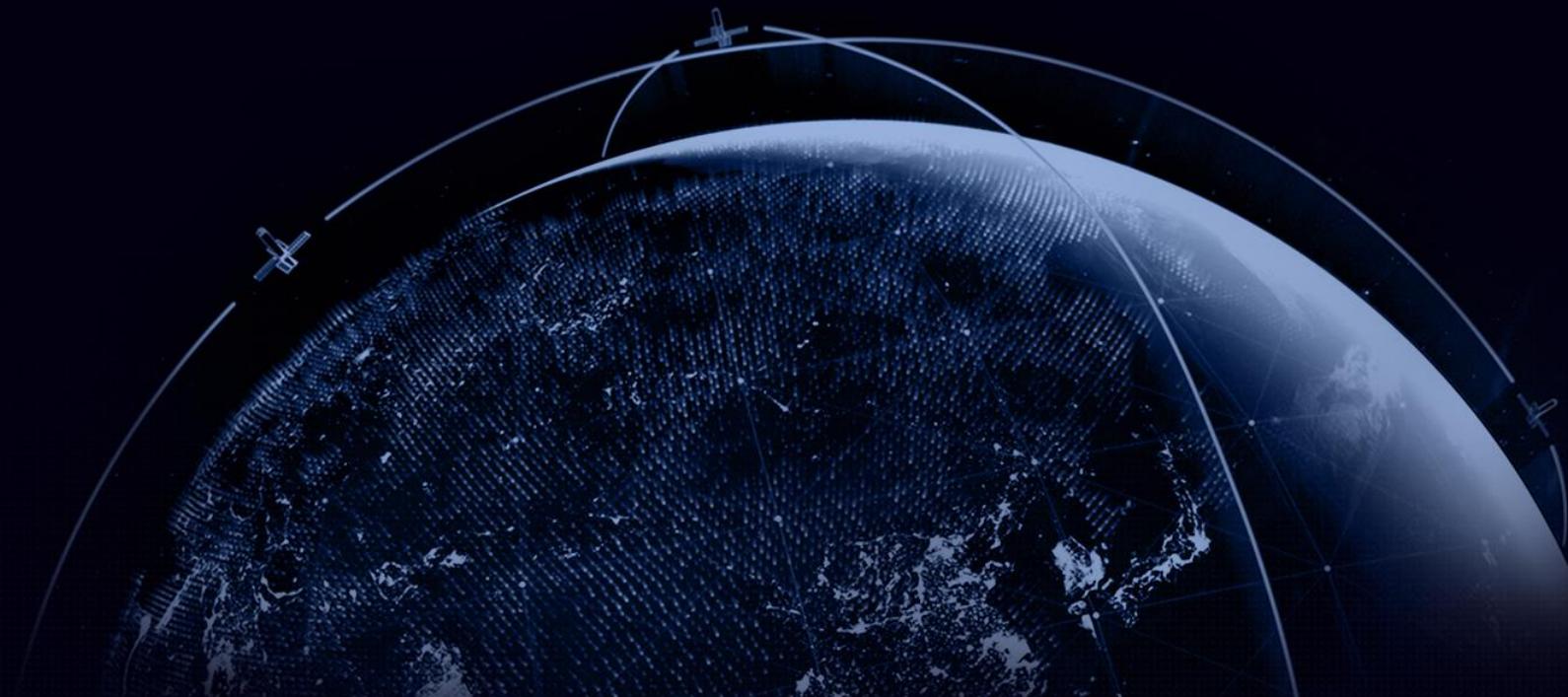


2019

NANO/MICROSATELLITE MARKET FORECAST, 9TH EDITION



QUANTITATIVE MODELING + MARKET EXPERTISE

STRATEGIC INSIGHTS



COST ESTIMATION &
ECONOMIC ANALYSIS

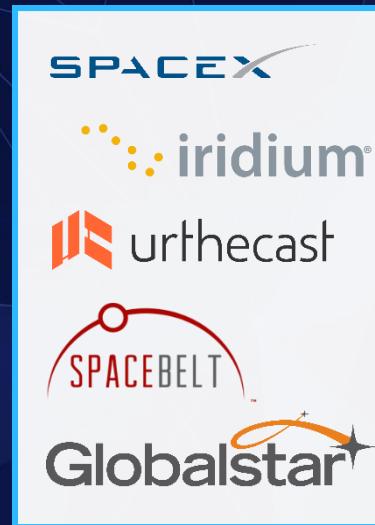
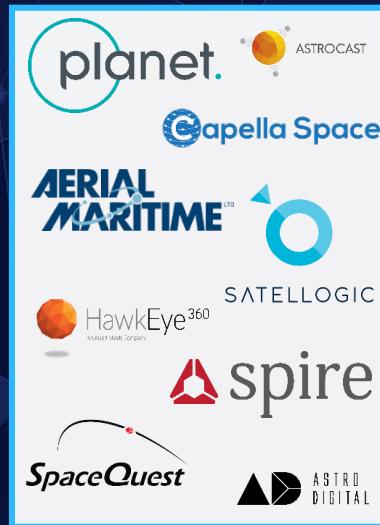


MARKET FORECASTING &
COMPETITIVE INTELLIGENCE



STRATEGIC ADVISORY &
CONSULTING SERVICES

Since 2008, SpaceWorks has actively monitored companies and economic activity across both the satellite and launch sectors



0 - 50 kg

50 - 250kg

250 - 1000kg

1000 - 2000kg

2000kg+

Custom market assessments are available for all mass classes

NANO/MICROSATELLITE DEFINITION



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

FORECASTING METHODOLOGY

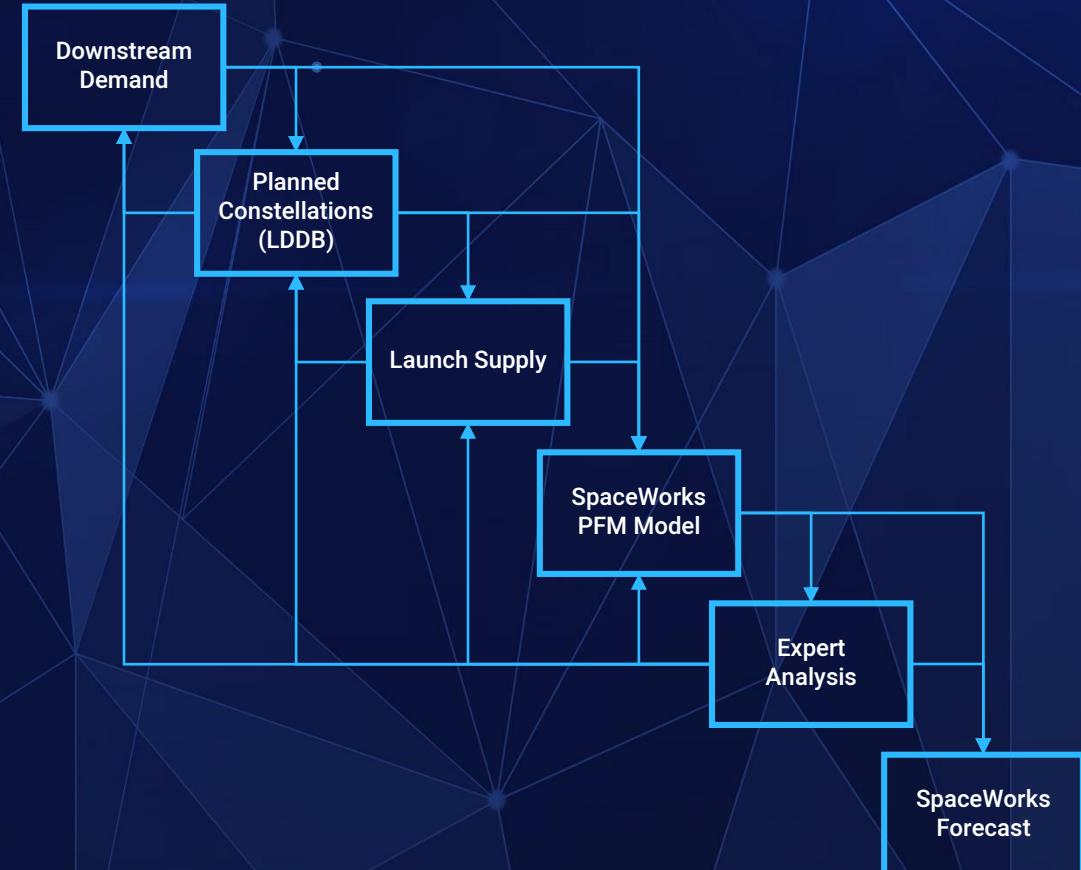
SpaceWorks' **proprietary Launch Demand Database (LDDB)** serves as the data source for all satellite market assessments

- The LDDB is a catalogue of over 10,000+ historical and future satellites containing both public and non-public satellite programs

SpaceWorks newly updated **Probabilistic Forecast Model (PFM)** is used to generate future market potential

- The PFM considers down-stream demand, announced/planned satellite constellations, and supply-side dynamics, among other relevant factors

The team of **expert industry analysts at SpaceWorks** further interprets and refines the PFM results to create accurate market forecasts





2018

SpaceWorks forecasted 2018 nano/microsatellite launches with unprecedented accuracy – actual satellites launched amounted to just 5% below our analysts' predictions. In line with SpaceWorks' expectations, the industry corrected after a record launch year in 2017, sending 20% less nano/microsatellites to orbit than in 2018. A flurry of launches in Q4 helped limit the magnitude of this decline and brought with them a number of industry success stories: the long awaited flight of Spaceflight's SSO-A, Rocket Lab's first (and second) commercial launches, the takeover of CubeSat-based IoT, and much more.

2019+

SpaceWorks' 2019 projections have been revised to reflect the changing attitudes of civil and military operators, as well as the rapid progress of commercial satellite IoT ventures. Increasing global demand in downstream data analytics and communications markets continues to drive growth in the nano/microsatellite segment, but concerns remain about how many operators demand can realistically support. SpaceWorks predicts 294 nano/microsatellites will be launched in 2019, representing a 17% increase from 2018.



