

# 2017

The background of the slide features a satellite in space. The satellite has a white body with several gold-colored solar panels extending outwards. It is positioned in the upper right quadrant. Below the satellite, the Earth's horizon is visible, showing a blue sky and a brownish-yellow landmass. The overall image is a composite of these elements, with a blue horizontal band separating the title area from the satellite image.

# Nano/Microsatellite Market Forecast

# 2017 Nano/Microsatellite Market Forecast

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Published by:

**SpaceWorks Enterprises, Inc. (SEI)**

Atlanta, GA

# 2016

**SpaceWorks' 2016 projection estimated 210 nano/microsatellites across all sectors would launch globally in 2016; however, only 101 nano/microsatellites actually launched. This represents a decrease of 23% compared to 2015. Launch delays were a major factor contributing to the market falling short of expectations.**

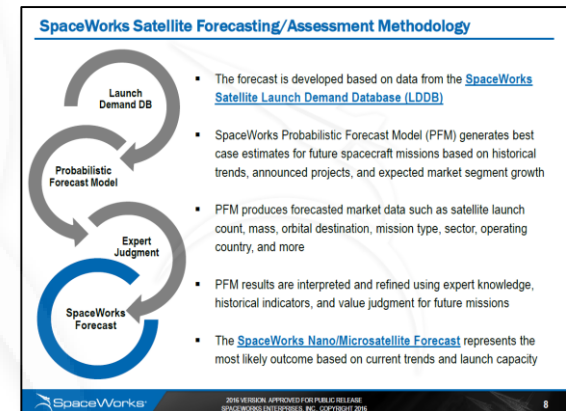
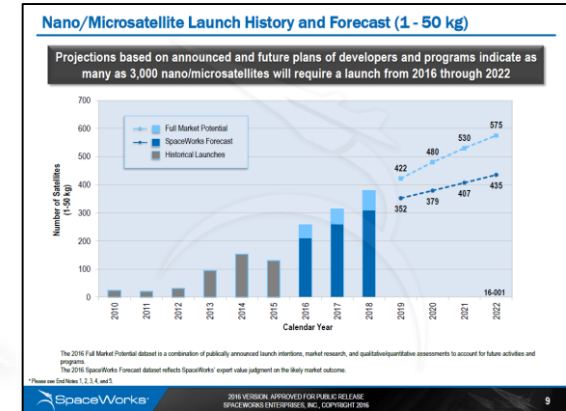
# 2017+

**SpaceWorks' 2017 forecast reflects that technical challenges and limited launch vehicle availability constrain near-term growth, despite a continuing backlog of satellites awaiting launch. Full Market Potential for the industry remains high, but this year's SpaceWorks Forecast predicts only 10% growth year over year in the future.**



# SpaceWorks Satellite Forecasting/Assessment Overview

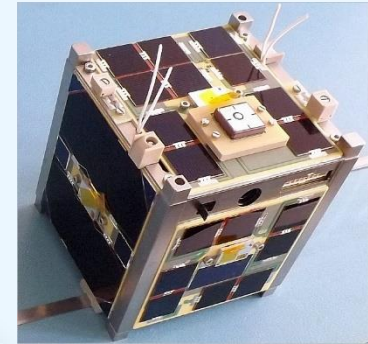
- For nearly 10 years, SpaceWorks has actively monitored global satellite activities in all mass classes (0.1-kg to 10,000-kg) and has provided customized market assessments for commercial and government customers
- Since 2011, as a service to the small satellite community, SpaceWorks has published a complimentary market assessment covering the Nano/Microsatellite segment
- SpaceWorks' proprietary satellite Launch Demand Database (LDDb), a catalogue of over 10,000 historical and future missions, containing both public and non-public satellite programs, serves as the data source for all assessments



SpaceWorks-developed market assessments deliver valuable industry knowledge to our customers, enabling organizations to make informed future investment decisions

# Nano/Microsatellite Definitions and Terminology

- Many nanosatellites are based on the “CubeSat” standard
  - Developed in by California Polytechnic State University and Stanford University in 1999
  - Consists of any number of 10 cm x 10 cm x 10 cm units
  - Each unit, or “U”, usually has a volume of exactly one liter
  - Each “U” has a mass close to 1 kg and not to exceed 1.33 kg (e.g. a 3U CubeSat has mass between 3 and 4 kg)
- This report bounds the upper range of interest in microsatellites at 50 kg given the relatively large amount of satellite development activity in the 1-50 kg range



Technical University of Berlin's  
BeeSat 4 CubeSat

Satellite Class	Mass Range
Femtosatellite	10 – 100 g
Picosatellite	< 1 kg
Nanosatellite	1 – 10 kg
Forecast Scope	1 – 50 kg
Microsatellite	10 – 100 kg
Small Satellite	100 – 500 kg

# 2016 Highlights

- Launch delays continued to reduce market potential and added to a growing backlog of satellites awaiting launch
  - Over 100 small satellites were impacted by 2016 launch delays
  - SpaceX's Falcon 9 family delivered zero small satellites in 2016
- First flight of SHERPA, a large payload adapter for small satellites, was further delayed, causing several customers to seek alternative launch arrangements
- Commercial Earth observation and remote sensing constellations (e.g., Planet and Spire) accounted for nearly half of nano/microsatellites launched in 2016
- China was responsible for operating 13% of all nano/microsatellites launched in 2016, second only to the United States (63%)



