We're going to have spares in space, as well, should something happen."

To accomplish this upgrade, Iridium purchased eight rockets from another commercial player in the industry. "We needed somebody to launch our satellites, and we could have gone with NASA, but we bet on SpaceX. The price was right, and we believe in what they're doing," Einfeldt says.

Other businesses involved in upgrades to these "Iridium NEXT" satellites are broadband services provider ViaSat, which supplies key radio frequency hardware, and Orbital ATK, which Matteson says is "assembling, integrating, and testing those satellites."

Why space business matters on planet Earth

While the business of space has all of us gazing toward the stars, it has broad benefits for those rooted to Earth.

"Space makes the whole world go around now," says Matteson. "Whether it's the debit card transactions that are time-stamped by GPS satellites or getting from point A to point B following Google Maps instead of old-school paper maps, space touches our lives every day in ways we probably don't even realize. We take it for granted."

Everywhere you look

Ask Matsumori why those of us on this wet,

PHOTOS COURTESY OF ORBITAL ATK AND IRIDIUM

Top: **A picture taken from a chase airplane shows Orbital ATK's Stargazer carrier aircraft releasing its commercial rocket, Pegasus®, which ignites, beginning its climb to orbit.**
Bottom: **Iridium NEXT satellite.**

blue planet should care about the machinery we send into orbit, and he'll be hard pressed to give you just one answer. He'll try, though. He lumps several items under the header "critical applications."

Among the must-have capabilities from space that Matsumori pinpoints is Earth observation for things like weather forecasting. "The only way to get critical weather data is via satellite," he says. "You can't do it any other way."

Agriculture and forest management are other applications dependent on the broad view from beyond our planetary atmosphere. "Typically, the sensors on a satellite will look at a spectrum of images through different frequencies and be able to get information about what's going on," Matsumori says. Agribusinesses are using satellite imagery to estimate crop yields, evaluate crop health, guide decisions about fertilization and watering schedules, and help identify optimal crop types for different areas.

Matsumori also sees communication as a critical space-related application: "The only way to provide communication coverage for any place on Earth is by satellite," he says. Therein lies the primary mission of many a corporation.

Moving up in the world

One company leading the way is ViaSat, headquartered in Carlsbad, Calif., with a location in Tempe's ASU Research Park. When it queried British consumers late last year, 27 percent were worried that poor broadband would spoil their 2016 Christmas festivities. Among millennials, that number rose to 45 percent.

Lucky for all these internet addicts, companies like ViaSat dedicate themselves to bringing broadband to all, including those who have been cleared for takeoff and are now cruising at 35,000 feet. "What ViaSat has done is offer much more than broadband on a plane," says **Jason Guiles** (*MBA '10*), a program manager for this satellite-based internet service provider. "With the amount of bandwidth we have today, we can have hundreds of planes, at any given time, full of people streaming video from Netflix, Amazon Prime, YouTube, or Hulu" on personal electronic devices like iPads and smartphones. Remember, the aircraft is moving at hundreds of miles an hour.

Right now, ViaSat provides such service on more than 550 commercial planes, mostly traveling over land, but with the recent launch of ViaSat-2, the world's highest-capacity communications

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satellite, ViaSat will be the first internet service provider to provide high-speed, high-quality internet over water, including the Atlantic Ocean. Another 830 planes are in the queue for equipment install, as the company recently inked big deals with American Airlines in the U.S., El Al Israel Airlines, Finnair, Scandinavian Airlines System, and Icelandair throughout Europe. The company also provides its high-speed connectivity to U.S. government VIP and special mission aircraft.

On land, ViaSat brings internet to around 830,000 subscribers in North America and Europe. It is also one of the companies that helps people in remote areas get high-speed internet connectivity. It's not just for the well-heeled living in high-priced mountain communities or rural retreats. "Because we have so much capacity on our satellites, we're looking at new programs we call shared or village Wi-Fi," Guiles says. "We're working with towns in Mexico to deliver the internet to areas that have never had service before."

"We estimate that most of the globe – 80 percent – is not covered by any communication system," says Einfeldt at Iridium, a Motorola offshoot that also brings the internet to the farthest reaches of Earth. "There's no ground-based communications infrastructure for more than 80 percent of the planet since nobody is about to build cell towers in the middle of the ocean."

Although users can't stream their favorite YouTube channels on an airplane using the Iridium network, the system has vital importance to planes and other transportation vehicles worldwide. That's because it does cover the whole world, which enables Iridium to create subsidiaries like Aireon. Starting in 2018, Aireon will begin to track and monitor aircraft around the world in real time.

