

START-UP SPACE

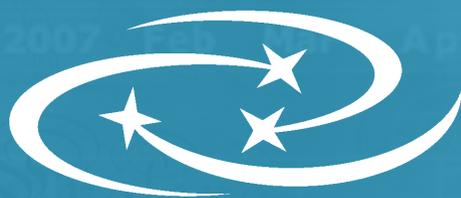
RISING INVESTMENT
IN COMMERCIAL SPACE
VENTURES

JANUARY 2016



THE TAURI GROUP





THE TAURI GROUP

About the Tauri Group: The Tauri Group Space and Technology Practice applies deep knowledge in the global space and satellite sectors to the needs of government and commercial clients. Many of the existing, authoritative data sets characterizing the space industry and sub-segments were originated by The Tauri Group or by Tauri analysts. The Tauri Group provides official launch industry data to the FAA Office of Commercial Space Transportation; assesses technology investments for NASA; delivers industry analysis and acquisition support for the Department of Defense; and provides market, investment, strategic, and technology analysis for leading aerospace organizations around the world.

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Executive Summary

Start-Up Space examines space investment in the 21st century and analyzes investment trends, focusing on investors in new companies that have acquired private financing. Space is attracting increased attention in Silicon Valley and in investment communities world-wide. Space ventures now appeal to investors because new, lower-cost systems are envisioned to follow the path terrestrial tech has profitably traveled: dropping system costs and massively increasing user bases for new products, especially new data products. Investors say that large valuations and exits are demonstrating the potential for high returns.

Start-Up Space reports on investment in **start-up space ventures**, defined as space companies that began as angel- and venture capital-backed start-ups. The report tracks seed, venture, and private equity investment in space ventures as they grow and mature over the period 2000 through 2015. The report includes debt financing for these companies to provide a complete picture of the capital available to them and also highlights space venture merger and acquisition (M&A) activity.

Significant Investment. Space ventures have attracted over \$13.3 billion of investment, including \$5.1 billion in debt financing, since 2000. Over 80 angel- and venture-backed space companies have been founded since 2000. Eight of these companies have been acquired, at a total value of \$2.2 billion. See Table E-1.

Investment Type	2000-2005 (millions)	2006-2010 (millions)	2011-2015 (millions)	Total 2000-2015 (millions)
Seed/Prize/Grant	\$640	\$286	\$328	\$1,254
Venture Capital	\$186	\$373	\$2,300	\$2,859
Private Equity	\$240	\$900	\$695	\$1,835
Acquisition	\$0	\$568	\$1,651	\$2,219
Public Offering	\$0	\$0	\$23	\$23
Total Investment	\$1,066	\$2,127	\$4,997	\$8,190
Debt Financing	\$0	\$3,969	\$1,098	\$5,067
Total with Debt	\$1,066	\$6,096	\$6,095	\$13,257

Table E-1. The magnitude of space investments varies based on investment type and time period.

Recent Growth in Space Investment. Space investment activity has increased dramatically.

- Looking at investment only (excluding debt financing), nearly two-thirds of investment in space ventures since 2000 has been in the last five years.
- In the early 2000s, an average of three space companies were started per year. In the last five years, the number of new companies has averaged eight per year.
- Three-quarters of the value of acquisitions of space ventures since 2000 has been transactions in the last five years (\$1.7 of \$2.2 billion). Monsanto acquired the Climate Corporation for \$930 million in 2013, Google

“You can now make money with space investment, which wasn’t largely a true statement before.”

—Silicon Valley VC

acquired Skybox Imaging for \$478 million in 2014, ViaSat acquired WildBlue for \$568 million in 2009, and Uber acquired deCarta in 2015 for an undisclosed amount.

Record-Setting 2015. The year 2015 was a record-setting year for space ventures with investment and debt financing of \$2.7 billion.

- 2015 was the largest investment year (excluding debt financing) of in the 15-year study period with investment of \$2.3 billion.
- More venture capital (\$1.8 billion) was invested in space in 2015 than in the prior 15 years, combined.
- More than 50 venture capital firms invested in space deals in 2015, the most in any year.

Space Unicorn. One start-up space company, SpaceX, has joined an elite group of companies, called “unicorns,” which are private companies with a valuation of \$1 billion or more. Planet Labs could be the next unicorn in the space industry.

Hundreds of Investors. This research has identified over 250 investors in start-up space companies; all investors are not always disclosed, so the total number of investors is higher. Investors in space companies are primarily based in the United States, representing 66 percent of the total; California is home to half of these investors. The non-U.S. investors, representing 34 percent, are based in 25 countries. Jeff Bezos, Richard Branson, and Elon Musk are well known “space billionaires”; of the 1,826 people on Forbes’ Billionaires List, 21 have an affiliation to a space enterprise.

Leading VCs Investing in Space. Over 110 venture capital (VC) firms have invested in space companies. A handful of VCs have repeatedly invested in common with others; notably, Bessemer, Draper Fisher Jurvetson, First Round Capital, Founders Fund, Khosla, and RRE Ventures. At least two of them have invested in each of these firms: Accion Systems, Planet Labs, Rocket Lab, Skybox Imaging, SpaceX, Spire Global, and The Climate Corporation. See Figure E-1.

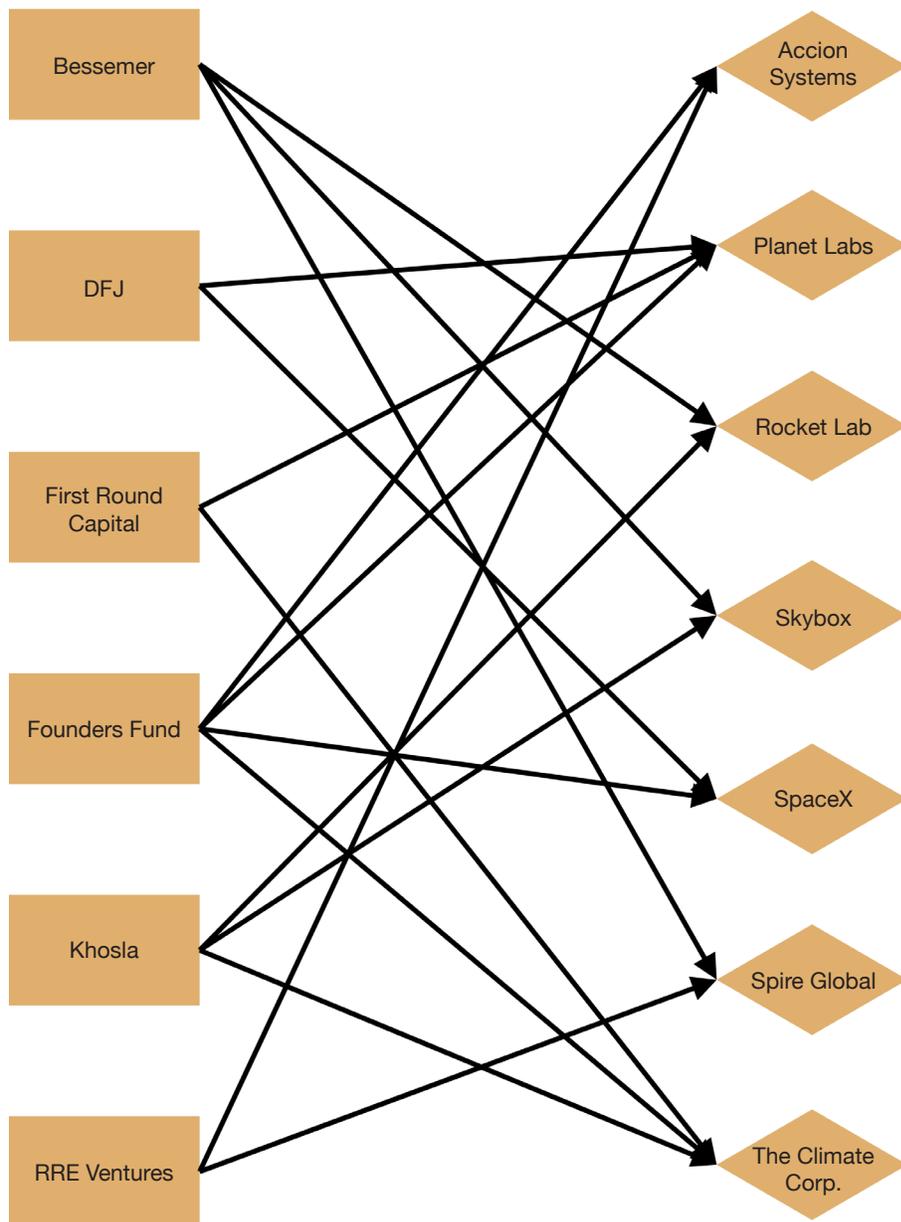


Figure E-1. Common investments among VCs

Executive Summary

Expectation of Sizable Returns. Angels and VCs—many involved in the largest deals in 2015—talked to The Tauri Group about their outlook and motivations. Interviewees attributed the increase in venture investment in space to more attractive opportunities and to successful exits (that is, situations in which early investors have seen returns on their investments). One investor summed up investor expectations succinctly, “You can now make money with space investment, which wasn’t largely a true statement before.”

The Tauri Group conducted this study to characterize those in the investment community who are pursuing space opportunities, and to understand the motivations of these investors. This report will inform NASA and the public about activity in this emerging space ecosystem, and assist government and industry leaders in decision-making as new space firms and capabilities create new options and alternatives. In addition, the report will be a resource for commercial space ventures that seek investors. The report and the project on which *Start-Up Space* is based were funded in part through a research grant from the Emerging Space Office located at NASA Ames Research Center in support of the Office of the Chief Technologist at NASA Headquarters.



Note that analysis of investment magnitude (i.e., dollar value) throughout this report is based on data through December 31, 2015. Analysis of investors and transactions is based on data through October 2015.

Introduction

***Start-Up Space* characterizes investment in start-up space ventures and provides insight into the investor's perspective.**

Space is attracting increased attention in Silicon Valley and in investment communities world-wide. In fact, more venture capital was invested in space in 2015 than in all of the previous 15 years, combined. Space ventures have become attractive to investors because new, lower-cost systems are envisioned to follow the path terrestrial tech has profitably traveled: dropping system costs and massively increasing user bases for new products, especially new data products. Investors say that large valuations and exits are demonstrating the potential for high returns.

Space ventures are defined here as space companies that began as angel- and venture capital-backed start-ups. (This terminology and definition are intended to generally differentiate space ventures from aerospace and defense contractors and large, publicly-traded space enterprises.) *Start-Up Space* seeks to provide insight into the dynamics of this growing space industry segment and the investment driving it.

Start-Up Space characterizes investment in start-up space ventures and provides insight into the investor's perspective.

Purpose and Background

Increased investment in space ventures has meaningful consequences for the space industry in general, for how NASA operates, and for the opportunities and public benefit the industry will yield in the future. Insight into investment in space ventures will inform NASA about the goals and objectives of investors so that it can better partner with industry as a developer of technology, provider of expertise, flight provider, and customer. NASA also seeks appropriate mechanisms for engagement with investors in the space ecosystem.

The *Start-Up Space* report and the project on which it is based were funded in part through a research grant from the Emerging Space Office (ESO), located at NASA Ames Research Center, in support of the Office of the Chief Technologist at NASA Headquarters, and in part by The Tauri Group. The project and report support ESO's mission of "monitoring, investigating, and reporting on opportunities enabled by the rapidly growing national and international entrepreneurial space communities," by conducting an analysis of entrepreneurial trends in commercial space since 2000.

The Tauri Group conducted the study on which *Start-Up Space* is based and produced the report. The Tauri Group has provided support to this project as part of its ongoing commitment to aiding good decision-making in industry, government, and academia by providing the space community with rigorous analyses of industry dynamics.

Start-Up Space examines space investment in the 21st century and analyzes investment trends, focusing on investors in new companies that have attracted private financing. This is a key aspect of current investment trends in space: desirable capital that could be directed at any industry sector is flowing into space companies. This report seeks to inform NASA and the general public about activity in this emerging space ecosystem, and to aid government and industry leaders in decision-making as new space firms and capabilities create new options and alternatives to consider.

Introduction

Methodology

Our data set consists of publicly-reported investment transactions in start-up space ventures as they grow and mature, with details on investment level and investors where reported; additional companies for which little or no transaction data was reported, but which we have identified as space ventures; and qualitative data about investment trends and investor motivations. A key element of the qualitative data is results from interviews with industry leaders and private investors from around the world, including Silicon Valley/San Francisco, Washington, DC, London, Hong Kong, and Sydney.

Definition of Start-Up Space Venture

What is a start-up space venture?

Our definition of a space company is a business entity that provides space products or services, specifically one that:

- Manufactures satellites, launch vehicles, or other space-based systems
- Manufactures ground equipment
- Provides services that rely on these systems, such as satellite TV, radio, and broadband
- Provides analytic services based on data collected from space-based systems, either alone or in combination with terrestrial systems

Some firms do not have a clear enough business model to be easily identified as a space company. Particularly in analytic services, the use of satellite data may not be explicit.

To define a space **start-up venture**, we used a screening criterion that accepted those space firms that have received and reported seed funding, venture capital, or private equity investments. We term these firms start-up space ventures throughout this report. (There is no one standard, widely accepted definition for what constitutes a start-up. Typically, different stages within start-ups are described. For example, one typology is: seed stage is an idea that is not yet operational; early stage has begun operations but not yet fully operational; growth stage has commercial revenues but needs outside capital to scale; expansion stage is just prior to an initial public offering (IPO). These are examples; there is no universally agreed-to set of definitions. Venture capital firms may focus on a particular stage, for example building a portfolio of early stage companies, or one with a growth stage focus.)

Data Set

We include in our data set all firms that meet this criterion at any time during the period 2000–2015. Analysis of investment magnitude (i.e., dollar value) throughout this report is based on data through December 31, 2015. Analysis of investors and transactions is based on data through October 2015.

Note that the data set includes all types of investment (seed, venture, private equity, acquisition, and public offering) in the firms that fall within the definition of start-up space ventures. A firm that receives venture funding and then receives a significant

investment from a private equity group would be considered a start-up space venture by our definition, and the investments of both the venture firm and the private equity group would be included. On the other hand, a long-standing aerospace firm that recapitalizes and receives an investment from the same private equity group would not be considered a start-up and the private equity investment would not be included in this analysis. The focus of this analysis is new space ventures and the capital they are attracting.

Note that the seed category includes funding from prizes (such as business plan competitions or XPRIZE), foundations, and crowdfunding campaigns. We also include debt financing for space ventures to provide a complete picture of the capital available to the management team at these companies.

Sources of data on companies and investments include Tauri Group databases; company and investor press releases; annual reports, investor materials, and SEC filings; financial newsletters and databases such as CrunchBase, PitchBook, and CB Insights; news articles from major media outlets, such as Wired, Bloomberg, Fortune, and Forbes; trade press, such as SpaceNews, Milbank's Space Business Review, and business journals; and on-going engagement with industry subject matter experts. Where possible, we confirmed the details of each investment using multiple sources. We further validated our data with investment bankers, industry experts, the management team at space companies, and through targeted interviews.

The data set includes only publicly reported transactions; it does not include proprietary investment information. In some cases, transaction value, funding round, or investor is undisclosed.