Credit: Spaceflight Industries

**Spaceflight Industries' SHERPA**



Credit: Spaceflight101

**Planet's Flock-2b Dove Satellites**

# 2016 Nano/Microsatellite Applications and Associated Examples

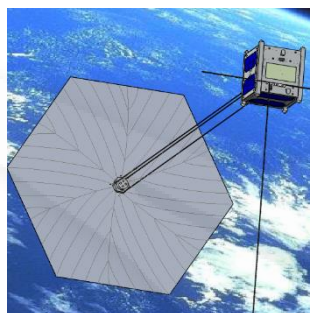


Credit: <http://space.skyrocket.de>

## Communications

### ITF 2

Mass: 1.3 kg  
Launched: 12/2016



Credit: JAXA

## Technology

### Waseda-SAT 3

Mass: 1.3 kg  
Launched: 12/2016



Credit: Satellogic

## Earth Observation

### NuSat 1 (Aleph-1)

Mass: 37 kg  
Launched: 5/2016



Credit: Earth Observation Portal

## Scientific

### RAVAN

Mass: 5 kg  
Launched: 11/2016



Credit: <http://space.skyrocket.de>

## Technology

### CELTEE 1

Mass: 1.3 kg  
Launched: 11/2016



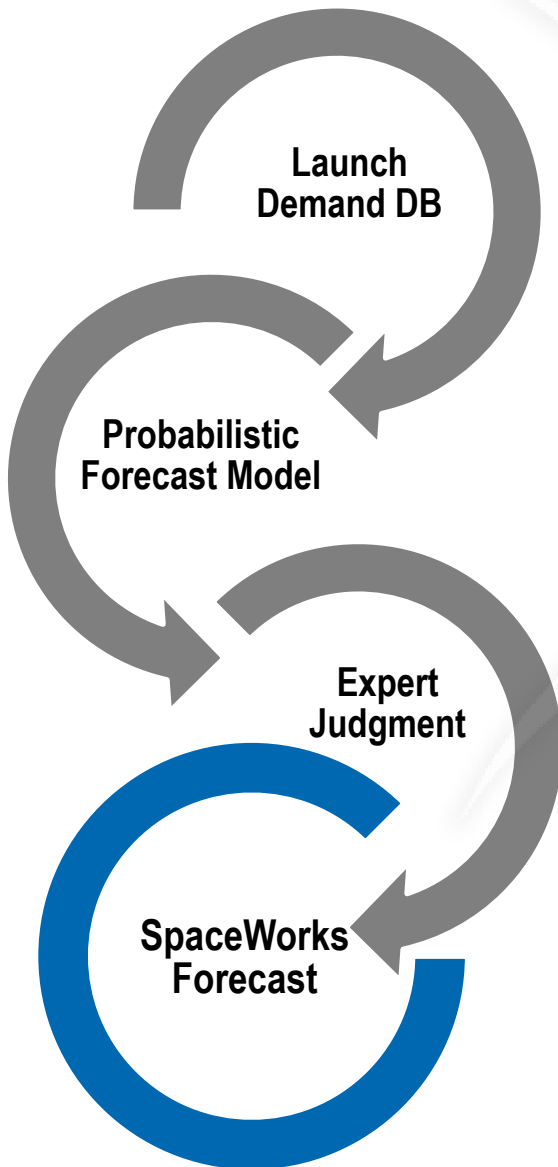
Credit: Spire

## Remote Sensing

### Lemur-2

Mass: 5 kg  
Launched: 5/2016

# SpaceWorks Satellite Forecasting/Assessment Methodology

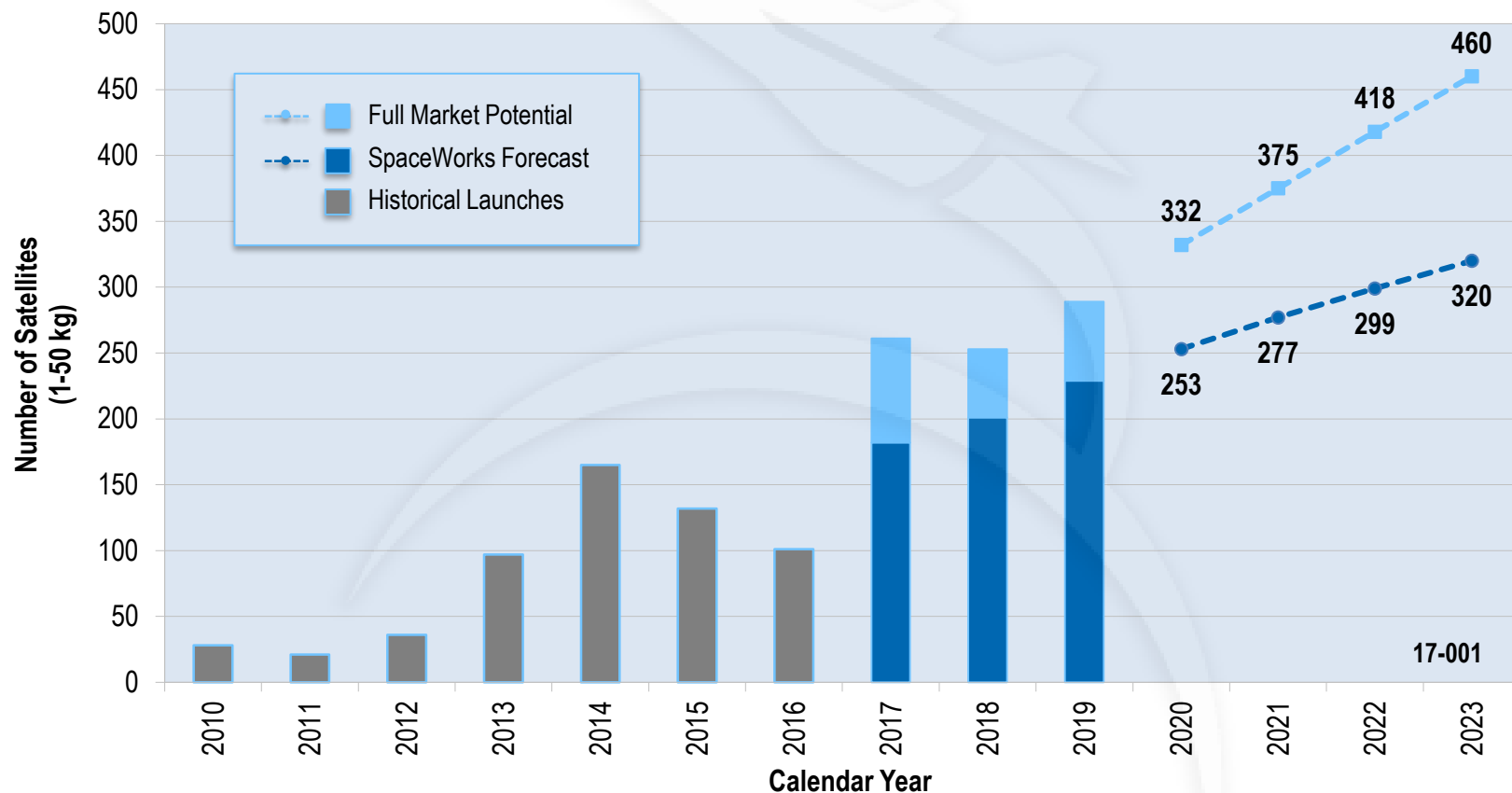


- The forecast is developed based on data from the [SpaceWorks' satellite Launch Demand Database \(LDDDB\)](#)
