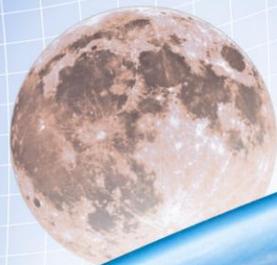


NEWSPACE NATION

AMERICA'S EMERGING
ENTREPRENEURIAL
SPACE INDUSTRY

★★★★★
2nd Edition
★★★★★



JEFF KRUKIN

NewSpace Nation: America's Emerging Entrepreneurial Space Industry
(e-book reader version)

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www.jeffkrukin.com

Introduction

When I wrote the first addition it was initially available only at Lulu.com, a print-on-demand publisher, and it included many logos and images. I have decided that this second edition will only be sold in digital format, so to support the greatest variety of devices and avoid the need to create multiple formats I have removed all logos and images (except one!).

This is an industry primer, intended as a quick read to give you an overview of the NewSpace industry and help you see new business opportunities and appreciate how companies will play a vital part in moving humanity into the solar system. And you will learn enough to drop attention-getting comments at your next office party! Sprinkled throughout this primer are links to company websites, interviews, and more.

Any errors are entirely mine, and I welcome corrections and feedback. Please contact me via my website.

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Front and back cover artwork by Peter Thorpe

www.peterthorpe.net

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1. What is the NewSpace industry?

The term “NewSpace” evolved from “alt.space,” a term used in the 1980’s and 1990’s to identify the “alternative” space community that was attempting to conduct space activity with a considerably different business approach than NASA and its contractors. This is the emerging commercial space industry, the antithesis of the decades-old civil space program we know as NASA and its large contractors like Boeing, Lockheed Martin, and so forth. Today, this primarily means entrepreneurs and their small- or medium-size firms having these characteristics:

- Space-related products and services are sold with a fixed-price (versus the traditional space industry’s cost-plus government procurement model)
- Customers include individual consumers, corporations, and government agencies
- The company is funded primarily by the owner(s), angel investors, and/or venture capital
- A significant portion of the company’s revenue is earned from non-government entities
- When doing business with NASA it is more likely to be within the format of a Space Act Agreement rather than the more odious, costly, bureaucratic, and oversight-heavy Federal Acquisition Regulations process

It is important to note that while many entrepreneurs and companies easily fit these criteria, other companies exist in that gray area between NewSpace and traditional aerospace. For example, although Boeing and Orbital Sciences Corp. have received funding from NASA’s commercial space industry development efforts, I do not consider them to be NewSpace or entrepreneurial companies. I recognize that others may disagree. Sometimes, labeling a company as “NewSpace” is more art than science, more of a subjective and qualitative judgment than a measurable quantitative appraisal.

2. How is NewSpace different from the traditional space industry?

Sometimes it is easier to define “NewSpace” by understanding how the traditional aerospace industry (a.k.a. legacy space, classic space, or “OldSpace”) is different, and thus the type of company *not* considered to be a NewSpace firm. It helps to remember that the space age began as an element of the US-USSR Cold War, with the Apollo program being one of the most visible elements of this ideological conflict. The traditional space industry is a direct result of this Cold War competition, which led to the industry having these characteristics:

- Represented by large and usually (but not always) slow-to-change entities like NASA, Boeing, Lockheed Martin, Raytheon, Northrop Grumman, etc.
- Federally dominated civil space programs
- Military space programs
- Taxpayer funded
- Costly and complex cost-plus (vs. fixed-price) procurement bureaucracy and processes (i.e., Federal Acquisition Regulations)

Another key distinction between NewSpace and the traditional space industry is not unique, but instead reflects the different priorities of entrepreneurs and small businesses versus those of large established companies. The former are typically focused on creating new markets and new jobs with breakthrough technologies and/or new uses for existing technology. Large established companies, however, are typically focused on protecting their existing customer base and not inclined to create new technologies or industries that will disrupt their current markets.

The result has been seen time and time again; those who embrace and support the successful entrepreneur benefit from the new industries and jobs that come from that person's vision, whereas the established firms often do not see or attempt to prevent the emergence of these new industries that threaten their existing markets, thereby losing the first-mover positioning advantage for a coming technology and/or economic wave. I experienced the latter when I was a Systems Engineer at IBM (1981-1992) as the company sought to defend its domination of the mainframe market and was slow to perceive the emerging threat of mid-range systems such as DEC's VAX line.

3. What are the NewSpace industry sectors and companies?

In my view, NewSpace is currently characterized by six sectors, and each is reviewed here along with representative companies to provide a snapshot of the sectors and give you a flavor of the industry, if you will. This is not a complete list of current NewSpace companies or their activities. Indeed, the NewSpace industry is young and evolving and new sectors and companies will continue to emerge, and some existing companies will fail to get beyond their business plans, websites, and PowerPoint presentations. Like any new industry faced with risk and opportunity, NewSpace should be monitored for additional future sectors and companies, and for new investment possibilities and business relationships.

3.a. Atmospheric flight

Despite the glamour and other-worldliness of space travel, at its most fundamental nature NewSpace is simply about commercial transportation and facilities. Space-related flights within the atmosphere make vital contributions to the development of the technologies and operational processes required for commercial space transportation. Even though these companies operate within the atmosphere, I consider them to be a part of the NewSpace community because their products and activities directly support the growth of the industry.

3.a.1. Rocket Racing League[®] (www.rocketracingleague.com)

Low-altitude rocket racing is an outgrowth of the Ansari X PRIZE-winning flights of *SpaceShipOne* in 2004, and ongoing rocket engine development for commercial spaceflight. This makes it part of NewSpace, even though spaceflight is not involved.

