MBA 295T.1

Entrepreneurial Strategy

SATELLOGIC: CREATING AND CAPTURING VALUE FROM MICRO-SATELLITE IMAGERY[1]

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Kurt Billick was in a comfortable place in his life. He had built a wide-ranging and successful career in finance, beginning as an agricultural commodities trader and finally owning his own hedge fund. After receiving his MBA from UC Berkeley Haas in 1994, Kurt worked as a sell-side research analyst covering the mining industry. He spent the next 15 years at both investment banks like UBS and specialized hedge funds, managing global commodity portfolios with assets of hundreds of millions of dollars. In 2010, Kurt founded Bocage Capital, an asset management firm where he successfully raised over $1.5B in institutional assets from a variety of investors. As Chief Investment Officer at Bocage, he leveraged his expertise in energy, power, metals and agriculture to invest in futures, equities, currencies, and corporate debt securities.

In early 2017, Kurt was ready for a new challenge. At a networking event, he reconnected with a friend from Haas who worked at Google Ventures. Their discussion veered towards the rise of new private-sector companies in the satellite space industry and their implications for diverse sectors like energy, commodities and agriculture. Kurt had been following these developments as a keen observer of new technological developments in these areas, including past experience around commodities, and agricultural securities, and he had strong views on the industry. “The cost issues are too significant,” he professed, implying he had reservations about the potential of the technology to have broad impact. Aware that Kurt was looking for his next act, his friend had a sudden realization. “I know the guy you need to meet,” he said to Kurt.

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[1] This case was developed by Abhishek Nagaraj and Gauri Subramani solely for the purposes of classroom discussion. It is not intended to illustrate either effective or ineffective handling of an administrative situation, nor as a source of data. Some case details have been adapted to facilitate the learning objectives of the case. It should not be quoted, reproduced, distributed, or shared in hard copy, electronic or any other form without express permission from the authors. Feedback is welcome to nagaraj@berkeley.edu.

The Satellite Industry

In 1954, the U.S. Air Force began developing satellites for military intelligence. The goal of these early programs was to take photographs from space and relay them back to earth. These early satellites were equipped with a panoramic camera intended to photograph the Soviet Union. The exposed film would be de-orbited for mid-air or ocean recovery. In case the aircraft missed, the capsule would float for two days, during which time Navy boats attempted to recover it. The first of these satellites, developed by a joint Air Force and CIA project named Corona, was launched in February 1959, and the program had 38 public launches before the ending in 1972.[2] While people outside of the government (for example, the Polaroid Corporation) were instrumental in the creation of the Corona satellites, the program itself was funded and managed by the U.S. government. The mission of the program, which cost an estimated $850 million at the time, was to collect data and monitor foreign military sites to help American leaders make national security decisions.

During this time period, other government agencies were working on creating communications and weather satellites designed for civilian, rather than military, use. A Department of Defense program launched the world's first communications satellite at the end of 1958, and in 1960, NASA launched a weather satellite with cameras whose images provided the first accurate weather forecasts using satellite data. In 1966, the Department of the Interior announced Project Earth Resources Observation Satellites, a program intended to gather information about natural resources from satellite images. The program was renamed as Landsat in 1975, and has launched eight satellites successfully, with plans to launch Landsat 9 in 2020. The latest Landsat satellite has spatial resolution of 30m which meant that each pixel in an image mapped to a 30m x 30m area. The satellite also has a temporal resolution of 16 days, which implies that new image is captured for a given region approximately twice every month. The Landsat program, which has provided freely accessible medium resolution imagery of the earth for over 40 years, remains the most continuous and prominent freely-available source of medium-resolution satellite imagery available to this day.

Beginning in the 1960s, AT&T and Bell Telephone Laboratories launched commercial satellites that could transmit television and telephone signals. However, it was not until the 1990s that the commercial satellite market began to grow, in part due to the Land Remote Sensing Policy Act of 1992 that allowed private companies to enter the satellite imaging business. WorldView Imaging Corporation, which was later renamed DigitalGlobe, was one of the pioneers in this field and commercialized satellite images and data analysis. DigitalGlobe launched a number of satellites that cost hundreds of millions of dollars to build and launch and provided very high

[2] https://www.army.mil/article/173155/project_corona_americas_first_photo_reconnaissance_satellite

resolution imagery as compared to Landsat. DigitalGlobe's latest satellite, Worldview-4, built at a cost of $835 million,[3] was launched in November 2016 and provides images at a resolution 0.3m[4] with a temporal resolution of four to five days.