- SpaceWorks Probabilistic Forecast Model (PFM) generates best case estimates for future spacecraft missions based on historical trends, announced projects, and expected market segment growth
- PFM produces forecasted market data such as satellite launch count, mass, orbital destination, mission type, sector, operating country, and more
- PFM results are interpreted and refined using expert knowledge, historical indicators, and value judgment for future missions
- The [SpaceWorks Nano/Microsatellite Forecast](#) represents the most likely outcome based on current trends and launch capacity



# 2017 Nano/Microsatellite Launch History and Forecast (1 - 50 kg)

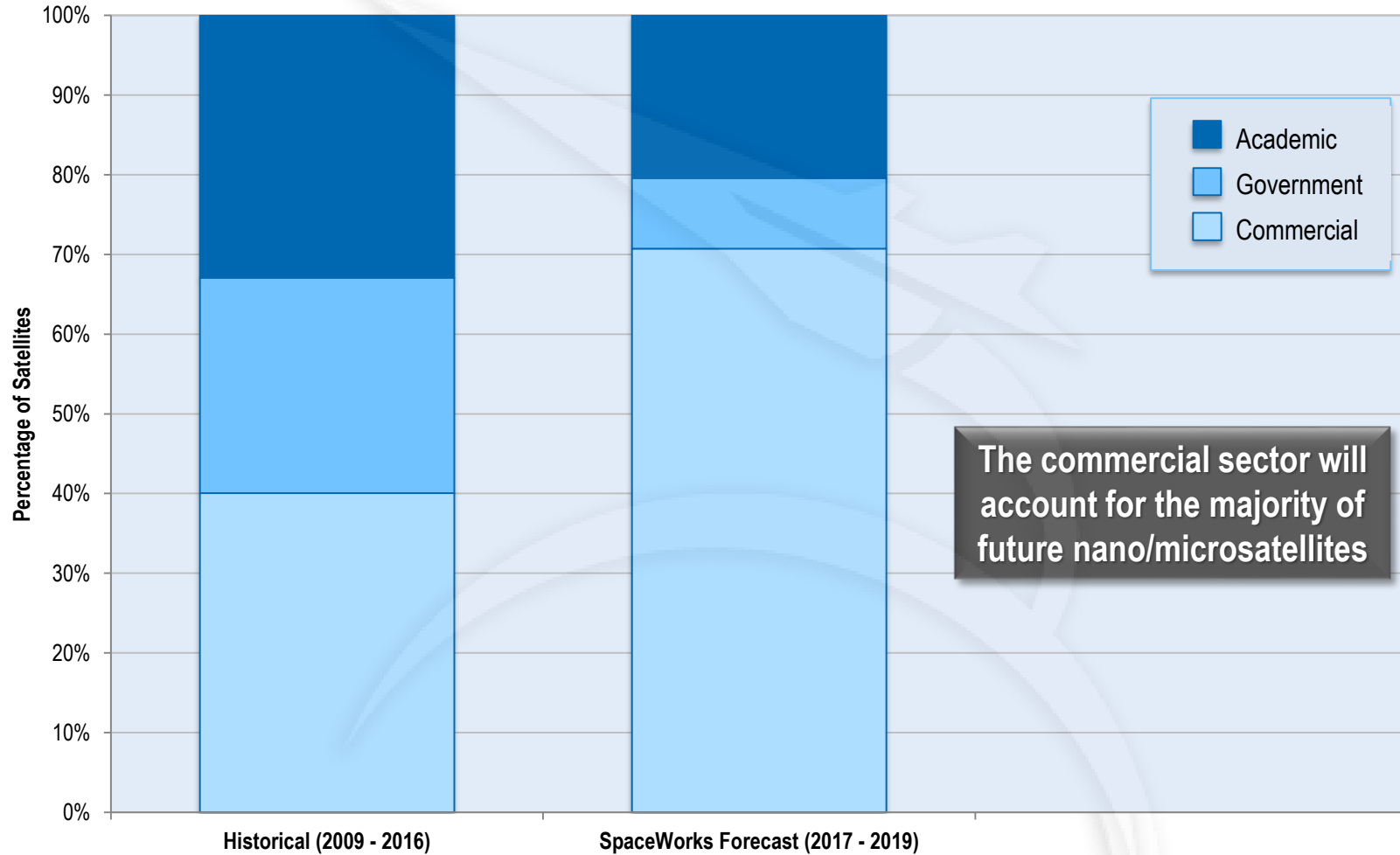
Projections based on announced and future plans of developers and programs indicate nearly 2,400 nano/microsatellites will require a launch from 2017 through 2023



The 2017 Full Market Potential dataset is a combination of publically announced launch intentions, market research, and qualitative/quantitative assessments to account for future activities and programs. The 2017 SpaceWorks Forecast dataset reflects SpaceWorks' expert value judgment on the likely market outcome.

\* Please see End Notes 1,2, 3, 4, and 5.

