Small Satellite Market Observations

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ABSTRACT

Since 2008, SpaceWorks has actively monitored global small satellite activities, and annually publishes a summary update to the satellite development and launch communities. SpaceWorks' 2014 Projection estimated between 140 and 143 nano/microsatellites across all sectors would launch globally in 2014; 158 nano/microsatellites actually launched, representing an increase of nearly 72% compared to 2013 and a growth of over 40% per year since 2009. The data source for this assessment is a subset of the SpaceWorks Satellite Launch Demand Database (LDDB), an extensive collection of all known historical missions, announced future satellite projects, and estimated future commercial missions. This paper presents the latest observations and trends for the nano/microsatellite market based on over 1,100 identifiable satellites currently under development with masses between 1 kilogram and 50 kilograms.

INTRODUCTION

For the last four years, SpaceWorks has produced an annual projection of the nano/microsatellite (1-50 kg) industry. Last year's projection estimated between 140 and 143 nano/microsatellites would launch globally in 2014; 158 nano/microsatellites actually launched, an increase of nearly 72% compared to 2014 (Figure 1). In particular, 107 of the 158 were satellites operated by commercial entities.

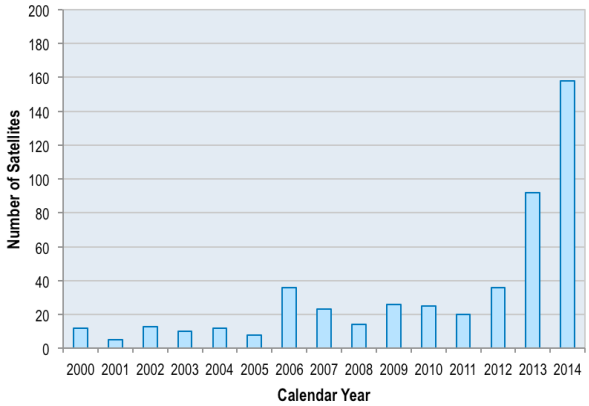

Figure 1: Historical Nano/Microsatellites Launched from 2000 to 2014

Definitions and Terminology

Throughout this paper, the term "nano/microsatellite" is used on numerous occasions, and the author's use of this term refers to satellites with a total mass between 1 and 50 kg. Nanosatellites are generally defined to be those whose total mass is between 1 and 10 kg and microsatellites include those whose total mass lies between 11 and 100 kg. This paper only includes microsatellites with masses up to 50 kg given the relative large amount of satellite development activity in the 1-50 kg range by comparison to the 51-100 kg range (Table 1).

Table 1: Mass Ranges by Satellite Class

Satellite Class	Mass Range
Femtosatellite	10 – 100 g
Picosatellite	< 1 kg
Nanosatellite	1 – 10 kg
Nano/Microsatellite (Scope of this study #1)	**1 – 50 kg**
Microsatellite	11 - 100 kg
Small Satellite	101 - 500 kg

The term "small satellite" is also used and refers to satellites with a total mass between 101 and 500 kg. The mass ranges indicated here refer to the satellite's gross mass, which may or may not include propellant, depending on whether the particular satellite has propulsion.

2014 HIGHLIGHTS

Over the last four years (2010 – 2013), the number of launches has remained relatively constant, with an average of 80 attempts per year.[1] With 92 worldwide launches in 2014, the industry experienced the second highest annual launch rate since 1994.[2]

Notable Nano/Microsatellite Activity

Of the 158 satellites nano/microsatellites launched in 2014, commercial companies contributed more than two-thirds. In fact, more commercial nano/microsatellites launched in 2014 (107) than all of last year combined (92), 87% of which Planet Labs contributed. To date (mid-June), Planet Labs has launched 113 CubeSats (93 in 2014), the largest quantity ever contributed by a commercial company. Figure 2 shows other notable satellites that launched in 2014. [2]