Founded in 2005 by X PRIZE founder Peter Diamandis and two-time Indianapolis 500 champion team member Granger Whitelaw, "The Rocket Racing League[®] is an aerospace sports and entertainment organization that combines the competition of racing with the excitement of rocketry. The NASCAR-style racing league features rocket-powered aircraft (X-racers) that will be flown by top pilots through a 'three-dimensional track way' at venues throughout the world. With millions of fans who enjoy racing and air shows, and an even wider audience enthralled with humanity's next step into space, rocket racing is destined to become the future of racing!" (Source: Rocket Racing League[®])

The RRL[™] conducted successful Rocket Racer[®] flights on August 1st and 2nd, 2008 at the Experimental Aircraft Association's AirVenture show in Oshkosh, WI. While this vehicle was powered by XCOR Aerospace rocket engines, subsequent test flights were made on August 25th and 26th with Armadillo Aerospace engines at the Oklahoma Spaceport.

The Mark III X-racer was unveiled at the QuikTrip Air & Rocket Racing Show in Tulsa, OK in April 2010, where two X-racers flew together for the first time in what was intended to be the

beginning of the “2010 World Exhibition Tour.” Unfortunately, the RRL™ continues to face financial challenges, which has delayed plans by several years and in 2009 saw the termination of its lease with Las Cruces, NM for land adjacent to Spaceport America.

3.a.2. Zero Gravity Corporation (ZERO-G)® (www.gozerog.com)

Founded in 1993, “After 11 years of surmounting meticulous procedures and safety regulations, co-founders Dr. Peter H. Diamandis, veteran astronaut Dr. Byron K. Lichtenberg and NASA engineer Ray Cronise acquired FAA approval for G-FORCE ONE, a specially modified Boeing 727-200, to take passengers on commercial parabolic flights. In October 2004, ZERO-G flew its first commercial flight operating under the same safety standards of all major air carriers and established its place into the extreme tourism industry as the first and only commercial Zero Gravity flight for the general public.” (Source: Zero Gravity Corp.)

ZERO-G has certainly targeted a unique niche for fun and profit, but “fun” isn’t its only market. Weightlessness is also quite valuable for inanimate business payloads, and in September 2008 five small companies flew their new products aboard G-FORCE ONE® to support their space hardware development.

Space Adventures (Section 3.e.2.) acquired ZERO-G on January 1, 2008 as a wholly-owned subsidiary.

3.b. Suborbital transportation

Suborbital transportation refers to flights up to altitudes between approximately 35 miles (60 kilometers) and 62 miles (100 kilometers), resulting in 1-4 minutes of microgravity during the flight. In these flight profiles the vehicles do not achieve sufficient speed to complete an orbit around the planet. With the first two companies profiled below flying aircraft-like vehicles, you might think of this within an aviation context, in that this is extending aviation to much higher altitudes. Nevertheless, it is spaceflight. And while “space tourism” has certainly captured the attention of the media and public, new research opportunities are emerging due to the anticipation of routine, low-cost flights on suborbital reusable launch vehicles (SRLV).

This is a growth industry. Consider these statistics compiled by The Tauri Group:

- Spaceflight service revenues and deposits increased from \$28.8M in 2006 to \$50M in 2008
- Revenue from sales of hardware, hardware development, and support services increased from \$123M in 2006 to \$213M in 2008
- \$1.51B invested

Anticipated markets other than space tourism include technology (aerospace and other) test and demonstration, education, media and public relations, basic and applied research, military, and remote sensing. Further in the future, as technology progresses, we might see point-to-point flights.

3.b.1. NASA Flight Opportunities Program (www.flightopportunities.nasa.gov)

Residing within NASA’s Office of the Chief Technologist, this program demonstrates the growing recognition within NASA that NewSpace provides a valuable and low-cost technology development platform for the space agency and the research community. With a mission statement “To develop and provide flight opportunities for Space Technologies...,” the Program has three goals:

- Provide reduced-gravity environments, brief periods of weightlessness, and high-altitude atmospheric research for technology development
- Expand platform opportunities and test environments for technology development
- Create opportunities for the public, especially the STEM education community, to engage in NASA's space technology mission and the emerging commercial space industry

Two recent announcements demonstrate how NASA will use this Program:

- May 13, 2011: NASA selects 16 payloads to fly on the Zero-G aircraft, and on two commercial SRLVs; Masten Space Systems' Xaero and Armadillo Aerospace's Super Mod. Flights are scheduled through 2011.
- August 9, 2011: NASA selects seven companies to integrate and fly technology payloads on commercial SRLVs; Armadillo Aerospace, Near Space Corp., Masten Space Systems, Up Aerospace Inc., Virgin Galactic, Whittinghill Aerospace LLC, and XCOR Aerospace.

3.b.2. Virgin Galactic (www.virgingalactic.com)

Virgin Galactic, founded in 2004, is perhaps the best known company in this sector, grabbing the space tourism headlines with its plans to operate a fleet of five *SpaceShipTwo/WhiteKnightTwo* spaceship/carrier aircraft combinations. Revenue flights are expected to begin in 2012 or 2013, several years later than originally planned (Who said rocket science was easy?). The first *SpaceShipTwo* (named *VSS Enterprise*) continues to undergo its test flight regimen, having flown solo seven times since its rollout in December 2009. The first of two *WhiteKnightTwo* carrier aircraft (*VMS Eve*) had its maiden test flight at Mojave Air & Space Port on December 21, 2008, reaching an altitude of 16,000 feet, and completed its flight tests by September 2009. The Spaceship Company (www.thespaceshipcompany.com) is the manufacturer of both vehicles.

Other potential markets for suborbital transportation include microgravity and other scientific research, remote sensing, spaceflight hardware qualification, and military and homeland security applications. Beyond these initial applications, the company has stated that it is looking to future technological advancements that will support suborbital point-to-point transportation. Think of this as the ultimate step-up from the *Concorde* Supersonic Transport Mach 2 flights between New York and London and similarly distant large cities. Students at the International Space University in Strasbourg, France produced a report about this; "Great Expectations: An Assessment of the Potential for Suborbital Transportation." Virgin Galactic also intends to offer orbital human spaceflight in the future.

In August 2011, the company was one of seven selected by NASA to provide what it calls "near-space flight services." As NASA Press Release 11-258 states, the firms were selected "...to integrate and fly technology payloads on commercial suborbital reusable platforms that carry payloads near the boundary of space."