The technology monitors Automatic Dependent Surveillance-Broadcast (ADS-B) signals, which planes equipped with the proper devices send. "Right now, planes flying over the North Pole or an ocean often cannot be seen by any ground radar," Einfeldt explains. "With Aireon, we can get global flight tracking anywhere," he says, adding that this could end tragic accidents like the one that left all 239 people aboard Malaysia Airlines flight MH370 lost at sea.

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Jason Guiles
(*MBA '10*), Program manager, ViaSat

The Aireon technology also will likely save airlines' and their passengers' money. "Because of the gap in radar coverage, flight controllers don't want planes flying anywhere near each other over an ocean," Einfeldt explains. "It also means planes have to follow a particular path so that they can get as much radar coverage as possible. This technology means we'll be able to track direct routes over the ocean." They also can fly closer together. Both changes allow for greater scheduling flexibility and fuel savings for airlines.

Playing it safe

Communication isn't the only place where space capability has become crucial. "The importance of space to national defense is paramount," says Orbital ATK's Matteson.

"I think evidence of this is shown by how the U.S. government is trying to establish a new military branch within the Air Force," he adds. He's speaking about the Space Corps, which was part of the National Defense Authorization Act (NDAA), a bill that lays out military spending for 2018.

Such legislation passes annually, but this year's NDAA called for the first new branch of the armed services since 1947, when the U.S. created the Air Force. As the legislation envisions it, the Space Corps would be a division within the Air Force just as the Marine Corps fits within the Navy. And, like the Marines, the Space Corps would provide "combat-ready forces," according to the bill, which has not yet passed.

"Unfortunately, we've become just like every other war-fighting country, very dependent on space," said Republican Congressman Mike Rogers of Alabama in a June 25, 2017, interview with National Public Radio. As a sponsor of the Space Corps, Rogers told NPR, "The Russians and Chinese have realized that if they can take our eyes and ears out, which is what our satellites are, they might be able to compete or have an advantage against us." He added: "It's natural that you're going to see war-fighting move up into that domain."

What kind of applications do those satellites deliver to military leaders? Naturally, there's communications and surveillance. "Satellites keep a watchful eye on the world," Matteson notes. "They can provide early warning and detection of rocket launches from other countries as well as data and communication links for the military."

Launch vehicles – aka missiles – also are crucial to defense, and they're vitally important to testing those defenses. Among other things, the company Matteson works for – Orbital ATK – makes both target and interceptor missiles used to validate the United States' missile defense system. The interceptor chases down the target, Matteson explains. "It's like a bullet hitting a bullet."

Back on Earth, satellites help soldiers track munitions, says Iridium's Einfeldt. "You could, for example, turn landmines off and on if you planted them somewhere," he notes.

And, of course, there are specific communications technologies for military use. Guiles notes, "ViaSat's global network of satellites can give military players situational awareness for enhanced intelligence, surveillance, and reconnaissance missions," he says. To illustrate, he invites us to imagine troops from several military branches all operating in the same region. "If everyone is using the same satellite communications backbone, they'll be able to understand who is nearby, whether the other troops are allied forces, or whether there's an enemy in the area."

The small sat revolution

So how big are the satellites that relay our favorite TV shows, show us our way around a new town via GPS, and help farmers predict crop yields? Are they the size of a car? A suitcase? A toaster? The answer is "yes."

"To date, everybody's been focused on larger satellites that stay in space a longer period," says Matsumori, who is on the board of advisors for satellite propulsion company Accion Systems. "Now what is happening is that given new technologies and lower cost, people are starting to spend on small satellites that have roughly the same capabilities" as the traditional large satellites.

Matsumori explains that traditional satellites can weigh 11,000 pounds, while many being launched today are a few thousand pounds or even lighter. Some are no bigger than a loaf of bread.

The larger, traditional satellites are placed into geostationary orbit, which means they fly some 22,000 miles or more above Earth, staying over the same part of Earth and following its