Motivated by the high costs of traditional satellites, in 1999, Jordi Puig-Suari of California Polytechnic State University and Bob Twiggs of Stanford University[5] helped to develop specifications for a small satellite that weighed less than 2 kilograms and could be launched as a secondary payload, a small payload on a launch vehicle that was already sending a larger satellite to space. They called these small satellites CubeSats, and their initial intention was to enable grad students to design, build, and operate these small satellites. These satellites were much cheaper to launch and the materials to create a CubeSat were themselves relatively low-cost, with a total price tag of $50,000.

Until 2013, most CubeSat launches were done by academics and institutions, but starting in 2013, most newly deployed CubeSats were for commercial projects.[6] A number of companies were created, most notably Planet Labs, which was founded in 2010 to exploit the commercial potential of the CubeSat technology. By 2018, Planet had launched over 175 of these small satellites (called "doves") which can image the earth at a 3m resolution, and collectively, aim to provide an image of every point on the planet's surface every day.[7]

Building an Affordable Satellite

Emiliano Kargieman, a.k.a. EK, an Argentinean tech entrepreneur, got the idea for creating a satellite company when he was attending a Singularity University program at NASA Ames Research Center in 2010. Singularity University was a Silicon Valley think tank that offered programs for executives and managers on emerging technologies and fields of study like human enhancement and AI.

Emiliano came to Singularity University after leaving his role as a Managing Director and co-founder of Aconcagua Ventures, the tech venture capital firm he had founded in Argentina. He had spent four years building the company and investing in early-stage software, internet, and medical device companies in Latin America. He was still involved in an advisory role with the first company he founded almost 15

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[3] https://spacepolicyonline.com/news/enhancedview-news-not-so-rosy-for-geoeye/

[4] https://dg-cms-uploads-production.s3.amazonaws.com/uploads/document/file/196/DG2017_WorldView-4_DS.pdf

[5] https://www.ft.com/content/c7e00344-111a-11e8-940e-08320fc2a277

[6] https://sites.google.com/a/slu.edu/swartwout/home/cubesat-database

[7] https://www.planet.com/products/satellite-imagery/files/Planet_Combined_Imagery_Product_Specs_December2017.pdf

year prior, an information security software provider based in Boston. He had no prior experience with space technology, and his hope was to learn more about the sector, as well as to talk with entrepreneurs from other fields.

Emiliano was surprised to learn that the pace of innovation in information technology had far outstripped the development of space technology. At the time, it took ten years to build a functioning satellite from start to finish. Satellites were subject to physical limitations; the quality of the photos they took were reliant on the amount of power the satellite had, and the size of a satellite determined how much data it could store. It seemed that satellites either had to be large and expensive and thus have poor ground coverage because of the cost and difficulty of launch, or be small and cheap and provide low-quality data and images.

SATELLOGIC: A Venture Takes Shape

It occurred to Emiliano that it must be possible to find some middle ground between time-intensive, high-cost satellites and low-cost but low-value satellites. He imagined that the data and images collected by these satellites could provide real-time information on infrastructure, natural resources, and even social conflicts. He drew a blueprint for a satellite made of inexpensive individual components that could be easily replaced while the satellite system remained reliable, and he envisioned launching 300 satellites into space to provide imaging around the globe.

Later in 2010, Emiliano founded Satellogic, a company focused on executing this mission. He had connections in the tech community in Argentina, and felt he could better recruit engineers and raise capital there. Emiliano's first priority was building a strong technical team at Satellogic. He began by hiring five software and electrical engineers, three of whom he knew well from his prior work. He was also able to raise some capital from the Argentine space agency as well as some local angel investors. Notably, many of the first engineers that Emiliano hired were not from the satellite industry, but were instead general technologists. Because there were restrictions on importing the required parts in Argentina, the satellites were manufactured in Uruguay. Satellogic was also incorporated in Uruguay, which allowed it to avoid U.S. regulations on satellites. The company didn't have to comply with the U.S. International Traffic in Arms Regulations (ITAR) restrictions because it didn't use any American technology, and as a result it was able to launch satellites from restricted countries, like China, which U.S.-based companies could not do. The North American Aerospace Defense Command (NORAD) monitored objects in space, including satellites, and issued collision warnings, and the company was subject to international communications regulations.

