SpaceWorks' 2016 Nano/Microsatellite Market Forecast

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ABSTRACT

Since 2008, SpaceWorks has actively monitored global nano/microsatellite activities, and annually publishes a summary update as a free service to the small satellite development and launch communities. SpaceWorks' 2016 projection of the 1-50 kg satellite market forecasts over 35% growth in 2016 compared to our 2014 projection due to the combination of a growing backlog due to limited launch opportunities in 2015 and continued interest from the commercial sector. This paper presents detailed observations and projections for the nano/microsatellite market based on over 780 satellites with masses between 1 and 50 kilograms in development over the next three years (2016 to 2018). 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. Analysis of development trends by sector and purpose show continued development by the civil sector for science or technology demonstration and strong growth from commercial operators primarily for earth observation. Launches to date have utilized existing large launch providers and taken secondary payload slots minimizing launch vehicle costs. Growing numbers of companies are attempting to develop dedicated small satellite launch vehicles and are projecting to charge a premium for the added benefits they will offer small satellites. Due to the increasing complexity in the launch market the capability to model addressability in a comprehensive manner has been developed.

INTRODUCTION

In 1999, California Polytechnic State University and Stanford University developed the CubeSat to give universities more opportunities to become more involved in the space industry. Since then, the small satellite industry continues to expand domestically and internationally. While academia continues to heavily participate to the global small satellite market, the commercial sector's contributions are becoming more significant, with numerous start-up companies offering space-based solutions to issues on Earth.

Since 2011, SpaceWorks has produced an annual nano/microsatellite (1-50 kg) market projection. Last year, the projection estimated 163 nano/microsatellites would launch globally in 2015; 131 nano/microsatellites actually launched, a decrease of 17% compared to the record year in 2014. Despite the decrease, 2015 had the second highest number of nano/microsatellite launches in history (see Figure 1).

In March of this year, SpaceWorks released its annual update to the projection[1], the focus of this paper, which reflects continued growth in the quantity of future nano/microsatellites needing a launch. With continued support from academia and the flurry of commercial activity, SpaceWorks believes the 1-50 kg satellite market is real and will continue to flourish.

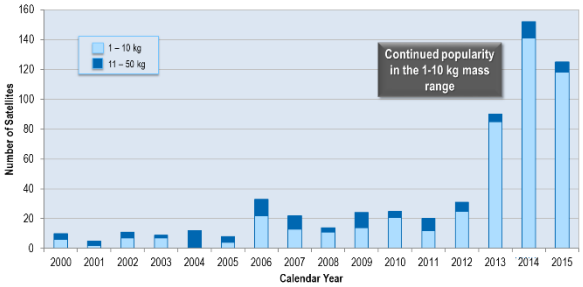

Figure 1. Historical Nano/Microsatellites Launched from 2000 to 2015

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 study limits the upper end of microsatellite mass to 50 kg given the relative large amount of satellite development activity in the 1-50 kg

range by comparison to the 50-100 kg range (see Table 1). 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.

Table 1: Mass Ranges by Satellite Class

Satellite Class	Mass Range
Femtosatellite	10 – 100 g
Picosatellite	< 1 kg
Nanosatellite	1 – 10 kg
Scope of this study	**1 – 50 kg**
Microsatellite	10 – 100 kg
Small Satellite	100 – 500 kg

SpaceWorks Launch Demand Database (LDDB)

The data source for this study is the SpaceWorks Satellite Launch Demand Database (LDDB). The LDDB is an extensive database of all known historical (2000 – 2013) and future (2014+) satellite projects with masses between 0 kg and 10,000+ kg. As of January 2016, the LDDB contained 780 future (2016–2018) nano/microsatellites. Future satellites in the LDDB include publicly announced nano/microsatellite 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 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), orbital parameters (apogee, perigee, eccentricity, inclination, period), launch year, launch date, launch location, and launch vehicle.