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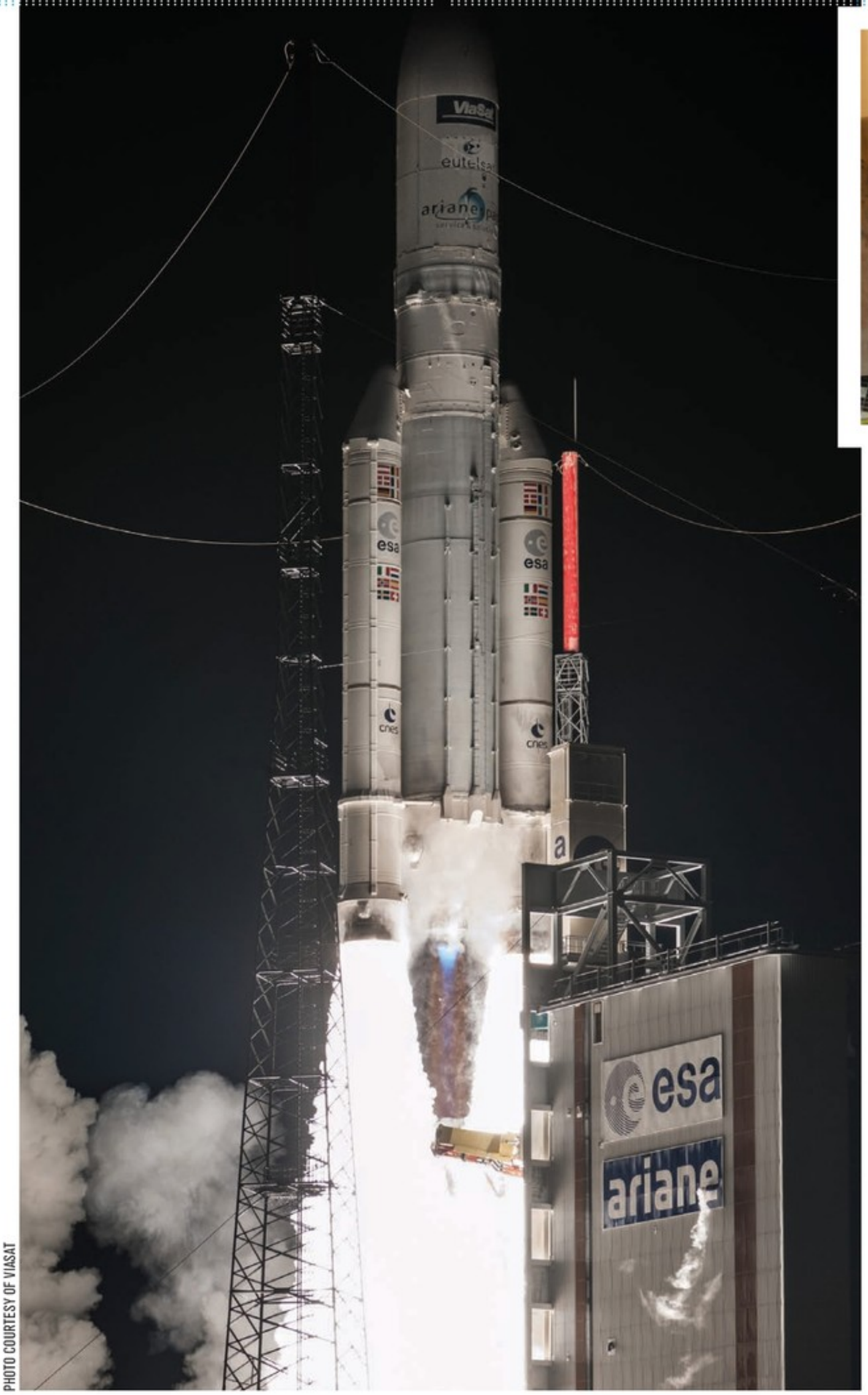

PHOTO COURTESY OF VIASAT

ViaSat-2, the world's highest-capacity communications satellite from broadband services company ViaSat, before it successfully launched into space on June 1, 2017. The satellite will offer high-speed internet service to millions of people on the ground, in the air, and at sea.

Mason Takidin
(MS-BA '16)

Breathe from your core

Yoga, singing, meditation: There are plenty of activities during which you might be instructed to breathe from your core. As it turns out, we all do.

"The electromagnetic field around earth is derived from the moving of molten iron in the core, deep below the planet's surface," explains **Mason Takidin** *(MS-BA '16),* project resource analyst at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California. That electromagnetic field protects the planet from solar winds, which speed through space at several hundred miles per second and can strip a planet of its breathable gases.

JPL is preparing for NASA's Interior Exploration using Seismic Investigations, Geodesy, and Heat Transport (InSight) mission. NASA will land a robotic terrestrial explorer on Mars equipped with geophysical instruments that will probe beneath the planet's surface. "It's very important to study the depths of a planet beneath its crust," Takidin says.