With its new team and manufacturing facilities, Satellogic launched its first satellite using a Chinese rocket in April of 2013, and then launched another in Russia later

that year. In September of 2013, the company announced its seed funding round and raised $2 million, all from Latin American investors. In the following three years, the company raised two more rounds of funding, and its 2015 Series A was led by Chinese internet giant Tencent. Throughout this time, Satellogic maintained a low profile and did little external marketing and PR, unlike some of its competitors. The company then followed up with more launches, launching their sixth micro-satellite into orbit on June 15, aboard a Long March-4B rocket that took off from Jiuquan Satellite Launch Center[8] in China. It also announced that it had raised $27 million in a Series B round, again led by Tencent along with a few other investors at in the summer of 2017.

In addition to the technical team working on the satellites themselves, Emiliano hired other employees who would help the company make the most use of and develop monetization strategies for their unique data. Because similar talent was not available in Argentina, Emiliano developed a team in Tel Aviv, Israel through personal connections with a researcher in the image recognition and computer vision space. He also enlisted Marco Bressan, a well-known Argentine data scientist who lived and worked in Barcelona, Spain and built a team of data scientists in Barcelona. By the end of 2017, Satellogic had 100 employees across its three offices in Argentina, Tel Aviv and Barcelona, as well as a small office in San Francisco.

Satellogic's Technology

Satellogic's technology was in many respects superior and significantly cheaper as compared to its competition. The company's satellites had 1m ground resolution, while Planet, its most visible competitor, had images were 3-5m in resolution, and the resolution of images from this distance was too low to distinguish between individual objects, like cars and trees. Satellogic satellites also were the only ones in the small-satellite space that offered hyperspectral imaging (at a 30m resolution). Hyperspectral imaging allowed Satellogic to capture data beyond the visible spectrum, allowing for the detection of specific minerals (which reflect light at a certain wavelength) or assess the state of vegetation. The implications of hyperspectral data for agricultural markets was particularly exciting as this information could be used to monitor crop and soil health and ecological monitoring among a variety of other applications.[9] The arrival of hyperspectral remote sensing to the civilian market through the Landsat program had revolutionized mineral and oil discovery, and Satellogic's technology had the potential to provide such information at a significantly greater spatial and temporal resolution and at a cheaper cost than before. Satellogic's goal to launch a constellation of 300 satellites would enable them to achieve average revisit times of around five minutes anywhere on the planet for

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[8] https://techcrunch.com/2017/06/23/satellogic-raises-27m-for-affordable-high-resolution-imaging-satellites

[9] https://ieeexplore.ieee.org/document/6581194/

one meter resolution multi-spectral imaging, a feat that was impossible with any other competing platform. Further, these satellites were also capable of capturing 720p-4K video across its different spectral bands.

Satellogic's competitive edge also came from the low price of its satellites, which cost roughly one tenth of what the same product from Planet did and well under 1% what a DigitalGlobe satellite cost. This low price was possible because of the satellites' small sizes and lower launch costs. Being headquartered in and manufacturing in South America also helped Satellogic lower its development costs and achieve cost leadership in the small satellite industry. Additionally, Satellogic used commercial technology and relied less on each individual satellite and more on the network of satellites, which allowed the company to use lower cost components that could be replaced in each satellite.

Evaluating the Satellite Market

When Kurt's MBA classmate introduced him to Emiliano, Kurt was interested in the company, but he had no experience in technology. Despite this fact, Emiliano wanted Kurt to come onboard. Kurt's main focus would be to develop a strategy for Satellogic's emerging data pipeline, find applications for the imagery and develop a solid commercialization strategy that would help transform the technological promise of the company into real value for its customers and stakeholders. Satellogic was small, with fewer than 100 employees, most of whom were in technical roles. Kurt told Emiliano, "I'm interested, but I'm not qualified. This isn't a job I've ever done before. I've never sold anything, other than my hedge fund. But I think I understand your markets. And I'd like to try."