2018 HIGHLIGHTS

Rocket Lab's Electron achieved its first successful launch in January of 2018, marking a new era of responsiveness for small satellite launch

- Rocket Lab followed with another two launches in Q4, enough to claim the 4th most nano/microsatellites launched in 2018

The long-awaited flight of Spaceflight's SSO-A, made its voyage from Vandenberg in November, lofting 60+ nano/microsatellites in one of the largest rideshare launches to date

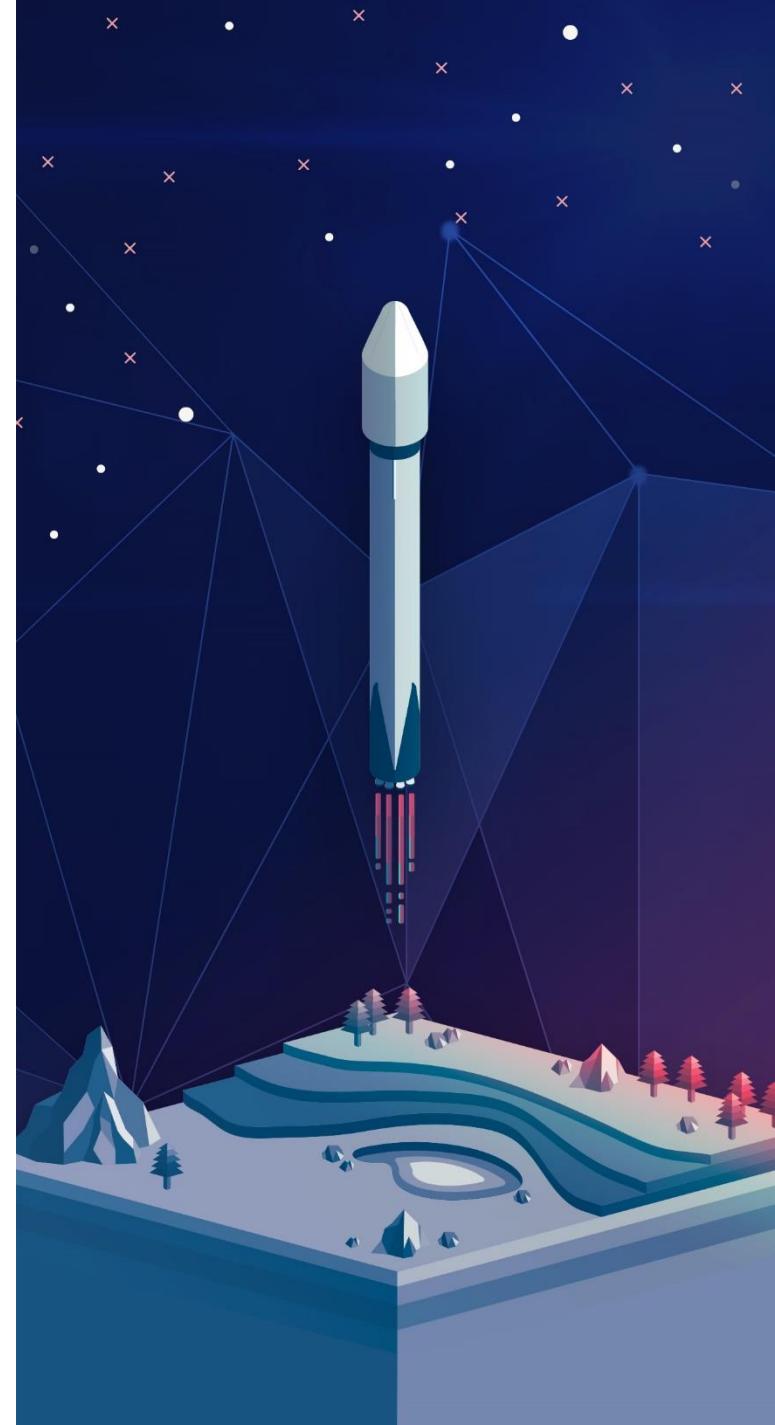
- This launch marked the most satellites ever launched at once from US soil

Competition began heating up in the satellite IoT market, with seven different companies launching their first IoT nano/microsatellite in 2018

- AstroCast, Fleet Space, Hiber, Swarm Technologies, Kepler Communications, Myriota, and MSI Tech. all made their IoT debut this year

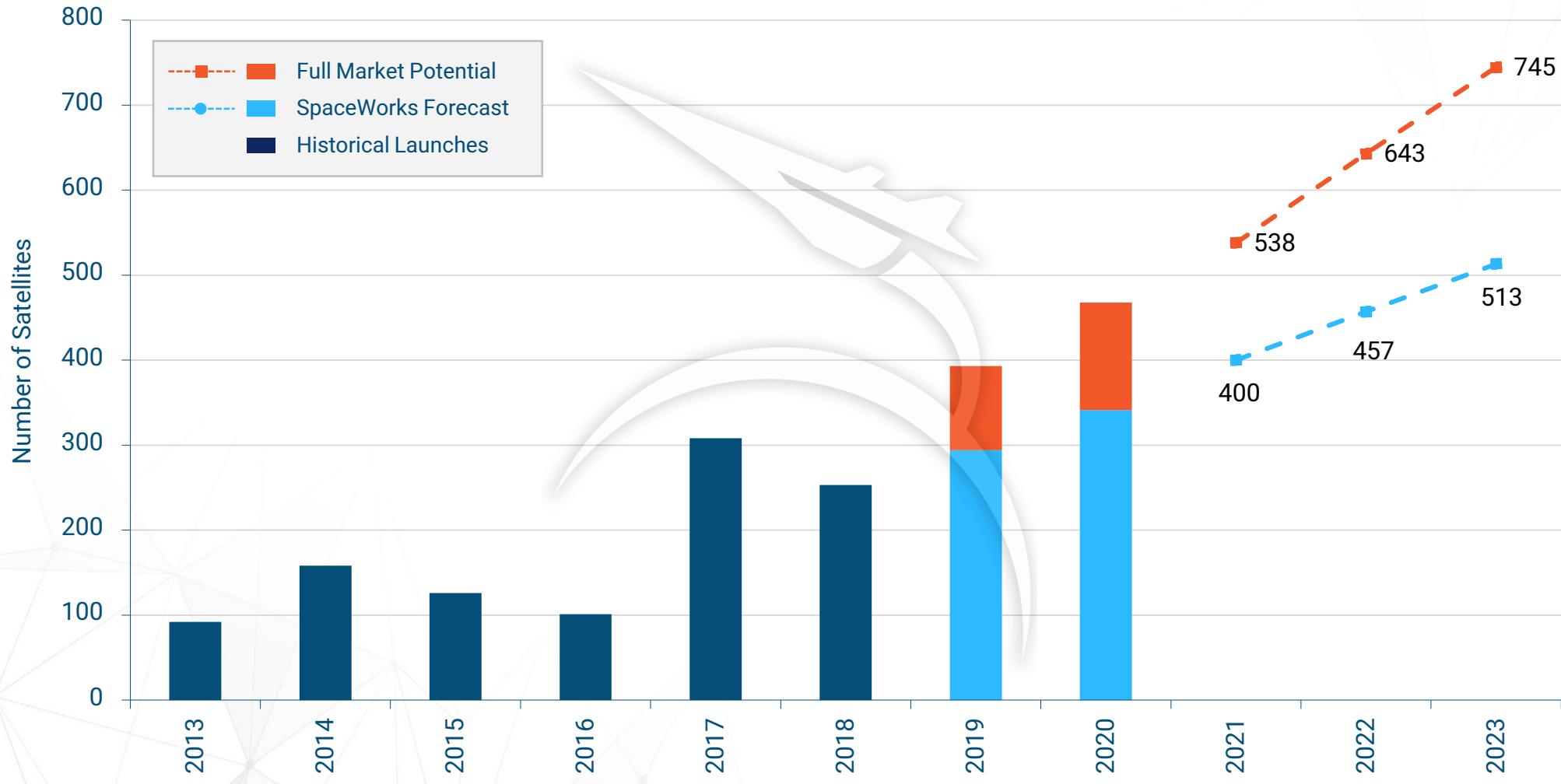
The civil operators segment experienced strong growth for the second year in a row, launching over 100 nano/microsatellites, nearly 20% more than in 2017

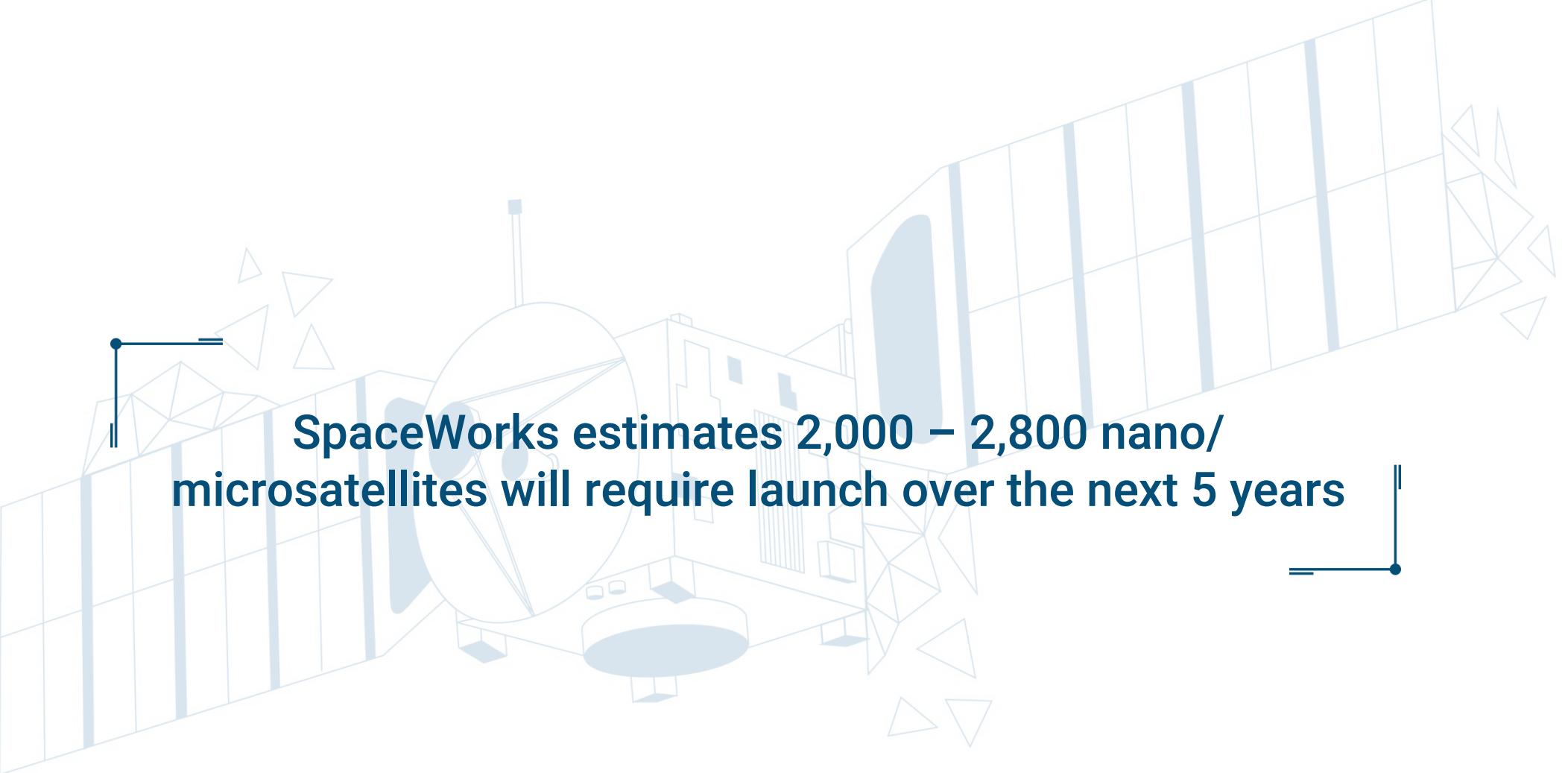
- MarCO A & B (Wall-E & EVA) launched with the Mars InSight rover, highlighting the broader acceptance of nano/microsatellites for scientific missions



SATELLITE LAUNCH HISTORY & MARKET FORECAST

Nano/Microsatellites (1 – 50 kg)





**SpaceWorks estimates 2,000 – 2,800 nano/
microsatellites will require launch over the next 5 years**



OPERATORS & ASSOCIATED EXAMPLES

Nano/Microsatellites (1 – 50 kg)

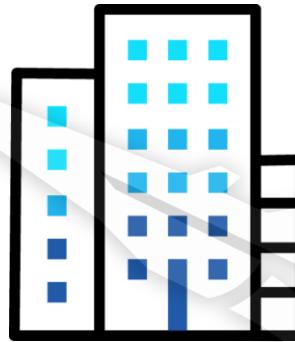


Military

Operators whose primary satellite purpose is to support national defense activities.