The data set generally excludes government funding, except for certain grants. A few quasi-government corporations are included, where they participate in funding rounds with economic development objectives.

Overview of Start-Up Space Ventures

Over 80 new angel- and venture-backed space companies were started in the period 2000 to 2015. In the early 2000s, an average of three such companies was started per year. In the last five years, the number of new angel- and venture-backed companies averaged eight per year, and that average excludes new firms that have not yet secured investment. There is generally a multi-year lag from when a company is founded to when it receives external investment. Therefore, recently founded companies have not had a chance to raise (and/or announce) external funding. The number of examples of start-up space ventures that have not announced investment in the box below further signals a continuing growth trend.

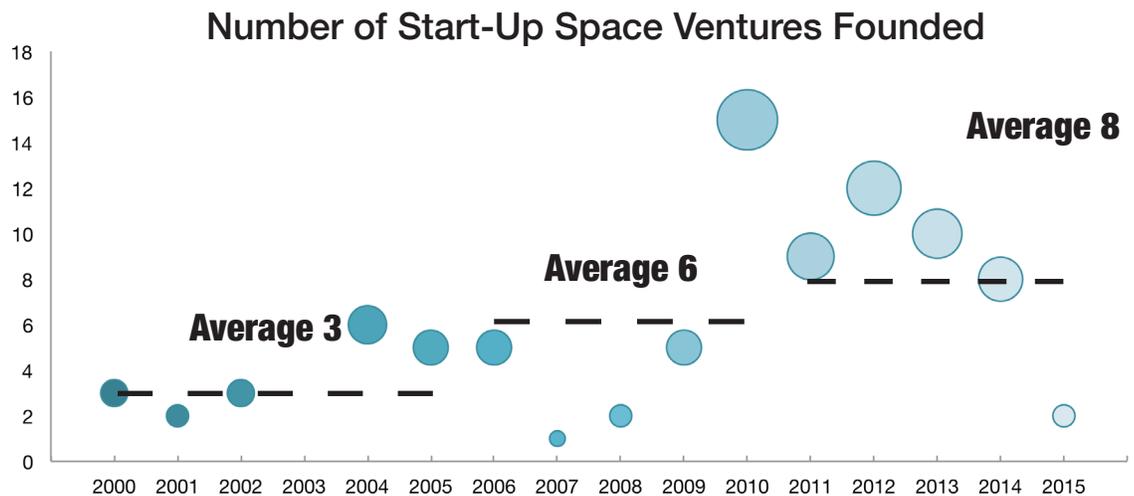


Figure 1. Over 80 angel- and venture-backed space companies have been founded since 2000. Excludes companies that have not announced investment, including many founded in the last few years.

Space start-ups that have received funding from announced sources are listed throughout the report, and there is a group of companies so new that they have not announced any investment. (The list below contains examples). Reasons for not announcing funding include actively pursuing funding or protecting a competitive advantage. Another group of companies has announced investment, but not who the investors are. These companies include ARTEMIS Space, Escape Dynamics, Falcon Nano, Gateway Galactic, GeoOptics, HySpecIQ, ispace technologies, Microlaunchers, and Spaceknow.

Examples of start-ups that have not announced investment

Alpha CubeSat	Exploration Solutions	OffGlobe	Sunstar Aircraft Industries
Andespace	Generation Orbit Launch Services	Orion Applied Science & Technology	Swiss Space Systems
Aquila Space	Hybrid Galactic	PlanetiQ	Tempus Global
Asteroid Mining Corporation	ImageSat	RocketShip Tours	United Space Structures
AstroTechnic Solutions	Kosmo Studio	Send2Space	XpressSAR
Carbon Origins	Kubos	Solstar Communications	
Corvix Space Systems	Made in Space	Space Travel Alliance	
DMCii	Moonspike*	SpaceBIT	
Electrospray Propulsion Systems	Norstar	Stylish Astronaut	*unsuccessful Kickstarter campaign; funds raised were forfeited per Kickstarter policy

#StartupWeekend Space

Indicative of the growth in start-up space, “StartupWeekends” are intense weekend events, pitching and prototyping start-up ideas, some of which may turn into new companies. A StartupWeekend for space in 2015 reflects increased interest in space start-ups. With the slogan “Think big, be bold, #BeSpacial,” the first StartupWeekend Space in Europe and Asia took place in April 2015 in Bremen and Shanghai simultaneously. With 124 participants across the two regions, the events attracted aspiring and current entrepreneurs from within and outside the space sector to create space start-ups. Eleven teams in Bremen and seven in Shanghai were formed, supported by experienced mentors with technical, managerial, entrepreneurial, and policy backgrounds. The simultaneity of the events allowed the mentors to provide support to both locations, giving the teams developing their business ideas insights into a market in a separate region.

The events ended with short five-minute pitches to panels of judges comprised of investors, entrepreneurs, and technical experts. Winning teams chosen by the panels were awarded prizes aimed at advancing their presented business concepts. Six months later, six of the eleven Bremen teams are continuing their projects with one team incorporated and funded. Since the pilot events, StartupWeekend Space has gained grassroots traction in Europe and Asia with a follow-up event occurring in Gdansk, Poland in October 2015 and additional events being planned in both regions.



Overview of Space Investors

Types of Investor

This analysis considers six categories of investor, to aid in understanding trends in investment and investor motivation. The investor typology consists of: angel investors, venture capital firms, private equity (PE) firms, banks (typically not strictly investors, but an important source of capital), corporations (as strategic partners and/or internal investors, or through corporate venture funds), and public markets. This typology conceptually groups some investor types that could be treated separately but share characteristics, such as sovereign wealth funds (included in private equity category) and hedge funds (included in the venture capital firm category). While investor categories continue to shift and evolve, the typology here provides a useful (and generally accepted) broad brushstroke description of groups of investors and their typical investment behaviors.

We describe each type of investor and typical (1) role as a funding source, including the stage of involvement, (2) preferred funding instrument (e.g., debt, equity, or hybrid debt/equity instruments) and (3) general objectives in investing. For illustrative purposes, examples of select space deals are also provided.

Angel Investors

Typically, angel investors are individuals or families (to include family offices) that have accumulated a high level of wealth and seek potentially high returns by investing in ventures during their early stages. Investment by angels into space ventures is usually in the form of straight equity into the company. Investments often range from \$50,000 to more than \$1 million. There is a highly-visible special category of angel investor in the space ecosystem, consisting of billionaires and other ultra high net worth individuals who have personally staked new space companies. The investment level by space billionaires far exceeds typical angel levels.

By getting in at the ground floor (i.e., when a company is usually at its nascent stage, just starting development of its product or service), an angel investor can realize an attractive potential return, as the early investment will secure a significant foothold in the investee company. Time horizons for angel investors are about 5 to 7 years, meaning they seek to realize their return (i.e., exit) about 5 to 7 years from the date of investment. Angels may expect an equity stake in the company as high as 30 to 40 percent in return for their investment; however, frequently, angel stakes are much lower, especially after subsequent, larger investors join the capital structure. Upon exit, angels may expect to receive at least 5 to 10 times their investment. Angel investors range from those who can comfortably make a \$50,000 investment to, as noted, particularly in commercial space ventures, multi-billionaires who have already made their mark in technology-driven enterprises, such as Jeff Bezos of Blue Origin (Amazon) and Elon Musk of SpaceX (PayPal).

Venture Capital Firms

Venture capital (VC) firms are groups of investors that invest in start-up, early stage, and growth companies with high growth potential, and accept a significant degree of risk. The trade of risk for potential high returns results in a high failure rate; a recent research study by a Harvard Business School faculty member finds that, “About three-quarters of venture-backed firms in the U.S. don’t return investors’ capital.”

VC funding has traditionally come in stages (or rounds), generally designated Series A, Series B, Series C, etc. The form of investment is equity; specifically, the instrument is usually preferred stock, which gives the VC firm an equity ownership stake in the investee company, but at a higher priority (or preference) than investors at common equity (e.g., founders, employees, and angels) and a lower priority than any holders of company debt. The preferred shares are usually convertible to common stock in the instance of an IPO (see “Public Markets”) or sale of the company, which are the typical instances of a VC’s exit. There is substantial variation in the size of rounds, but Series A investment rounds typically range from \$2 to 10 million; Series B, in the low tens of millions of dollars; and Series C, in the high tens of millions of dollars. Investment syndicates comprised of multiple VC firms may significantly increase these levels. Note that the distinct ‘series’ model for VC investments is evolving with more continuous investment by an ongoing team of investors emerging as a trend.

An example of a space-based company receiving multi-stage VC investment is Skybox Imaging, a company founded in 2009 with the intention of building and launching small satellites in constellation form to provide frequent Earth imagery updates to customers around the globe. Its first round of VC funding was a \$3 million Series A tranche (by Khosla Ventures) in 2009, followed by an \$18 million Series B funding (by Khosla Ventures and Bessemer Venture Partners) in 2010. In 2012, Canaan Partners and Norwest Venture Partners joined the original two firms, leading a Series C funding that raised an additional \$70 million (for a total of \$91 million in VC funding). The exit for these VCs took place in 2014 when Google bought Skybox Imaging for \$478 million (representing about

5.5 times the total VC funding). Another example is Planet Labs, which reported five investment rounds at increasing valuations, as shown in Figure 2. These rounds represent \$206 million of investment (including debt financing), involving 17 named investors and others. Many investors participated in multiple rounds.

Space-oriented VC funds are emerging from this class of investors. Seraphim Capital is a \$126 million space-focused fund raised by Airbus Defence and Space, Thales

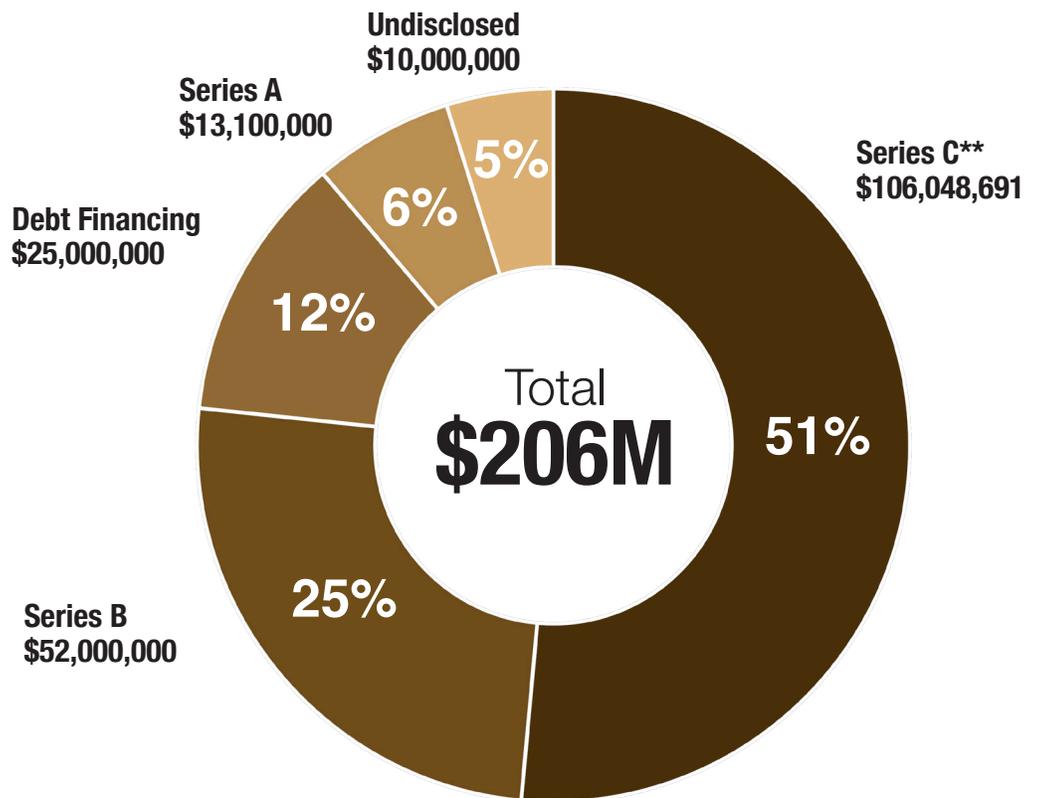


Figure 2. Angel and venture capital investment in Planet Labs.

***Amount shown for Series C is current as of July 10, 2015, per SEC Form D; \$26,749,999 left to be raised in amended investment round.*

Overview of Space Investors

Alenia Space, Telespazio, Com Dev, and Avanti Communications (per Via Satellite). Based in London and focused mostly on UK-based companies, the fund represents an interest in space investments (broadly defined, to extend to technologies developed for use in space and now being applied in other areas). Bessemer Venture Partners announced a \$1.6 billion fund to invest in innovative companies, to include the space sector. They note their investment in Skybox Imaging “was just the beginning.” Rocket Lab and Spire Global are also part of their portfolio. Russia and China launched a venture fund in 2015, with space technology as one focus area (reported by Fortune).

Private Equity

Private equity firms or groups are formed by investors to directly invest in companies. They typically invest in established companies (not start-ups) at large transaction sizes, and often acquire an entire company or a group of related companies that can be merged. Examples of investors represented include many types of institutional investors (e.g., large pension funds), as well as aggregated pools of high net worth individuals.

The larger investment firms, which typically have multi-billion dollar investment funds from which to draw, have shown some interest in space over the past 15 years. Firms such as Blackstone, Columbia Capital, Permira, Apax, and Carlyle Group have historically shown an appetite for investing in space-based firms, typically in the telecom industry or government contracting. Larger private equity firms are likely to invest between \$100 million to \$1 billion, usually in the form of equity. Sometimes, they invest in the form of later stage capital (i.e., later than angel and VC investors) or through outright purchase of targeted companies. This has been the case for several large commercial satellite operators.

Examples of private equity investment in space include Blackstone’s \$200 million investment in Sirius Satellite Radio and its nearly \$1 billion purchase of the commercial satellite capacity provider, New Skies Satellite; Columbia Capital’s substantial investment in XM Satellite Radio; and Apax, Permira, and Carlyle Group’s multi-hundred million dollar investments in the acquisitions of large satellite services companies, such as Intelsat, Inmarsat, and PanAmSat from 2003 to 2004. Permira bought Asia Broadcast Satellite for \$200 million in September 2010; however, there have been few space-related private equity deals since the financial downturn in 2007/2008. Investment of \$490 million in Virgin Galactic by Aabar Investments in 2009 and 2011 is one example. Being a start-up founded in 2004, providing launch services sets it apart from earlier private equity deals in existing satellite communications companies.

Corporations

Corporations have often provided the funding necessary to bring space-based programs to initial operating capability, as well as to sustain ongoing programs. Corporations invest internally, in R&D, in manufacturing, in operations and processes, and in many other areas to enhance capabilities to create or strengthen an existing expertise/advantage. (A special category of internal investment typical of space firms for whom the U.S. government is a major customer is “independent research and investment (IR&D),” which is a type of government-sanctioned R&D

expenditure that affects how the government pays a contractor firm for the work that it does.)

A corporation may also provide funding for a venture, usually in the form of straight equity or sometimes in the form of debt, with the option to convert the instrument into equity of the investee company. Some companies may also invest through a corporate venture fund, which acts as a company-owned VC equivalent.