You may be wondering why, in a publication about American NewSpace activity, I am including Virgin Galactic, part of Sir Richard Branson's British parent company known as Virgin Group. Virgin Group determined that the United States provides the best business and regulatory environment necessary for Virgin Galactic's initial operations and success, which is why its first vehicles are being manufactured and based here. For these reasons, and because the company's operations will have a large impact on the American NewSpace and traditional space industries, Virgin Galactic deserves to be included here. Of course, the company intends to operate at non-US locations such as Spaceport Sweden in Kiruna (www.spaceportsweden.com).

3. b. 3. XCOR Aerospace (www.xcor.com)

While Virgin Galactic is targeting customers willing to pay \$200,000 to fly to an altitude of 100km, XCOR Aerospace (founded in 1999) is segmenting the market by offering flights for \$95,000 to an altitude of 61km with the *Lynx*, announced on March 26, 2008. By August 2011, the company was placing orders for long-lead structural elements for the airframe, and the aerodynamic design is expected to be finalized after the last round of wind tunnel tests scheduled to begin in August. *Lynx* will be able to fly up to four times each day and provide three-four minutes of microgravity during its flights,

A review of the two companies' vehicles shows key distinctions in addition to those of price and altitude. For example, *Lynx* is a single stage vehicle vs. the *SpaceShipTwo /WhiteKnightTwo* multi-stage concept, which means a lower cost to develop and operate the vehicle... and thus the lower ticket price. The *Lynx* will carry one passenger who will enjoy the view from the cockpit while seated next to the pilot, but he will not be able to float around like the multiple passengers of *SpaceShipTwo* who will sit behind the cockpit in a separate passenger compartment.

Like Virgin Galactic, XCOR realizes that space tourism is not the only revenue stream for its vehicles. For example, in July 2011 it announced the signing of a Memorandum of Understanding with the Planetary Science Institute to fly the human-operated Atsa Suborbital Observatory. And in August the company was one of seven selected by NASA to provide suborbital flight and payload integration services for research and scientific flights.

XCOR is also looking to non-US operations, having announced agreements with the Yecheon Astro Space Center South Korea in December 2009 and Space Experience Curacao in October 2010 (www.portsky.net/english and www.spaceexperiencecuracao.com, respectively).

XCOR Aerospace has done its market research and determined that the suborbital flight marketplace can be segregated into multiple categories with various needs and price points. And in the best sense of free markets and no-holds barred competition, customers will determine if XCOR is right or wrong. In this regard, space travel is no different from other forms of transportation provided by the private sector, because competition and engineering/cost tradeoffs rule as they do in air, sea, and land transportation. This is why you do not see only one type of car, truck, ship, airplane, helicopter, and so forth. Instead, we have different vehicles for different requirements and markets. And so shall it be in space.

While the two previous companies' vehicles will carry passengers (as well as payloads) and use runways for takeoff and landing, these next two companies are focused on payloads and will launch and land vertically.

3.b.4. Masten Space Systems (www.masten-space.com)

Located in Mojave and founded in 2004, the company achieved recognition of its engineering capabilities in 2009 by winning a \$150,000 second prize and \$1,000,000 first prize in the NASA Centennial Challenges Program/Northrop Grumman Lunar Lander Challenge X PRIZE.

The company is focused on developing reusable rocket technology and vertical takeoff, vertical landing (VTVL) rockets, and as seen above (Section 3.b.1.) has won significant NASA business. Additionally, in August 2010, NASA's Commercial Reusable Suborbital Research (CRuSR) Program, now part of the Flight Opportunities Program, awarded \$250,000 for test

flights. In May 2011 the firm signed a \$400,000 contract with Space Florida for demonstration launches of its Xaero rocket at Cape Canaveral.

3.b.5. Armadillo Aerospace (www.armadilloaerospace.com)

John Carmack, co-founder of id Software and lead programmer of the highly successful computer games *Doom* and *Quake*, started Armadillo in 2000 in Texas. The company applies a rapid build and fly test cycle, also known in the industry as “fly, crash, learn, fly again, repeat as necessary.” This has been amply demonstrated with over 200 flight tests involving over a dozen different vehicles. It has operated with this philosophy in numerous prize competitions; the 2004 Ansari X PRIZE, the 2006 and 2007 Wirefly Z PRIZE Cups, and the 2007-2009 Lunar Lander Challenges. Despite several failures, some quite spectacular with crashes and engine explosions, the firm has won a total of \$850,000 in prizes.

In 2010 it received \$225,000 from NASA’s CRuSR Program for test flights, and as seen above (Section 3.b.1.) has won significant NASA business. Also in 2010 the firm entered into an exclusive marketing arrangement with Space Adventures.

Through 2011 Armadillo has struggled with the test flights of its new Tube Rocket, *Stig*, and its new SuperMod rocket, *Dalek*. Development and test flights will continue.

3.c. Orbital transportation

Orbital transportation refers to flights that carry passengers and/or payloads outside the Earth’s atmosphere and to an altitude where the speed of the vehicle is sufficient to place it in orbit around the planet. For decades this has been the domain of large entities like NASA, Arianespace, and United Launch Alliance (a joint venture between Boeing and Lockheed Martin), but NewSpace companies have entered this field and may well dominate if the established players do not compete... or cannot compete because their internal organizations and processes, created for a government-oriented, cost-plus contract dominated space program, are simply too costly. Boeing faces this challenge as it seeks to enter the market with its CST-100 capsule.

3.c.1. NASA Commercial Crew & Cargo Program (www.nasa.gov/offices/c3po/home/)

Like its commercial suborbital counterpart (Section 3.b.1.), this program also demonstrates NASA’s investment of financial and technical resources to help NewSpace companies develop commercially viable space transportation (vs. NASA’s traditional approach of creating government owned and operated systems).