Examples

US Naval Research Laboratory
DARPA
Colombian Air Force

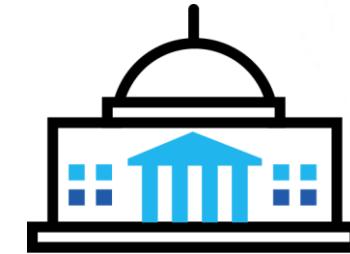


Commercial

Operators whose primary satellite purpose is for-profit revenue generating activities.

Examples

Planet Labs
Spire
Astro Digital



Civil

Operators whose primary satellite purpose is non-military or non-profit activities.

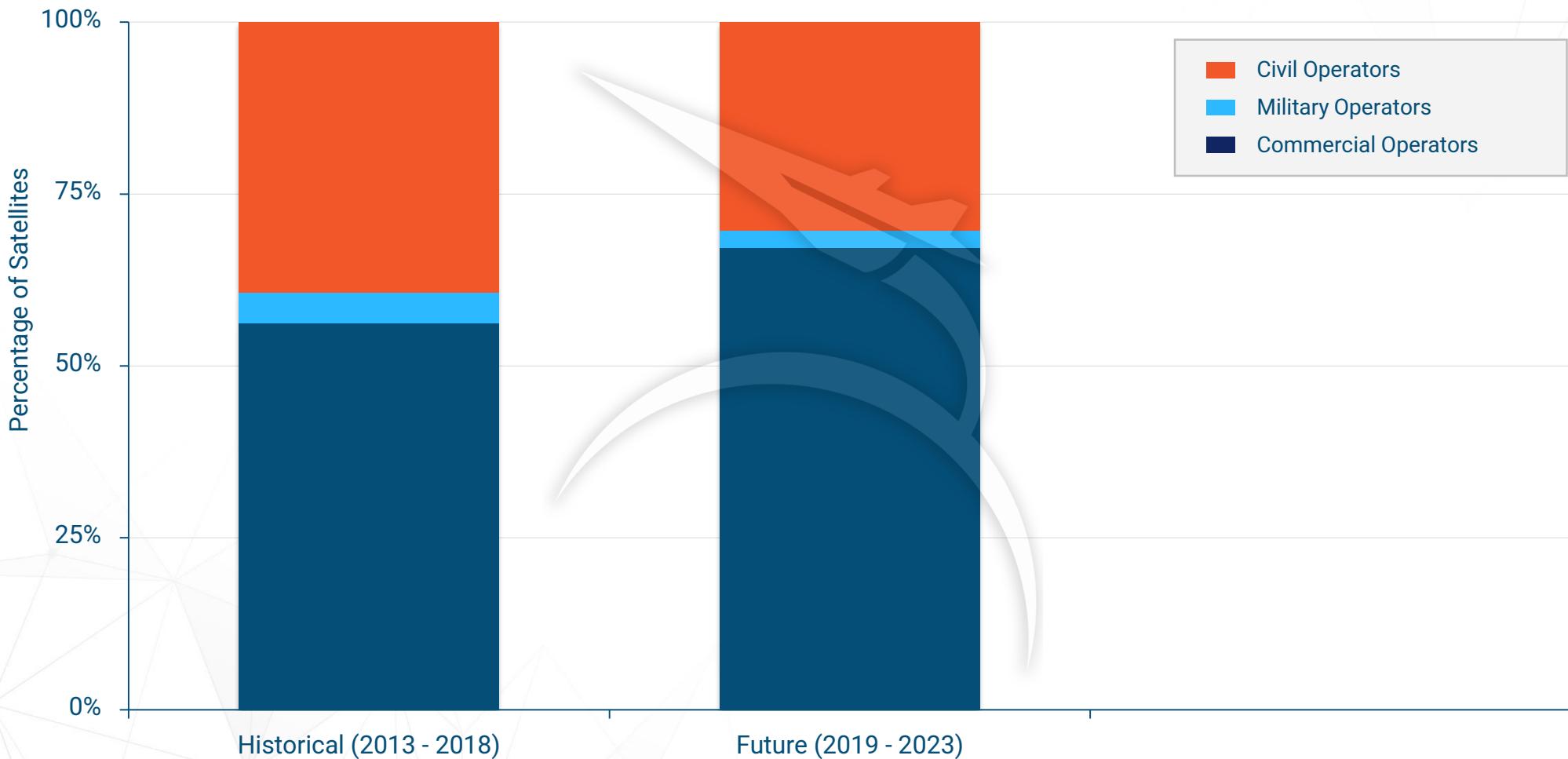
Examples

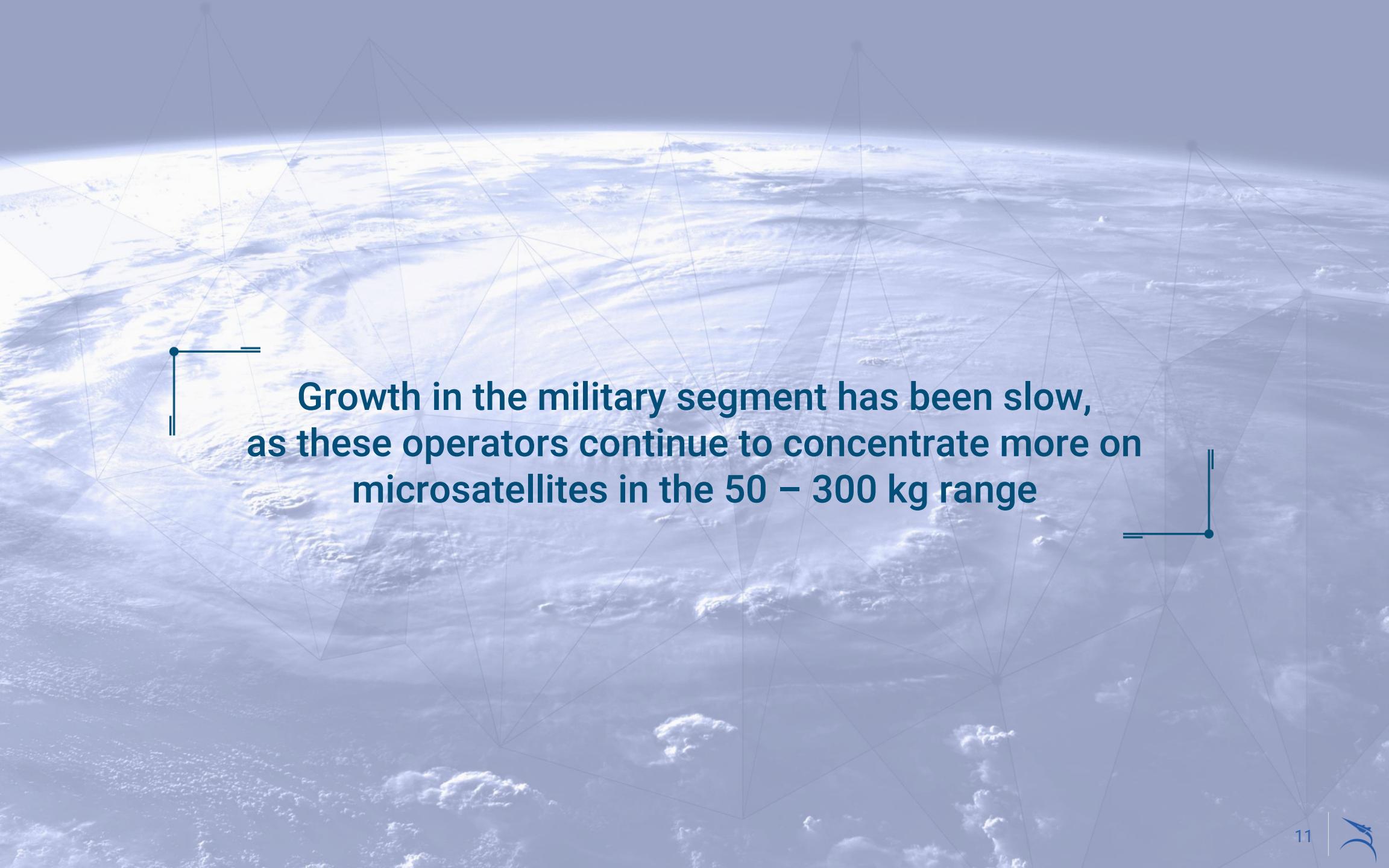
NASA
Kyushu Institute of Technology
The Aerospace Corporation



SATELLITE OPERATOR TRENDS

Nano/Microsatellites (1 – 50 kg)



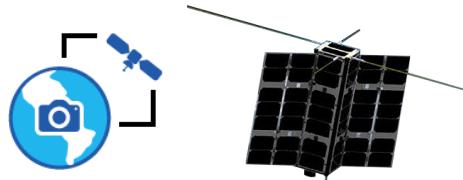


**Growth in the military segment has been slow,
as these operators continue to concentrate more on
microsatellites in the 50 – 300 kg range**



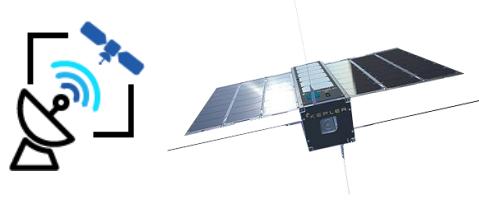
INDUSTRY VERTICALS & APPLICATIONS

Nano/Microsatellites (1 – 50 kg)



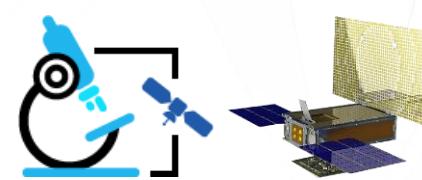
Earth Observation/ Remote Sensing

Ex. Lemur-2 (Spire)



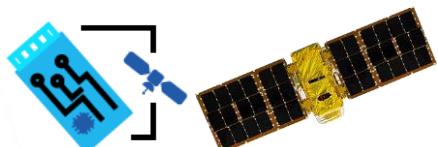
Communications

Ex. KIPP (Kepler Comm.)