FUTURE NANO/MICROSATELLITE MARKET TRENDS

Nano/Microsatellite Trends by Sector

Traditionally, nanosatellites have been predominantly developed and built by academic institutions. However, as we previously predicted the share of civil nano/microsatellites is decreasing in the presence significant growth from the commercial sector. Figure 2 illustrates the changing makeup of this segment of the market. Due to this recent growth in the commercial industry, the civil sector now represents 40% of historical nano/microsatellites and is expected to represent around one-quarter of future launches. In contrast the commercial sector now represents 37% of historical nano/microsatellites and is expected to continue growing as it now represents over two-thirds of future nano/microsatellites.

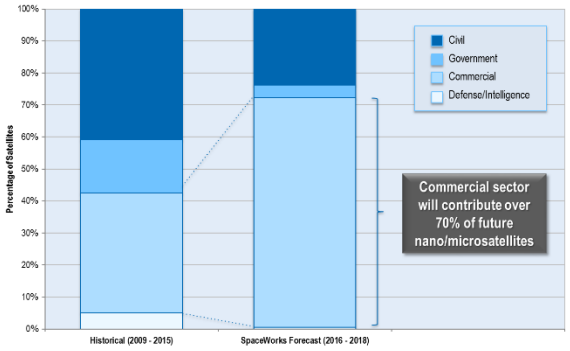

Figure 2. Historical (2009-2015) and Future (2016-2018) Nano/Microsatellite Trends by Sector

By some traditional definitions of space industrial sectors, non-defense government space activities are a subsector of the civil sector. Note that here non-defense government activities are placed in a separate sector. "Government" refers to those nano/microsatellite development efforts that occur within/by the government agency or organization (e.g. NASA, JAXA). "Civil" refers to all other non-defense development activities (e.g. universities, federally funded research institutions), though the funding source may be a government agency.

Nano/Microsatellite Trends by Purpose

Four categories have been established to describe the general purpose of nano/microsatellite missions. These categories are: technology (missions focused on developing and demonstrating new technology), communications, Earth observation/remote sensing, and science (missions focused on collecting space-based data).

Figure 3 illustrates the historical (2009-2015) trends in nano/microsatellite applications. Satellites in this mass range predominantly focused on technology development and demonstration, driven by the widespread use of CubeSats in academic settings. In many of these cases, the primary goal of the mission is learning the process of designing and producing a spacecraft, rather than collecting data or performing specific experiments.

Future nano/microsatellite applications, as shown in Figure 4, starkly contrast with historical trends. Where previously nano/microsatellite missions focused on developing or demonstrating innovative technologies,

current and future nano/microsatellites will execute missions typically reserved for larger spacecraft. This is particularly true of Earth observation/remote sensing missions, which will comprise nearly three-quarters of the market by 2018, compared to only 37% from 2009–2015. This dynamic growth is due to the arrival of commercial satellite developers who plan to use small satellites to provide novel and innovative space-based solutions for on-Earth applications.

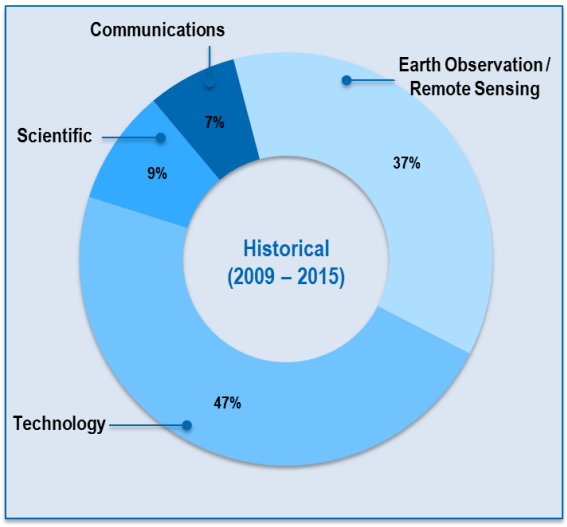

Figure 3. Historical Nano/Microsatellite Trends by Purpose (2009 – 2015)