This Program manages the Commercial Orbital Transportation Services (COTS) projects, begun in 2006 as the initial phase of the Program to develop several types of cargo and crew capabilities through a \$500 million investment. Space Exploration Technologies and Orbital Sciences Corp. received funds under this program (they are also required to apply their own funding), and both companies are working to complete the milestones required for providing cargo transportation to/from the International Space Station (ISS). In December 2008 the ISS Program Office announced its order of twelve resupply flights from SpaceX for \$1.6 billion, and eight flights from Orbital Sciences Corp. for \$1.9 billion.

The crew transportation portion (Capability D) of COTS was transferred to the new Commercial Crew Development (CCDev) Program in 2009, which was funded with \$50 million from the American Recovery and Reinvestment Act (ARRA). These funds were divided among Blue

Origin, Boeing, Paragon Space Development Corp., Sierra Nevada Corp., and United Launch Alliance. Four of these companies received funds under CCDev 2 Space Act Agreements announced in April 2011:

- Blue Origin: \$22 million
- Sierra Nevada Corp.: \$80 million
- Space Exploration Technologies: \$75 million
- Boeing: \$92.3 million

In July, NASA announced a new Space Act Agreement with United Launch Alliance, under which the company will provide technical information about using its Atlas V rocket (currently only used for payloads) to launch astronauts.

3.c.2. Space Exploration Technologies Corp. (SPACEX) (www.spacex.com)

Space Exploration Technologies (SPACEX) was established in 2002 and is the builder of the Falcon 1 and Falcon 9 rockets and Dragon space capsule for both commercial and government cargo and passengers.

In September 2008, the company had its first successful Falcon 1 launch on its fourth attempt from Kwajalein Atoll, Republic of the Marshall Islands, and in July 2009 the Falcon 1 placed its first payload (RazakSAT) into orbit. Falcon 9's maiden flight lifted off from Cape Canaveral spaceport in June 2010, and the second launch in December 2010 carried the Dragon capsule into space for two orbits before it splashed into the Pacific Ocean. The launch, orbit, and reentry of a space capsule, which was once the sole province of government, was accomplished by a private company for the first time.

NASA is counting on SpaceX, along with Orbital Sciences Corp., to provide commercial transport for both astronauts and cargo to and from the International Space Station. As of this writing (August 18, 2011), NASA has selected November 30th as the launch date for a Falcon 9 that will carry a Dragon capsule to dock with the ISS nine days later.

You might wonder about the capabilities of a company that failed with its first three launch attempts. A little perspective helps, as NASA's history demonstrates that launching rockets is also not easy for government agencies and their contractors. On July 29, 1960, the day after NASA announced the Apollo program, its first Mercury Atlas rocket disintegrated 58 seconds after launching from Cape Canaveral. Several similar failures occurred during the next four months. Launch failures still occur.

SPACEX founder and Chief Technology Officer Elon Musk has made it clear at numerous conferences that orbit is not his final destination. His goal is to build vehicles that will provide reliable, low-cost (compared to NASA programs), commercial access to the Moon, Mars ... and the rest of the solar system.

3.c.3. Sierra Nevada Corp. (www.sncorp.com)

A multi-faceted company that manufactures products for non-space markets, its Space Systems business was established in 2009 by combining its MicroSat Systems subsidiary, SpaceDev (acquired in 2008), and Starsys (acquired by SpaceDev in 2006). The company's *Dream ChaserTM* vertical takeoff, horizontal landing lifting-body spaceplane (to be launched on an Atlas V rocket) was originally conceived by SpaceDev as a suborbital vehicle, but was revised in 2005 based on NASA's HL-20 lifting body design. Its primary mission will be the transportation of

up to seven crew and cargo to the ISS, and perhaps future Bigelow Aerospace (Section 3.d.1.) and other commercial orbiting habitats and facilities.

Having won two NASA Commercial Crew Development (CCDev, CCDev 2) awards totaling \$100 million, all milestones to-date have been completed on time and within budget guidelines.

3.c.4. Blue Origin (www.blueorigin.com)

Certainly the most secretive of the NewSpace companies, Blue Origin was founded in 2000 by Jeff Bezos, founder of Amazon.com. The firm is developing the *New Shepard* vertical takeoff, vertical landing vehicle to fly passengers on suborbital flights from its West Texas launch site, and the first development vehicle *Goddard* launched and landed in November 2006. Still, the company's participation in NASA's CCDev and CCDev 2 Programs places it in the Orbital Transportation section of *NewSpace Nation*. After all, if the company can reach orbit, it can certainly handle suborbital flight.

3.d. Orbital destinations

It has been said that the journey matters more than the destination, and perhaps this is best exemplified by the suborbital journeys offered by companies like Virgin Galactic and XCOR Aerospace. Even so, if the NewSpace industry is to grow, destinations are also important.

3.d.1. Bigelow Aerospace (www.bigelow-aerospace.com)

Did you know that an American company launched its first commercial space habitat (1/3 scale) into orbit on July 12, 2006? And that the second test module was placed in orbit on June 28, 2007?

Bigelow Aerospace, LLC licensed NASA technology and spent \$100 million through 2007 developing an inflatable commercial habitat that will be used for orbiting hotels, university campuses, laboratories and research facilities, on-orbit training for government and commercial astronauts... and just about anything else the purchaser desires. In February 2011, NASA recommended that the company be given a partially exclusive license to market some of its patented technology. The first full-size habitat is expected to be open for business in 2015.

As if commercial inflatable habitats orbiting overhead aren't amazing enough, consider the subject of a published Feb. 22, 2007 interview with MSNBC's Alan Boyle; "Bigelow Shoots for the Moon." Here is an excerpt from that interview:

"But by 2012, the focus could start shifting from low Earth orbit, or LEO, farther out into space. One of the key places in Bigelow's plan is a point about 200,000 miles (323,000 kilometers) out from Earth in the moon's direction, where the pulls of terrestrial and lunar gravity balance each other.