Scientific

Ex. MarCO-A/Wall-E (JPL)



Technology

Ex. Tongchuan1 (Spacety)



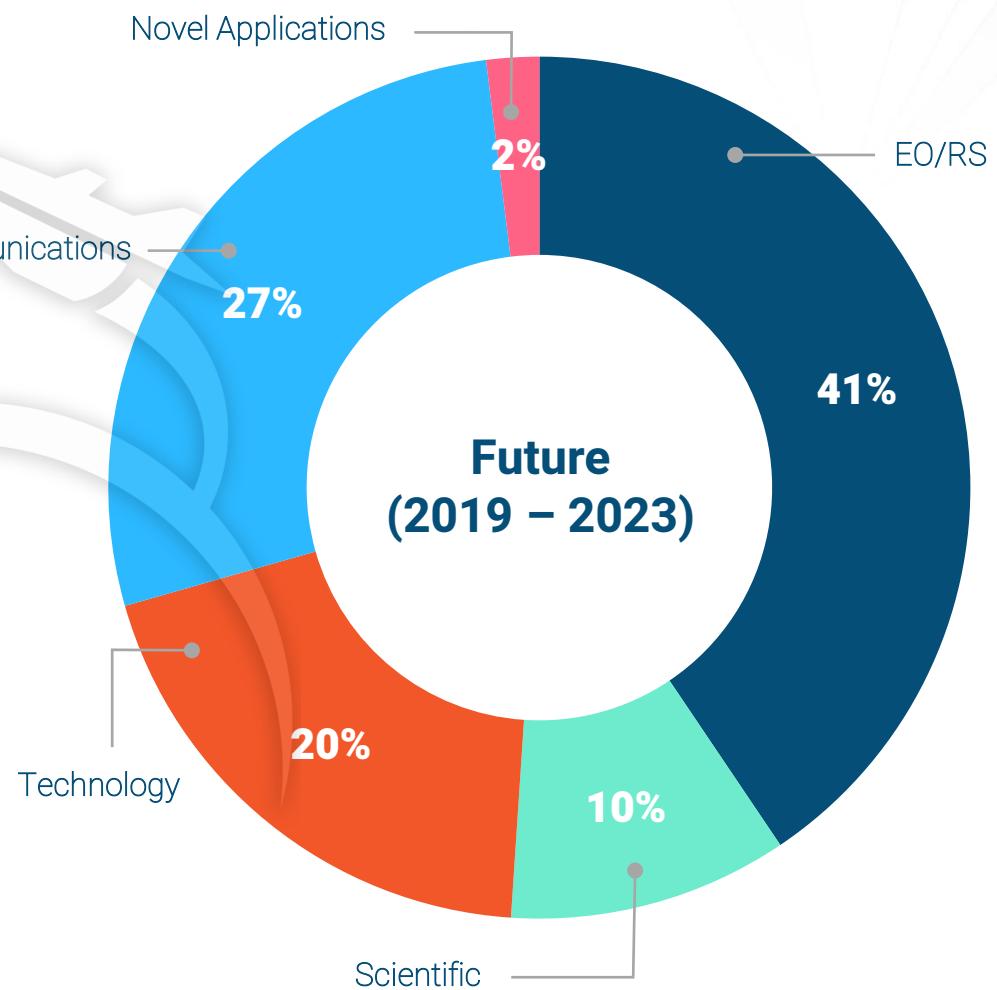
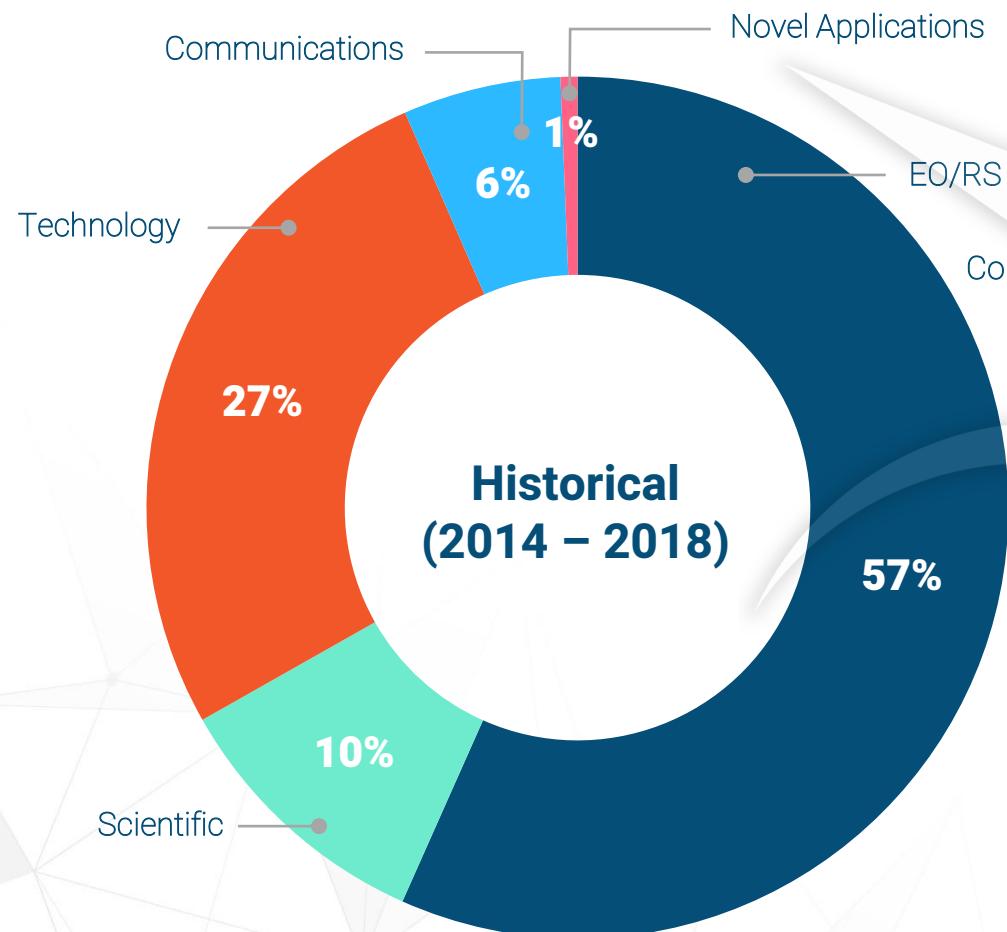
Novel Applications

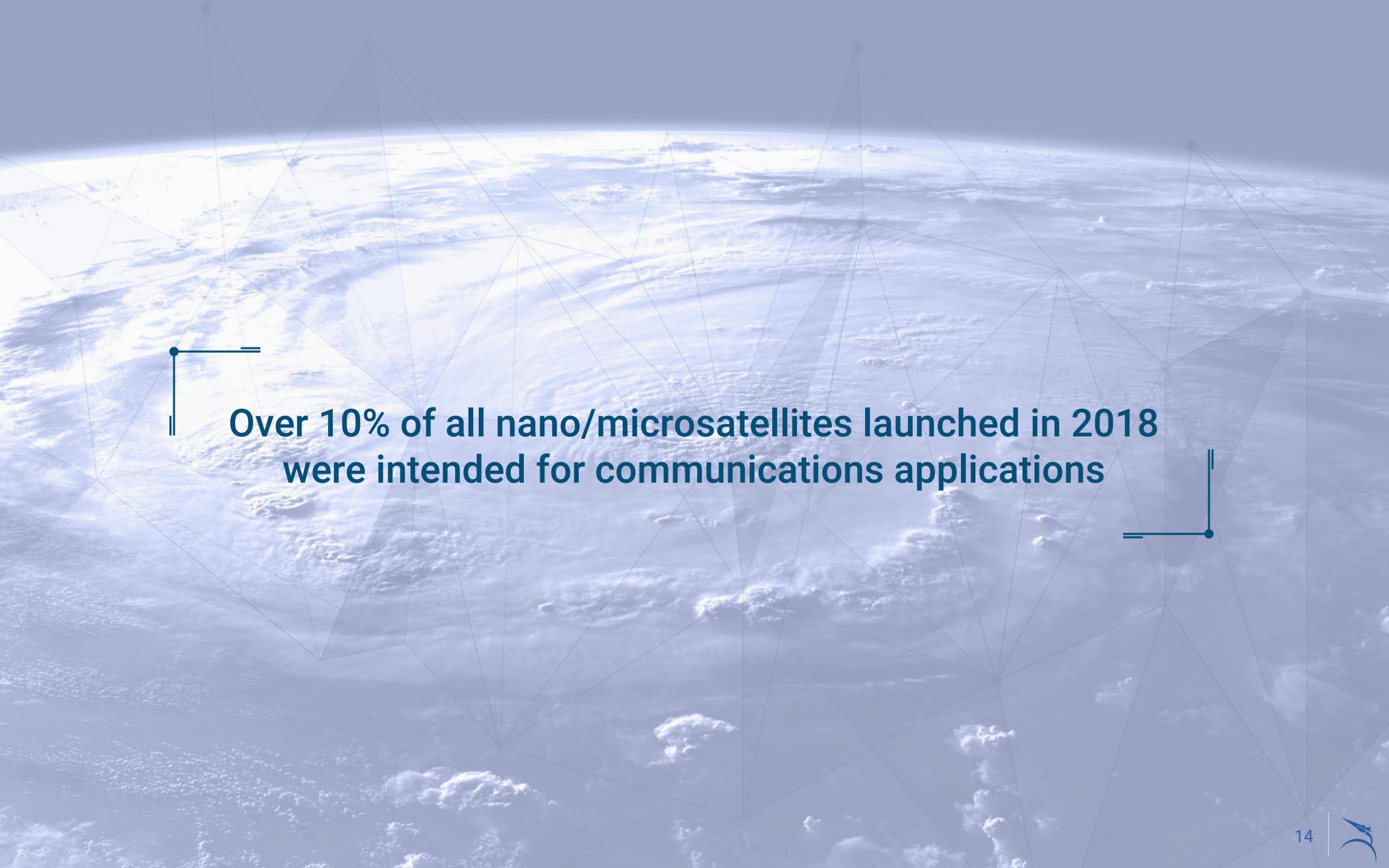
Ex. Enoch (LACMA)



SATELLITE APPLICATION TRENDS

Nano/Microsatellites (1 – 50 kg)