Examples of where the corporation serves as a strategic partner include Liberty Media, a longtime cable operator, investing in DirecTV; WildBlue, a satellite-based broadband delivery platform; and O3b, a fledgling satellite-based internet delivery constellation, in the multi-hundreds of millions of dollars to over \$1 billion from 2006 to 2010. In 2009, SES, a commercial geosynchronous orbit (GEO) satellite fleet operator, invested \$75 million (30 percent stake, early in the investment cycle) in O3b. More recently, the industry has seen a bevy of disparate investors in space, with Google buying Skybox and major companies, such as Virgin, Coca-Cola, Intelsat, Airbus, Qualcomm, and Hughes Network Systems, investing a total of \$500 million in a satellite constellation, focused on providing customers internet access. In addition, Google invested \$900 million in SpaceX in February 2015 “to support continued innovation in areas of space transport, reusability and satellite manufacturing.”

Corporations also acquire firms. A recent record-setting example is the AT&T purchase of DirecTV in 2015 for \$48.5 billion, which set a new bar for acquisition of a space company. Note that DirecTV is not a start-up venture by our definition. This transaction is more typical of the merger and acquisition activity for established companies. Corporations have recently acquired firms that fit the model of start-up space ventures; The Climate Corporation by Monsanto for \$930 million and Skybox Imaging by Google for \$478 million represent exits by new space ventures.

Banks

Banks have been heavily involved in providing funding for space-based programs of large, established firms (such as GEO satellite operators) during the past 15 years. The basic model is that equity investors provide a substantial “cushion,” (e.g., 30 percent of the total capital expense, or CapEx, required for a certain program, such as deployment of a satellite or satellites). The remainder of CapEx (or other types of programmatic expenditure) is financed by debt, sometimes in the form of “convertible debt,” meaning that the initial instrument is in the form of debt. At certain trigger points, the debt can be converted, in whole or in part, into an equity stake in the financed company.

Commercial banks such as Wachovia, Wells Fargo, and Citibank, in the U.S., and Deutsche Bank, BNP Paribas, and ABN AMRO, in Europe, have provided debt financing at a magnitude of \$100 million to \$1 billion (sometimes exceeding \$1 billion) per funding event. Most of the companies financed are companies with large satellite CapEx requirements, such as Intelsat, SES, and Inmarsat, for which multiple GEO satellites are required: each costs \$250 million to \$300 million to build, launch, and insure. Other companies financed (e.g., Iridium and GlobalStar) have \$2 billion to \$3 billion CapEx requirements for low Earth orbit (LEO) satellite constellations.

Overview of Space Investors

The Export-Import Bank's authorization lapsed in July 2015. On December 4, 2015, the Bank resumed activities with President Obama's signature on the reauthorization bill.

In addition, government-backed banks (i.e., export credit agencies), such as U.S. Export-Import (Ex-Im) Bank and COFACE of France have provided debt funding (or guaranteed third-party debt funding) for several satellite systems. Ex-Im Bank has provided multi-hundred million dollar debt financing over the past 3 years to satellite operators, including ViaSat of the U.S., AsiaSat and Asia Broadcast Satellite in Asia, and Space Com in Israel. COFACE has backed the debt obligations of several satellite constellations, including O3b, GlobalStar, and Iridium. Both Ex-Im Bank and COFACE have provided loans and debt guarantees to an Australian company, NewSat, for \$400 million. Moreover, Ex-Im Bank provided \$525 million in debt financing for ViaSat in November 2014. Proceeds were earmarked for the build and launch of the company's two Ka-Band (broadband) satellites.

Banks are less likely to have a major role in providing financing start-up ventures.

Note that investment banks and investment bankers, often visible actors in complex investment transactions typically involving private equity, corporations, and/or public markets, act as brokers arranging and facilitating these transactions, rather than lenders or investors. Investment banks play a variety of roles, including advising on capital raising approaches and more strategic transactions such as merger and acquisition (M&A), as well as underwriting a capital raising event (e.g., an IPO). Investment banks often focus on large transactions (typically in the multi-\$100 million to over \$1 billion range) and all the leading space/satellite communications companies have their "top drawer" financial advisors in the name of investment banks. These institutions will usually take the role of "lead managers" of a financing transaction, often with several fulfilling that position (e.g., J.P. Morgan, Lehman Brothers, and UBS acted as joint lead managers for a \$500M capital raise in 2007 for mobile satellite services fledgling operator, TerreStar (now owned by DISH Network)).

Public Markets

Toward the later stages of a space-based company's funding trajectory, there can be a public sale of the company's equity (common stock), or IPO. The IPO enables additional capital to be raised to supplement prior fundings and also provide previous investors an exit vehicle for their investments (i.e., sell their equity shares in the public market place). Many established space companies and government contractors have long since had their IPOs and continue to trade publicly. Examples include Boeing, Lockheed Martin, Orbital ATK, and Harris Corporation.

IPOs in the space industry have ranged from around \$100 million (e.g., GlobalStar and Orbcomm) to about \$2 billion (e.g., Intelsat). Secondary offerings (post-IPO) also serve to provide funds for capital expenditures and other corporate purposes (e.g., operations, working capital, and retirement of debt). In 2014, Iridium raised \$170 million through public sales of \$50 million in common stock and \$120 million in convertible preferred stock. IPOs of space start-ups have been very limited, such as UrtheCast going public on the Toronto Stock Exchange through a reverse IPO in 2013. See Table 1.

Type of Investor	Characterization of Investor	Typical Space Industry Investment	Investment Type	Examples of Transactions	Expected Returns/Exit Horizon
Angel Investors	High-wealth individuals or families seeking high returns through early stage investment	\$50K - \$1M	Equity	Space Angels Network and NanoRacks	5-10X investment/ 5-7 years
Venture Capital Firms	Groups of investors focusing on early stage, high growth ventures and accept a significant degree of risk	\$2M - high tens of millions	Equity, preferred stock in several tranches (e.g., Series A, B, C)	Skybox Imaging with multiple VCs investing \$91M	5X investment/ 5 years
Private Equity Firms	Large investment houses, which have multi-billion dollar investment funds –focus on established companies	\$100M - \$1B	Equity	Blackstone \$200M investment in Sirius Sat Radio	3-5X investment/ 3-5 years
Corporations	<p>Large companies providing strategic investments to support large CapEx space projects</p> <p>Internal R&D for special projects</p> <p>Independent R&D as government contractor</p> <p>Merger and acquisition activity</p> <p>Venture investing</p>	\$100M - \$1B	Equity and sometimes debt	<p>Google \$900M investment in SpaceX</p> <p>SES investing \$75M in O3b</p>	Significantly less returns than for PE firms/horizon is over a long term
Banks	Private and government-backed banks providing substantial debt funding layered over equity	\$100M - \$1B	Debt, sometimes convertible into equity	Ex-Im Bank providing \$525M in debt to finance ViaSat satellites	Straightline interest rates (e.g., 5-10%)
Public Markets	Later stage funding vehicle for supplementary fundings	\$100M - \$2B	Equity	Iridium raising \$170M in an IPO	Serves as a vehicle to allow the earlier investors to exit

Table 1. Different types of investor pursue different types of investment objectives.

Space Investment by the Numbers

Cumulative investment (including debt financing) in start-up space ventures since 2000 totals \$13.3 billion. This includes seed investment (and a small amount of grants and prizes), venture capital, private equity, acquisitions, public offerings, and debt financing. Looking at investment only (excluding debt financing), nearly two-thirds of investment in start-up space firms since 2000 has occurred in the last five years. The vast majority has been venture capital.

The year 2015 was a record-setting year for space ventures, with investment and debt financing of \$2.7 billion. It was the largest investment year, \$2.3 billion (excluding debt financing), of the 15-year study period. More venture capital (\$1.8 billion) was invested in space in 2015 than in the prior 15 years, combined.

The mix of investment types (including financing) has evolved over the last 15 years. Seed funding is evident in most years, though comparatively small compared to other investment types. Private equity and debt financing are prominent in the middle years of this timeframe, whereas acquisitions and venture capital become more pronounced in recent years. See Figure 3 for year-by-year investment. In addition, Table 3 shows investment by type in three periods, 2000-2005, 2006-2010, and 2011-2015, and Table 4 shows annual averages for each.

Magnitude of Investment in Start-Up Space Ventures

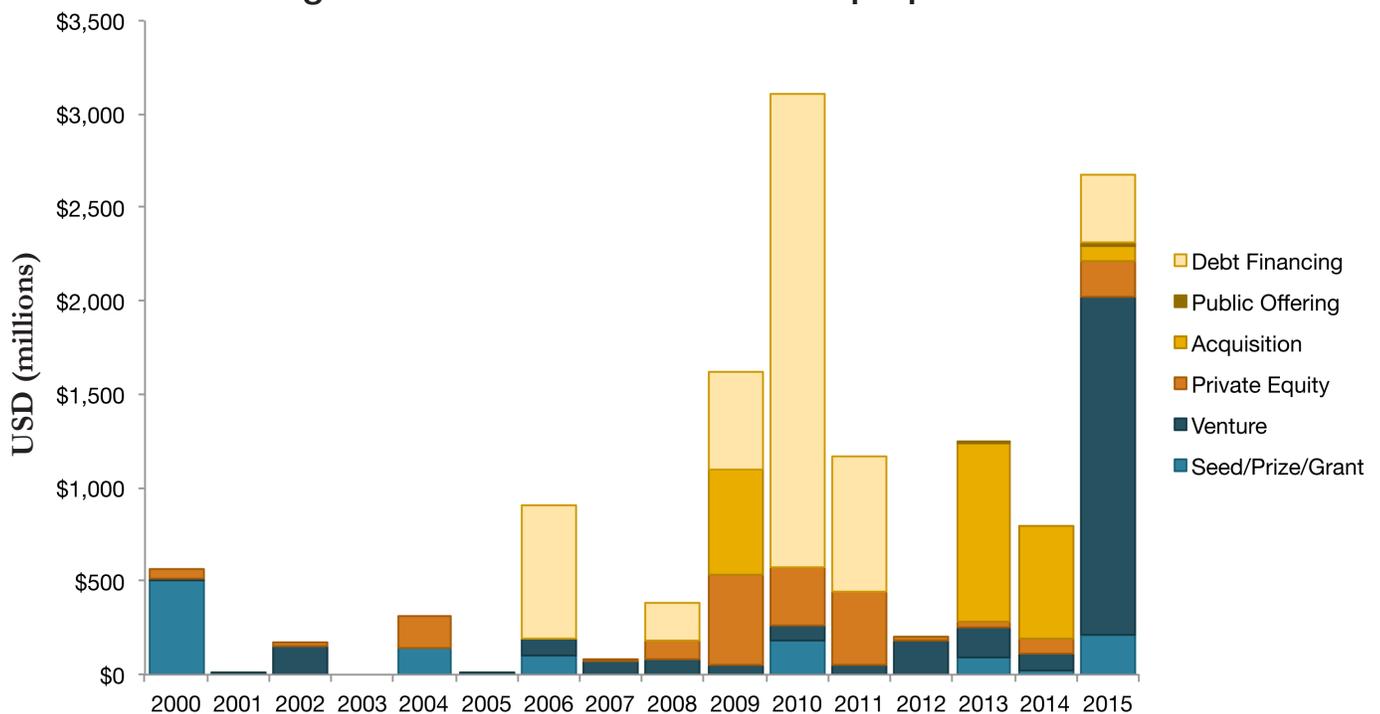


Figure 3. The mix of types of investment in space companies varies over 2000 to 2015.

Seed Funding

For the total period, seed funding is \$1.3 billion. Note that the large seed funding amount in 2000 primarily represents an estimated \$500 million commitment by Jeff Bezos to Blue Origin; that amount is counted here in the year of the company's founding. However, the timing of the commitment is not public. It may be spread more evenly over the 15-year period, and (based on company activity and employment) appears to have been spent at a higher rate in recent years. Excluding the investment in Blue Origin in 2000, seed funding has increased in each of the periods considered, with nearly half (43 percent) in the 2011 to 2015 period.

Venture Capital

Venture capital investment totals \$2.9 billion with 80 percent in the last five years. In fact, venture capital in 2015 outstrips all venture capital to date by a factor of 1.7. VCs invested \$1.8 billion in 22 firms (such as series A funding for Astroscale and Orbital Insight, and series B funding for Mapbox and Spaceflight Industries) in 2015. In the years prior, VC investment totaled \$1.0 billion in 31 firms. The largest venture rounds were in 2015: They were SpaceX's \$1.0 billion series E and OneWeb's \$500 million series A.

Private Equity

Private equity investment in space start-ups is \$1.8 billion with 49 percent in the second time period. Aabar Investments provided \$380 million to Virgin Galactic in 2009 and another \$110 million in 2011. O3b received investment of \$230 million in 2010 from an assortment of investors, including Google, North Bridge Venture Partners, Allen & Company, SES, Liberty Global, HSBC Principal Investments, Development Bank of Southern Africa, Sofina, and Satya Capital. In 2011, LightSquared raised \$265 million.

Acquisition

Acquisitions total \$2.2 billion with 74 percent (\$1.7 billion) in the last five years. Over 80 angel- and venture-backed space companies have been founded since 2000; eight of these companies have been acquired. The substantial values for acquisitions in 2013 and 2014 represent Monsanto's acquisition of the Climate Corporation for \$930 million and Google's acquisition of Skybox Imaging for \$478 million, respectively. The next largest acquisition was WildBlue by ViaSat for \$568 million in 2009.

Investors in start-up ventures can see substantial returns if the start-up is acquired. Table 2 shows three companies that started and exited during the study timeframe. Note that in the Skybox transaction, the acquisition value was approximately 5.3 times the reported previous investment. In the Climate Corporation example, it was 8.5 times. Other acquisitions during the study timeframe include BlackBridge by Planet Labs (undisclosed), Deimos by UrtheCast (\$84.2 million), and SkyWave by Orbcomm (\$130 million).

Space Investment by the Numbers

Company	Seed Investment (millions)	Venture Capital (millions)	Private Equity (millions)	Debt Financing (millions)	Acquirer	Acquisition Value (millions)
Skybox Imaging	-	\$91	-	-	Google	\$478
deCarta	-	\$52	\$4	-	Uber	undisclosed
The Climate Corporation	\$4	\$109	-	-	Monsanto	\$930
WildBlue	-	\$206 (+\$187 pre-2000)	-	\$420	ViaSat	\$568

Table 2. Investors in several space start-up ventures have seen substantial returns through acquisition.

Public Offering

One hundred percent of the \$23 million raised through public offering (UrtheCast) is in the last five years (2013 and 2015).

Debt Financing

Debt financing for space ventures totals \$5.1 billion with 78 percent in the 2006 to 2010 period. The transactions were for Protostar (2006, 2008), WildBlue (2006), O3b (2009, 2010, 2011), LightSquared (2010), and DigitalGlobe (2011). In 2015, O3b, Planet Labs, and UrtheCast obtained significant debt financing.

Investment Type	2000-2005 (millions)	2006-2010 (millions)	2011-2015 (millions)	Total 2000-2015 (millions)
Seed/Prize/Grant	\$640	\$286	\$328	\$1,254
Venture Capital	\$186	\$373	\$2,300	\$2,859
Private Equity	\$240	\$900	\$695	\$1,835
Acquisition	\$0	\$568	\$1,651	\$2,219
Public Offering	\$0	\$0	\$23	\$23
Total Investment	\$1,066	\$2,127	\$4,997	\$8,190
Debt Financing	\$0	\$3,969	\$1,098	\$5,067
Total with Debt	\$1,066	\$6,096	\$6,095	\$13,257

Table 3. The magnitude of space investments varies based on investment type and time period.