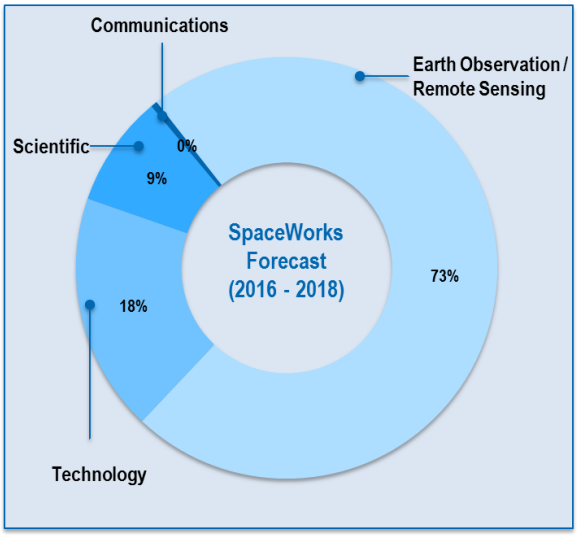

Figure 4. Future Nano/Microsatellite Trends by Purpose (2016 – 2018)

Nano/Microsatellite Size Trends

The nanosatellite mass class largely consists of spacecraft that utilize the CubeSat standard, a modular architecture that defines 1U as a 10cm cube with a mass of approximately 1 kg. The CubeSat's modular nature has enabled many space-related development activities and can be credited with the growth and transformation of the nanosatellite 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.

Figure 5 illustrates the historical and projected mass distribution of spacecraft in the nanosatellite mass class. While still popular, the use of single unit CubeSat missions, which supplied nearly half of historical nanosatellite missions, has diminished compared to larger, more capable CubeSats. The 3U CubeSat form factor has exploded in popularity due to its adoption as the de-facto standard by the commercial companies and the maximum envelope for many of the most affordable launch providers. In recent years, 6U and 12U CubeSats are not uncommon, as satellite applications continue to diversify. Although the volume of these CubeSats remain within the standard CubeSat form factor, many future missions are becoming more technically advanced, increasing the average mass per CubeSat unit. Traditionally, a 3U CubeSat would be limited to 4 kg, but future missions with the 3U form factor have masses ranging up to 6kg. The 4-6 kg mass range accounts for over 60% of the future nanosatellite market, with larger, more advanced 3U CubeSats making up the majority of satellites in this range.

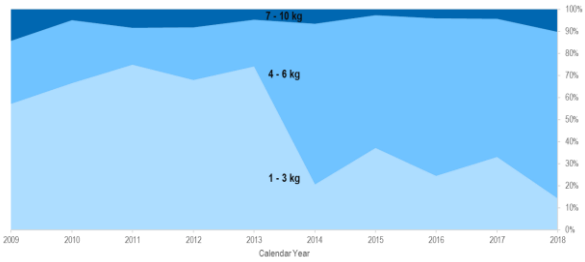

Figure 5. Nanosatellite Size Trends

SPACEWORKS' 2016 NANO/MICROSATELLITE GLOBAL LAUNCH DEMAND PROJECTION

Methodology and Assumptions

SpaceWorks considers two different projections in the 2016 Nano/Microsatellite Market Assessment: the Full Market Potential and the SpaceWorks Projection. The

Full Market Potential dataset contains all currently known past and future nano/microsatellites from the SpaceWorks LDDB, with the addition of an inflation factor to account for known unknowns plus assumed sustainment of certain current projects and programs (e.g. follow-on to NASA Ames EDSN, CSLI, DARPA SeeMe) and the growth of numerous new and existing commercial companies. In contrast to this, the SpaceWorks Projection dataset reflects SpaceWorks' expert interpretation on the likely market outcome. However, neither projection places value judgment on whether satellite developers will successfully meet their announced launch date or not.

SpaceWorks has projected global launch demand in the nano/microsatellite market according to a Gompertz logistic curve "best fit" regression from 2016 to the year 2022.

The SpaceWorks Projection and Full Market Potential datasets include some known nano/microsatellite programs for which a specific launch date has not been announced. The satellites belonging to these programs are distributed across the period (date range) for launches according to the announced program objectives.