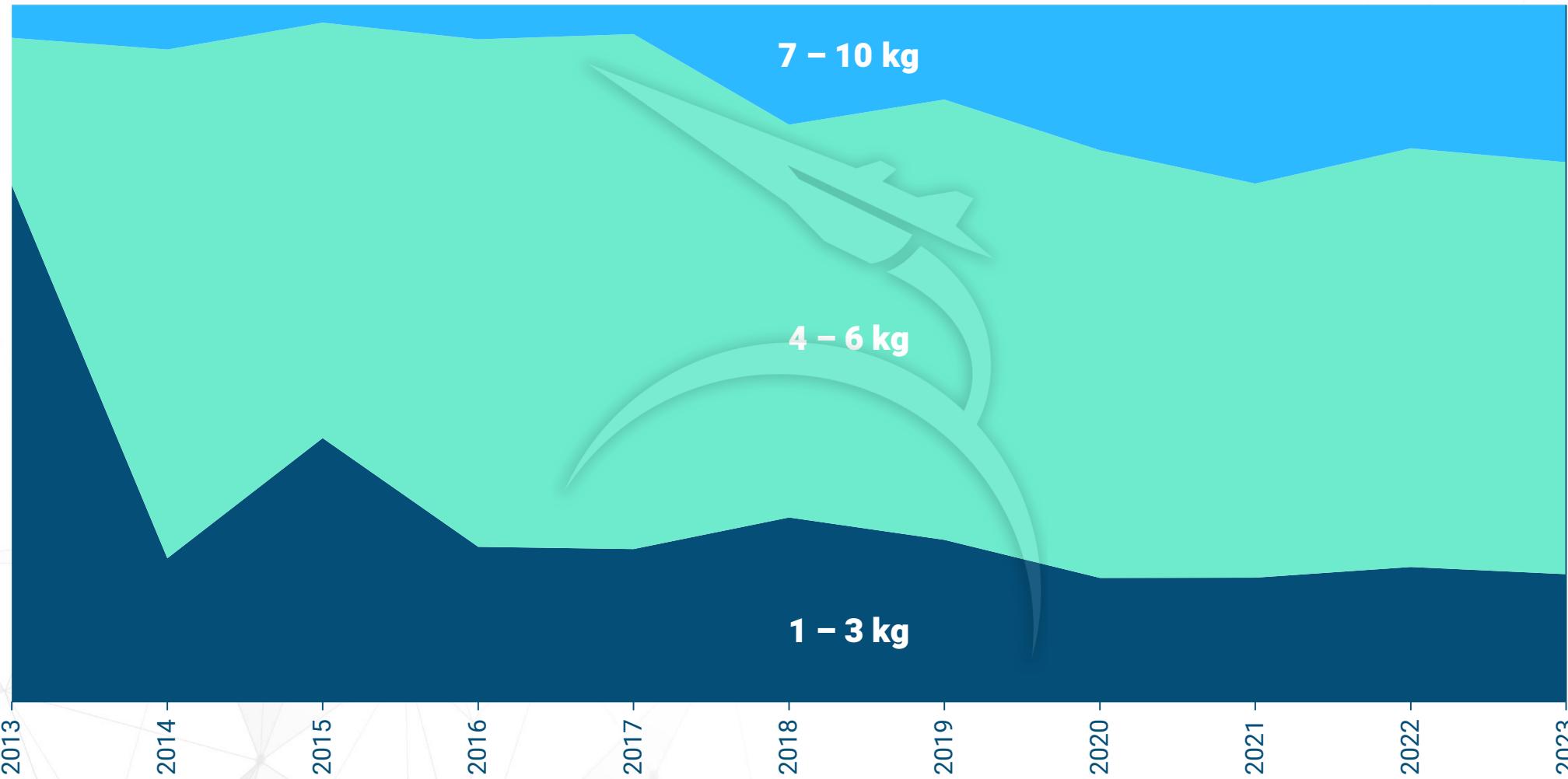


**Over 10% of all nano/microsatellites launched in 2018
were intended for communications applications**



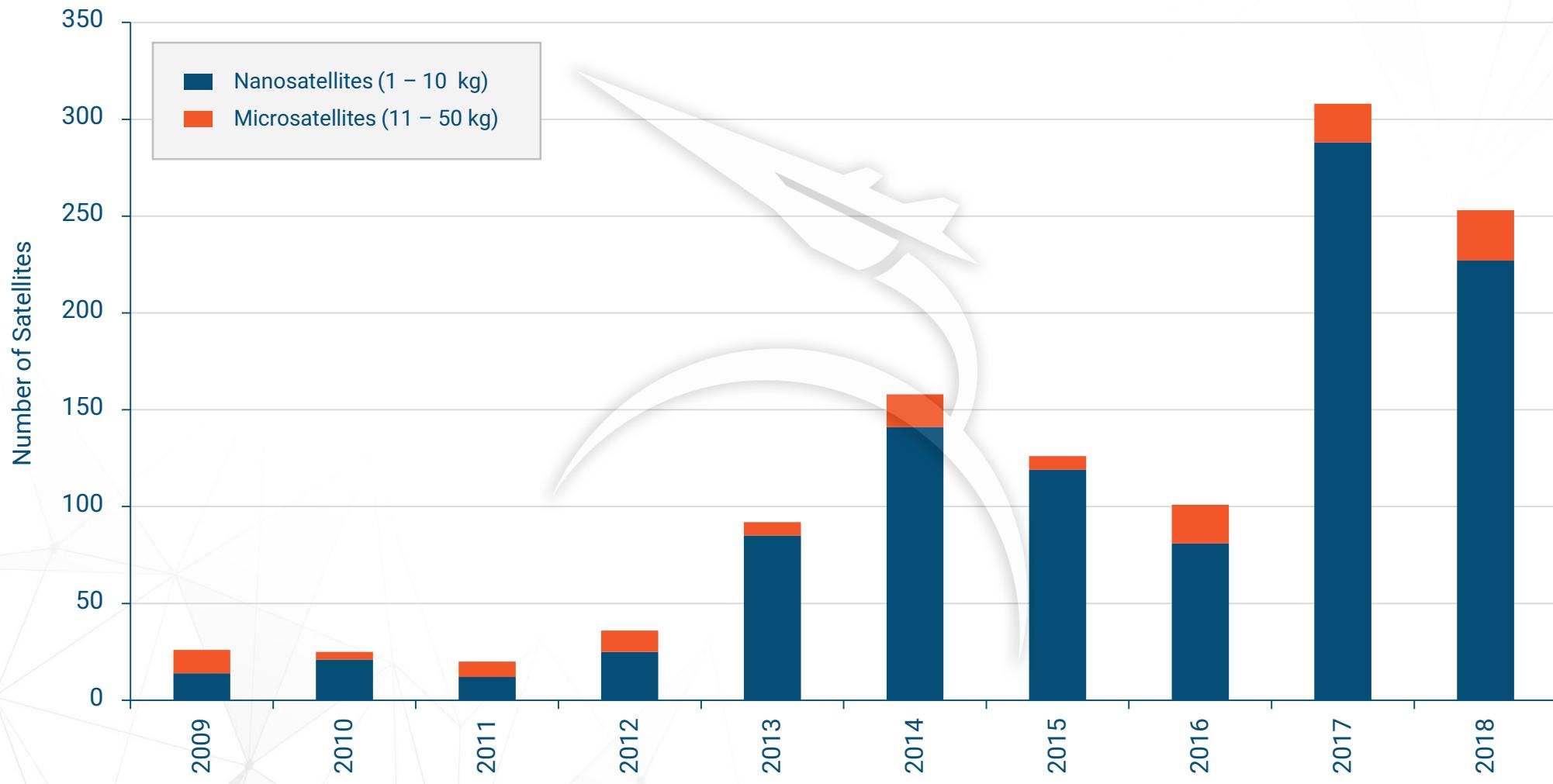
SATELLITE SIZE TRENDS

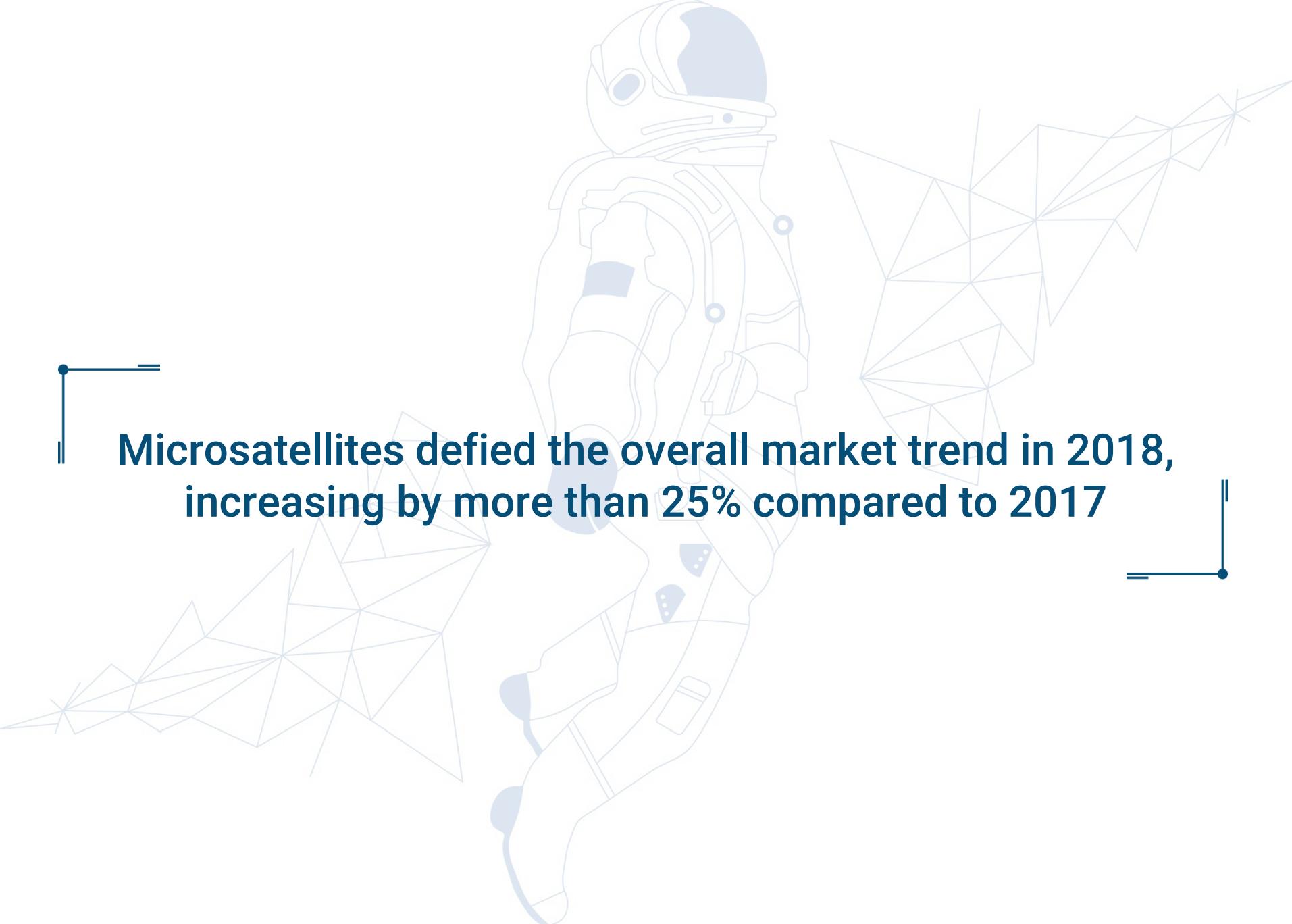
Nanosatellites (1 – 10 kg)



HISTORICAL SATELLITE SIZE TRENDS

Nano vs. Microsatellites (2009 – 2018)



