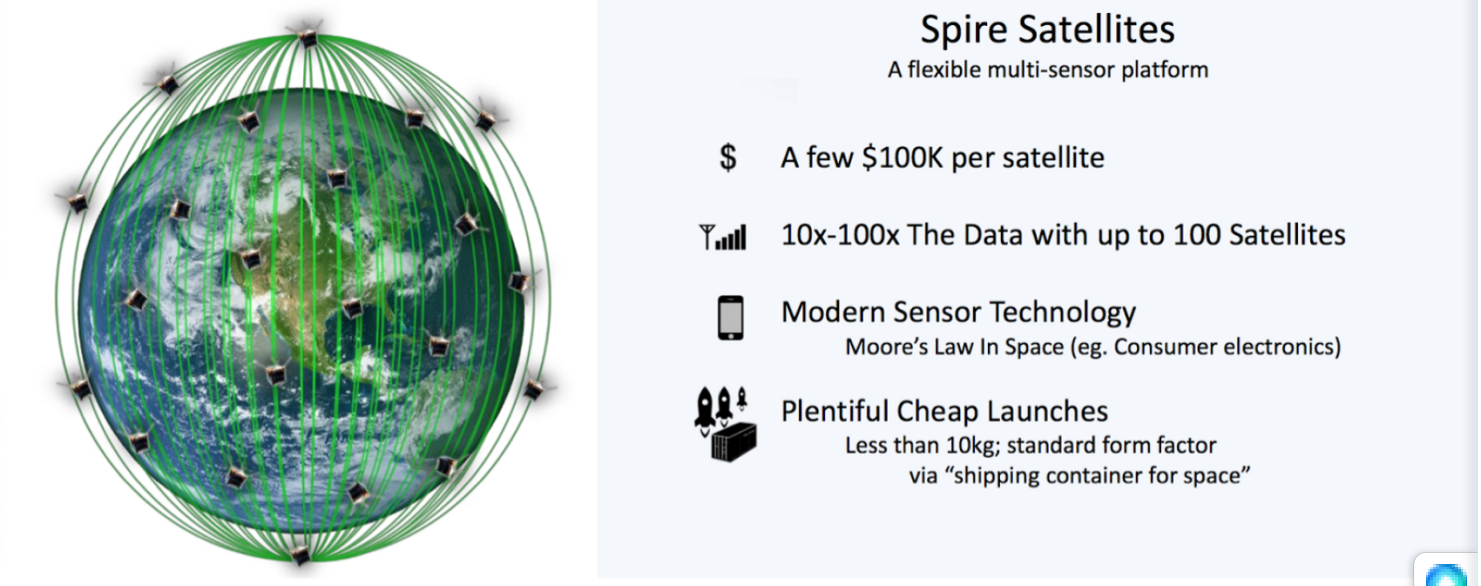
# Spire

To: BVP Group
From: David Cowan, Sunil Nagaraj, and Josh Benamram
Date: May 23, 2015
Re: Spire Series B Flash

On Tuesday, Spire CEO Peter Platzer will present to the partnership by video from Glasgow, Scotland. Spire is developing and deploying a flexible multi-sensor platform in Low Earth Orbit (LEO). The first two markets Spire will address are marine vessel tracking and weather prediction. To date, Spire's team of 50 has successfully launched 4 testing satellites and signed customer contracts worth $9.3M. In the next 6 months, they will launch their first 20 production satellites across 4 launches as they push toward their goal of a constellation of 125 small satellites.

As part of our active spacetech roadmap, we have canvassed the ecosystem for startups like Skybox that are embracing the economics of cheap, software-driven microsats. We have found Spire to offer the most exciting combination of space know-how, entrepreneurial DNA, successful satellites on orbit, and customer traction.




Peter raised a $25M Series A one year ago, led by RRE Ventures (Will Porteous) with an $8M check. This round was done at a $100M post-money valuation when the company had no signed contracts and had launched only 2 test satellites. Despite having $20M in cash left today, Peter has been receiving inbound interest in a Series B, so he just signed a term sheet from Promus Ventures who will lead a $25M Series B with a $5M check at a $200M pre-money valuation. But Peter has been advised on many fronts to get BVP in his company, and so he is offering us an allocation of the Series B preferred round.