Investment Type	Average 2000-2005 (millions)	Average 2006-2010 (millions)	Average 2011-2015 (millions)	Average 2000-2015 (millions)
Seed/Prize/Grant	\$107	\$57	\$65	\$78
Venture Capital	\$31	\$74	\$460	\$179
Private Equity	\$40	\$180	\$139	\$115
Acquisition	\$0	\$114	\$330	\$139
Public Offering	\$0	\$0	\$5	\$1
Average Investment	\$178	\$425	\$999	\$512
Debt Financing	\$0	\$794	\$220	\$317
Average with Debt	\$178	\$1,219	\$1,219	\$829

Table 4. The annual average of space investments varies based on investment type and time period.

The average investment level per year, as noted above, is \$829 million, which is affected by a surge in debt financing in 2010. Looking at the other investment types, the average venture capital level is \$179 million per year, with an average of \$460 million in the most recent five-year period. The average acquisition level is \$139 million per year, but is \$330 million per year in the most recent period. The average seed funding level was \$65 million per year in the last five years, up from \$57 million per year in the prior period. These three investment types show an upward trend, while private equity is trending down. See Figure 4.

Average Investment in Start-Up Space Ventures, by Period

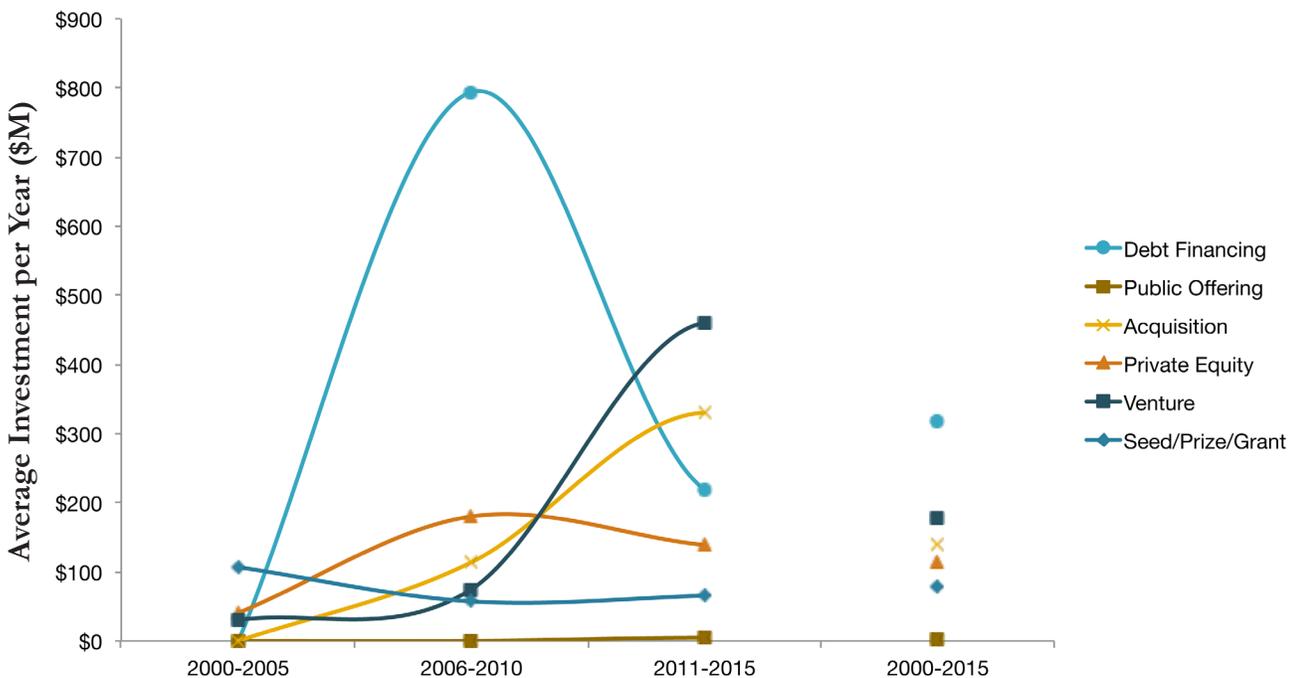


Figure 4. Seed, venture funding and acquisitions are trending up, while PE and debt financing are trending down.

Space Investment by the Numbers

Valuation

Substantial valuations can accompany substantial investment in space ventures. While valuations for all companies are not publicly available, there are some notable valuations. SpaceX has joined an elite group of companies, called “unicorns,” which are private companies with a valuation of \$1 billion or more. SpaceX is valued at \$12 billion and holds the number 8 spot on Fortune’s Unicorn List, which numbers just over 130 companies as of August 2015. Two more space start-ups have been highlighted as potential unicorns. Planet Labs was identified by CB Insights as being on track to a \$1 billion valuation. Accion Systems won a start-up pitch contest at Fortune Magazine’s Brainstorm Tech conference, convincing the judges that it might be worth \$1 billion someday.

Space Investors by the Numbers

Overall

This research has identified over 250 investors that have provided funding to early stage and start-up space companies. All investors are not always disclosed, so the actual number of investors is even higher. Over the 15-year time period, we looked at the distribution of investors across the five categories. Venture capital firms represent the largest number of investors in space companies, followed by angel investors. These two investor groups comprise two-thirds of the investors in space ventures. Private equity firms, corporations, and banks (debt financing) make up the remaining third. There is small participation by a few altruists, who have provided grants or prizes, such as Thiel Foundation, Knight Foundation, XPRIZE Foundation, and Space Frontier Foundation, primarily through business plan or other competitions. See Figure 5.

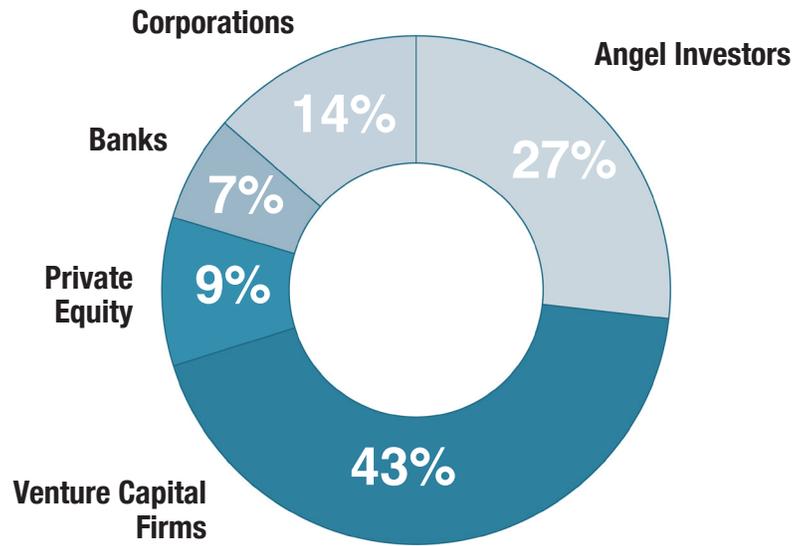


Figure 5. By number of investors, VCs are the largest investor group for space start-ups.

The number of investors has grown over the last 15 years. From 2000 to 2005, the number of investors per year averaged 7, and from 2006 to 2010, averaged 19. From 2011 to 2015 (partial year), the average is 55. This is nearly an eight-fold increase from the first period to the third. Figure 6 shows the unique investors in each year.

Number of Investors in Start-Up Space Ventures

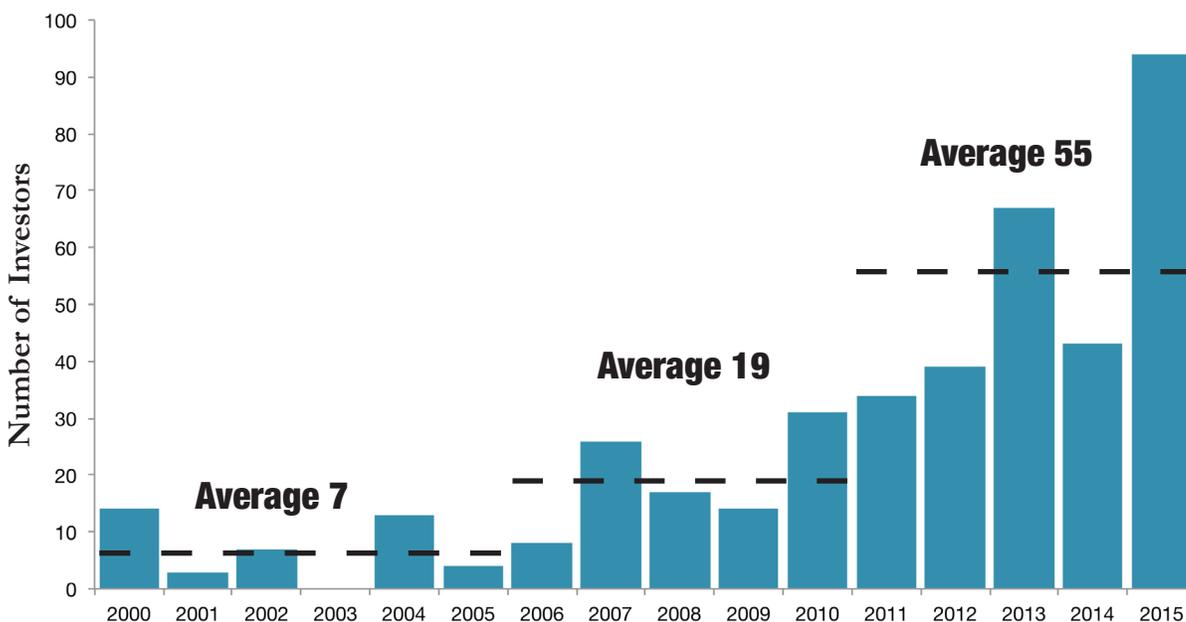


Figure 6. The average number of space investors per year has grown from 7 to 55.

Space Investors by the Numbers

The mix of investors changes from year to year, as shown in Figure 7. The trend for each investor group is discussed in the sections below. Venture capital firms are prominent in almost every year. Angels are also pronounced, particularly in the second half of the period. Activity by private equity firms and corporations is notable throughout. The year 2015 was also an active year for corporations investing in space companies, particularly with the slew of international firms investing in OneWeb. There is very little activity in public markets as UrtheCast is the only company that goes public (through a reverse IPO). Banks (typically providing debt financing) appear prominently in 2010 and 2011. Deals for O3b and LightSquared brought many banks to the table in 2010 and O3b and DigitalGlobe in 2011.

Number of Investors in Start-Up Space Companies

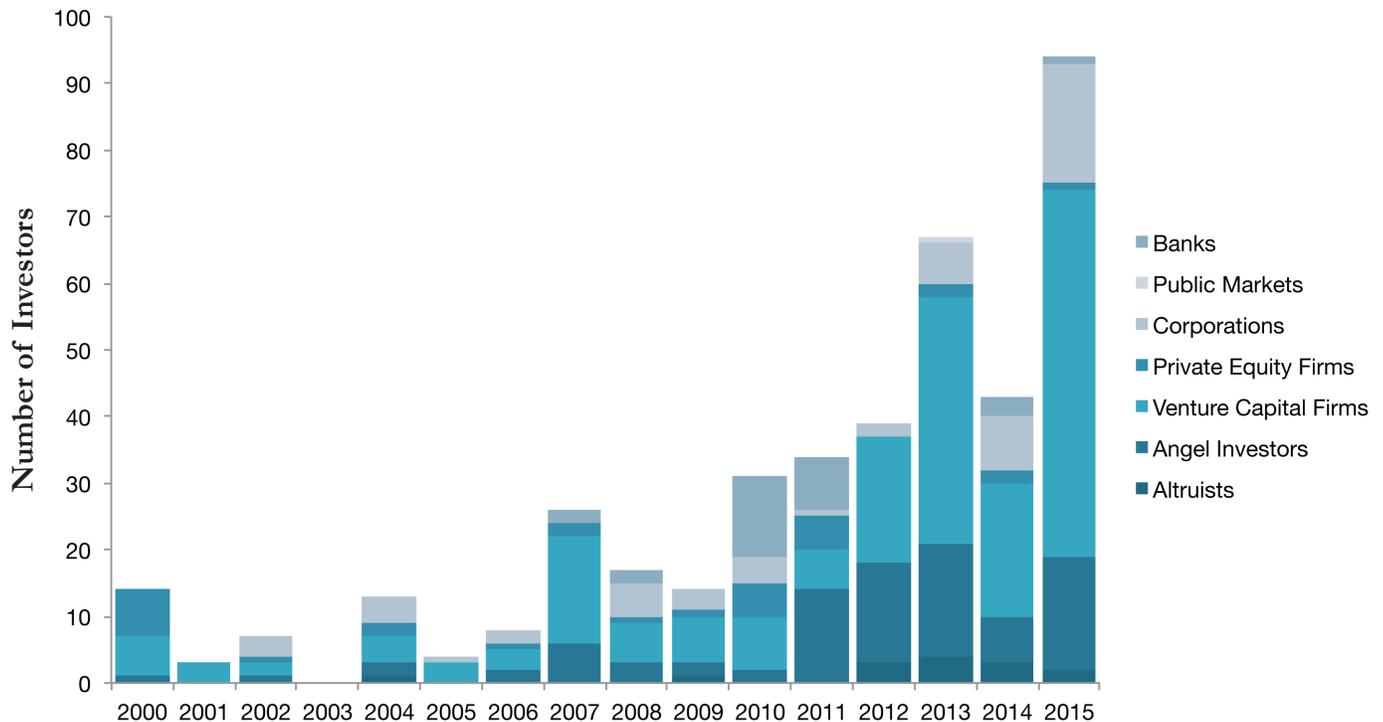


Figure 7. The mix of investors in space companies varies year to year.

Investors in space companies are primarily based in the United States. These 176 investors make up 66 percent of the total. California is home to the majority of investors (81), representing 30 percent of the total. The other 95 investors or 36 percent are located elsewhere in the United States, with New York as a notable example.

The non-U.S. investors are based across the globe. These 90 investors are in 25 countries, represented in 4 regions. The United Kingdom and Canada are each home to more than 10 investors in space companies, with the United Kingdom hosting about 20 percent of non-U.S. investors. Japan, Hong Kong, and Russian Federation are home to five or more space investors.

Europe			
Belgium	Luxembourg	United Kingdom	
Denmark	Netherlands		
France	Russian Federation		
Germany	Switzerland		
Middle East			
Israel	Jordan	United Arab Emirates	
Asia/Africa/Oceania			
China	India	New Zealand	
Cote d'Ivoire	Japan	Singapore	
Hong Kong	Korea, Republic of	South Africa	
Americas			
Argentina	Brazil	Canada	Mexico

Angels

Since 2000, over 60 angel investors have invested in early stage space companies. Angel investors include individual angels and groups of angels. Angels must be accredited investors, as defined by the Securities and Exchange Commission, with either earned income that exceeds \$200,000 (or \$300,000 if married) per year or has a net worth over \$1 million. For example, Space Angels Network has over 100 accredited angels. To be included in the data set, at least one angel has announced their investment. Most angel investments are not made public, so the actual number of investors is higher.