While not happening as quickly as anticipated, Bigelow Aerospace would turn that region of space, called L1 (Lagrange points: www.wikipedia.org/wiki/Lagrangian_point), into a construction zone. Inflatable modules would be linked up with propulsion/power systems and support structures, and then the completed base would be lowered down to the moon's surface, all in one piece." (Source: <http://cosmiclog.msnbc.msn.com/archive/2007/02/22/65477.aspx>)

Once the sole province of government, habitable space facilities are now being manufactured by an entrepreneur at a fraction of the cost of the International Space Station.

3.e. Services, support, and the supply chain

The pilots and passengers may get all the glamour and glory, but they're just the bright stars at the top of the gravity well. Pilots and passengers need training, passengers and cargo need to be booked, and space vehicles need parts from suppliers.

3.e.1. NASTAR Center (www.nastarcenter.com)

Environmental Tectonics Corp. formally opened the National Aerospace Training and Research Center in October 2007 to provide spaceflight training for the commercial space travel industry. It will also support the training and research needs of the military and civil aviation communities.

This is just one example of a company that used its experience in non-space markets (biomedical systems, entertainment technology, information systems, high performance composites, and more) to become part of the NewSpace services supply chain.

3.e.2. Space Adventures (www.spaceadventures.com)

“Founded in 1998, Space Adventures, Ltd. is the world’s premier private space exploration company and the only company currently providing opportunities for actual private spaceflight and space tourism today. Using proven equipment and working side-by-side with professional astronauts and cosmonauts, we are the first and only company to have sent private clients to space. Our clients having cumulatively spent over two months aboard the International Space Station. (Source: www.spaceadventures.com/index.cfm?fuseaction=about_us.welcome)

Best known for brokering citizen flights to the International Space Station, beginning with Dennis Tito in 2001, the company also makes arrangements for suborbital and atmospheric flights (the latter due to the January 2008 purchase of Zero Gravity Corporation.). Not exciting enough? Then dig deep into your wallet for \$150 million (was only \$100 million when the first edition of *NewSpace Nation* was written in late 2008) and you can purchase a seat on a Russian Soyuz capsule for a 17-day trip around the Moon and back, with a stopover at the International Space Station (What? No direct flight!). In June 2011, rumors began circulating that James Cameron, famed Hollywood movie director, had purchased one of two seats available for the scheduled 2015 journey.

It is worth noting that this significant step in extending the human economy into space is a direct result of what may be called the seed efforts of the United States and Soviet governments during the Cold War race to the Moon. Indeed, this is what governments should do; take the risks and provide the investments that lead to the establishment of new technologies, markets, and industries.

3.e.3. Orbital Outfitters (www.orbitaloutfitters.com)

When you fly on a commercial airliner, you know you're going to get the safety lecture that includes the use of the oxygen mask; “If you are seated next to a child, or someone who insists on acting like a child, ...” If the cabin loses pressure that mask will become your dearest friend.

Now imagine yourself in the cabin of a suborbital spacecraft at an altitude of thirty-five miles or more, and the vehicle suddenly loses its internal atmosphere. An oxygen mask will not be enough to keep you alive, because you will freeze to death at that altitude without something warmer than a cashmere sweater wrapped around you as the vehicle descends to a safe altitude.

You have seen the space suits worn by NASA astronauts, and they are too cumbersome, have more capability than is needed, and are much too expensive for the needs of suborbital spaceflight pilots and passengers. This presented entrepreneurs with an opportunity, and so entrepreneurs established Orbital Outfitters in 2006 to meet this need for the NewSpace industry. The Industrial Suborbital Spacesuit (IS3) is the company's first emergency pressure suit designed for suborbital operations. For obvious reasons, it is also known as a "get me down" suit. XCOR Aerospace became Orbital Outfitter's first customer, and whether you are flying on the *Lynx* or another company's vehicle, you will be wearing something similar.

Like most new technology-based products, the first iteration will likely be more concerned with function than fashion ("I don't care how I look, just keep me alive!"). Of course, this will change as the industry matures and other companies begin manufacturing spacesuits and need to differentiate their products. How long do you think it will be before you can choose your color... and keep the suit after your flight for an extra charge? Think this won't happen? Remember when cell phones, iPods, and personal computers were all based on the same simple designs and dull colors? Today, cell phones have become a fashion accessory, iPod commercials have shown them literally dripping with bright colors, and some PC's seem sculpted rather than manufactured. People spending \$100,000 or more will not hesitate to indulge themselves if they can personalize their spacesuits. Space bling will happen.

3.e.4. Supply chain companies

Before anybody flies, spacecraft must be manufactured, and they require a myriad of components and subsystems from the manufacturing supply chain. For example, Armadillo Aerospace has been a supplier of rocket engines to the Rocket Racing League[®], a perfect example of the supply chain within the industry. But what about purchasing components and parts from outside the NewSpace industry... or from entirely outside the entire space industry?

Masten Space Systems kindly provided me with information about their purchase of \$250,000 worth of parts from suppliers a few years ago, and you may be surprised at the names of these companies:

- Metals Superstore
- Orchard Supply and Hardware (that's right, a hardware store)
- Flometrics
- Summit Racing (high-performance auto parts)
- McMaster & Carr (industrial supplier)

As the NewSpace industry evolves, it will not only take us to the Moon and planets, it will create jobs and economic development that will ripple throughout non-space industries. And it will do this with greater growth and consistency than politically motivated government space expenditures will ever accomplish.

3.f. Commercial spaceports

If "What goes up, must come down" is a truism, then "What comes down, must quickly go back up with more paying passengers and payloads" is equally valid for the NewSpace industry, just as it is for commercial aviation. This drives the need for commercial spaceports, because Federal spaceports like Florida's Kennedy Space Center and California's Vandenberg Air Force Base cannot by themselves meet the commercial operations requirements of the NewSpace industry.

Several states see the impending economic growth and job creation that will result from these commercial spaceports, and they are working to various degrees to either build them from scratch or upgrade existing facilities previously used by the Federal government. This section reviews several existing and potential commercial spaceports intended to serve the emerging NewSpace industry.