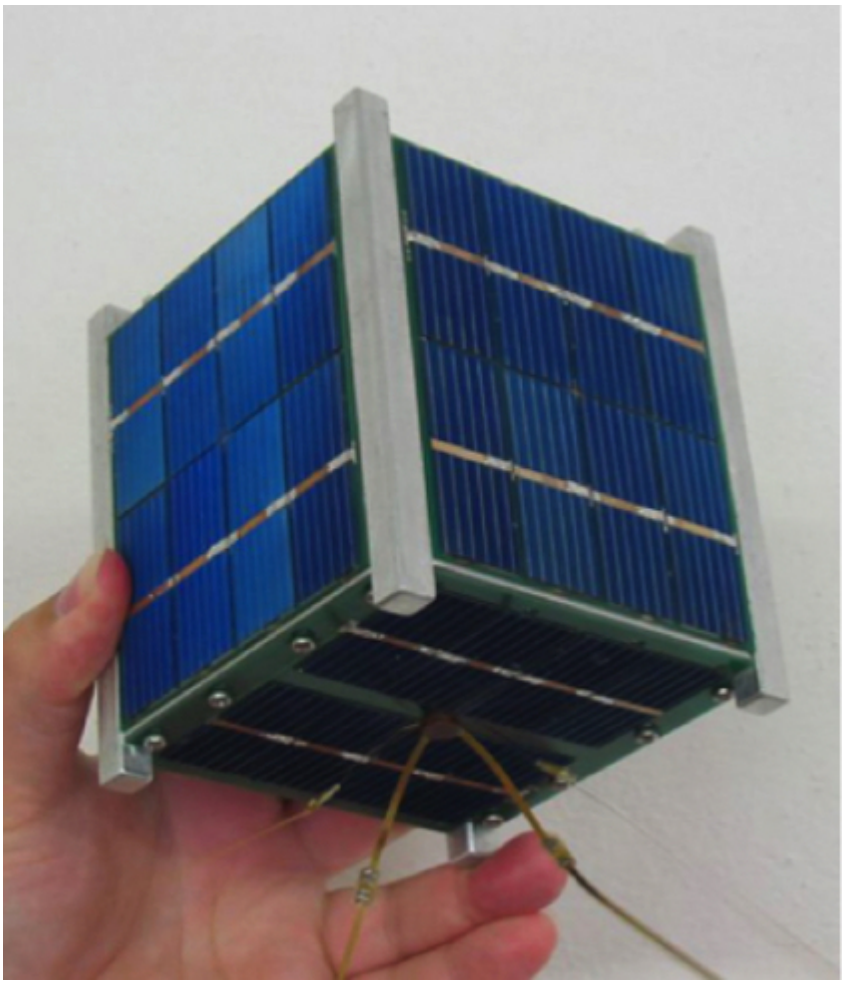
We look forward to your feedback on this investment.

# Spire's Vision

Spire is a space-based intelligence company that leverages new trends including component standardization, miniaturization ("Moore's law in space") and software-defined capabilities to pursue data markets newly available for small satellites. Spire currently operates in marine asset tracking and weather data markets - specifically AIS and GPS-Radio Occultation (GPS-RO) - but aims to deploy a flexible multi-sensor platform.

In many markets, Spire will offer a better product than legacy providers at a fraction of the cost. This is possible because of the economies of scale inherent to the small satellite model, specifically the lower cost to build, launch, and operate a large constellation of small sensors instead of a single monolithic satellite. This approach allows for a better end-product by enabling Spire to offer real-time data with global coverage. (Skybox Imaging leveraged the same advantage but for geospatial imaging.)

# Product



Spire has designed a cubesat to operate in what will eventually be a 125-satellite constellation to collect RF measurements for high-value markets. A cubesat is a relatively new standard format for satellites that is measured in "U" where a 1U cubesat is a 10x10x10cm cube (see photo to the right). With the creation of a standard for this small satellite chassis (or "bu[illegible]he industry is rapidly innovating components, construction, and launch techniques to drive down cost dramatically. In[illegible]n has driven major improvements in small-scale memory, computing power, antenna, and bandwidth. Furthermore, thes[illegible]mallsats are becoming cheap enough that a failure is not detrimental to the constellation. These small satellites are

typically placed into an 400-600km Low Earth Orbit (LEO) where they typically degrade and burn up in the atmosphere in 2-5 years. This not only improves measurement sensitivity (because they are closer to Earth) but also ensures older satellites de-orbit and make room for replacement satellites with newer technology. Spire follows the philosophy best articulated by Planet Labs, another spacetech company doing low-res geospatial imaging, which talks about their cubesats in the same way that Amazon or Google talk about servers: they realize that servers or satellites regularly die but that the overall cluster is resilient to failure.