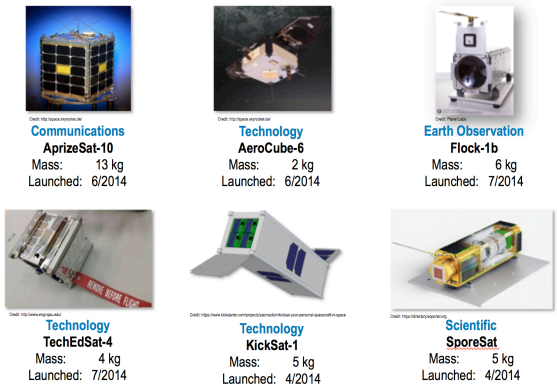

Figure 2: Nano/Microsatellite Applications and Associated Examples

Antares carried 32 CubeSats on the July 13th launch to the ISS, the third of five Commercial Resupply Services (CRS) missions that occurred last year. Unfortunately while deploying the satellites from the ISS, the NanoRacks CubeSat dispenser experienced two failures (one non-deployment event and one unplanned deployment), forcing 14 satellites to remain on-board. [2]

Since most nano/microsatellites launch in large clusters as secondary payloads, a single failure can result in significant loss. Unfortunately, this happened on October 28th, 2014, when 30 nano/microsatellites were lost after Antares failed shortly after launch. As a true testament to the agile development practices of the small satellite community, Planet Labs built and delivered two satellites to include on the SpaceX CRS-5 mission that replicated the specifications of the 26 satellites lost on Antares just a few months before. [2]

Notable Small Satellite Activity

Multiple companies were rumored to be developing large communication satellite constellations in 2014. In early 2015, the rumors were confirmed when SpaceX and OneWeb (formerly WorldVu, Ltd.) announced their plans to pursue sizable constellations of 4,025 and 648 satellites, respectively (Figure 3). Both companies have secured significant funding as well as launch arrangements. [2]

Figure 3: Graphical Representation of Coverage Provided by OneWeb Satellite Constellation[27]

OneWeb, backed by Virgin Group and Qualcomm, expects its Ku-band satellite Internet constellation to cost up to $2 billion to build and deploy.[3] OneWeb received bids from Airbus Defence and Space, Lockheed Martin Space Systems, OHB AG, Space Systems/Loral, and Thales Alenia Space to build the constellation of more than 600 satellites.[4] OneWeb's cost goals were aggressive, targeting ~$500,000 per 150-kg satellite, which is comparable to some CubeSat budgets.[2] In June of this year, OneWeb selected Airbus to build 900 satellites (includes spares), with the first launching in 2018.[5] Airbus plans to build all but ten of the satellites in the United States. [5]

SpaceX's competing satellite Internet constellation will consist of more than 4,000 satellites.[6] With more than $1 billion in combined funding from Google and Fidelity, SpaceX opened a satellite manufacturing facility in Seattle, where the company will employ hundreds of people.[7,8] Musk expects the satellites to weigh a couple hundred kilograms each and hopes to have an initial constellation deployed in five years. [6]

These recent multi-million and multi-billion dollar investments in these and other ventures confirm the commercial sector's continued interest in the nano/microsatellite and small satellite industries.

NANO/MICROSATELLITE TRENDS

SpaceWorks Launch Demand Database (LDDB)

SpaceWorks maintains an internal Satellite Launch Demand Database (LDDB) to support near-term market forecasting as well as other financial and business case analysis. The LDDB is an extensive database of all known historical (2000 – 2014) and future satellite projects with masses between <1 kg and 10,000+ kg. Future satellites in the LDDB include publicly announced projects and programs and quantitative and

qualitative adjustments to account for the expected sustainment of current projects and programs (e.g. follow-on to NASA's EDSN and CubeSat Launch Initiative programs), as well as the continued emergence and growth of numerous existing commercial companies.

In addition to the satellite's mass, the LDDB contains other types of information about the satellite: satellite owner/operator, country of owner/operator, contractor, sector (civil, government, military, commercial), application (Earth observation/remote sensing, technology, science, communications, reconnaissance), orbital parameters (apogee, perigee, eccentricity, inclination, period), launch year, launch date, launch location, and launch vehicle. A recent update to the LDDB incorporates data on uplink and downlink frequencies and data rates.

For far-term forecasting (~10 years), SpaceWorks uses satellites within the LDDB to discretely extrapolate demand, enabling more detailed market simulations. This "populator" uses historical and future satellites, along with their defining characteristics, to produce the demand. These discrete satellites are used to predict future launch vehicle flight rates, to deliver far-term satellite forecasts, and to support other market assessments.

Mass Trends

The modular nature of the CubeSat enables many space-related development activities and can be credited with the growth and transformation of the small satellite market. Given the significance of the CubeSat standard in defining the market, it is important to monitor developments and changes in the CubeSat architecture as the market continues to evolve.