During the company's first few years, Emiliano and his team prioritized developing their satellite technology and hiring the right engineers to do so. The established market for satellite imaging was primarily foreign governments and agricultural, energy, and mining asset monitoring. Kurt commented, "The approach with regards to customers was very much 'If we build it, they will come.' We could all see there's a path, so it felt more like a blocking and tackling job. There's an existing market, and our costs are so low, we should be able to penetrate the existing market." However, translating this promise of "build it and they will come" was proving to be more challenging than they originally thought.

Satellogic's existing clients mostly resulted from inbound inquiries about the company, and most of then were in the agriculture and commodities industries. The company had spent very little time actively thinking about a strategic focus and in targeting new customer segments that might be interested in the technology. To demonstrate the value that satellite imaging could provide for a new client, the company would deploy a pilot over a small area for a few customers. Along with the

satellite images, Satellogic also provided data analysis generated by machine learning algorithms that overlaid these photos. Satellogic's leadership was selective in choosing which clients to take on, and focused on providing data to answer problems with a broad audience.

Satellogic's Future Direction

Satellogic's first goal was to get to a constellation of about 60 satellites by 2019, which would allow it to provide high resolution multispectral imagery and medium resolution hyperspectral imagery of the surface of the earth at a frequency of about 2 hours for any given location. As is common in the satellite industry, the team was facing a few technical challenges in order to achieve this objective. Solving these challenges was key to delivering images at the required quality as well as volume required for practical and commercial application. The team felt confident about its ability to deliver on this technical promise.

On the commercial side, a major impediment to Satellogic's plans to complete the constellation was raising enough capital at an attractive valuation to enable Satellogic to manufacture and launch 60 satellites. They believed that if they were the first company to launch a complete fleet of 60 satellites providing high resolution multispectral images, then "there is a natural monopoly here," and that they could leverage their first-mover advantage to protect such a monopoly.

However, in order to achieve this vision, it was critical for Satellogic to discover key applications and new customer segments for Satellogic's imagery. They needed to discover these key applications in order to excite potential customers and attract investors who would be willing to invest at an attractive valuation and help Satellogic achieve its vision by 2019. This was Kurt's main challenge as he contemplated his next move. He wondered, "How do we show that this is a business worth building, without quite being there technically?"

He had a few different choices. First, it was clear to Kurt that his expertise, connections and familiarity with the mining and agricultural sectors would prove valuable. These firms were used to purchasing data from firms like DigitalGlobe for specific applications like monitoring their operations, for exploration of new resources, or for monitoring crop health. Satellogic's data could provide brand new applications that these firms might find very valuable. For example, hyperspectral data that Satellogic's satellites could provide important for agricultural companies trying to estimate crop yields.

Planet had cast a wide net with regards to clients, providing data and imaging to customers ranging from Monsanto and Bayer Crop Science to the Mexican government and Germany's space agency. The company had also acquired Terra

Bella, a satellite company owned by Google that produced high-frequency imaging and provided imaging for Google Maps. Other small satellite companies focused on ship-tracking data to counting cars in parking lots of retail stores, providing valuable indicators for the financial markets. The government applications in particular fascinated Kurt -- over 70% of the revenue of large players such as DigitalGlobe came from federal, state and local government applications including civilian requirements such as infrastructure, urban planning, and traffic monitoring.[10]

He wondered if Satellogic should pursue a strategy similar to Planet's and engage potential clients across several industries, and if so, how the company could deliver value across a broad set of industries. He would need to work with his team of data scientists and discover specific use-cases with each industry partner and provide data analytics to help them gain value out of Satellogic's limited data stream. Or, Satellogic could wholly outsource data and image analysis and integrate directly with clients' existing workstreams-- for example, by developing a tool providing real-time imaging and data that agricultural companies could add to their dashboards. Clients could then conduct their own analyses based on the information they received from Satellogic.