# Nano/Microsatellite Trends by Sector (1 – 50 kg)

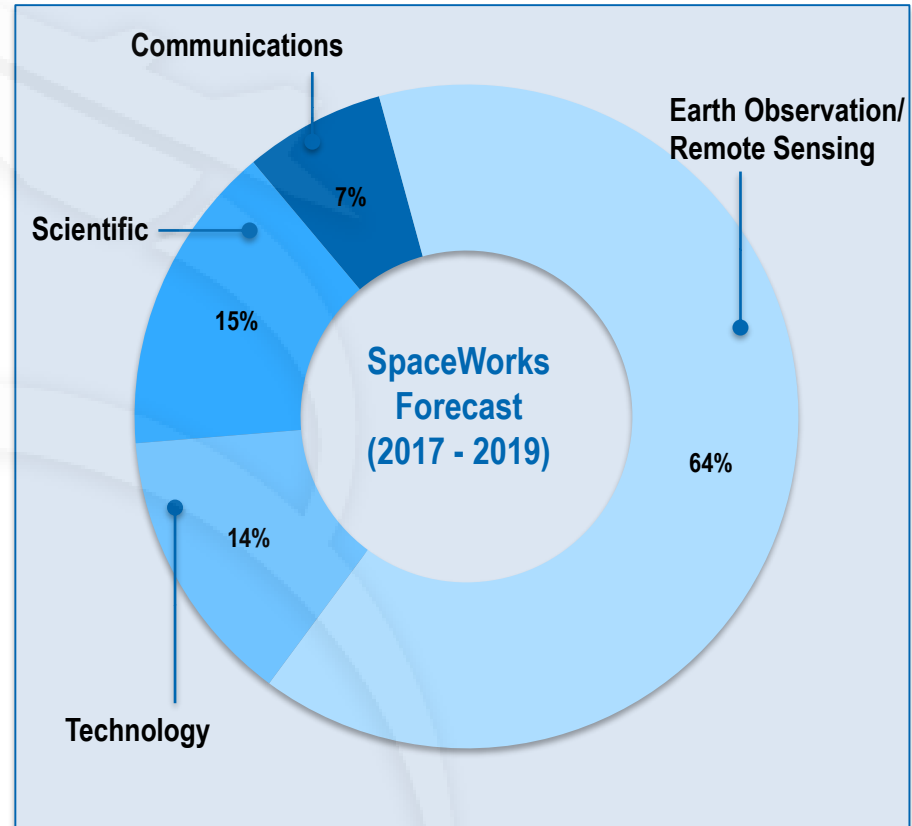
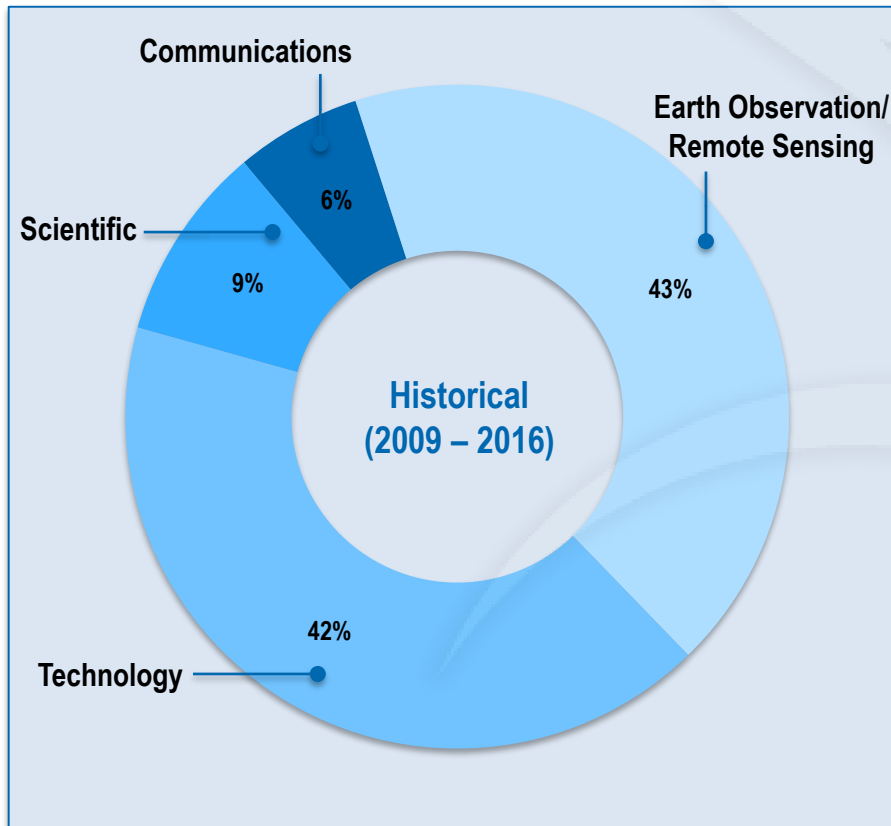


**Even with large commercial sector growth, 2017 is expected to be a record year for academic satellites as the industry works its way through the current launch backlog**

\* Please see End Notes 2, 5, 6, and 7.

# Nano/Microsatellite Trends by Purpose (1 – 50 kg)

Earth observation and remote sensing are expected to be the dominant use for nano/microsatellites in the future