Nano/Microsatellite Projection Results

The results of the 2016 Nano/Microsatellite Market Assessment are shown in Figure 6. Projections based on announced and future plans of developers and programs indicate between 2,300 and 3,000 nano/microsatellites will require a launch from 2016 through 2022.

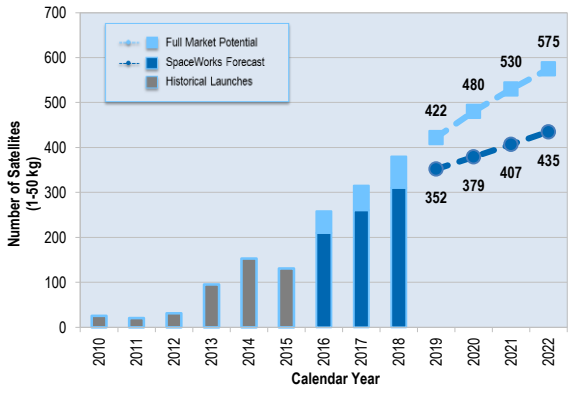

Figure 6. Nano/Microsatellite Launch History and Projection

Based on the announced launch data alone, 2016 should surpass 2014 for the most nano/microsatellites launched in a year. Commercial companies will contribute over half of all nano/microsatellites launched in 2016, continuing their growth since 2014.

The continued emergence and growth of commercial companies will result in an even greater increase by 2018, with the sector contributing 70% of all nano/microsatellites launched. Many companies have publicly revealed their near-term intentions regarding future launches of nano/microsatellites and the satellites' wide spectrum of revenue generating applications. Other companies have been more reserved, revealing only small details of their plans. Despite uncertainty regarding individual companies' intentions, compelling evidence suggests the commercial sector will have a meaningful and enduring impact on the nano/microsatellite industry.

HISTORICAL AND FUTURE LAUNCH OPPORTUNITIES

Existing and Emerging Launch Opportunities

To date CubeSats have found launch opportunites through secondary payload arrangements with medium and heavy lift launch vehicles. These arrangements are convenient in that the modest launch mass of a cubesat is easily accommodated by the larger launch vehicle. This has allowed relatively few launches to orbit the growing numbers of CubeSats without an impact on the greater launch vehicle market. Figure 7 shows the launch vehicle provider for all nano/microsatellite launches in 2015.

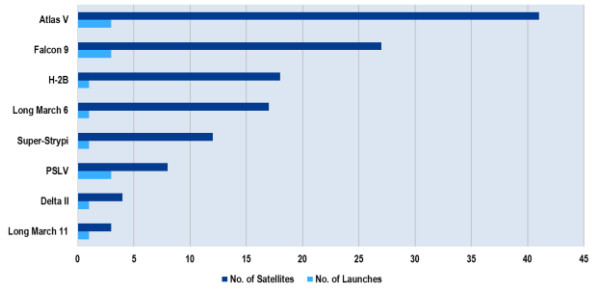

Figure 7. Launch Vehicle Providers in 2015

Large launch vehicles also have the benefit of a lower marginal cost per launched mass. This will continue to allow large launch vehicle providers to offer the lowest price launch opportunities to nano/microsatellites for secondary ride-share opportunities. Emerging dedicated launch vehicles have quoted higher marginal costs per launched mass as can be seen in Figure 8. This premium is defensible assuming operational constellations of nano/microsatellites begin to require specific orbit locations or other business driven requirements. Small dedicated launch vehicles will also potentially increase the resilience and reliability of orbiting and maintaining these large constellations by eliminating or minimizing the risk of a single launch failure has to a large fraction of CubeSats co-launched on one vehicle.