Spire has developed IP around a highly flexible cubesat platform that can easily integrate different payloads, enabling the Company to attack a number of application areas. The Company is pursuing marine asset tracking and weather data because both markets represent (1) established buyer bases with high contract values, (2) growing addressable markets, (3) technical payload characteristics that play into Spire's strengths in software defined radio, RF signal processing, and small component integration, and (4) areas that stand to significantly benefit from the real-time global coverage enabled by microsat constellations. The company will continue to pursue application areas that match these criteria.

Spire has designed a 3U (30x10x10cm), 5kg satellite that has several RF transceivers and a low resolution optics payload. The payload includes the following:

- 1 off-the-shelf AIS antenna for marine vessel tracking
- 1 Spire-designed AIS antenna with certain performance improvements
- 1 Spire-designed GPS-RO antenna for weather data collection
- 1 GPS-RO Antenna custom designed for spire by an antenna manufacturer
- 1 off-the-shelf imaging camera for marine vessel tracking
- 1 off-the-shelf infrared camera
- 2 UHF antenna for ground communications
- S-Band antenna for high-speed ground communications

The satellites will be launched into 600km sun-synchronous orbit. Each satellite costs $160K to build and an estimated $235K to launch on ride-shares. In the next 6 months, Spire will launch 20 satellites across 4 confirmed launches. This will achieve a 30-minute revisit time (when a satellite passes over the same spot on earth), which will make Spire the leader in gathering real-time AIS data. Even before launch, the Company is winning over customers because of the appeal of the constellation with global coverage and higher revisit rate.

# Market segment: AIS

Automated Identification System (AIS) is a standard maritime navigation safety communications system. The International Maritime Organization (IMO) mandates that AIS be fitted on all ships of 300 gross tonnage and upwards, and passenger ships irrespective of size. This covers approximately 100K vessels worldwide. AIS signals provide vessel information, including the vessel's identity, type, position, course, speed, navigational status and other safety-related information automatically to land- or space-based AIS sensors, other ships, and aircraft. AIS was originally championed as a navigation tool for collision avoidance, but the data are now used to improve maritime and coastal security, and for commercial applications in fleet tracking, marine insurance, commodity trading, and other areas.


Position reports are broadcasted very frequently (between 2-10 seconds, depending on the vessel's speed, or every 3 minutes if at anchor), while static and voyage related reports are sent every six minutes.

The AIS standard started to emerge in 2002 and already represents a global market estimated at $800M in equipment data sales in 2014. Around 2008, tech innovation made it feasible to deploy space-based AIS sensors for coverage of vessel activity beyond the coast. ORBCOMM and ExactEarth are the two companies that currently dominate the space-based market, with combined revenues in the range of $85-100mil. More on these 2 competitors in the Competition section of this flash.

Buyers of AIS include shipping and logistics companies, marine insurance, financial institutions & commodity trading firms, and governments. Vessel tracking applications use data to build maps of global fleet movements, for fleet management and monitoring. Insurance companies use AIS data to build risk assessment and pricing models, to estimate expected losses, and forensically investigate claims - for example, when a policy might be breached or when the covered vessel is in da[illegible]s area. Governments purchase AIS data for more secure monitoring of shoreline waters, rescues, enforcement of fis[illegible]ules. Finally, a growing number of data-oriented independent software vendors are purchasing data for analytics

applications to Wall Street, commodities trading firms, and other end users. Spire offers all these customers more granular data and better visibility of vessel and cargo behavior.