3.f.1. California: Mojave Air & Space Port (www.mojaveairport.com)

Home to NewSpace companies like XCOR Aerospace, Masten Space Systems, as well as the fabled Scaled Composites, this is where *SpaceShipOne* flew twice in October 2004 to win the Ansari X PRIZE. Many in the NewSpace community consider those two flights to be the “Kitty Hawk moment” of suborbital spaceflight. On June 17, 2004, this became the first inland launch site licensed by the Federal Aviation Administration for suborbital launches.

3.f.2. Florida: Cape Canaveral Spaceport (www.spaceflorida.gov)

Florida is synonymous with U.S. space activity, and while it continues to be NASA’s primary launch site it is also looking for NewSpace business revenue with a late-in-coming sense of urgency since shortly before the end of space shuttle flights. Space Florida, a public-private partnership, is responsible for marketing the spaceport to commercial launch providers. Recent successes include:

- Bigelow Aerospace signed a Memorandum of Understanding with Space Florida in February 2011, “...agreeing to work together to pursue and identify foreign and domestic companies that could benefit from utilization of Bigelow’s expandable, orbital space complexes.”
- Masten Space Systems signed a \$400,000 contract in May 2011 for a series of Vertical Takeoff Vertical Landing (VTVL) reusable suborbital launch vehicle demonstration flights
- SpaceX held official groundbreaking ceremonies at Launch Complex-40 on November 1, 2007 for its Falcon 9 rocket

3.f.3. Florida: Cecil Field Spaceport (www.cecilfieldspaceport.com)

Opened in 1942 and originally used by the US Navy, the Jacksonville Aviation Authority took ownership in 1999 after the 1993 Base Realignment and Closure Commission led to the military’s disuse of the airport. With four runways (three at 8000 ft. and one at 12,500 ft.) and existing aerospace tenants, both XCOR Aerospace and Virgin Galactic could use this location now that it received its Launch Site Operator License from the FAA in 2010. Still, Cecil Field remains in the “horizontal suborbital flight spaceport wannabe” category as it works to complete a Spaceport Master Plan by the end of 2011 and then obtain funding for the design and construction of additional facilities.

3.f.4. New Mexico: Spaceport America (www.spaceportamerica.com)

Spaceport America, located in Upham (near Truth or Consequences and the White Sands Missile Range), is the world’s first purpose-built commercial spaceport, and the state has put \$200 million into the project. Its design was unveiled in September 2007 by a team of U.S. and British architects and designers (URS Corp. and Foster + Partners). Groundbreaking for the 8.5 mile access road to the site occurred in September 2008. In December 2008 a Launch Site Operator License was issued by the Federal Aviation Administration’s Office of Commercial Space Transportation, and construction of the 200 ft. x 10,000 ft. runway began in August 2009.

In October 2010 I was privileged to attend the runway christening ceremony and observe the flyby and landing of the first *WhiteKnightTwo* carrying the first *SpaceShipTwo*. Construction of the Terminal Hangar Facility was well along at that time, but in May 2011 an investigative report by the *Albuquerque Journal* determined that completion was 12 months or more behind schedule. Other problems were reported, and changes in the New Mexico governorship and Spaceport America leadership likely exacerbated them. Still, in July 2011 the New Mexico Spaceport Authority announced the award of a \$7.5 million two-phase contract to Integrity Arts & Technology for development of the Spaceport America Visitor Experience.

I wonder if the first construction workers on the Moon and asteroids will belong to a union.

3.f.5. Oklahoma: Oklahoma Spaceport (www.okspaceport.state.ok.us)

Previously the Clinton-Sherman Air Force Base, it was licensed by the FAA in June 2006 to become the nation's sixth commercial spaceport. It was home for Rocketplane Global, Inc. before the company encountered financial problems, and it has been used for test flights by Armadillo Aerospace. A 13,500 ft. runway built for B-52 bombers and the first inland launch site to be part of the FAA-managed National Airspace System positions the spaceport for horizontal take-off and landing (HOTOL) reusable launch vehicles (RLV).

According to its website, "It is envisioned that the Oklahoma Space Industrial Development Authority, which is modeled after the first turnpike authority in the US, the Oklahoma Turnpike Authority, and the Florida Spaceport Authority, can be activated to become a test bed for emerging RLV technologies and other space related technologies, as well as becoming the benchmark for the commercial utilization of space." Although the spaceport received its Launch Site Operator License in 2006, the future of this facility is uncertain.

3.f.6. Virginia: Mid-Atlantic Regional Spaceport (www.marsspaceport.com)

The Virginia General Assembly created the Virginia Commercial Space Flight Authority in 1995, and since then it has passed two bills to support the presence of the commercial space industry. As seen on the MARS website, "The first, the Virginia Space Liability and Immunity Act, enacted in 2007, effectively made Virginia the most progressive state in the country in addressing the challenge that existing tort law posed to emerging human spaceflight transportation companies. The second, the Zero G Zero Tax Act of 2008, will provide an exemption from state income taxes to any space transportation company doing business in Virginia with the intent to either launch payloads from the Mid-Atlantic Regional Spaceport (**MARS**) or conduct spaceflight training." As in New Mexico, here we see a state government demonstrating vision and supporting that vision.

MARS is co-located with NASA's Wallops Flight Facility at Wallops Island, VA, and it operates under a joint Maryland-Virginia economic development partnership, which created the MARS name. In June 2008, Orbital Sciences Corp. announced it had selected MARS as the base of operations for its planned Taurus II rocket and automated cargo carrier (Cygnus).

Exemplifying the competitive nature of NewSpace, MARS beat Florida to win this business.

Like the companies they will serve, these spaceports will have varying degrees of success... or failure. Such is the nature of competition, and there is no reason for space transportation to be immune from the only force that will lower the cost of this transportation. As competition

increases and drives further technology development and the resulting new products and services, you should expect to see space transportation become fully integrated with existing commercial air, sea, and land transportation. It may take fifteen, twenty, or more years, but we will have a fully intermodal terrestrial-space commercial transportation infrastructure for carrying people and goods around the world and into the solar system. Think this is impossible? Why?