The most prominent angel investors are “space billionaires.” These billionaires have accrued their wealth through other successful businesses or investments and have either founded a space company or invested their own money in a space company. Jeff Bezos, Richard Branson, and Elon Musk are usually the first billionaires mentioned, but they are not the only ones. Of the 1,826 people on Forbes’ Billionaires List, 21 have an affiliation to a space enterprise. This represents about one percent of billionaires. See Table 5.

Other notable individual angel investors are Dylan Taylor and Esther Dyson. One has been involved with 6 different space start-ups, while the other has been involved

Space Investors by the Numbers

Forbes Rank	Name	2015 Net Worth (billions)	Source of Wealth	Notable Space Affiliation
1	Bill Gates	\$79.2	Microsoft, self-made	Kymeta
15	Jeff Bezos	\$34.8	Amazon.com, self-made	Blue Origin
19	Larry Page	\$29.7	Google	Planetary Resources
43	Charles Ergen	\$20.1	Satellite TV, self-made	DISH Network
51	Paul G. Allen	\$17.5	Microsoft, investments	Scaled Composites, Stratolaunch Systems, Vulcan Aerospace
56	Ma Huateng	\$16.1	Internet, self-made	Satellogic, Moon Express
81	Sheldon Adelson	\$31.4	Casinos, self-made	SpaceIL
100	Elon Musk	\$12.0	PayPal, Tesla Motors, Solar City, self-made	SpaceX
137	Eric Schmidt	\$9.1	Google, self-made	Planetary Resources
168	Ricardo B. Salinas	\$8.0	Retail, media	OneWeb
330	Richard Branson	\$4.8	Virgin, self-made	OneWeb, Virgin Galactic
393	Subhash Chandra	\$4.2	Media, self-made	Teledesic, ICO
462	Lynn Schusterman	\$3.7	Oil and gas, investments	SpaceIL
557	Yuri Milner	\$3.2	Facebook	Planet Labs, SETI
847	Peter Thiel	\$2.2	Facebook, Palantir, self-made	SpaceX
1006	Kavitark Ram Shriram	\$1.9	Venture capital, Google	Planetary Resources
1054	Craig McCaw	\$1.8	Telecommunications	Teledesic, ICO
1105	H. Ross Perot Jr.	\$1.8	Computer services, real estate	Planetary Resources
1324	Charles Simonyi	\$1.4	Microsoft, self-made	Planetary Resources
1324	Kenji Kasahara	\$1.4	Social networking website, self-made	Astroscale
1741	Morris Kahn	\$1.0	Software, self-made	SpaceIL

Table 5. Twenty-one billionaires have a notable space affiliation. (Source: Forbes Billionaires)

with Space Adventures and XCOR Aerospace. Two companies that included many individual investors are Astroscale (8) and Dauria Aerospace (6).

Angel investors have found power in numbers and pool their resources. Angels come together and invest in groups, often called syndicates, such as Boston Harbor Angels, which invested in XCOR Aerospace, and Green Angel Syndicate, which invested in Global Surface Intelligence. Space Angels Network has been particularly active with more than a dozen different transactions in the last 10 years.

Angels investing in space companies are primarily based in the United States. Angels based in the United States comprise 71 percent of the total. California is home to the majority of angels, representing 32 percent of the total. The other 39 percent are located elsewhere in the United States, including Washington, DC and New York.

The non-U.S. angel investors are based across the globe. Seven countries are represented in three regions. Japan, Russian Federation, and United Kingdom are home to multiple angels investing in space companies, with the Japan hosting about a third of non-U.S. angels.

Europe

Germany

Russian Federation

United Kingdom

Asia/Africa/Oceania

India

Japan

Singapore

Americas

Argentina

Canada

Angels have been increasingly investing in space companies. From 2000 to 2005, the average number of angel investors per year was 1. There was no angel activity publicly reported in 2001, 2003, and 2005. From 2006 to 2010, the average was 3. Starting in 2011, the average number of angel investors per year jumped to 14—a five-fold increase over the previous five years. See Figure 8.

Funded by Space Angels Network

Altius Space
Machines

Firefly Space
Systems

Planetary
Resources

Ansible Space
Communications
Systems

Golden Spike

Space Adventures

Astrobotic
Technology

LaserMotive

World View
Enterprises

Deep Space
Industries

NanoRacks

XCOR Aerospace

OmniEarth

Orbital Outfitters

Zero Gravity
Corporation

Non-U.S. angel investors have funded multiple space companies

Accion
Systems

Oxford Space
Systems

Astroscale

Planetary
Resources

Dauria
Aerospace

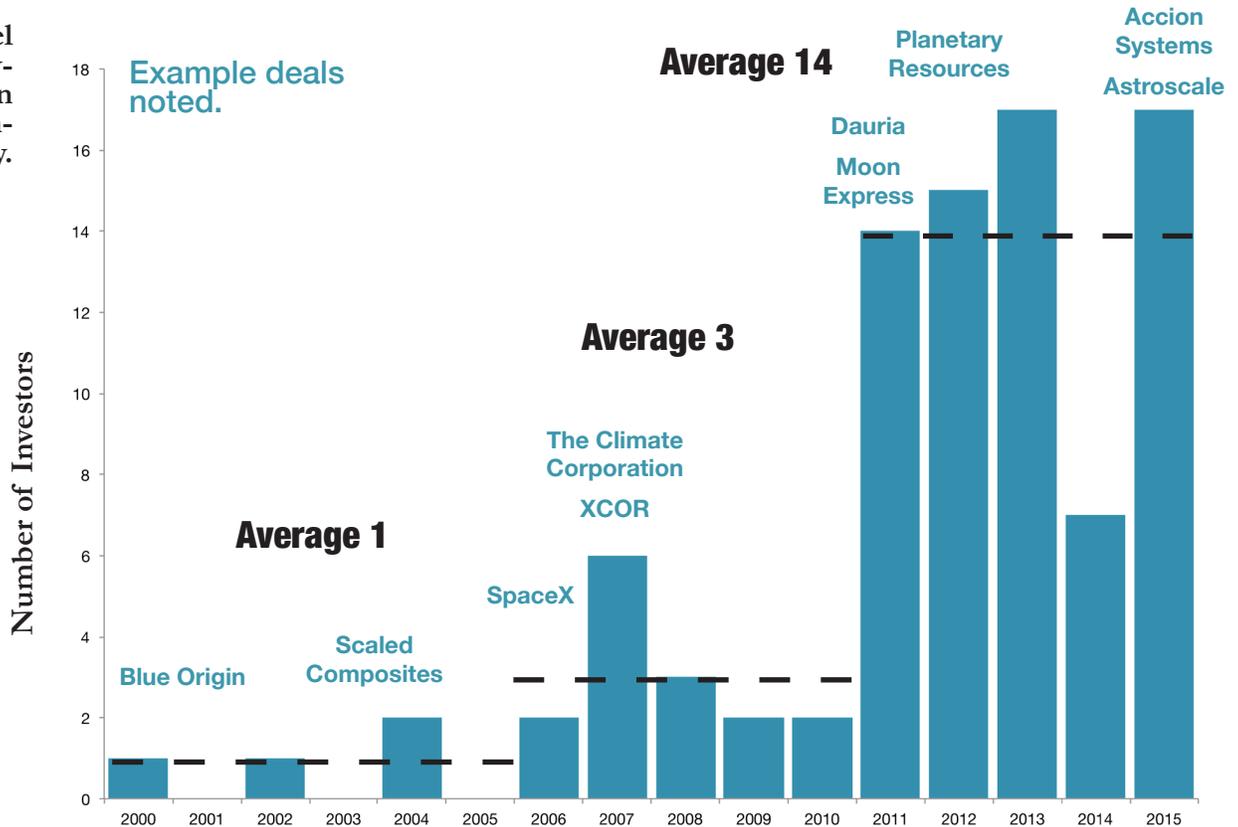
Satellogic

Global Surface
Intelligence

Space Investors by the Numbers

Number of Angel Investors in Start-Up Space Ventures

Figure 8. Angel investor activity increased in 2011 and continues to today.



Angel investors funded over 30 space companies since 2000

Accion Systems	Firefly Space Systems	Orbital Outfitters	Stratolaunch Systems
Altius Space Machines	Global Surface Intelligence	Oxford Space Systems	Swift Navigation
Ansible Space Communications Systems	Golden Spike	Planetary Resources	The Climate Corporation
Astrobotic Technology	Kymeta	PrecisionHawk	WildBlue
Astroscale	LaserMotive	Satellopic	World View Enterprises
Bigelow Aerospace	Mapbox	Scaled Composites	XCOR Aerospace
Blue Origin	Mishaal Aerospace	Space Adventures	Zero Gravity Corporation
Dauria Aerospace	Moon Express	SpaceX	
Deep Space Industries	NanoRacks	Stanford Systems	
	OmniEarth	Stott Space	

Venture Capital Firms

Since 2000, over 110 VC firms have invested in early stage space companies. VCs generally focus on start-ups and early stage ventures. We include incubators and accelerators in this investor group, since they provide funding as well as mentoring and networking. In 2015, over 50 VCs invested in space companies. This is the highest number over the period and it represents a partial year. See Figure 7. (We include Fidelity Investments in this investor group, since they provide venture capital to high-tech companies (and, in particular, invested in SpaceX) even though traditionally it runs mutual funds that focus on public company equity and debt.)

The number of VC firms investing in space companies has jumped significantly since 2012. From 2000 to 2005, the average number of VCs per year is 3. Over the next five years, the average is 8. From 2011 through a partial 2015, the average is 27. This is nearly a three-fold increase over the last ten years. See Figure 9.

The Tauri Group talked to VCs involved with the largest deals in 2015. We also spoke to many others through research interactions and related discussions.

Number of VC Investors in Start-Up Space Ventures

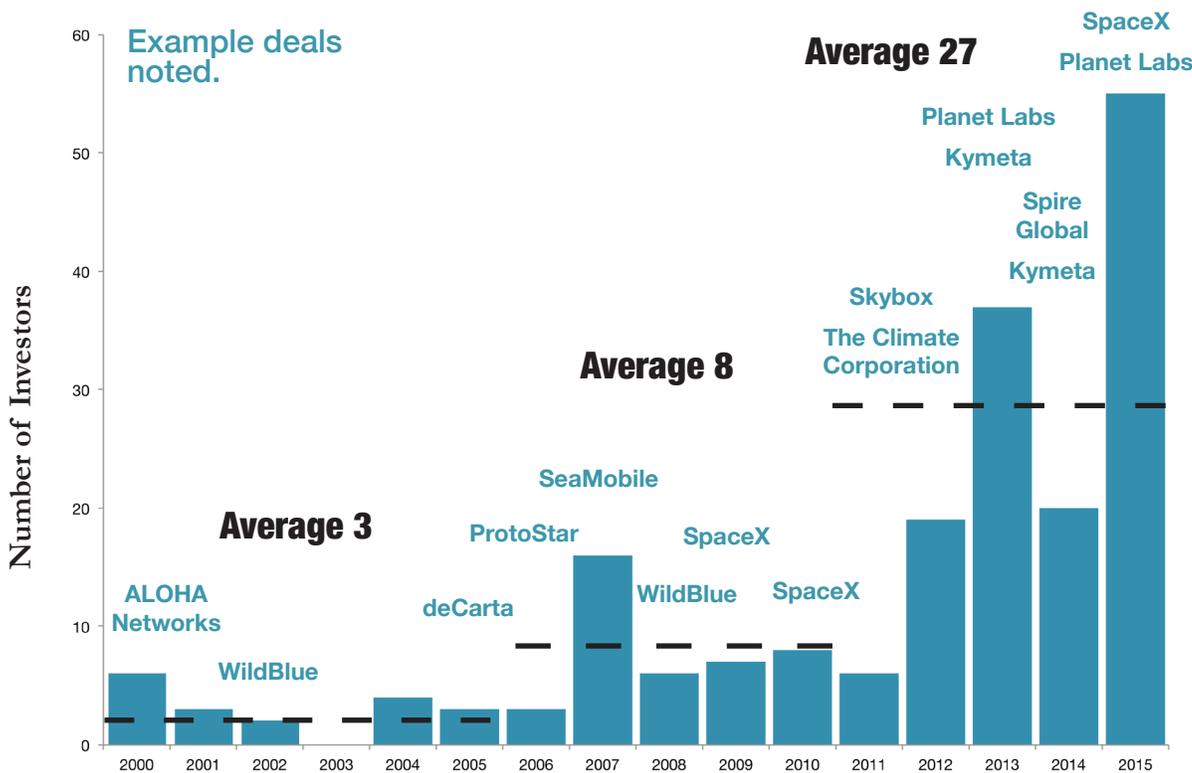


Figure 9. VC investor activity jumped in 2012 through today.

Space Investors by the Numbers

VCs investing in space companies

Acorn Technology Fund	First Round Capital [^]	Maryland Venture Fund (InvestMaryland)	Rothenberg Ventures
AME Cloud Ventures [^]	Formation 8 [^]	McLean Watson Capital	RRE Ventures [^]
Amplify.LA [^]	Founder Collective [^]	MENA Venture Investments	SDF Ventures [^]
Anthemis Group	Founders Fund [^]	Merus Capital	Sequoia Capital [^]
Asset Management Ventures	Foundry Group [^]	Mistletoe [^]	Seraphim Capital
Atomico	Fresco Capital [^]	Mitsui & Co. Global Investment	Shasta Ventures
Base Ventures	Galvanize Ventures [^]	Mobius Venture Capital	Sherpalo Ventures
Bessemer Venture Partners [^]	General Catalyst Partners [^]	Moose Capital	Silcon Badia
Bright Success Capital	GettyLab [^]	New Enterprise Associates	Sixela Venture Leasing
Broadband Capital AG	Grishin Robotics	NewGen Venture Partners [^]	SK Ventures
Business Instincts Group	Haiyin Capital [^]	North Bridge Venture Partners	Slow Ventures [^]
Cambrian Ventures [^]	HMS Hawaii Management	Norwest Venture Partners	Telcom Ventures
Canaan Partners	I2BF Global Ventures	NXTP Labs	TenOneTen Ventures [^]
Capricorn Investment Group [^]	Ignition Partners	Observatory Capital	Thrive Capital [^]
Cardinal Venture Capital	Index Ventures	O'Reilly AlphaTech Ventures [^]	Translink Capital
citizen.vc [^]	Industry Ventures [^]	OS Fund	Valor Capital Group [^]
CNF Investments	Innovate Indiana Fund	Osage University Partners	Vanedge Capital
Cottonwood Technology Fund [^]	Innovation Endeavors [^]	Pangaea Ventures [^]	VantagePoint Venture Partners
CrunchFund	In-Q-Tel	Par Equity	VegasTechFund
Data Collective [^]	Internet Ventures Scandinavia A/S	Pitanga Fund [^]	Venrock [^]
DBL Partners [^]	IQ Capital [^]	Pritzker Group [^]	Vilicus Ventures
Draper & Associates	JAFCO (Asia) [^]	Promus Ventures [^]	Vulcan Capital [^]
Draper Associates	Jump Capital [^]	Radiant Venture Capital	Wavemaker Partners
Draper Fisher Jurvetson [^]	K1W1 [^]	Rainbow Seed Fund [^]	Western Technology Investment [^]
DST Global [^]	Khosla Ventures [^]	Raymonds Capital	Y Combinator [^]
Elevator Ventures	Kinetic Ventures	Razor's Edge Ventures [^]	
E-Merge	Kleiner Perkins Caufield & Byers	Redpoint Ventures [^]	
Felicis Ventures [^]	Lemnos Labs [^]	RedShift Ventures	
Fidelity Growth Partners Asia	Longwall Venture Partners [^]	Richmond Global	
Fidelity Investments [^]	Lurkin [^]		
FIER CPVC - Montreal L.P.	Lux Capital [^]		

VCs investing in space companies are primarily based in the United States. VCs with headquarters in the United States make up 74 percent of the total. The plurality of VCs are based in California, representing 39 percent of the total. The other 35 percent are located elsewhere in the United States, with New York and Maryland as notable examples.