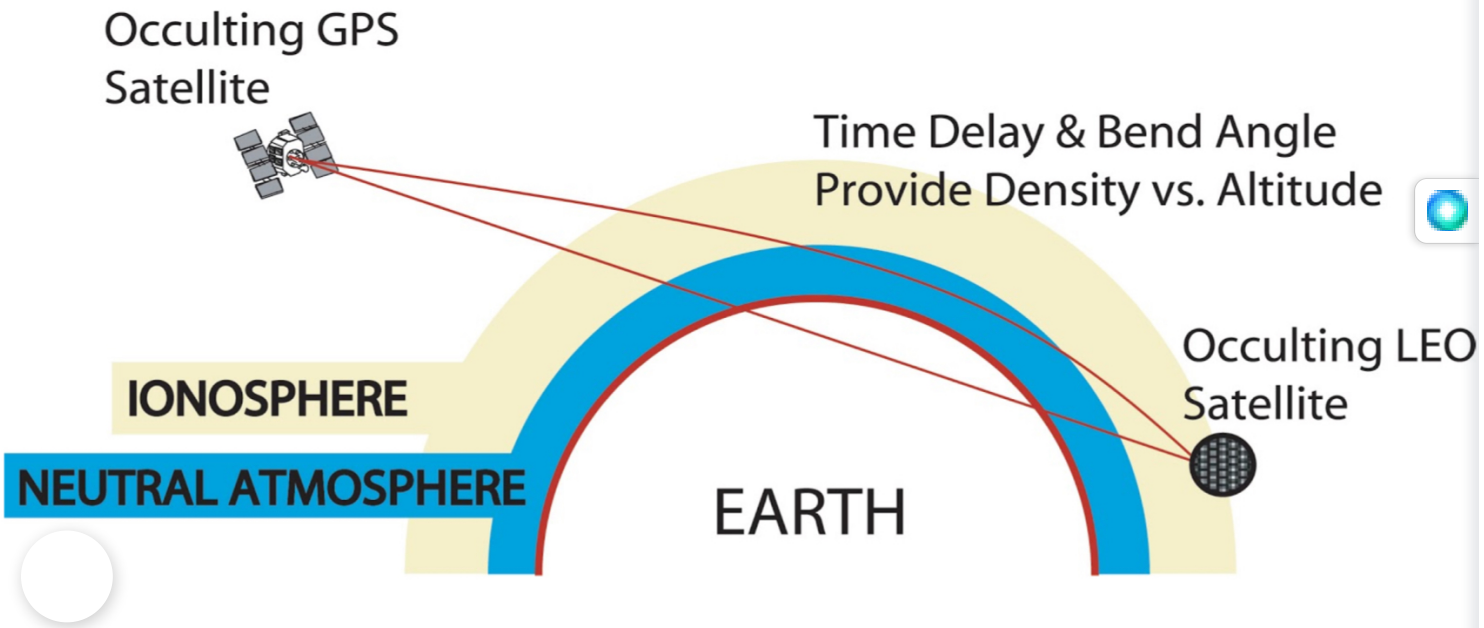
# Market segment: Weather

Beyond marine asset tracking, Spire is also pursuing the satellite weather data market. This area is attractive because of growing demand for better forecasting tools to help consumers, businesses, and governments navigate extreme and adverse weather conditions and the economic losses associated with them. In order to predict the weather, the ecosystem of public and commercial entities feed many data points into their own numerical weather prediction models (NWPM) that drive forecasts. The "holy grail" of weather forecasting is a system that is able to collect high-quality, global data at relevant altitudes of the atmosphere in real time. Spire is pursuing this opportunity because of several trends:

- Growing demand for real-time weather data (>10% of US GDP is directly affected by unpredictable weather, especially the heavy industry verticals like agriculture, oil & gas, and construction as well as transportation, logistics, insurance, and recreation/hospitality sectors.
- Global warming leads to a higher frequency of historically extreme weather systems
- Innovations in software defined radio
- Increasing maturity of GPS Radio Occultation (GPS-RO)
- The 2 major US weather satellites are reaching end of life next year
- Under budget pressure, NASA now inclined to buy vs build (eg SpaceX)

GPS Radio Occultation (GPS-RO) is emerging as one of the most promising contributors to forecast accuracy. The 32 satellites that comprise the familiar Global Positioning System (GPS) transmit signals to users on Earth to triangulate their position. These same signals also cut through the atmosphere and come out the other side, bending slightly due to properties in the atmosphere.

Appropriately-positioned satellites are able to measure a great deal from each occulted GPS signal to pull incredibly accurate data profiles for temperature, pressure and humidity at the point of the bend. Given that the GPS satellites and the measuring satellites are in constant orbit, a full profile of the Earth's atmosphere at virtually all altitudes can be computed.



GPS-RO measurements have been validated by the publicly-funded COSMIC satellite system, which was launched in 2006 but is now deteriorating and is well beyond its design life of 2 years. This data gap of high value measurements is what Spire is addressing with its constellation. COSMIC's successor, COSMIC-2 is composed of 2 phases. Phase 1 is funded by the Taiwanese who are partners with the US on developing the system because it helps them understand the water vapor in the lower troposphere which is fuel for typhoons. As a result, COSMIC-2 phase 1 will only gather GPSRO within the equatorial region for typhoon prediction when it is slated to launch in mid-2017. Phase 2 of COSMIC-2 has not yet been completely planned and is unfunded so the best estimates are that it may take until 2020 before it is on orbit. Bottom line is there appears to be adequate room for government and commercial to meet this need assuming customers will pay to improve the weather prediction accuracy. With that said, even if all COSMIC-2 satellites are launched on orbit, there will be ample opportunity for a complementary system due to the high saturation point of GPS-RO data.