History provides countless examples of one person's imagination motivating another person to create what was imagined. Just look at the communicator from the original *Star Trek* series and note the similarity to the [Motorola StarTAC®](#) cell phone, released in 1996. Coincidence? No, according to various websites (Such as [here](#) and [here](#)).

History also teaches us that those who create a new era are often blind to its full potential, as demonstrated by Orville Wright: "No flying machine will ever fly from New York to Paris ... [because] no known motor can run at the requisite speed for four days without stopping."

4. NewSpace rising

The NewSpace stage is set, the players are ready, the curtain is up, and the audience is waiting. It is exciting to imagine that within the next few years (later than originally forecast, to be sure) we will see the first revenue generating commercial suborbital passenger flights... and this is just the beginning. If you talk with the people in this industry you will hear the same message; these flights are not our end-goal, but a necessary evolutionary step for learning how to move to the Moon and beyond in an economically sustainable (i.e., commercially profitable) manner.

But there are challenges, to be sure, and this will not be an easy endeavor. Still, has that ever stopped the entrepreneurial spirit... in any industry? While public and political support for NASA's programs will rise and fall, the profit motive remains one of the most consistently powerful motivators on the planet.

5. Looking ahead to 2030

One of the most forward-thinking space commerce visionaries I have had the pleasure of meeting is Dr. Patrick Collins, a professor in the Environmental Policy Department at Azabu University in Japan. Several years ago he created an insightful [graphic](#) of how the space tourism business might appear in 2030. While you see businesses like hotels, sports centers, and lunar flights that are synonymous with space "tourism" activities, note the ancillary lunar water export businesses and propellant stations. As with Earth-bound economic activity, space-bound economic activity will take many forms. For example, several years ago I worked with Caterpillar as they studied the development of equipment for use on the Moon. Probably would not be called Earth-moving equipment!

Our commercial future in space is a well-conceived concept, and it is clear why some refer to the Moon as Earth's eighth continent. It is not only a transit station on the way to the outer solar system, but also an integral part of our Earth-space economy.

Still, if scientific exploration is more important to you than tourism, keep in mind that this commercial transportation, fuel, and accommodation infrastructure will support scientific exploration and research of our solar system (just as it does on Earth). In other words, business

and science are not mutually exclusive. Indeed, it is the former that will make the latter affordable and thus sustainable, and reduce the need to choose between manned and unmanned space exploration. Whether exploring the Moon, a comet or asteroid, or a distant planet, isn't it better to have scientists present with their instruments instead of instruments present without their scientists?

6. Closing thoughts and acknowledgements

I hope this introduction to the NewSpace industry has created an excitement and belief that humanity does indeed have a future in space, regardless of the ups and downs of government funding.

There are many more companies, all in various stages of credibility, capability, profitability (or not), and survivability than I covered here. You will find a directory (www.spacefrontier.org/press/directory) of them at the Space Frontier Foundation (www.spacefrontier.org), the premier non-profit space advocacy group that has worked tirelessly since 1988 to support this industry. They also produce a free monthly e-newsletter, *NewSpace News*. I recommend it. Other non-profit space advocacy organizations that support the NewSpace industry are:

- X PRIZE Foundation (www.xprize.org)
- Commercial Spaceflight Federation (www.commercialspaceflight.org)
- Space Access Society (www.space-access.org)
- National Space Society (remains very much a supporter of traditional NASA space programs) (www.nss.org)

My primary goal was to demonstrate the economic development possibilities and business opportunities that NewSpace is generating, and to unleash **your** imagination for the creation of additional wonders that nobody has yet conceived. What will be the result of hundreds, and then thousands, and then tens of thousands of people venturing into space for a brief flight or a few nights (what is "night" in space?) in an orbiting hotel? What new markets will be introduced, and what new products and services will be created to serve these markets? How will people view themselves, their world, and their relationship with the rest of humanity after seeing our beautiful, blue planet from space... without the political boundaries thrust upon us by our everyday lives? (For more on this I recommend reading Frank White's fabulous book, "The Overview Effect," and see also The Overview Institute (www.overviewinstitute.org)). As flight is extended to a higher and higher altitude, as space becomes an ever greater part of the global economy, how will this impact you and your family?

Looking to connect your business with the NewSpace industry, but not sure how to begin? Looking for an out-of-this world (if you'll forgive the pun) speech at your next event, or a thought-provoking white paper or magazine article? I am available to help you on a consulting basis.

To contact me, please come to www.jeffkrukin.com.

I am grateful to the following people for their support, recommendations, and editing:

- Bettina, my wonderful wife
- Patti Grace Smith, former Associate Administrator of the Federal Aviation Administration's Office of Commercial Space Transportation
- Michael Mealling, former Vice President for Business Development, Masten Space Systems

7. About the author

Jeff Krukin's space career began with boyhood evenings in the back yard gazing at the Moon, which ultimately led to a graduate internship at NASA Headquarters and lifelong passion for extending the human economy into orbit and beyond.

Jeff combined his technology and space interests as an IBM Systems Engineer at NASA's Johnson Space Center. During a 25-year Information Technology career that also included Attachmate Corp. and independent consulting, he specialized in strategic business and technology planning and implementation, along with technical sales, business development, marketing, and communications.

In 2004 Jeff left the IT industry to focus exclusively on his aerospace interests, beginning with various consulting projects. He initiated the North Carolina Aero/Space Economy Project and twice received grant funding to educate political, business, and economic development leaders about the entrepreneurial NewSpace industry and its potential impact on the state's key industries. He was the lead author of *The Aero/Space Economy in North Carolina: A Preliminary Assessment of Current Performance and Future Prospects*, and a key contributor to *North Carolina's Strategic Plan for Workforce Development in the Aviation and Aerospace Industries*.

From January 2005 through December 2007, Jeff was Executive Director of the Space Frontier Foundation, the first and most prominent NewSpace advocacy organization. During this period, and continuing today, he has engaged in various space business consulting projects for companies as diverse as Caterpillar, SpaceWorks Engineering, American Aerospace, Blue Force Technologies, and Presence Displays. In 2009 he was hired by the North Carolina Aerospace Alliance to organize and speak at the state's first NewSpace Commerce Forum.