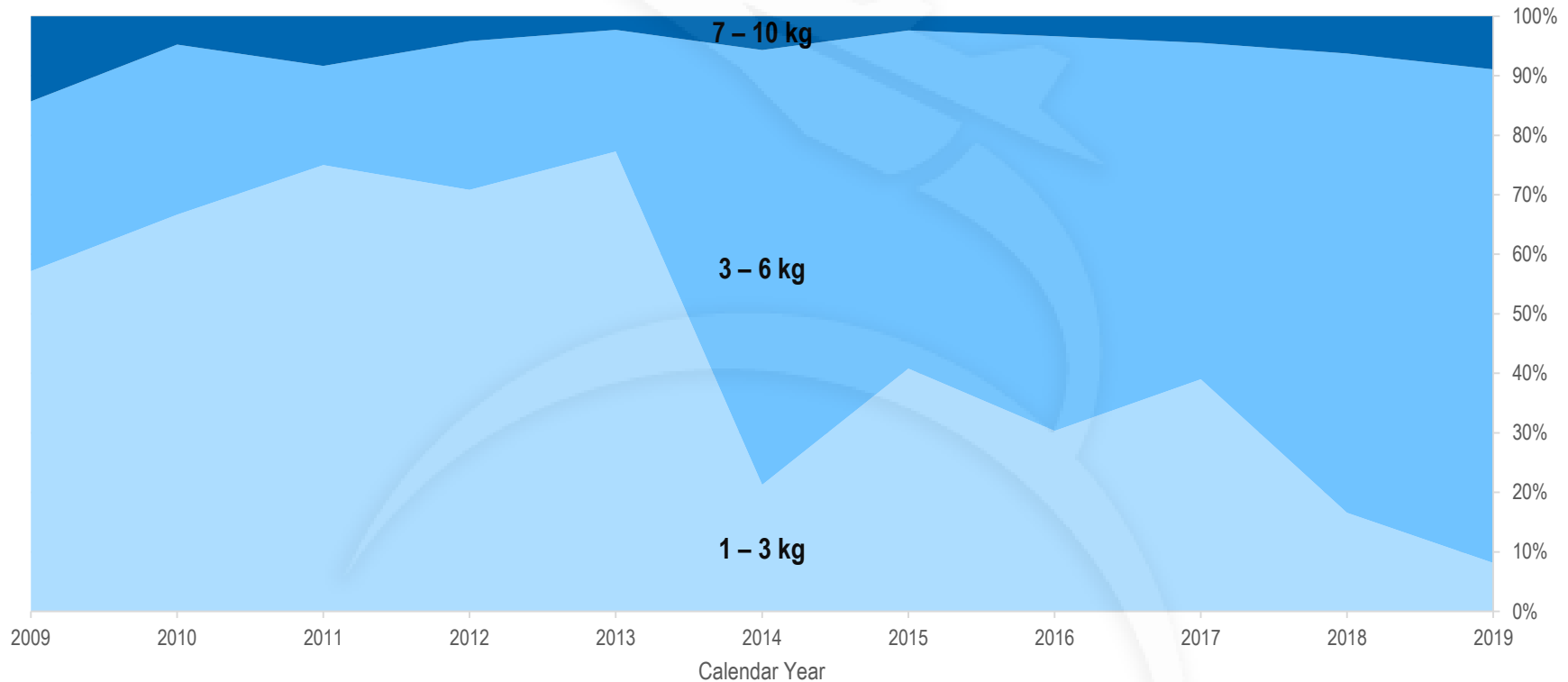


As form factors continue to increase, small communication satellites are becoming more viable, encompassing a small, but consistent portion of the market

\* Please see End Notes 2, 5, and 6.

# Nanosatellite Size Trends (1 - 10 kg)

The 3U form factor remains dominant in the market place as a result of its use by large Earth observation and remote sensing constellations

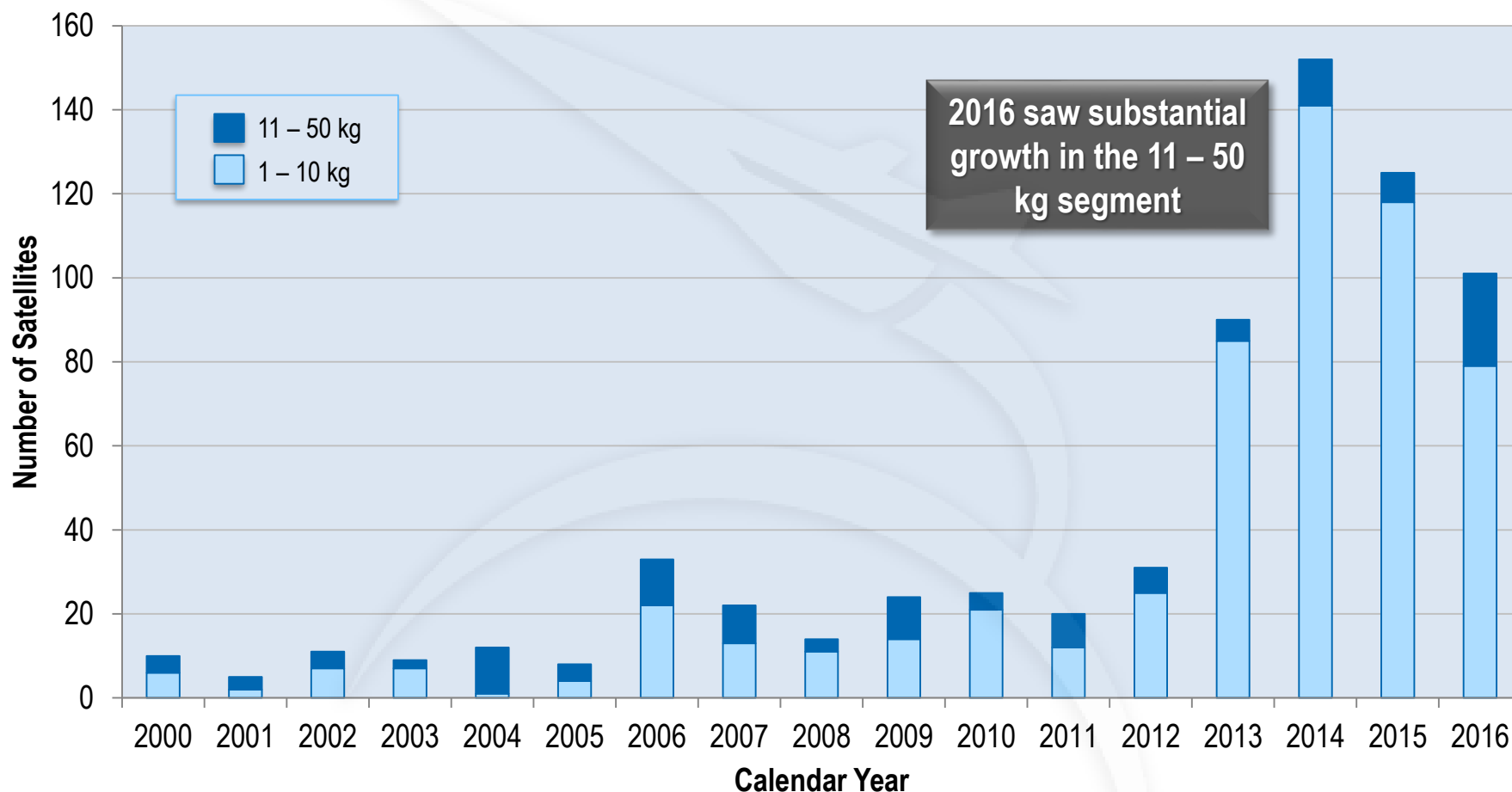


Overall growth is increasing in larger platforms (both CubeSats over 3U and non-CubeSats over 10kg) due to demand for additional payload capacity

\* Please see End Notes 2, 5, 6, and 8.