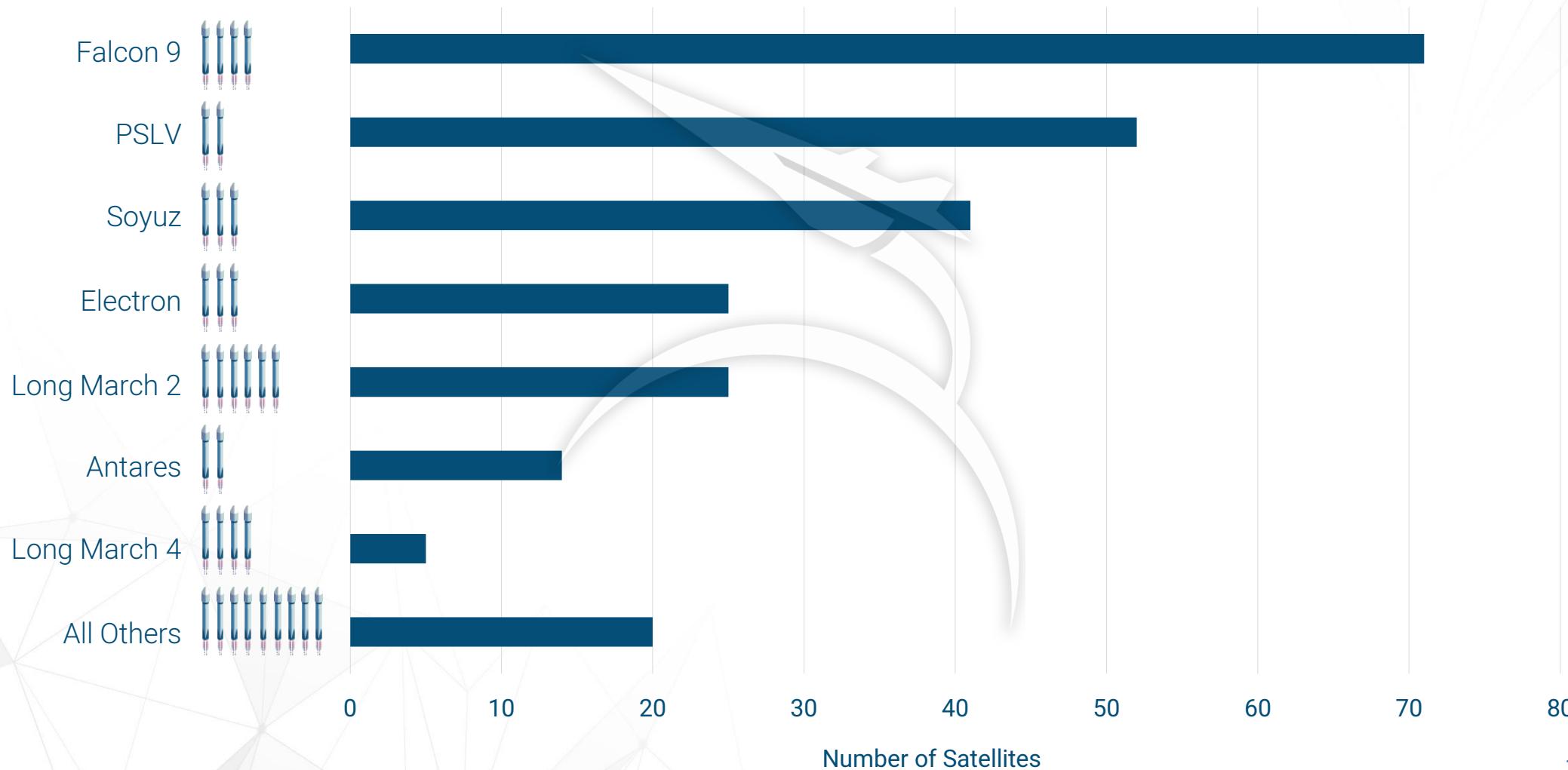


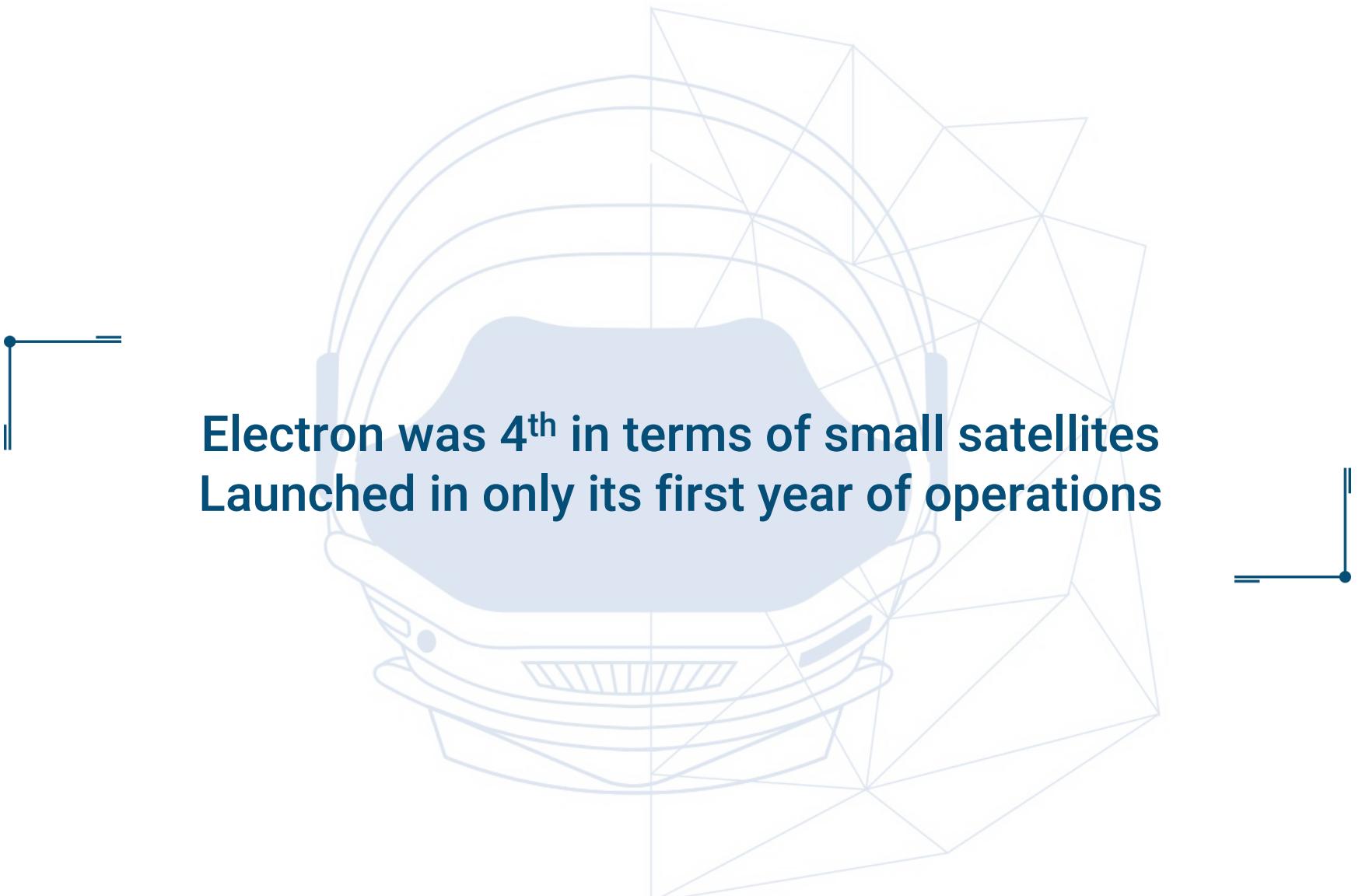
**Microsatellites defied the overall market trend in 2018,
increasing by more than 25% compared to 2017**



2018 RIDES TO SPACE

Nano/Microsatellites (1 – 50 kg)



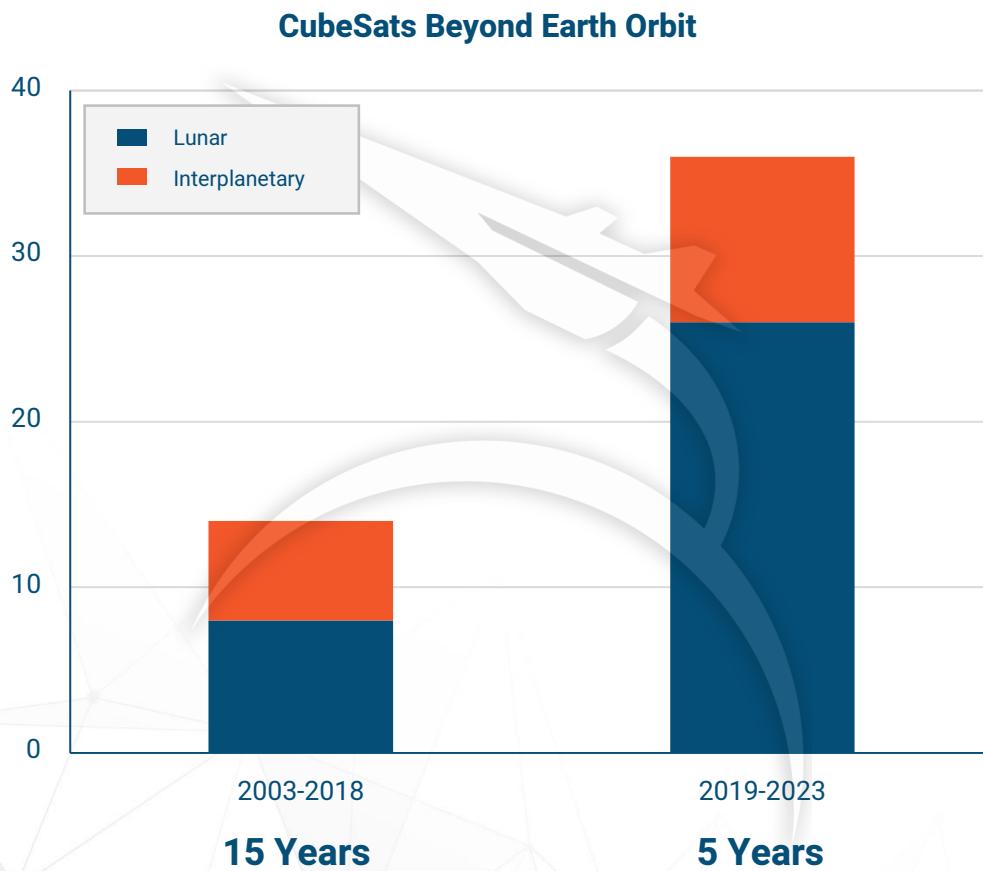


**Electron was 4th in terms of small satellites
Launched in only its first year of operations**



SMALL SATELLITES, LONG JOURNEYS

2019 CASE STUDY #1



From 2003 – 2018, only 14 nano/microsatellites were intended for destinations outside of LEO. Beyond Earth orbit is the domain of civil agencies, who have historically been hesitant to invest in small satellite technologies.

Understandably, the small satellite value proposition can be difficult to understand for interplanetary missions. Is it really worth jeopardizing the primary objectives?

It appears, however, attitudes are beginning to change. Four nano/microsatellites made their way beyond Earth Orbit in 2018, more than in the past 5 years combined. Over the next 5 years, as many as 35 are expected to launch.

SpaceWorks' research suggests that maturing component technology and a greater emphasis on cost-effective science are both major contributing factors to this increase in small satellites with long journeys.