NASA and the NOAA's Office of Space Commercialization have requested his participation in their strategic planning efforts. He is a member of COMSTAC STOWG (Commercial Space Transportation Advisory Committee Suborbital Transportation Operations Working Group) and the American Institute of Aeronautics and Astronautics Commercial Space Group

Jeff is a global event speaker, appearing across the United States and Europe, and in Canada, Australia, Singapore, and Hong Kong. He has been interviewed for newspapers, magazines, radio, and television from Los Angeles to Palm Beach, as well as in Europe and Asia.

He is also a writer, and his first space article was published in 1981. His articles and Op-Ed's have appeared on numerous websites and in publications such as *Space News*, the *Houston Chronicle*, *The News & Observer* (Raleigh, NC), *Ad Astra*, the *Houston Business Journal*, and the *Journal for Space Development*. His first book essays were published in Spring 2005 in "Tackling Tomorrow Today: Moving Along, Far Ahead," part of a book series written for high school students. He is the author of *NewSpace Nation: America's Entrepreneurial Space Industry*.

Jeff is an award-winning leader, receiving the ProSpace Activist of the Year award in 1998 for his instrumental work in creating and implementing that organization's lobbying strategy to move the Commercial Space Launch Amendments Act of 2004 through Congress and signed into law, laying the regulatory foundation for the NewSpace industry.

He received Attachmate's North America Systems Engineer of the Year award in 1999, and numerous other commendations throughout his IT career.

He is the creator of The Human-Space Connection[®] concept (www.jeffkrukin.com/Human_Space_Connection.pdf), serves on the Steering Committee of the International Association of Space Entrepreneurs, and is the NewSpace advisor to the North Carolina Aerospace Alliance.

With his diverse business, government, and non-profit experience and Master's Degree in Future Studies, Jeff provides a unique and insightful perspective on the exploration, settlement, and commercial development of space... and its economic and job creation potential at home.

Learn more at www.jeffkrukin.com and www.linkedin.com/in/jeffkrukin, and follow Jeff at <http://twitter.com/#!/jeffkrukin>

NEWSPACE NATION

★★★★★
2nd Edition
★★★★★

"Jeff Krukin has written a much needed and practical introduction to the evolving entrepreneurial space industry. Drawing on his experience as Executive Director of the Space Frontier Foundation and as a NewSpace business consultant with particular experience in state level engagement, Jeff brings invaluable insight about an emerging industry that promises to significantly impact our lives. Whether you are an investor, space exploration aficionado, or someone who just wants to know about these vehicles that will one day soon fly overhead, this primer should be on your must read list."

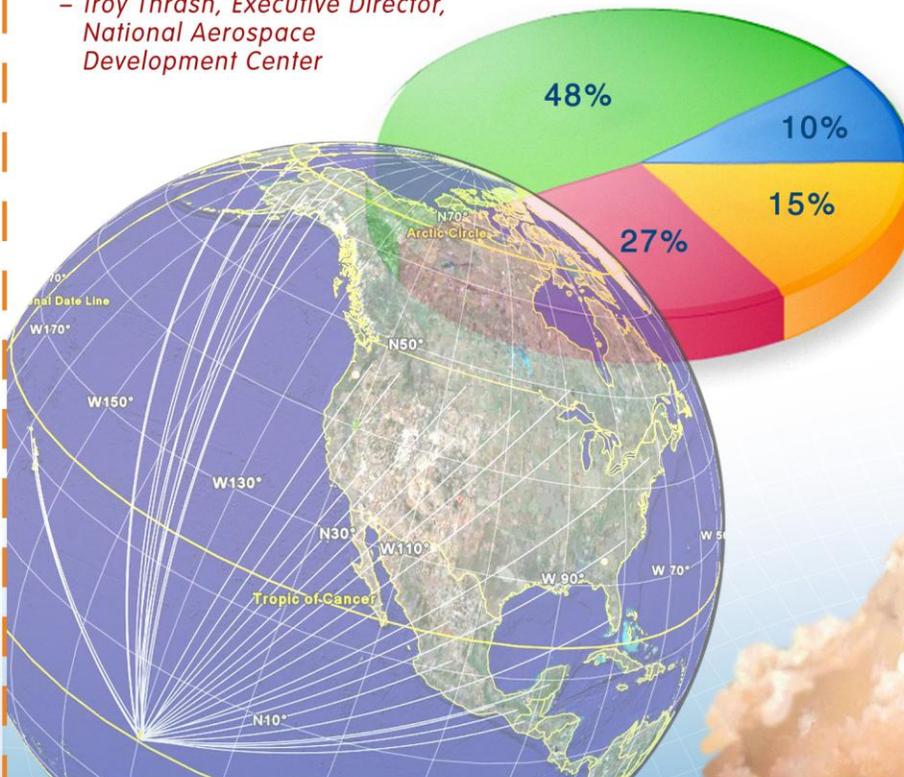
– *Patti Grace Smith, former Associate Administrator for Commercial Space Transportation, Federal Aviation Administration*

"Kudos for Jeff Krukin's *NewSpace Nation* for providing a compelling case that America's best space days are just ahead, thanks to the creativity and determination of entrepreneurs and those who support them. You won't find a better, more concise introduction to the NewSpace industry."

– *Michael Mealling, Vice President for Business Development, Masten Space Systems*

"Throughout my work on national aerospace programs, I've cited Jeff's excellent work in analyzing state industry clusters and comparing them to national economic data on commercial space transportation enabled industries. Jeff's results show that the space market extends far beyond the narrowly defined aerospace industry to include every sector of the economy. If you represent a non-space company and don't know how to approach this market, I strongly encourage you to talk with Jeff."

– *Troy Thrash, Executive Director, National Aerospace Development Center*



NEWSPACE BUSINESS DEVELOPMENT

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