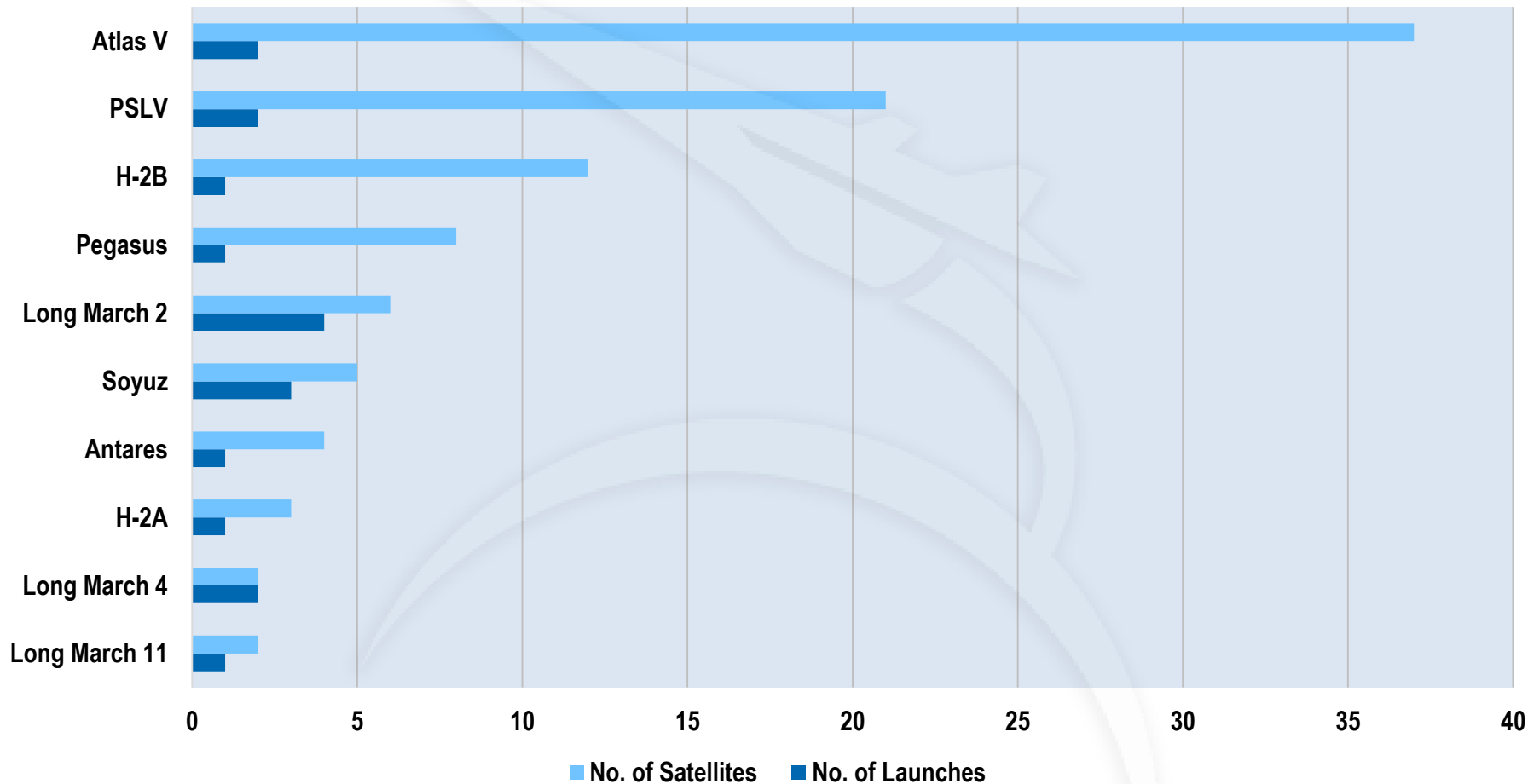
# Historical Nano/Microsatellites Launched: 2000 - 2016 (1 - 50 kg)



The nanosatellite (1-10 kg) market is still largely favored by operators, but the 11 - 50 kg and higher range is increasing in popularity

\* Please see End Notes 1 and 2.

# 2016 Nano/Microsatellites Rides to Space



**The number of vehicles offering rideshares for nano/microsatellites is increasing, yet there is still a lack of dedicated commercial rideshare providers**

\* Please see End Notes 1 and 2.

# 2017 Case Study #1: Small Satellite Launch Vehicles

- Several dedicated small satellite launchers are expected to fly for the first time in 2017, including Rocket Lab's Electron and Virgin Galactic's LauncherOne
- The dedicated launch vehicle landscape continues to shift, with several new entrants and notable withdrawals in 2016
- Non-US countries are beginning to invest in rideshare services, some scheduled to begin operations as early as 2017 (China & Spain)

Launch System	500km SSO Payload (kg) <sup>1</sup>	Stated IOC Date	Target Launch Price	Configuration
Electron	150	2017	\$33K/kg	Ground-launched two-stage rocket
LauncherOne	300	2017	\$33K/kg	Air-launched expendable rocket
Kuaizhou 1A	250	2017	\$57K/kg <sup>2</sup>	Ground-launched four stage rocket
Vector-R	28	2018	\$54K/kg	Ground-launched two-stage rocket, with optional electric third stage
LandSpace-1	400	2018	\$20K/kg	Ground-launched four-stage rocket
GOLauncher 2	44	2019	\$57K/kg	Air launched with solid and liquid
Intrepid-1	376	2019	\$14K/kg	Ground-launched, two stage, hybrid rocket
Arion 2	93	2021 <sup>2</sup>	\$38K/kg	Ground-launched, three stage, liquid rocket