The international investors have headquarters across the globe. Fifteen countries are represented in four regions. United Kingdom, Canada, Hong Kong, Jordan, and Switzerland are home to multiple VCs investing in space companies, with the UK hosting about one third of non-U.S. VC firms. See Figure 10.

Examples of Incubators

Lemnos Labs invested in Spire Global (small satellites)

NXTP Labs invested in Satellogic (small satellites)

Y Combinator invested in Bagaveev Corporation (launch)

Europe		Asia/Africa/Oceania	
Belgium	Switzerland	China	New Zealand
Denmark	United Kingdom	Hong Kong	Singapore
Russia		Japan	
Middle East		Americas	
Israel	Jordan	Argentina	Canada
		Brazil	

ALOHA Networks	Arabia Weather	Ardusat	Astroscale	Boundless Spatial	Dauria Aerospace
Global Surface Intelligence	HuaXun Microelectronics	Insight Robotics	Masterson Industries	NanoRacks	OmniGlobe Networks
Oxford Space Systems	Planet Labs	Planetary Resources	Rocket Lab	Rockzip	SatCap
Satellogic	SkyWave Mobile Comm.	Spire Global	The Climate Corporation	XCOR Aerospace	

Figure 10. VCs headquartered outside the U.S. have invested in a range of space companies.

Space Investors by the Numbers

VC firms funded over 45 space companies since 2000

Accion Systems	LightSquared	SeaMobile
ALOHA Networks	Mapbox	Skybox Imaging
Arabia Weather	Mapsense	SkyWave Mobile Communications
Ardusat	Masterson Industries	Spaceflight Industries (includes BlackSky Global)
Astroscale	Moon Express	SpaceX
Bagaveev Corporation	NanoRacks	Spire
Boundless Spatial	O3b Networks	Swift Navigation
Dauria Aerospace	OmniGlobe Networks	TerraGo Technologies
deCarta	Orbital Insight	The Climate Corporation
Descartes Labs	Oxford Space Systems	UrtheCast
DigitalGlobe	Planet Labs	Weather Analytics
Firefly Space Systems	Planetary Resources	WildBlue
GATR Technologies	PrecisionHawk	World View Enterprises
Glactica	ProtoStar	XCOR Aerospace
Global Surface Intelligence	Rocket Lab	
HuaXun Microelectronics	Rockzip	
Insight Robotics	SatCap	
Kymeta	Satellogic	

Nine VCs have invested in three or more space companies. Draper Fisher Jurvetson and Founders Fund have each invested in five companies; the rest invested in three. A couple of these firms indicate that they have a space specialization in their portfolio. See Figure 11.

A handful of VCs have repeatedly invested in common with other investors. These include Bessemer, Draper Fisher Jurvetson, First Round Capital, Founders Fund, Khosla, and RRE Ventures. At least two of them have invested in each of these firms: Accion Systems, Planet Labs, Rocket Lab, Skybox, SpaceX, Spire Global, and The Climate Corporation. The relationships are diagrammed in Figure 12.



Figure 11. VCs investing in multiple space companies

Space Investors by the Numbers

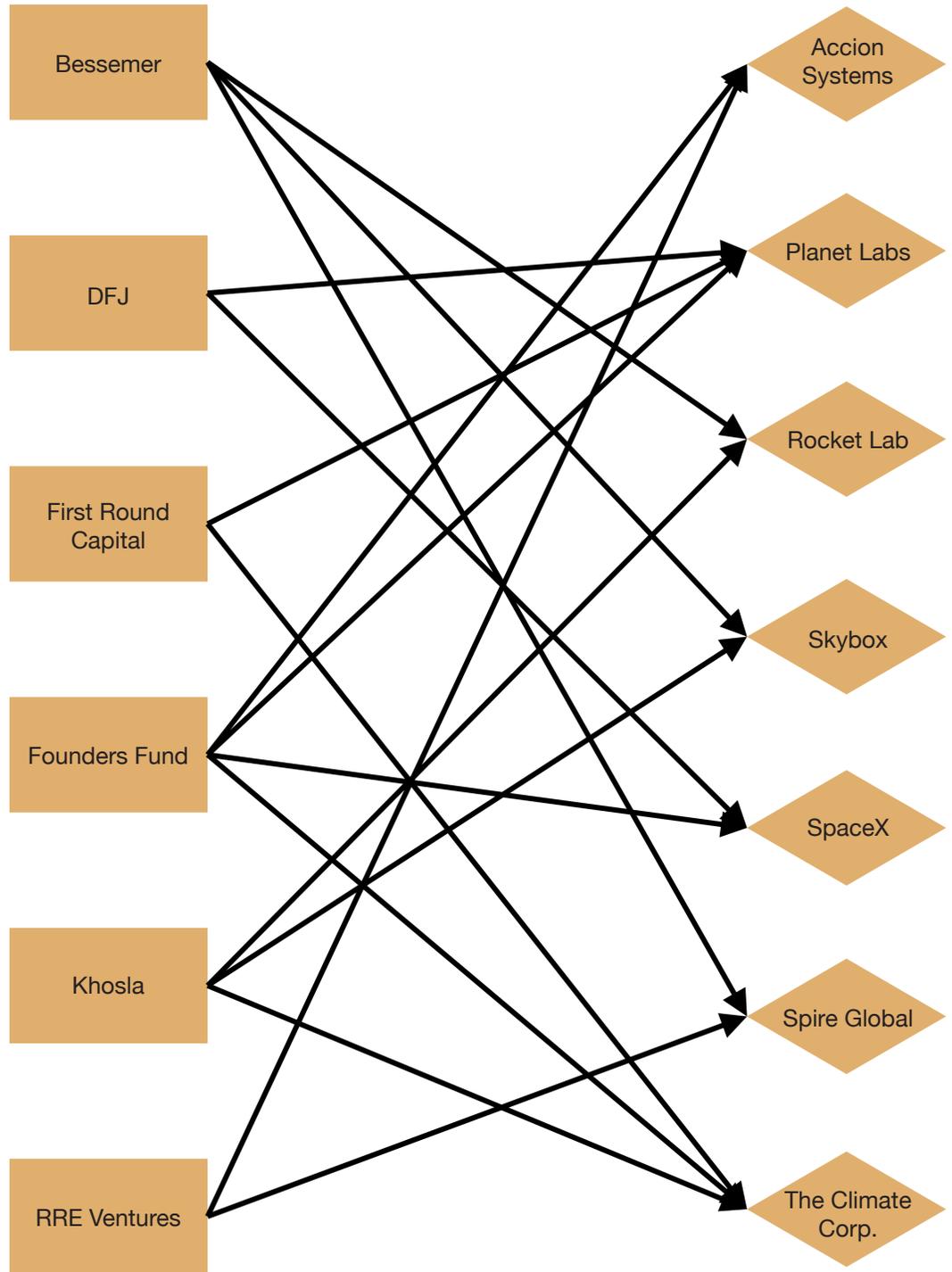


Figure 12. Common investments among VCs

Private Equity Groups

Since 2000, over 20 private equity firms have invested in early stage space companies. The number of PE firms investing in space companies has varied over the time period, but the average is constant at 2. LightSquared and O3b transactions dominate in 2000, 2004, 2010, and 2011. See Figure 13.

Number of Private Equity Investors in Start-Up Space Ventures

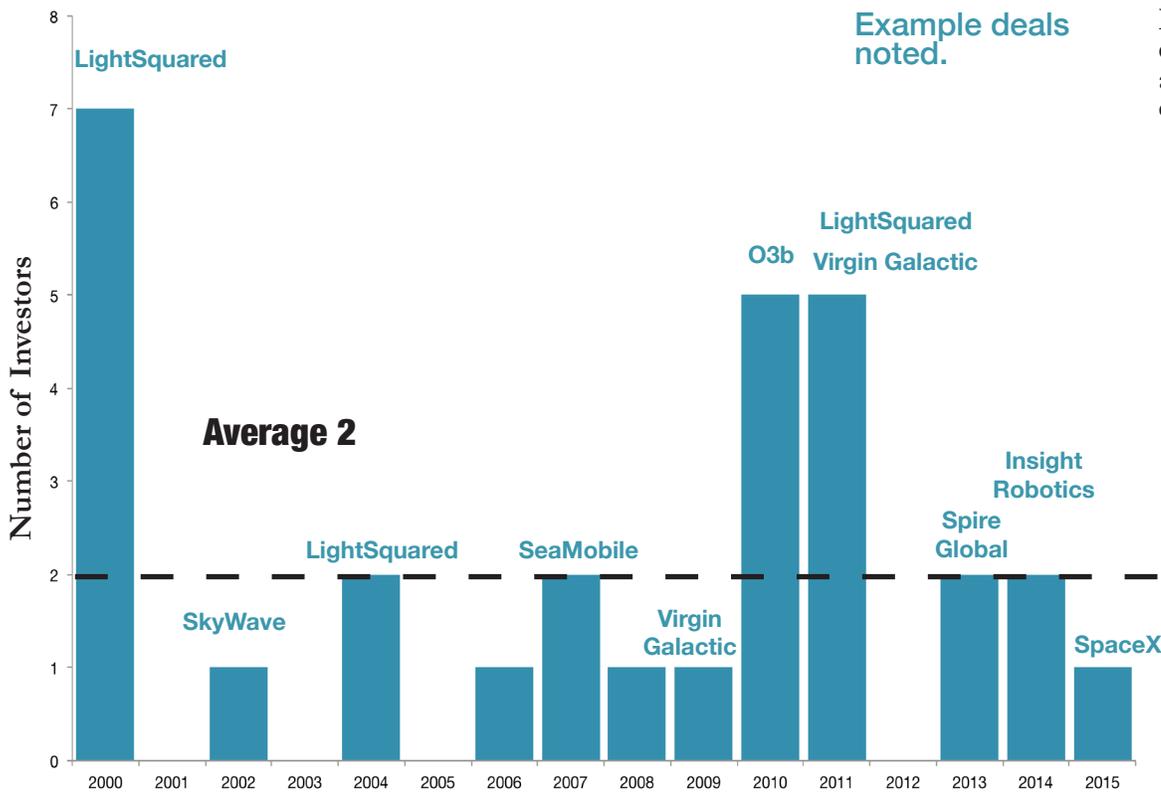


Figure 13. Private equity investor activity is variable over the time period.

PE firms investing in space companies are split between the United States and elsewhere across the world. Firms with headquarters in the United States make up 44 percent of the total. The majority of U.S. firms are based in New York and California, representing 24 percent of the total. The other 20 percent are located elsewhere in the United States. Non-U.S. firms comprise 56 percent of the total. See Figure 14.

Space Investors by the Numbers

Figure 14. Private equity firms reported to be in space start-ups are distributed between U.S. and non-U.S. locations.

U.S.	Non-U.S.
Ampal-American Israel Corporation	Aabar Investments PJS
Beamonte Investments	BMO Capital Partners
Chart Capital Partners	Caldera Pacific Capital Partners
Columbia Capital	Coralinn
Desert Sky Holdings	Desjardins Business Capital régional et coopératif
Fall Line Capital	Emerging Africa Infrastructure Fund
Harbinger Capital Partners	Financial Force Ltd
Kresge Foundation	Israel-Canada (T.R) Ltd
Spectrum Equity Management	Luxempart
Tennenbaum Capital Partners	Nevis Capital
Valor Equity Partners	Polar Communication
	Satya Capital
	Sofina
	TechnoPlus Ventures

One of the largest single investments in a space venture by non-U.S. investor was \$280 million by Aabar Investments in Virgin Galactic in 2009.

The international investors have headquarters across the globe. Eight countries are represented in four regions. United Kingdom, Israel, and Canada are home to multiple private equity firms investing in space companies, with the U.K. hosting about one quarter of non-U.S. PE firms.

Europe	Asia/Africa/Oceania
Belgium	Hong Kong
Luxembourg	South Africa
United Kingdom	
Middle East	Americas
Israel	Canada
United Arab Emirates	

PE firms have been reported as funding 15 start-up space ventures since 2000

Clyde Space	SeaMobile	Virgin Galactic
Insight Robotics	Shiron Satellite Communications	WildBlue
Kymeta	SkyWave Mobile Communications	XCOR Aerospace
LightSquared	SpaceX	
O3b Networks	Spire Global	
OmniGlobe Networks	Swift Navigation	

Corporations

Since 2000, over 30 corporations have invested in space ventures. The number of corporations investing in space ventures rose steadily since 2012. We include corporate venture funds in this investor group. 2015 was a peak year for the number of corporations investing in space ventures. From 2000 to 2005, the average number of investors per year is 1, and from 2006 to 2010, the average is 3. From 2011 through a partial 2015, the average is 7. This number more than doubled. See Figure 15.