The appeal of cheaper, more advanced private sector alternatives to publicly funded weather infrastructure is winning over policy makers. The National Defense Authorization Act (H.R. 4435) authorizes the DoD to explore commercial satellite capabilities and has put limits on public investment in weather instrumentation. The Weather Research and Forecasting Innovation Act (H.R. 1561), passed just a few days ago on May 19th, aims to drive our weather agency (NOAA) towards private sector data sources, by setting a timeline and allocating more budget for commercial weather pilots programs.

# Other Market Segments

Spire is pursuing further development plans in asset tracking and weather markets. Similar to AIS for monitoring of maritime vessels, Automatic Dependent Surveillance-Broadcast (ADS-B) is the standard of monitoring of global airfleet traffic. The FAA has mandated that virtually all aircraft flying in United States airspace above 10,000 feet must be equipped with ADS-B Out by 2020. The European mandate

for ADS-B is June 2016, for new aircraft and June 2020, for retrofit. Currently air traffic is largely monitored with terrestrial ADS ground stations that only provide coverage of around 10% of the globe. The limitations of ground-based ADS poses several problems that can be addressed with satellite-based coverage, including limited or no surveillance over oceans and remote land regions, routing and fuel inefficiency to maintain comms link, and slow data transmission times. When Spire's constellation adds ADS capability, they will be able to address these issues at a far lower price point than the cost of building and maintaining terrestrial ground systems.

Spire is also engaged in conversations about a next generation weather monitoring sensor, using a promising new technique called GPS-Reflection that would allow for measurements of wind and ocean surface properties. More generally, CEO Peter Platzer has said, "if it sends out an RF signal, I can do it. And if anyone cares and pays me, I will do it."

# Customer traction

Spire has been aggressively selling product. The Company has already secured over $9M in contracted revenue that will turn on when the first 20 satellites go live. Spire also has a number of signed LOIs that further provide visibility.

# State of Technology

Spire will launch 23 satellites this year across 4 launches. The Company has contracted launch capacity aboard the H2A rocket from Japan, SpaceX Falcon-9, the Indian PSLV, and Russia's Soyuz. The first batch of satellites are being completed now in Glasgow, Scotland in a facility shared with ClydeSpace. ClydeSpace is the world's most experienced cubesat builder, so Peter has a combined team of Spire employees and ClydeSpace employees assembling the first 20 satellites.

To date, Spire has deployed 4 cubesats across 3 launches. The first two cubesats provide basic telemetry data, validating the core engineering platform. The first version of the integrated AIS/RO cubesat was launched to sun-synchronous orbit in May 2014. The satellite provided AIS, as well as GPS lock (established communications with high orbit GPS satellite). The satellite's engineering data validated proper functioning of the on-board computer, batteries and solar.

The Company has made significant progress in ground station development, with 9 currently deployed across the continental US and Hawaii. The first international ground station is undergoing installation in Glasgow. Ground stations allow for up and down communication with the satellites, uplink for

calibration instructions and programming commands, downlink for sensor data transmission. By June 2015, Spire is targeting 14 online ground stations, with new locations across Australia, Pacific Islands, South America, Africa, and the Middle East.

We sent an expert space consultant to visit Spire's San Francisco and Glasgow, Scotland offices. He spent a day with team members in each location to go through their technical plans. He evaluated the quality of their technical team as well as the feasibility of their plan. He came away impressed

with the team's approach and skillset. In particular, he was happy that the team is already working on all various elements including ground stations and data analysis as well as the spacecraft and RF payloads. His only concern was about the scalability of their skills given that they have only ever run 1 or 2 satellites in orbit at the same time. He believes they are preparing for this but operating a constellation of 125 satellites is a much more complicated ordeal. We are including his report as an attachment to this memo.

# Team

Spire has a strong technical team, with backgrounds in satellite technology, software development, and the Company's application areas. The Company already has a robust sales operation that has been driving customer interest, locking down contracts and LOIs. The Spire team approaches satellite build with software development principles. Enabled by commoditization and redundancy in the constellation, Spire emphasizes continuous integration and deployment, an approach that makes the company far more agile than the competition.