Rideshare Provider	LEO <sup>1</sup> Payload (kg)	Stated IOC Date	Target Launch Price	Configuration
Spaceflight Launch Services	5	2013	\$59K/kg <sup>3</sup>	Rideshare broker for numerous launch vehicles
Nanoracks	5	2013	\$60K/kg <sup>4</sup>	ISS deployment with resupply mission launch rideshare

**If successful, Rocket Lab's Electron and Spaceflight's SHERPA have the potential to dramatically increase the number of small satellites launched in 2017**

1. SSO payload normalized from available data if necessary

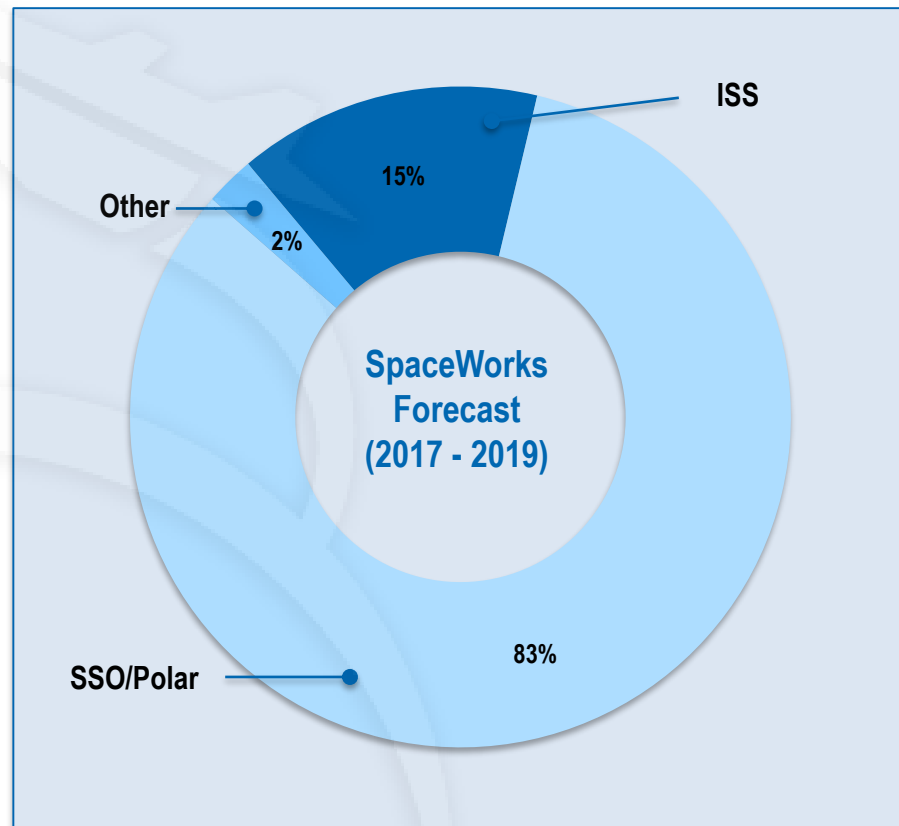
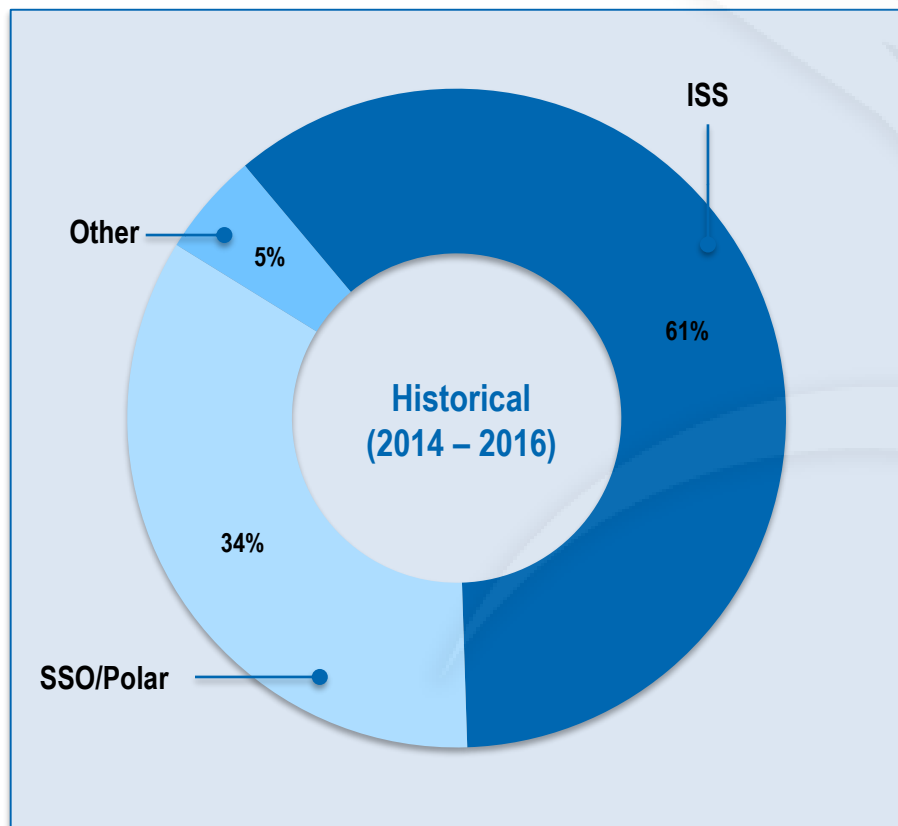
2. Estimated

3. For 3U CubeSat

4. Commercial pricing.

## 2017 Case Study #2: Nano/Microsatellite Orbit Destinations

ISS orbit has been historically favored by nano/microsatellites due to convenience; as dedicated launchers emerge, ISS deployments are expected to decrease significantly



Over 80% of nano/microsatellites launched in the next 3 years are expected to launch to a sun-synchronous or polar orbit, as compared to only 39% in the previous 3 year period

\* Please see End Notes 2, 5, and 6.