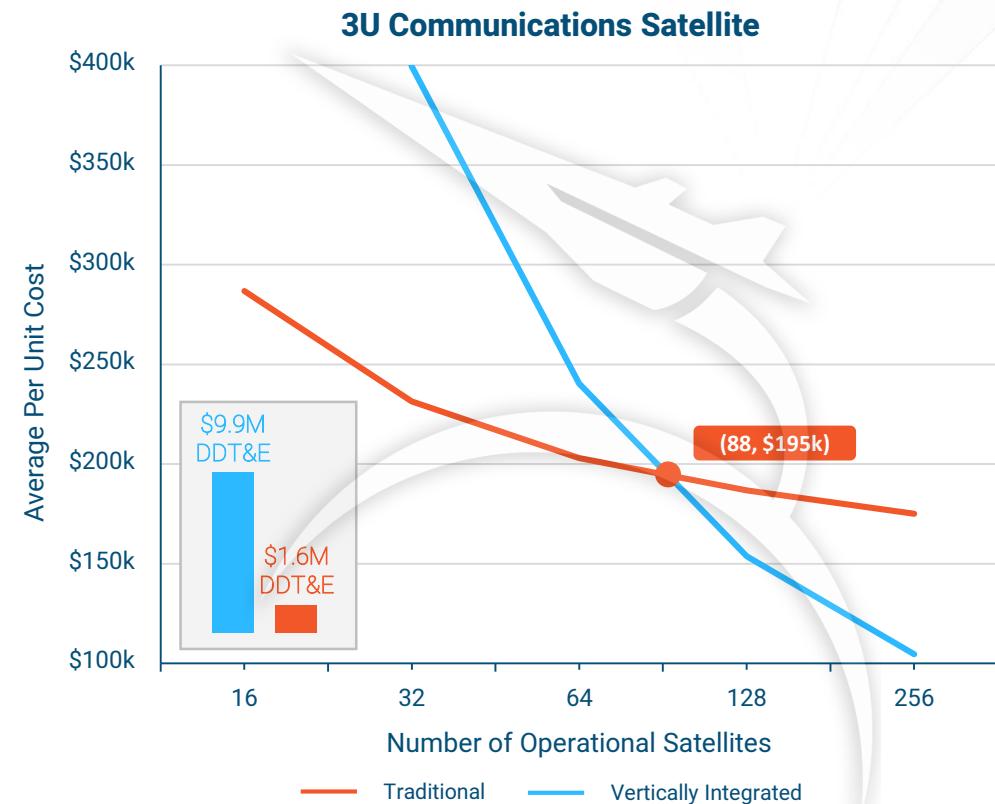
THE RISE OF VERTICAL INTEGRATION

2019 CASE STUDY #2

For small satellite companies, the allure of economies of scale and less reliance on outside suppliers makes vertical integration hard to resist. Still, vertical integration is a costly, and near irreversible corporate strategy, with significant associated risks.

An original study conducted by SpaceWorks, first published at the NASA Cost & Schedule Symposium, indicates that market power, supplier disruptions, and quality control all play a role small satellite firm's decision to vertically integrate, but constellation size is likely the most compelling motivator.

SpaceWorks' research suggests that a vertically integrated approach starts to become financially attractive for 3U spacecraft at constellations sizes of 80+, depending on various firm-related characteristics.



To learn more about the rise of vertical integration in the small satellite sector, check out SpaceWorks' multi-part series, "A Different Approach", at www.spaceworks.aero/insights



SMALL SATELLITE LAUNCH VEHICLE LEADERBOARD

2019 CASE STUDY #3

Rank ¹	Name	Stated IOC	Payload to SSO (kg) ²	Target Launch Price ³	Major Recent Milestone(s)
1	 Electron	2018	150	\$33K/kg	Multiple commercial launches + \$140M fundraising round
2	 Launcher One 	2019	300	\$40K/kg	Captive carry test complete
3	 Kuaizhou 1A	2017	250	\$57K/kg	Successful orbital launch and satellite deployment
4	 ZhuQue 	2018	200	\$70K/kg ³	Failed orbital launch attempt
5	 Small Satellite Launch Vehicle (SSLV)	2019	700	\$12K/kg ³	Development announced by Indian Space Research Organization
6	 Vector-R	2019	28	\$54K/kg	\$70M Series B fundraising round led by Kodem Growth Partners

¹ Rankings based on SpaceWorks' Launcher Maturity Index, a subjective assessment of launch vehicle operators based on a variety of factors – please see end notes ²SSO payload normalized from available data when necessary ³Estimated



2019 FORECAST CONCLUSIONS

Of the 262 nano/microsatellites SpaceWorks predicted to launch in 2018, 253 actually launched – a margin of error of less than 5%

- Greater launch consistency and better execution on the part of small satellite operators, in addition to a shift in forecasting methodology to focus on downstream demand, all contributed to the increase in forecast accuracy

While civil operators are beginning to embrace nano/microsatellite technology in greater numbers, military operators remain slow to adopt

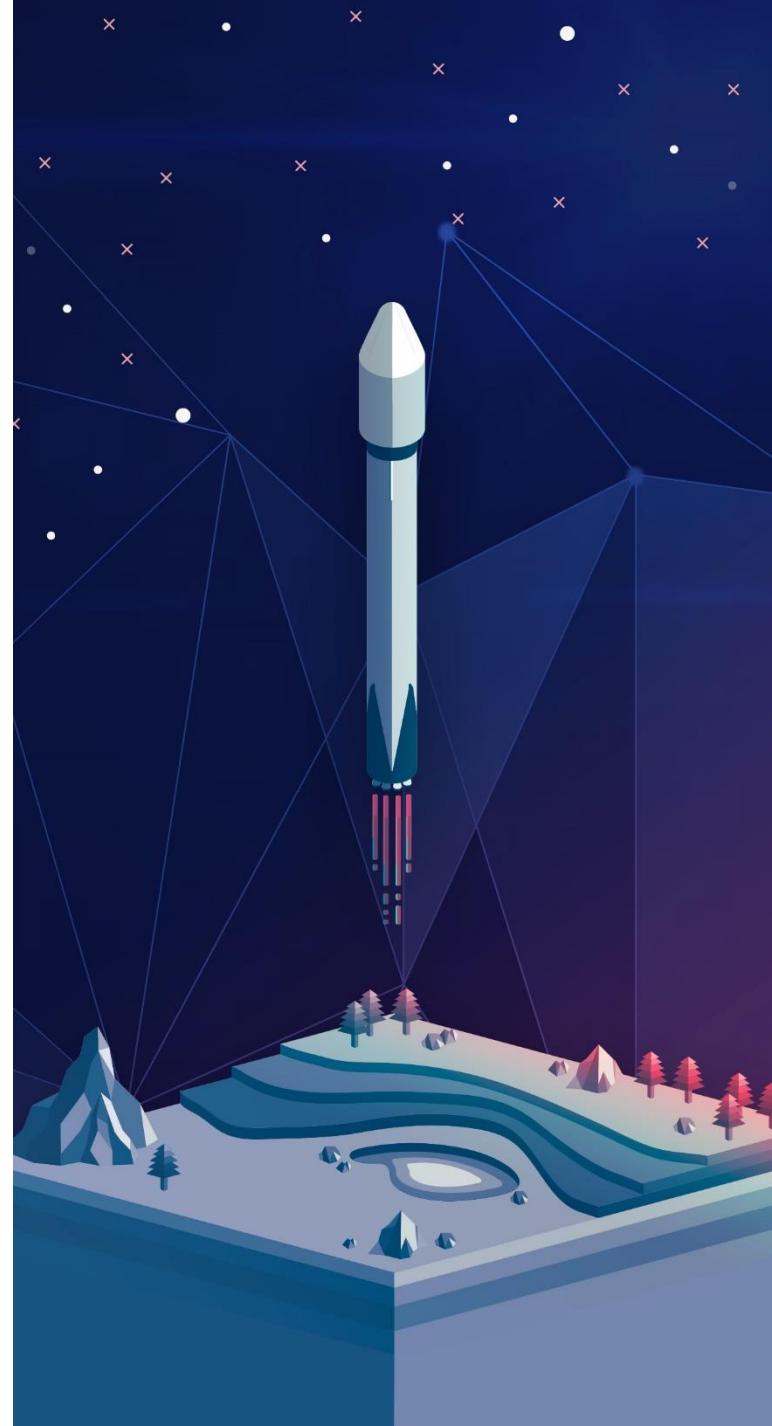
- Military demand is expected to be more concentrated in the 50 – 300 kg range, where payload capabilities are greater

Earth Observation & Remote Sensing operators are beginning to diversify, targeting applications beyond traditional optical imagery

- Operators are looking towards hyperspectral, SAR, GPS Occultation, ADS-B, and live-video to maintain growth trajectories

Satellite IoT is expected to be the largest driver of market growth in the future, and may be coming sooner rather than later

- Initial growth in the communications segment is greater than was seen in the early years of the Earth Observation & Remote Sensing segment



INSIDE LOOK!



SpaceWorks provides economic consulting services to clients across the space industry, from government agencies to satellite manufacturers.

This year, SpaceWorks is providing an exclusive **INSIDE LOOK!** at questions answered through other SpaceWorks engagements.

INSIDE LOOK! U.S. COMMERCIAL SPACE POLICY

SpaceWorks monitors the changing regulatory landscape for commercial space activities



May 2018

The Secretary of Transportation was tasked to allow for faster design-to-flight processes by streamlining commercial space launch and re-entry operations licenses



June 2018

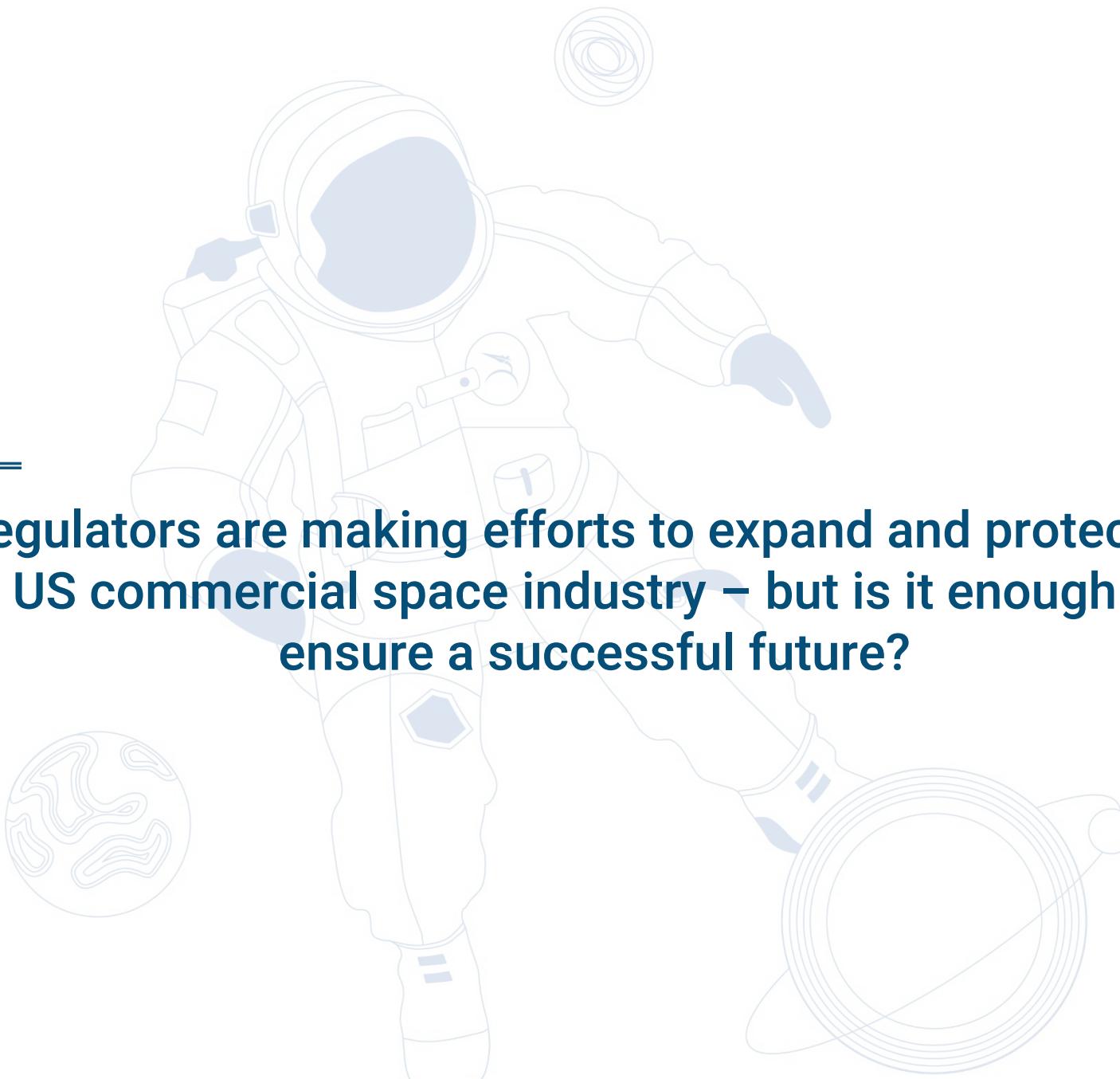
The Secretary of Commerce was assigned to foster continued growth and innovation in Science & Technology, Space Situational Awareness, and Space Traffic Management activities