Peter Platzer, CEO, has a deep technical and business background. Peter has

degrees in Physics, Space Science, and a Harvard MBA. He has previously worked at CERN (Europeon organization of Nuclear Research and operator of the LHC),

Boston Consulting Group, NASA, and a quant trading firm.

Russ Muzzolini, CTO, heads the software and data development divisions. Russ has a computer science background was previously VP of engineering at Shutterfly.

The satellite build, launch and operation team is headed by Jeroen Cappaert, Joel Spark, and Jeff Kuehne, with shared experience at NASA, EADS Astrium (aerospace manufacturing), and Lockheed Martin.

Sh[illegible]t Ali Shah and Theresa Condor lead the sales organization. Shabahat was previously Director of Global Strategic Sa[illegible] Oracle, and Theresa VP of Sales at Citi-Group Trade Finance, and Maritime Sales at Windmill. (Theresa is married to

Peter Platzer.)

# ITAR

The International Traffic in Arms Regulations (ITAR) control the export and import of defense-related goods and services on the United States Munitions List (USML). ITAR regulates satellite technology because of implications of rocket/missile development and the potential of sensitive payload

technology, among other things. ITAR can have onerous restrictions in different areas of the satellite lifecycle.

Spire is in the process of transferring all the technology out of the US, and within a few years they will be totally ITAR free. 13 months ago, they started transitioning certain components from ITAR controls to EAR (export control) which is regulated by the Department of Commerce and less oppressive. All future component integration and satellite development will be done in Spire's Glasgow and Singapore offices. San Francisco will remain the main office, and house ground station operations and data analytics. Since all equipment launched into space will never enter the US, they will not be subject to ITAR. As of now, the only satellite component that is ITAR controlled is the FOTON receiver (RO payload). However, the ITAR rules state that if <25% of the satellite is ITAR-controlled components, then the satellite is still EAR controlled; but still that means they can't launch with China currently. (New Zealand, on the other hand…)

# Competition

The AIS market is led by ORBCOMM and ExactEarth, a subsidiary of ComDev. Spire is well positioned to take market share from both legacy players, and expand the market further. In fact, about half of Spire's contracted and LOI pipeline in AIS data is comprised of dissatisfied ORBCOMM/ExactEarth customers. A large portion of Spire's pipeline are new buyers, who previously considered AIS but held back because of data quality concerns. Spire won them over with the appeal of global coverage in close to real-time at a very reasonable price point.

Based on our market and technical diligence, and Spire's customer engagements, we have confidence that Spire will win this market. Spire's advantages include:

- The ability to create higher value end-product through data-fusion techniques
- The ability to deliver higher quality product through on-board data analyze for immediate reaction and download bandwidth optimization
- The ability to provide high revisit time at a low price point (matching revisit would require major capital investment)
- A technology roadmap for improved capabilities

In the weather data market, Spire's competition includes public missions (COSMIC) and a small number of startups also looking to capitalize on the RO data-gap opportunity. The publicly funded instruments do not pose a threat because they are deteriorating, and funding delays/commercialization pressures have pushed meaningful global coverage several years into the future.

PlanetIQ and GeoOptics are the other RO startups. We have engaged in investment conversations in both. PlanetIQ stands out as the more serious player between the two, with a very strong technical team. After deep diligence on PlanetIQ, we de[illegible] to stand back and move our attention to Spire. We were compelled by Spire's far greater expertise in developing ar[illegible]oying satellite systems, strong RO technology, encouraging diligence calls with potential customers and stakeholders, more

solid pipeline of customers, and the approach of attacking multiple markets at once in order to hedge risk.

After deep conversations with both PlanetIQ and Spire, PlanetIQ's technical experience in RO was convincing enough for us to float the idea of an acquisition, where BVP would fund Spire's acquisition of the company. Peter has been fairly supportive of the idea, though the interest of PlanetIQ's major shareholder has waned after some initial enthusiasm (we believe they have a $10M financing term sheet from a corporate strategic partner). The two companies have a very different philosophy behind satellite development and overall approach to the market. While PlanetIQ aims to be a weather data and weather-related services company, Spire is a space-based intelligence company with a flexible, but deep, platform approach. Having studied the relevant markets, we were won over by Spire's experience in space technology, low cost and high capability model.