Number of Corporations Investing in Start-Up Space Ventures

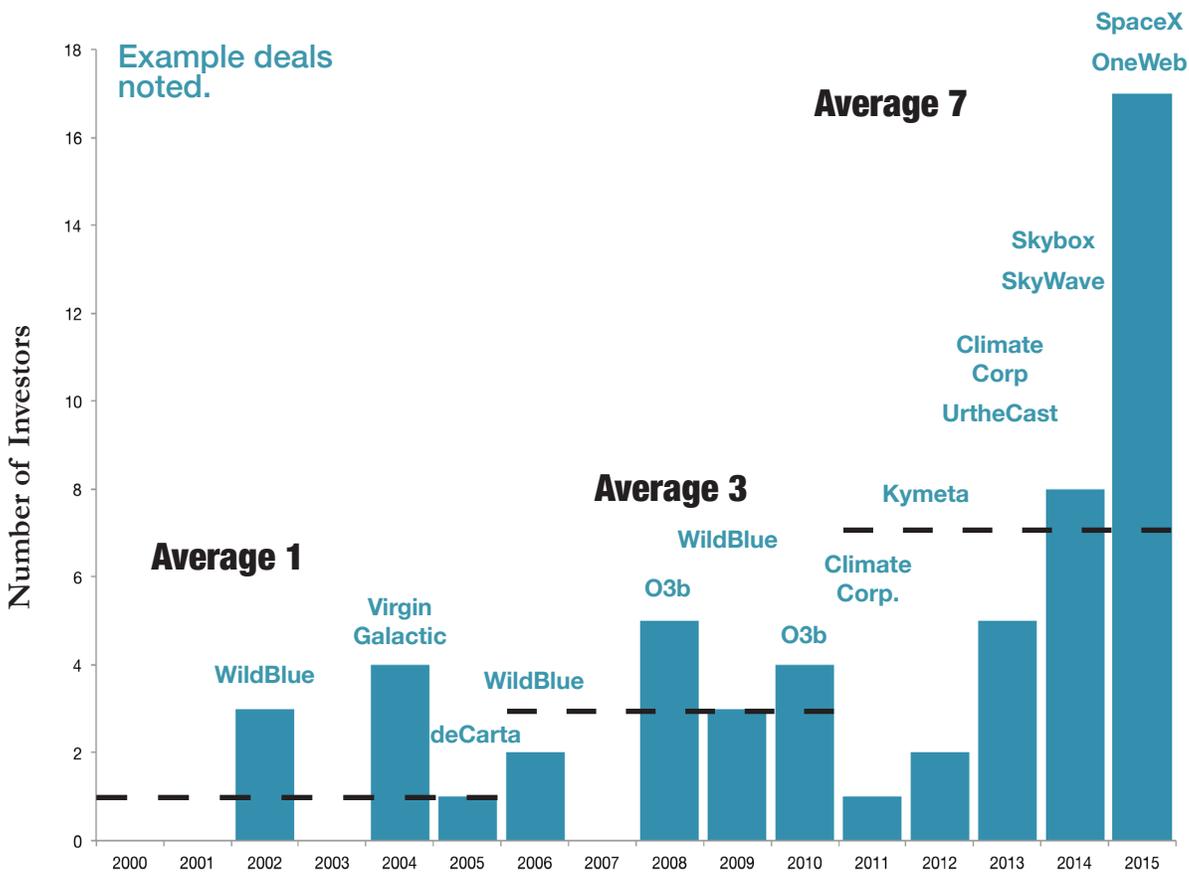


Figure 15. Corporations investing in space ventures picked up starting in 2012.

Space Investors by the Numbers

In 2015, OneWeb reported a group of companies spanning the globe had invested \$500 million

U.S.

Hughes Network Systems, Qualcomm Incorporated, The Coca-Cola Company

Non-U.S.

Airbus Group (Netherlands), Bharti Enterprises (India), Intelsat (Luxembourg), Virgin Group (UK), Totalplay (Mexico)

Corporations investing in space ventures are split between the United States and elsewhere across the world. Firms with headquarters in the United States make up 56 percent of the total. The majority of U.S. firms are based in California, representing 20 percent of the total. The other 26 percent are located elsewhere in the United States, with New York as a notable example. Non-U.S. firms comprise 44 percent of the total.

Both traditionally space companies and non-space companies are investing in new space ventures. Existing space corporations represent 47 percent of this investor group, while non-space corporations represent 53 percent. Existing space corporations that are headquartered in the U.S. make up 22 percent, while non-U.S. corporations make up 25 percent. Non-space corporations that are headquartered in the U.S. make up 33 percent and non-U.S. make up 19 percent. See Figure 16 for the distribution between U.S. and non-U.S. companies and space and non-space companies.

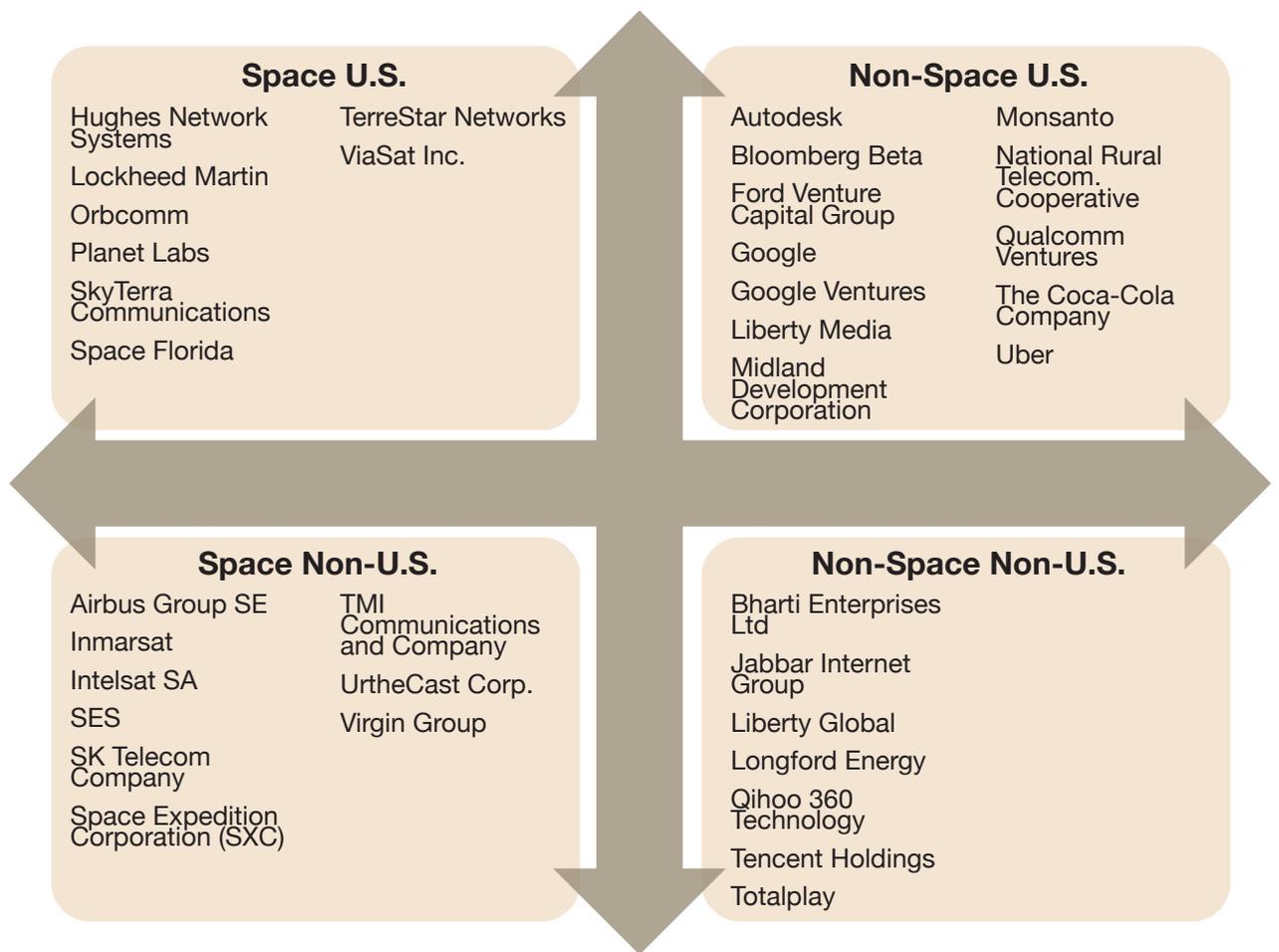


Figure 16. Corporations investing in space ventures are more likely to be headquartered in the U.S. and less likely to be considered a space company.

The corporations outside the United States have headquarters across the globe. Nine countries are represented in four regions. Canada and United Kingdom are home to three or more corporations investing in space ventures. China, Luxembourg, and Netherlands each have two companies that have reported investing in space ventures.

Europe	Asia/Africa/Oceania
Luxembourg Netherlands United Kingdom	China India Korea, Republic of
Middle East	Americas
United Arab Emirates	Canada Mexico

Corporations have invested in over 20 space ventures since 2000; about a third of them are acquisitions. Acquisitions include BlackBridge by Planet Labs, deCarta by Uber, Deimos by UrtheCast, Skybox Imaging by Google, SkyWave by Orbcomm, The Climate Corporation by Monsanto, and WildBlue by ViaSat. Additionally, UrtheCast went public through a reverse IPO with an existing company, Longford Energy.

Corporations have invested in over 20 space ventures since 2000; about a third of the investments were acquisitions	
Arabia Weather	Satelloptic
BlackBridge Corp. (acquired)	Skybox Imaging (acquired)
deCarta (acquired)	SkyWave Mobile Communications (acquired)
Deimos (acquired)	SpaceX
Kymeta	Spire Global
LightSquared	Swift Navigation
Moon Express	The Climate Corporation (acquired)
O3b Networks	UrtheCast (reverse IPO)
OneWeb	Virgin Galactic
Orbital Insight	WildBlue (acquired)
Orbital Outfitters	XCOR Aerospace
Rocket Lab	

Space Investors by the Numbers

Banks and Other Financial Institutions

Relatively few—about 1 in 10—of the transactions covered in this analysis have reported debt financing as a significant component. Some examples of ventures receiving debt financing are:

- BlackBridge received \$22 million in debt financing from the Business Development Bank of Canada and Bank of Montreal in 2014.
- DigitalGlobe received \$600 million in debt financing in 2011.
- O3b Networks received \$525 million in debt financing from COFACE, France's export credit agency and others.
- Planet Labs received a debt facility of \$25 million from Western Technology Investment.

Investor Motivations

A key objective of this study is to understand commercial space from the perspective of those investing in creating new companies. Who is involved in space investing, and how has that changed over time? What are their motivations? What is the vision they have for the future of the industry? How do they perceive the industry to have changed over the previous 10 years? Who has driven this change, and what has NASA's role been? What metrics do they seek in a company in which they invest?

The perspective of investors significantly enhances the analysis of the investment deals described in the previous section. Investor behavior is the key to understanding why space investments are trending up and what we might see in the future. This analysis targets the investment community behind start-up space ventures—the sources over the last few years of billions of dollars to fund dozens of new, entrepreneurial space firms.

We talked to venture capitalists, mostly senior partners, at some of the most successful firms in Silicon Valley, as well as angel investors, entrepreneurs, investment bankers, venture attorneys, and international investors. We interviewed investors in the largest recent space deals and investors in firms that have invested in multiple space deals. We also interviewed investors in leading firms that have chosen not to invest in space.

Here is what they said.

The State of Investment in Start-Up Space

The investors we interviewed agreed that space investment activity has significantly increased. One senior partner in a space-leading venture fund said, “For established venture funds, I would guess that 10 percent have seriously considered investing in a space-related start-up. Three years ago, that number was 1 percent.” Another investor said, “You just had Steve Jurvetson [partner at DFJ], board member of SpaceX, and investor in Planet Labs] three years ago.”

Why Has Venture Investment in Space Increased?

Interviewees attributed the increase in venture investment in space to more attractive opportunities and to successful exits (that is, situations in which early investors have seen returns on their investments). One summed up investor expectations succinctly, “You can now make money with space investment, which wasn't largely a true statement before.”

New opportunities enabled by decreased costs and higher potential returns

Interviewees saw increased investment opportunities primarily (though not exclusively) related to small satellites, driven by decreased costs and by new potential for returns. Interviewees pointed to the reduction in cost of satellites associated with what one called the “CubeSat revolution” and to “commodity components that are powerful and cheap.” Satellite systems use off-the-shelf technology and very small satellites that are easily and quickly manufactured to present a much different value proposition for investors. The timeline from design to operations has also shortened significantly, which means investors can potentially expect to see returns on their investment more quickly.

Investor Motivations

Decreased costs make venture investing feasible for space. Instead of hundreds of millions or billions of dollars to deploy a space system, small satellites can be developed for tens or hundreds of thousands of dollars, and full systems can be deployed for tens of millions.

A partner in a major venture capital firm said, “You actually can experiment now. If you are spending \$300 million on a satellite and launch, you have to know exactly what you are doing. You can’t do things prospectively. You really can’t take much risk. It is hard to take a risk on completely new technology that is so new that it might not be space-qualified if it costs that much. But if it is cheap to try things out, people are not limited.”

Interviewees attributed improved potential for returns primarily to the products and services enabled by data analytics (combined, of course, with reduced costs). Satellite systems are seeing technical advancements in the way they process and use data. Many start-up space ventures are vertically integrated, with the end product or service based on data analytics and tools like those used in IT/web/terrestrial tech

“I love [space]. I remember going to NASA’s visitor center as a kid, and that got me into engineering. I have a passion for it.”

—VC partner

ventures. This has drawn interest of investors who are familiar with data analytics-driven businesses, and who see significant potential in satellite businesses that track and analyze economic activity around the world or predict weather on a frequent, detailed, local basis.

Exits and demonstrated value creation

Successful exits are the lifeblood of venture investing trends. For space investments, many interviewees pointed to SpaceX building a valuable company and the sale of Skybox to Google. One noted, “SpaceX has really opened the doors. Space used to be the domain of NASA and large military contractors, and SpaceX showed that it is possible to build a purely

commercial enterprise doing launches. They have out-executed some of the more traditional folks. That gave permission to a whole bunch of other folks to think about the problem.” Some interviewees also held up Planet Labs as an example of successful value creation.

Deal flow is still limited

A number of interviewees pointed out that space deal flow is limited. One suggested that the peak of new space starts has passed, at least for the next year or two, while investors wait and evaluate the performance of the current crop of new starts to see if anticipated market demand materializes.

What Motivates Individual Investors?

One interviewee said, “In Silicon Valley, you have the winners and you have everybody else.” Given the competitive VC culture, it was interesting that investors often identified personal affinity as a reason they invest in space, as well as financial motivation.

When investors spoke of why they put money into space, they binned themselves pretty consistently into one of three categories:

- I am interested in space, and financially motivated by a particular investment (with the emphasis on space interest)
- I am financially motivated, and interested in space (with the emphasis on financial motivation)
- I am financially motivated, and I don't care that it is space (typically focused on the view of space systems as another type of IT platform with unique capabilities, that is undergoing the same transformation that combines dropping hardware costs with massive growth in applications and demand)

The first two categories were a bit more common than the third. One VC felt this was a generational difference. That investor said, “[Space] is still something of a vanity investment, with extraneous reasons beyond the financial returns. I am like that, Steve Jurvetson is like that. I would guess that others are like that. More junior investors have to focus on the return. Older, established investors can say, ‘Well, I might lose that \$10 million, but it’s worth the chance.’”

An investor at one of the world’s most successful venture capital firms, said, “Individual investors have personal interests in space. That includes me, but it is a very secondary factor...I have invested because it is a new source of revenue, not out of infatuation with space.”

Finally, the remarks of one investor reflect the views of a small but significant subset of non-space focused interviewees. He said the space aspect was completely unimportant not only for him, but for the entrepreneur that is leading a satellite company he funds; both focused on the investment value associated with new mass market products on a platform with rapidly dropping costs.

Interest and activity increased, but not all investors are putting money into space. What accounts for the investors who pass on space deals? We spoke to investors who would be good candidates for space investment—technologically-oriented and even space affiliated, and asked why they chose not to invest. Their answer: a combination of limited deal flow and questions about risks and return. An established, strongly space-affiliated investor (education, interest, life experiences) said that he has looked for space investments but has not made any; he does not see deal flow for space deals that fit his particular model, which is post-revenue with returns in 3 to 5 years.

A senior and respected space operations expert now working in start-up space captured concerns about risk and return: “There are a lot of guys out there who are

“There are not many entrepreneurs who dreamed of better data storage as kids. But space entrepreneurs are turning their childhood passion into real businesses. The people I have worked with [in space ventures] are serious business people. Maybe they have more of a twinkle in their eye than other entrepreneurs, but they are not running businesses differently.”