The motivation for designing the CubeSat was to provide academia with a design standard to minimize development cost and time and to enable greater accessibility to space from a financial and launch availability perspective.[9] Academia embraced the new platform and was the primarily responsible for developing, building, and launching the first CubeSats. Given the novelty of the standard and efforts to minimize complexity and launch costs, not surprisingly, most early nanosatellites were 1U CubeSats, As participation and confidence in the standard grew, and as academia and commercial entities alike realized the opportunities provided by a 200% increase in volume, 3U CubeSats (with masses of 4 to 6 kg) have become increasingly appealing (see Figure 4).

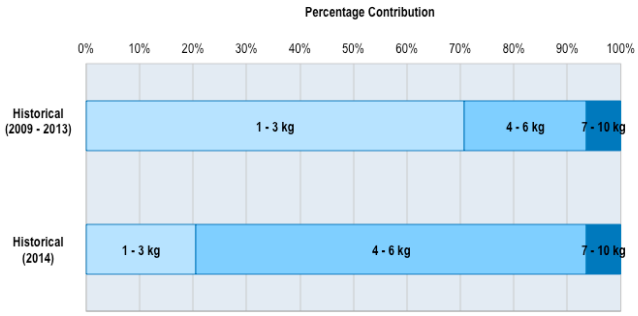

Figure 4: Nano/Microsatellite Mass Trends

Larger CubeSats, namely 6Us and 12Us are becoming more common, as satellite applications continue to diversify. The shift to larger, more capable CubeSats is evident when examining NASA's CubeSat Launch Initiative (CSLI) program. The program began in 2010 and sought to offer universities and government organizations the opportunity to launch a CubeSat as a secondary payload on an existing mission.[10] The 2015 CSLI solicitation for proposals invited organizations with 6U CubeSat designs to apply for a launch opportunity, where previously only 1U, 2U, and 3U CubeSats were considered.[11] To further reinforce this trend, of the twelve missions selected in the inaugural year of the NASA CSLI program, all but three were 1U or 1.5U CubeSats.[12] Fast forward five years later to 2015 and only four satellites selected were smaller than a 3U CubeSat (one 1U, three 2Us).[13]

Although the volumes remain within the standard CubeSat form factor, many future missions are becoming more technologically advanced, increasing the average mass per CubeSat unit. Traditionally, each "U" was limited to 1.33 kg, but the NanoRacks CubeSat Deployer Interface Control Document (NCSD ICD) now limits each "U" to approximately 2.82 kg, more than doubling the previous maximum mass properties.[14]

Trends by Sector

Civil organizations (which includes academic institutions) continue to contribute a significant portion of nano/microsatellites compared to the other sectors (Figure 5). Government space agencies continue to foster growth within the industry, especially for academic and non-profit organizations. Since its inception, NASA's CSLI program has awarded launches to 119 CubeSat missions (some of which include multiple satellites).[12] In the next five years, NASA CSLI plans to select at least one CubeSat from each of the fifty states; CubeSats from 29 states have been selected in the six years since the program began.[10]

The European Space Agency (ESA) has also been highly supportive, flying seven university CubeSats on the Vega's maiden flight in 2012. In 2013, ESA invited six teams to participate in the three phases of the "Fly Your Satellite!" program, with the best CubeSats winning a launch.[15,16] Similarly, Korea Aerospace Research Institute (KARI) awarded five winners a launch opportunity in 2015 as a part of the University Cube Satellites Mission and Design Contest.[17]

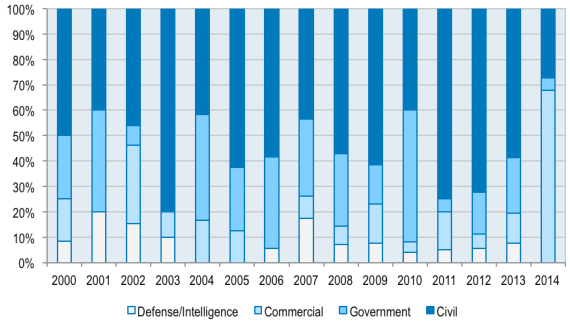

Figure 5: Nano/Microsatellite Trends by Sector

While the number of nano/microsatellites launched by the civil sector in 2014 was comparable to previous years, the sector contributed less than 30% of the total, compared to 2000 to 2013, when the sector contributed more than half of satellites launched (56%, on average). This was due to the rising impact of the commercial sector in 2014, with 107 satellites launched. Planet Labs, an Earth-imaging firm founded by former NASA Ames Research Center (ARC) employees and based in San Francisco, supplied 93 of the 107 satellites, more than all 1-kg to 50-kg satellites launched in 2013 (92).