# 2017 Nano/Microsatellite Market Forecast Conclusions

- SpaceWorks Forecast projects 2017 will be a record year for nano/microsatellite launches, with **182 satellites expected to launch, representing an 80% increase from 2016**
  - Projections for the Full Market Potential indicate as many as 2,400 nano/microsatellites will require a launch from 2017 through 2023
  - Commercial Earth observation and remote sensing constellations continue to make up a substantial portion of the market, encompassing 63% of all nano/microsatellites launched in 2016; however, this segment will experience slower future growth as these constellations reach a sustainment phase
- Compared to previous years, the **SpaceWorks Forecast has been reduced by almost 20%** to reflect the chronic delays experienced by launch providers and satellite operators
  - Small satellite launch vehicles have been slow to materialize and delays of dedicated rideshare launches have resulted in a backlog of nano/microsatellites that will need a launch in 2017-2018
  - Concentration of launch opportunities on dedicated rideshare mission increases the impact of launch delays, highlighting the need for frequent, dedicated small satellite launch vehicles
- 2016 saw sizeable growth in the 11 – 50 kg range, indicative of an **overall market trend of growing mass sizes** to accommodate more demanding payloads and new applications

\* Please see End Notes 2, 3, 4, 5, 6, and 7.

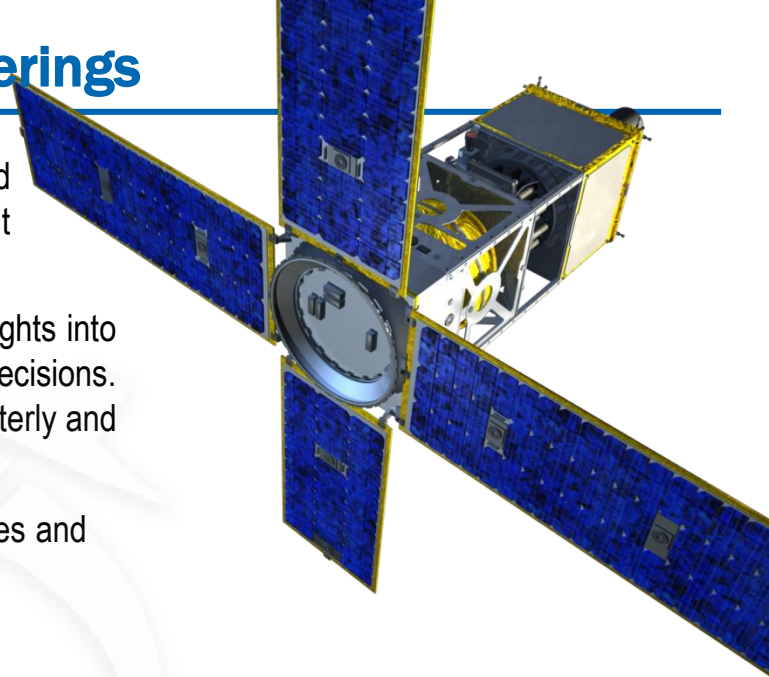
# SpaceWorks Forecasting / Assessment Offerings

Since 2008, SpaceWorks has actively monitored global satellite activity and completes customized market assessments for commercial and government customers in the satellite and launch vehicle communities.

SpaceWorks' commercially-available market assessments provide valuable insights into this dynamic market, enabling clients to make sound future investment decisions. Assessments can be provided at a frequency determined by the customer; quarterly and bi-annual reports are the most popular.

For additional information or to request a quote for our custom support packages and market forecasting services, please contact:

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**Forecasting services are available in the following standard satellite mass classes (custom mass ranges also available):**

- |                           |                  |
|---------------------------|------------------|
| • Picosatellite:          | <1 kg            |
| • Nanosatellite:          | 1 – 10 kg        |
| • Microsatellite:         | 11 – 100 kg      |
| • Small satellites:       | 101 – 500 kg     |
| • Medium satellites:      | 501 – 1,000 kg   |
| • Large satellites:       | 1,001 – 5,000 kg |
| • Extra-large satellites: | 5,001 kg+        |

**SpaceWorks can provide forecasts of satellite market trends based on the following characteristics, depending on customer needs:**

- |                                        |                         |
|----------------------------------------|-------------------------|
| • Mass class                           | • Addressability        |
| • Country of satellite owner/operator  | • Satellite application |
| • Sector of satellite owner/operator   | • Orbital parameters    |
| • Uplink or downlink frequency band(s) | • Satellite lifetime    |
|                                        | • Power                 |
|                                        | • Propulsion system     |
|                                        | • Launch vehicle        |

**In addition to the satellite market, SpaceWorks can determine commercial viability and forecast markets and trends in other key industry segments:**

- Expendable/reusable launch services
- LEO payload delivery
- ISS commercial crew/cargo services
- Propellant depots w/ commercial resupply
- Space tourism
- Space-based solar power
- Satellite servicing
- High speed point-to-point transportation

# End Notes

1. The number of satellites may not equal the number of launches since many small satellites are multiple-manifested (i.e. more than one satellite co-manifested on a particular launch vehicle). Historical data includes failed launch attempts.
2. The data used throughout this presentation (both historical and future) may not represent all global nano/microsatellite activities.
3. The SpaceWorks Forecast 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.
4. Future projections from 2020-2023 are determined by Gompertz logistic curve “best fit” regression with a set market saturation point (asymptote for number of satellites).
5. The Full Market Potential dataset contains all currently known past and future nano/microsatellites from the SpaceWorks LDDb, with the addition of an inflating factor for known unknowns plus assumed sustainment of certain current projects and programs and the continued emergence and growth of numerous existing commercial companies. The SpaceWorks Forecast dataset reflects SpaceWorks’ expert value judgment on the likely market outcome.
6. These graphs are based on the SpaceWorks Forecast data set only, and do not include the additional satellites contained in the Full Market Potential dataset.
7. “Government” encompasses state-sponsored space agencies, defense activities, and federally funded research institutions. “Academic” refers to University-sponsored programs, though the funding source may be a government agency.
8. Nanosatellites are binned by rounding mass to the nearest whole number. Picosatellites less than 1 kg are not included.



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