—Silicon Valley attorney specializing in technology ventures

Investor Motivations

unfortunately attracting money but won't be able to deliver on the promise. Either they won't be quick enough or they won't be able to close the business case... But too many folks say: 'I've got an imaging satellite, and I can solve your problem. What is your problem?' What do your clients look for?"

What Does an Investor Look for in a Venture?

Much as with investments in other industries, investors consider the strength of the management team, the strength of the technical solution, and potential demand for the product or service when deciding to make an investment. Leadership and market were the two most consistently mentioned considerations. One comment

“The evolution of the satellite industry is paralleling the development of software systems that use 98 percent COTS.”

–VC with a background in network systems

was, “We look for three things when we invest: Great management, billion dollar market, and an unfair advantage (IP or technical edge). The question I always ask is, what is the market?” Another interviewee said, “There always needs to be a big ‘E’ entrepreneur who is the keeper of the vision of the company. And then you augment that expertise as required.” And, “What is the product? This is the most important. How does it scale?”

The focus of the investor group was an important consideration. Many investors said we do invest in this or we don't invest in that, and that shapes our choices. Focus ranged from business or product type (for example, we don't invest in consumer internet products, or we focus on software), industry (we specialize in transportation), business phase (we are looking for early stage firms with unique IP), or time frame (we will accept longer returns, up to seven years). This investor focus is particularly important for an entrepreneur. And, of course, some investors specifically use affinity as a key element of their investment decision process, such as Space Angels, a long-standing group of space-focused angels investors based in the U.S., and a newly-established venture fund, Seraphim, in the United Kingdom created to invest in space opportunities and leverage U.K. national investment in space and satellite applications. Matchmaking a fund's focus to a venture's needs significantly increases odds of investment.

VC firms typically make investment decisions by seeking the approval of a group of partners, and they like to invest in management teams that they know, or that have proven track records. Several interviewees noted that building a relationship prior to seeking funding can make it easier to get partner agreement on an investment. One gave this guidance to entrepreneurs who don't value track records: “Come see me before you need money, and introduce your business. Drop by every quarter for a year. Tell me what you plan to do in the next quarter, and then come back and show me you did it. If your business is interesting to us, I'll mention this to my partners every quarter, and then, when it is time to write a check, you will have built a reputation and credibility with us. I won't have to start from ground zero to persuade people to agree to the investment.”

Finally, an investor in a highly successful venture capital firm laid out the topics that are key to the firm's evaluation process, and how they apply to space investments.

1. Can a new market form? Many start-up space companies are using new data, doing different things without a direct analog in the past. We try to assess the markets for these products and services analytically, but a lot of it ends up being a judgment call. Once companies get a ways along and have a better handle on what they are doing, you can be more analytic. But generally, for a company creating a new market, a lot is subjective.

2. Do they have access to resources they need? Here we are asking not about money, but about other things like the inputs to their products (for example, a satellite data stream).

3. Team We look at the background of the team and whether we think it is credible for the team to put a real solution together. Also, we like to see a team that is pragmatic. One of the challenges of this general area is that people are infatuated with space, and they have big ideas. They don't always match the idea that investment is about financial return.

4. Threats We try to make sure the government or some of the large companies can't disturb the market. For example, we look at where Skybox and Google might be headed when looking at a related venture to see if they will likely enter that area. Also, historically, some technologies related to space were fairly heavily regulated by military concerns, which creates risks, although that is changing as the government changes its views.

“We want founders with big vision, and the credibility to pull it off, but they can't be completely crazy. We are not a not-for-profit activity.”

—VC partner

Most Challenging Element of a Space Investment

Interviewees said that the challenging parts of space investments were gauging the market opportunity and managing the time horizon. One interviewee spoke about the challenges of the space supply chain, describing it as “very weak, especially for smaller providers” and in fact pointed to this as a future market opportunity. Another said the difficulties are “almost never about the technology or the management team.”

In general, market opportunity was the number one challenge; space markets were described as “hard to define, size, and time.” An interviewee captured the views of many investors, saying he tells visionary entrepreneurs, “I agree with you that this is a huge opportunity in 20 years, but what about 2 or 5 years?”

Future Outlook and NASA Role

Future Outlook

Investors we interviewed had an overall rosy view of the future of the space industry. Several investors mentioned that they thought that in the long term we would see a trend of commercialization of space, to include private space travel or colonization of the Moon or Mars. In the nearer term, many mentioned launch availability, cost, and frequency as being drivers of change and advancements in the space industry. While some investors mentioned that the near future would provide an opportunity for new technologies and system architectures to be tested in the real market, there was a general feeling that the markets of space weather and climate monitoring, data communications, and vertical integration of data and data analytics will be successful areas within the space market. One investor envisioned a future where space-provided data was so ubiquitous that it would be a competitor with terrestrial internet providers. A few investors mentioned the idea that a successful human spaceflight operator and customers could draw new markets and new investments, and make space investments more mainstream. One thing most investors agreed on, is that the space market is changing—summed up by one investor as the next 7 years will have the same amount of change as the last 50.

“We are clearly at an inflection point where interest and investment are increasing. Lots of companies are now competing for excellent people.”

—Silicon Valley attorney specializing in technology ventures

Start-up space investors are optimistic about the future of space ventures—that, after all, is why they are start-up space investors. They differ, however, in their views of the immediate future of investing. One experienced Silicon Valley hand said succinctly, “Once everyone knows that space is a good place to invest, it’s too late.”

A number of investors highlighted the rich opportunity now for venture investing in space, compared to potentially fewer opportunities in the future. One concern raised was the near-term (one-to-two-year) time horizon for a market correction or dramatic downturn associated with highly valued technology firms. “If there is a tech crash, it will increase the risk factor for everyone. Now is the boom time.” Such an event could eliminate available capital and limit investor appetite, said some interviewees. Another concern was straightforwardly that the market might become saturated, and that the ventures funded now reflect the full range, for example, of imaging companies and products that can be supported.

“The next 7 years will have the same amount of change as the last 50.”

—Silicon Valley investor

And some interviewees also saw future risk arising from the speculative nature of new space ventures and competition from more established space enterprises. “For a lot of companies, I think we’re going to see soon what they can really do. Will it be the big guys who build in the bunny suits? Rad hard, or who cares? It’s not totally clear that the new business models work yet.”

“NASA is an excellent place to get technical expertise... They have lots of smart folks.”

–VC partner
(multiple space ventures)

For every view that the start-up space market is reaching its limits, however, there was another view that it is just beginning, because new capabilities will create unpredictable and potentially massive demand. “New businesses create demand. Since Uber and Lyft arrived, the market for cabs in San Francisco has multiplied by 10.” Another opinion was that there will be continued investment in space start-ups, because investors with less clout and fewer resources than the Silicon Valley leaders are still looking for space opportunities. Several interviewees raised the question of whether the next group of ventures seeking funding will have business plans as attractive as the ground-breaking first wave.

Many interviewees highlighted a number of areas they felt would attract future investment. These included:

- **Support services for satellite ventures.** “The most interesting stuff is companies that are solving problems around the satellites.” Another interesting view was “...standards are market share. We need a canonical architecture for small satellites. This is the inception of open architecture for small satellites.”
- **Satellite technology.** “In the near term, the focus will be on small sat propulsion, sensors.” “Other areas that will get attention are: hyperspectral, antennas.”
- **Software.** Software included “disaggregated systems that are software controlled” as well as data analytics tools.
- **Launch systems that reduce cost and increase frequency.** Many investors said that lower cost launch and more frequent launch (one said “at least weekly”) were very important to them. For example, one said, that companies that will succeed are those that can “drive innovation in a fundamental area [such as launch].” Another observed, “I believe that if you make access to space easier there is a bigger chance we can see a flowering industry. I might be wrong about the timeline. But I believe that, and it drives investment.”

Many investors said that lower cost launch and more frequent launch (one said “at least weekly”) were very important to them.

Finally, some investors (more typically space-enthusiast angels than VCs) also talked about the future of humans in space, predicting habitation of the Moon and Mars, some with a recognition that the business case may not be the driver. One summed up, “philanthropists will make it happen” and another said, “that depends on the next [Presidential] Administration.” A related topic was the idea that launches of humans would be a driving force for future space investment and market growth, through their personal experience of space. “I see one catalyzing event being the flights of Virgin Galactic. Those early passengers may be future funders of space businesses. Putting people in space is actually key.”

Future Outlook and NASA Role

NASA Role in the Future

The perception of NASA's role in the new space environment is generally positive, though mixed. Most interviewees viewed NASA as a valued technical resource, some viewed it as an important customer or facilitator, and a few viewed NASA as irrelevant or even an impediment.

NASA as a Technical Resource

NASA's expertise is widely recognized and valued.

Many interviewees noted that NASA has played a role as an incubator for technology, concepts, and talent, benefiting the start-up space arena.

Interviewees described NASA expertise migrating to start-ups through entrepreneurship of NASA personnel, recruiting of NASA staff by ventures, and board memberships and consulting by retired NASA leaders. Comments included "New space companies are borrowing heavily from people with NASA or military backgrounds," and "The people at NASA, current and former, are also good and smart and you have to have people."

Investors also valued NASA's facilities and technology. One pointed to NASA as a resource, saying, "When a company is bootstrapping, they need to test in space (flight test). When they are in the seed and A rounds of funding, they need access to facilities."

Moreover, NASA's engagement or participation—especially through a research partnership or collaboration—was viewed as an indicator of credibility for a venture. NASA was widely viewed as a capable judge of technical merit.

NASA as a Customer

Some interviewees recognized the role of NASA's commercial launch initiatives has played in the changing space market over the last decade. Depending on their market focus, some said NASA's "biggest role is as a customer." One commented on NASA as having a unique role in space, in that "NASA is the most important customer in the world, in a way that doesn't exist in other areas."

On the other hand, some investors did not have a working knowledge of NASA's current role in the space industry, and saw NASA only as a potential customer or an example of the space industry of the past. (For example, one investor in a space company that was founded by NASA alums and actively uses the International Space Station answered that NASA was not really relevant to that business, when asked a question about the role of NASA.)

The dynamics of working with the government as a customer were a source of concern, as well as interest. Some investors praised NASA's recent efforts. "COTS has been a good program, after NASA made many mistakes in commercialization earlier (SpaceHab)."

Some investors were uninterested in working with the government, and by extension NASA. One interviewee pointed out that "NASA feels it is its job to create competition," rather than a successful company, and pointed to one innovative

start-up to which “NASA gave all sorts of awards” and then spent substantial resources to create a fairly direct competitor. Several others said that government generally is just a bad fit for venture-funded firms, because the government as a customer is “opaque.” One said, “Once you are in business, the government can be a big revenue source, but you can’t count on it.” Another summed up the venture capital preference to avoid government as a customer, saying, “Delivering the goods to the government is one model. The other is going directly to consumers. If the government is the customer, it makes it hard to do a venture capital play. Going to consumers is more exciting for venture. Government is a single point of failure that is not growing.”

As a slight counterpoint, the view of an extremely successful VC was that the Silicon Valley investment community avoids government as a customer out of a lack of familiarity, rather than because there is an unbridgeable mismatch between VC-funded ventures and government.

An interesting summary from an active satellite investor was that NASA may have been important in getting the industry to its current state, but that the important questions for investors are what NASA can do and what it will do in the future.

Finally, a few investors were cautious, uninterested, or actively negative toward NASA. Generally these concerns were addressed at engagement with government broadly, reflecting the potential barriers or delays that could result. Representative comments were, “Stay far away from NASA and government,” “NASA staying out of the way is the best thing,” and “Government involvement is not necessarily a blessing.”

Implications for NASA

The inputs from many of these interviews identify potential opportunities for NASA to engage emerging space ventures that are contributing to U.S. space capability and economic growth. Generally, NASA’s roles in space science, big space missions, exploration, and high risk technology development were valued (where they were known) and viewed as appropriate for the agency. Similarly, NASA’s role as a consumer of commercial capability was viewed as appropriate and beneficial for the agency as well as for businesses, and interviewees generally expressed the hope that NASA would continue to work with businesses that could provide important products and services.

Generally, interviewees expected and wanted NASA to continue as a valued source of facilities, resources, and technology. Many noted that working with NASA is challenging. Finding the door to open, establishing a relationship (whether a simple as access to test facilities on a paid basis, or as complex as an on-going research partnership on a complex technology), and, in particular, dealing with contractual mechanisms were all highlighted as difficult for start-up ventures (even well-funded ventures on a path of

“The business of venture is very forward-looking. The past is the past. The Planet Labs guys came out of NASA, but in terms of growing the business, what role does NASA play?”

–VC partner (satellite venture)

Future Outlook and NASA Role

growth and institutional maturity). Some interviewees were familiar with the NASA Ames Emerging Space Office (ESO), and viewed it as a business-friendly, useful point of access. Few others knew of a contact point or organizational point of entry at NASA.

NASA has many objectives that require or benefit from engagement with industry, from technology transfer objectives, to positive economic returns, to reducing costs and enhancing capability to meet mission goals. An enhancement as simple as a more publicized contact point for the investment community could directly benefit these objectives.

New Role for NASA

Study findings also suggest one potentially powerful new role for NASA to consider: Participate in In-Q-Tel or recreate the In-Q-Tel model. Investors viewed In-Q-Tel favorably. They noted that it provides firms with insight into government markets

Participate in In-Q-Tel or recreate the In-Q-Tel model.

and enables them rapid access to real government demand. In-Q-Tel represents government interests in the investment community by making venture capital investments in firms whose products or services address a specific government need. In-Q-Tel represents multiple federal agencies. NASA could establish a similar model, to enable it to meet unique requirements by fostering rapid-development commercial capabilities. Alternatively, NASA could explore becoming one of the agencies represented by In-Q-Tel. Several interviewees pointed out the benefits of this approach, which would enable NASA to immediately benefit from the strong working relationship In-Q-Tel has developed with Silicon Valley investors, based on In-Q-Tel's long-standing relationships and cultural adaptation to the VC culture in terms of processes and response time.

Potential Benefits of NASA Interaction with Start-Ups

NASA's enhanced interaction with start-up space ventures would contribute directly to national goals of economic growth. It could also foster the development of space products and services available for NASA and other government space organizations to use. The opportunities identified are potentially low-cost, budget-neutral, or even ways to reduce costs through new products and services. The core challenges for NASA are administrative—establishing easy and clear ways to work with start-ups so that they benefit from NASA's unique capabilities and expertise. Finally, NASA's effective collaboration with space start-ups can help preserve U.S. global leadership in start-up space.

Acknowledgments

This report was written and produced by The Tauri Group, which conducted the study on which it is based.

The study was supported in part by NASA under award Number NNX15AC02G, through the grant program of the NASA Ames Emerging Space Office.

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The Tauri Group gratefully acknowledges the support of the NASA Ames Emerging Space Office, led by Dr. Alexander MacDonald, Emerging Space Program Executive at NASA Headquarters Office of the Chief Technologist, and Dr. Daniel Rasky, Lynn Harper, and Bruce Pittman at the Space Portal Office at NASA Ames Research Center. We wish to thank the many investors that provided their expertise and shared their experience of space investment. We also wish to thank Raphael Perrino and Mark Hill for their key contributions to the project. We kindly thank our reviewers.

PHOTO CREDITS

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