Trends by Purpose

Five primary categories describe the general purpose of CubeSat missions. SpaceWorks' LDDB classifies satellites using the following categories:

- Technology (missions focused on developing and demonstrating new technology)
- Communications
- Earth observation and remote sensing
- Science (missions focused on collecting space-based data for research purposes)
- Reconnaissance

Historically, academic institutions initiated and completed a large majority of early CubeSat missions. Not surprisingly, many satellites in this mass range predominantly focused on technology development and demonstration during the same period, since many involved novel applications, at least related to the CubeSat form factor (Figure 6). In many of these cases, the primary goal of the mission was learning the process of designing and producing a spacecraft, rather than collecting data or performing specific experiments.

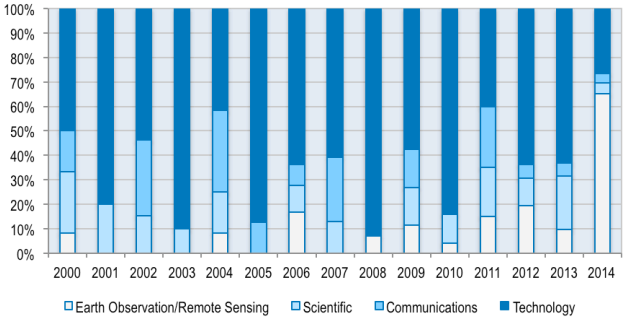

Figure 6: Nano/Microsatellite Trends by Purpose

Once dominated by billion dollar budgets and government space organizations, start-up companies continue to emerge, promising constellations of tens or hundreds of CubeSats for Earth observation and remote sensing applications.[18,19] The investment community has started to take interest, with hundreds of millions of dollars of funding dedicated in 2013, 2014 and early 2015. Planet Labs has raised more than $160 million as of early 2015.[20] Starting with the Dove-1 CubeSat launch in April 2013 through April 2015, they launched and deployed 113-3U CubeSats to continuously image the Earth. The company's goal is to deploy 150 satellites in a sun-synchronous orbit (SSO) within the next 18 months.[21]

Spire Global, also based in San Francisco, plans to launch at least 20 satellites in 2015 to offer maritime tracking services and to collect valuable weather data for commercial and government clients.[22] With a constellation of 100 satellites planned to be complete by 2017 and four experimental satellites launched to date, it's not surprising that Spire has raised $29 million from multiple sources, including various venture capital firms as well as KickStarter.[22,23]

Other NewSpace start-ups include Aquila Space, Outernet, and Novawurks. Aquila Space, a spinoff from Canopus Systems, plans to deploy a 20-satellite constellation to deliver "low cost high spatial and temporal resolution imagery" to emerging markets like precision agriculture.[24] Outernet plans to offer basic web access on a global scale, starting with three, 3U CubeSats launching in early 2016.[25] These satellites will be built with the help of the UK Space Agency and Clyde Space, a Scottish CubeSat component manufacturer. [25] California-based Novawurks is building modular Hyper-Integrated Satlets or HISats, 7kg "interchangeable, connectible, and replaceable" platforms that can be used alone or with other HISats to

provide payload support in the form of power, navigation, processing, and communication.[26]

SUMMARY

The CubeSat's modular nature continues to enable many space-related development activities and can be credited with the enormous growth and transformation of the satellite market. With the reduced cost of spacecraft components, what once could only be accomplished with a single large satellite is now possible with a sizeable constellation of smaller, low-cost satellites.

While academia continues to heavily participate in the global small satellite market, the commercial sector's contributions are becoming more significant. A number of start-up companies are offering space-based solutions to issues on Earth, a proposition that continues to captivate the venture capitalist community. Analysis of near-term trends by sector and satellite purpose reinforces the commercial sector's impact on the industry and also reveals the considerable number of nanosatellites, including some large constellations, which will be used for Earth observation and remote sensing applications.

Acknowledgments

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