Kurt also wondered about the value of a more "open" platform-style approach, where Satellogic would provide open APIs that allowed third party developers and researchers to use their data and crowdsource the value of their data. This approach could be more powerful in helping Satellogic discover new applications from unexpected sources. However, Kurt worried whether this would be a feasible strategy given the problem that Satellogic's full complement of images at the required quality and volume would not be available till 2019, by which time it was important to raise more capital and demonstrate the value of their product.

Next Steps...

As Kurt considered a variety of different options, one fact became clear to him. 2018 was going to be an important year for him and for Satellogic if they were to deliver on the extraordinary potential of the technology that Emiliano and his team had worked hard on building. It was essential to develop compelling use-cases and develop excited customers for their product offering in the coming months, and use this excitement to raise further financing that would get Satellogic to their first goal of launching a 60-satellite constellation. What Kurt and his team would achieve would not only have a huge impact on Satellogic's future but also on the future of humanity's everlasting quest to understand and harness the power of space technology for all.

[10] https://www.digitalglobe.com/industries/civil-government

Figures

Figure 1. A Satellogic micro-satellite Nu-Sat 1 under development[11]

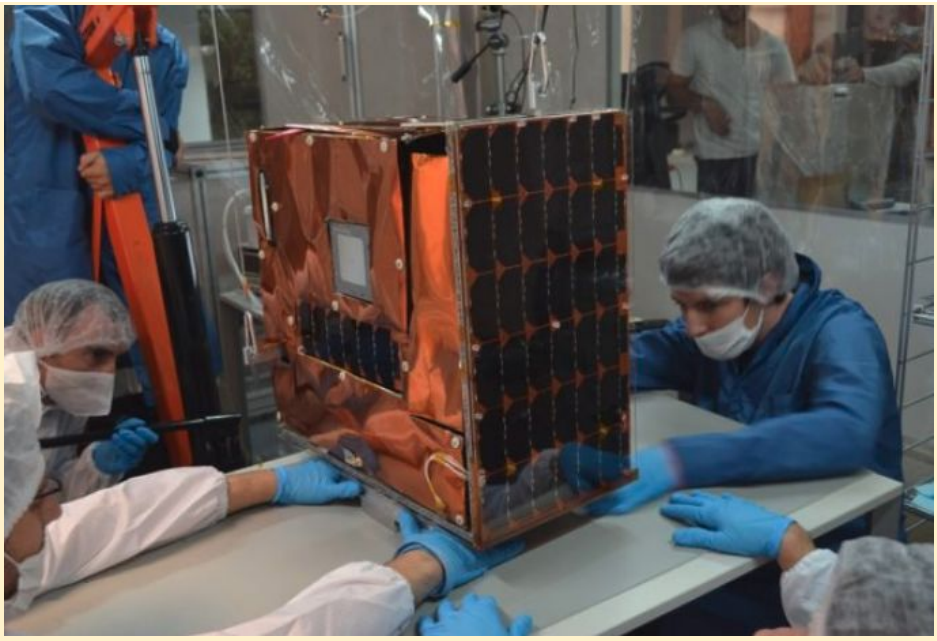

Figure 2. Capabilities of Satellogic Aleph-1 Constellation[12]

ALEPH 1 - PAYLOADS	Panchromatic	Multispectral	Hyperspectral	Thermal Infrared
Ground Samplig Distance	1m	1m	30m	90m
Swath	5km	5km	150km	92km
Spectral Bands	400-900nm	400-690nm 400-510nm 510-580nm 580-690nm 750-900nm	400-900nm up to 600 spectral bands 5nm FWHM	8µm-14µm 0.01K resolution
Modulation Transfer Function at the Nyquist	> 15.00%			
Dynamic Range	54dB raw / 66dB HDR			
Signal-to-Noise Ratio	43dB			
Boresight	25 deg			
High Definition Video	720p, 1080p, 4K, in every spectral band			

[11] http://spaceflight101.com/spacecraft/aleph-1/
[12] http://spaceflight101.com/spacecraft/aleph-1/

Figure 3: Comparison between 1-m and 30-m imagery[13]

Figure 4: Satellogic "Industry Solutions" Webpage[14]

[13] http://www.gisagmaps.com/landsat-naip-comparison/
[14] https://www.satellogic.com/industry-analytics