The birth of rocky planets

"InSight will help to build the foundation for future science missions on Mars," says Bruce Banerdt, the principal investigator for the InSight mission. "The interior of a planet retains the fingerprints of the origins of a planet and can help explain how it was formed." The InSight mission hopes to uncover the mysteries of Mars and answer why a planet like Earth has become drastically different.

InSight was originally slated to launch in 2016, but the trip was knocked off schedule by leaky equipment. "With Mars missions, you have to wait two years to relaunch because of the way the orbit works," says Takidin. The relative positions of Mars and Earth are only favorable for launching missions for a few weeks every 26 months.

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rotation. This orbit means we can track geostationary satellites without redirecting the antennas that communicate with them from Earth. Geostationary satellites' distant orbit is associated with latency; however, they have significantly more capacity than low-earth orbit (LEO) satellites that fly only about 1,000 miles above Earth.

In ViaSat's case: Its technology is orders of magnitude better than any other satellite – geostationary or LEO – in terms of capacity, performance, and the ability to enable broadband services at scale. While more capacity will not lower latency, it offsets the problem by enabling varying streaming media, data, and voice over internet protocol (VoIP) services.

"At low-earth orbit, the LEO satellites are moving around Earth faster than Earth itself," Matsumori explains. "One satellite doesn't cover one place on Earth. Multiple satellites zoom by, and you have to have coverage change between the satellites as they move over different parts of Earth. It's a complication in architecture design."

To overcome this design challenge, ViaSat is bringing to market an even more powerful geostationary spacecraft known as ViaSat-3. Just one ViaSat-3 class satellite will have 1,000 gigabits per second, or 1 terabit per second, of total network capacity, which is more capacity than all 400 communications satellites have in space today. ViaSat-3 will offer added flexibility to adjust its coverage area based on shifting user demand. The goal is to efficiently beam service to markets in need instead of spreading coverage "like peanut butter" equally across Earth with LEO satellites.

Here's another concern: Very small satellites, called nano or CubeSats, historically have had to "hitch a ride" into space with a larger payload, says Matteson. "Typically, they've been held hostage to the primary payload's schedule and orbit parameters." NASA, for instance, has a CubeSat launch initiative that puts small satellites built by schools and non-profits on its launches, but often these researchers must compete for that precious ride. "In this always-connected era, operational responsiveness is critical to both business and the government. When required, they must be able to get their small satellites into orbit on relatively short timelines," he continues.

New businesses and new offerings from established firms are coming online to address this need and help small satellites get off the planet. Orbital ATK is working on new designs and updates to its small space launch capabilities in order to meet the projected needs of those customers. So are other startups in the industry.

Many giant leaps for mankind

As we continue to explore outer space, our creativity brings the technology used for space business down to Earth. Whether warning us about imminent weather and missile launches or sharing a view of Earth from space and a light show like no other, space products and services make life easier, help us endure unstable times, and open our ideas of what we think is possible.

The solar arrays on NASA's InSight lander are deployed in this test inside a clean room at Lockheed Martin Space Systems in Denver. This configuration is how the spacecraft will look on the surface of Mars.

PHOTO COURTESY OF NASA/JPL-CALTECH/LOCKHEED MARTIN

The space industry is in a new period of rapid expansion in both capabilities and customers, even after many years of slow, steady progress. Startups are trying fresh approaches to bring us closer to space. Established space operators are renovating products and reutilizing the old. The universal reach of small satellites is attracting interest and investment from other industries and connecting the billions of people around the globe who don't have access to modern communications.

The way we live is going to keep evolving thanks to space business. The skilled professionals who comprise the space industry – some of whom are our alums – are prepared to take a leading role in making those changes a reality.

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Once landed, InSight's vehicle will move the main two instruments (the seismometer and a heat flow probe) from the lander deck to the Mars surface. This will be the first mission to robotically deploy instruments on another planet. The spacecraft will then measure ground movement using the seismometer, and will command the heat-flow probe to hammer up to 15 feet into the Mars ground to study the planet's interior heat flow.

It takes a village to raise a lander

"InSight is a very important project in a business sense because it shows JPL's collaboration strengths," says Takidin. "This is a mission with many foreign partners."

The lander will carry a seismometer from France, a heat probe from Germany, plenty of hardware from a host of private companies, as well as numerous colleges and universities will lend their expertise. It is Takidin's job to coordinate such players.

Working with InSight Project Manager Tom Hoffman, Takidin used analytical skills from his MS-BA program to effectively coordinate project control processes. The Jet Propulsion Lab does so much of this detailed coordination, it's considered a NASA leader. "We're sharing our experience with other NASA centers on how to monitor their projects and do project control when working with foreign partners," Takidin notes.