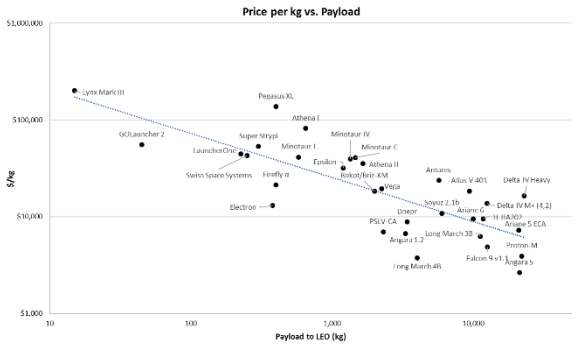

Figure 8. Launch Costs by Launch Mass

Addressability and Market Matching

The potential for small launch vehicles to capture a significant market share of nano/microsatellite launches is growing with the increasing use of small satellites for commercial purposes. At the same time the number of companies and countries interested in this market is also growing. Table 2 shows a partial listing of emerging launch vehicle providers, with the total number of companies active in this market currently around 15-20. As the number of launch providers grows the complexity of forecasting addressability increases as well. While in the past country of origin and launch vehicle price may have been primary drivers for satellite operators in selecting a launch provider in the emerging market conditions simple models are not effective for launch providers, investors, or satellite operators.

In order to capture the dynamic effects of the current market SpaceWorks has developed Market Match. Market Match is a probabilistic economic model designed to inform launch vehicle investment decisions and future launch costs. It takes into account market demand based on SpaceWorks satellite forecasts, competition from and comparative advantages of existing and proposed launch providers, and overall macroeconomic and political factors. The simulation provides a comprehensive forecast of a launch vehicle's economic performance using statistical methods.

Table 2. Small Satellite Launch Vehicles

Launch System	LEO Payload (kg)	Stated IOC Date	Target Launch Price	Configuration
Electron	165	2016	$30K/kg	Ground-launched two-stage rocket
LauncherOne	225	2017	$45K/kg	Air-launched expendable rocket
SOAR	250	2017	$44K/kg	Fully-reusable, rocket spaceplane
Super Strypi	300	2015	$54K/kg	Ground-launched 3-stage solid
M-OV	363-454	*Tbd*	*tbd*	Ground-launched hybrid rocket
Alpha	400	2016	$21K/kg	Ground-launched two-stage rocket
bloostar	90	2017	*tbd*	Ship-launched with balloon and rocket
GOLauncher 2	44	2018	$57K/kg	Air launched, with solid and liquid
PLD Arion-2	150	2021	tbd	Ground-launched three-stage rocket

Inputs to the model come from the SpaceWorks Launch Demand Database which contains detailed distributions for satellite mass, target orbit, operator characteristics, and for historical satellites selected launch provider. Candidate vehicle performance is characterized by payload capability by orbit, country of origin, and maximum flights per year. This information is added to the flight capture model to determine the likely flight rates for the candidate vehicle. When combined with a cost model of the candidate vehicle including non-recurring and recurring costs, learning curves, and operational timeframe the overall business case of the launch provider can be assessed on the net present value and internal rate of return. Finally, the launch vehicle pricing strategy can be optimized throughout the life of the vehicle and parameter sweeps to ensure the robustness of the simulation can be performed.

SUMMARY

The nano/microsatellite market shows continuing growth due primarily to emerging commercial operators building operational satellite constellations based around the 3U CubeSat standard. Civil and government

operators have continued to maintain their interest in small satellites for technology demonstrations and experimental applications. It remains to be seen if government and civil operators will move toward operational CubeSats in performing their primary missions. From 2010 to 2015, the nano/microsatellite market displayed average growth of 39% per year. The SpaceWorks Forecast projects 13% growth per year over the next six years (2016-2022), with 2,300-3,000 nano/microsatellites requiring a launch.

Growing numbers of launch providers are targeting this market with dedicated small satellite launch vehicles. As the market continues to evolve determining the addressable set of satellites becomes increasingly difficult. Market Match from SpaceWorks can give decision makers the data and confidence they need to justify investments in new launch vehicles or large satellite constellations.

Acknowledgements

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References

1. Doncaster, B., and Shulman, J. "2016 Nano / Microsatellite Market Assessment," SpaceWorks Forecasts, March 2016. www.spaceworksforecasts.com