June 2018

The Director of National Intelligence was asked to encourage firms to continually expand services by maintaining a timely and responsive regulatory environment for non-government orbital activities



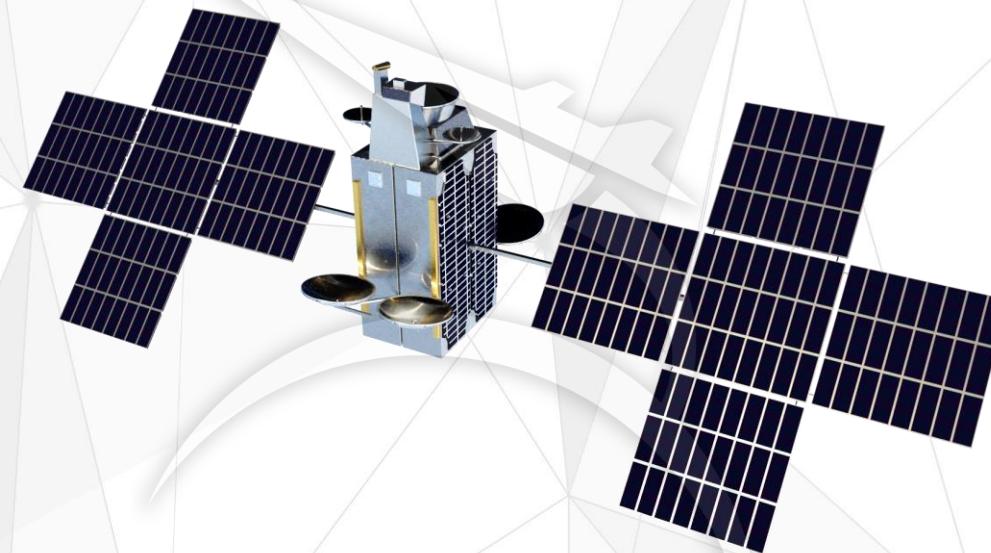


Regulators are making efforts to expand and protect the US commercial space industry – but is it enough to ensure a successful future?



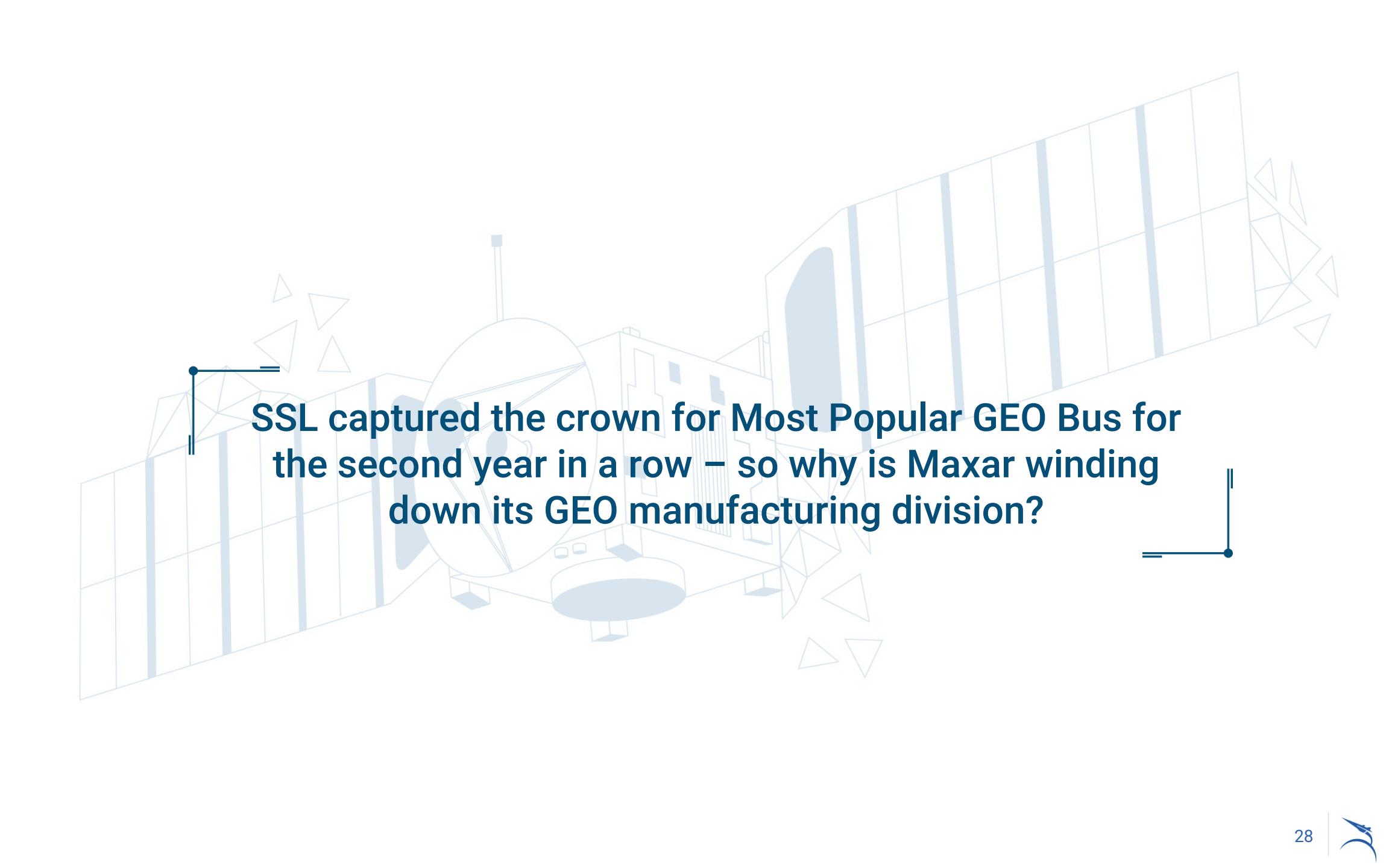
INSIDE LOOK! GEO SATELLITES

SpaceWorks actively tracks satellite manufacturing activity across all mass segments



**2018's Most Popular GEO Satellite Bus:
SSL-1300**





**SSL captured the crown for Most Popular GEO Bus for
the second year in a row – so why is Maxar winding
down its GEO manufacturing division?**



INSIDE LOOK! FUTURE LEO ECONOMY

SpaceWorks monitors the entire LEO economy, beyond traditional industry market segments



Human
Exploration



Communications



Space-Based
Data



In-Space
Services



Bio/Medicine



Space
Resources

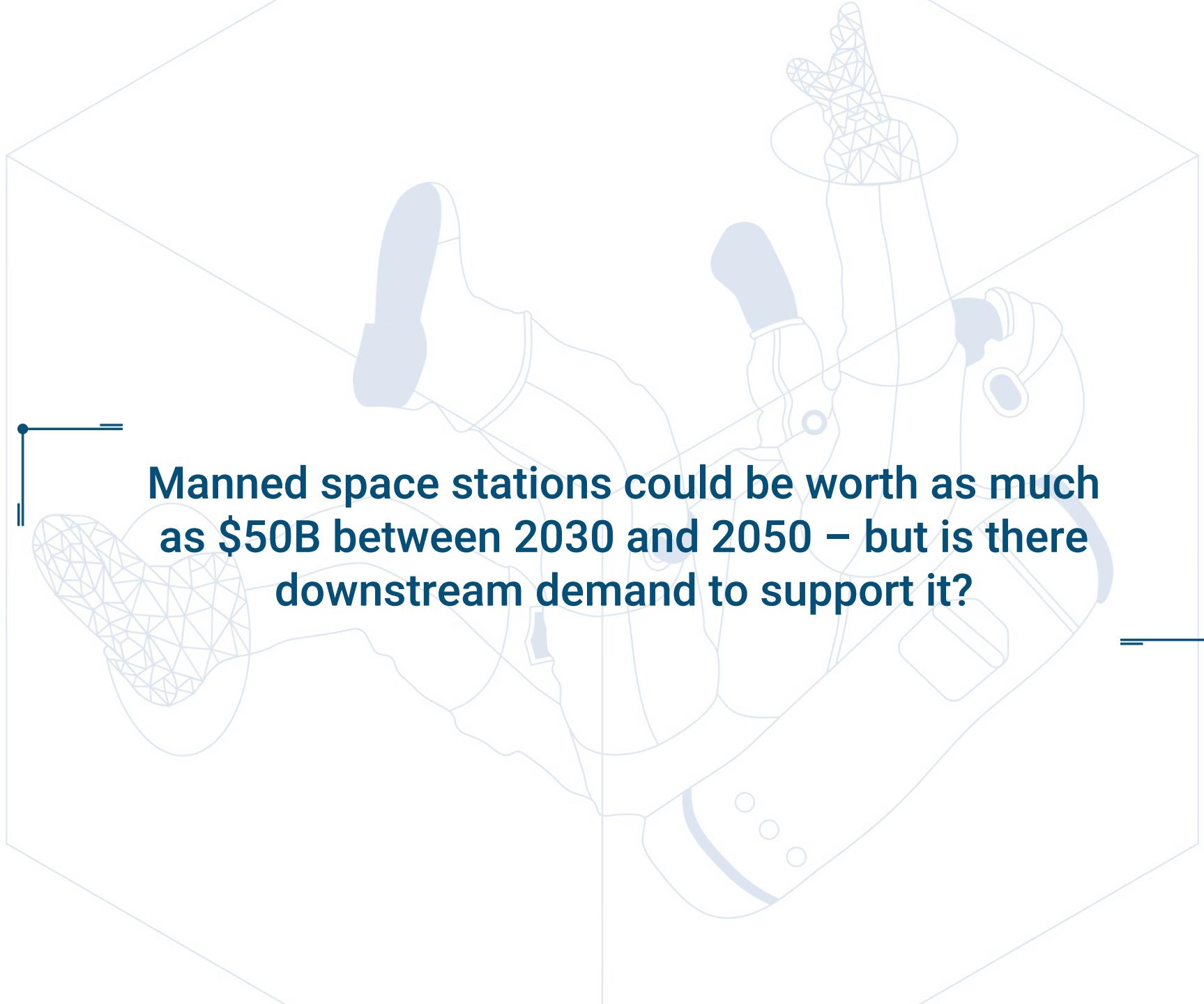


Space-based
Manufacturing



Novel
Applications



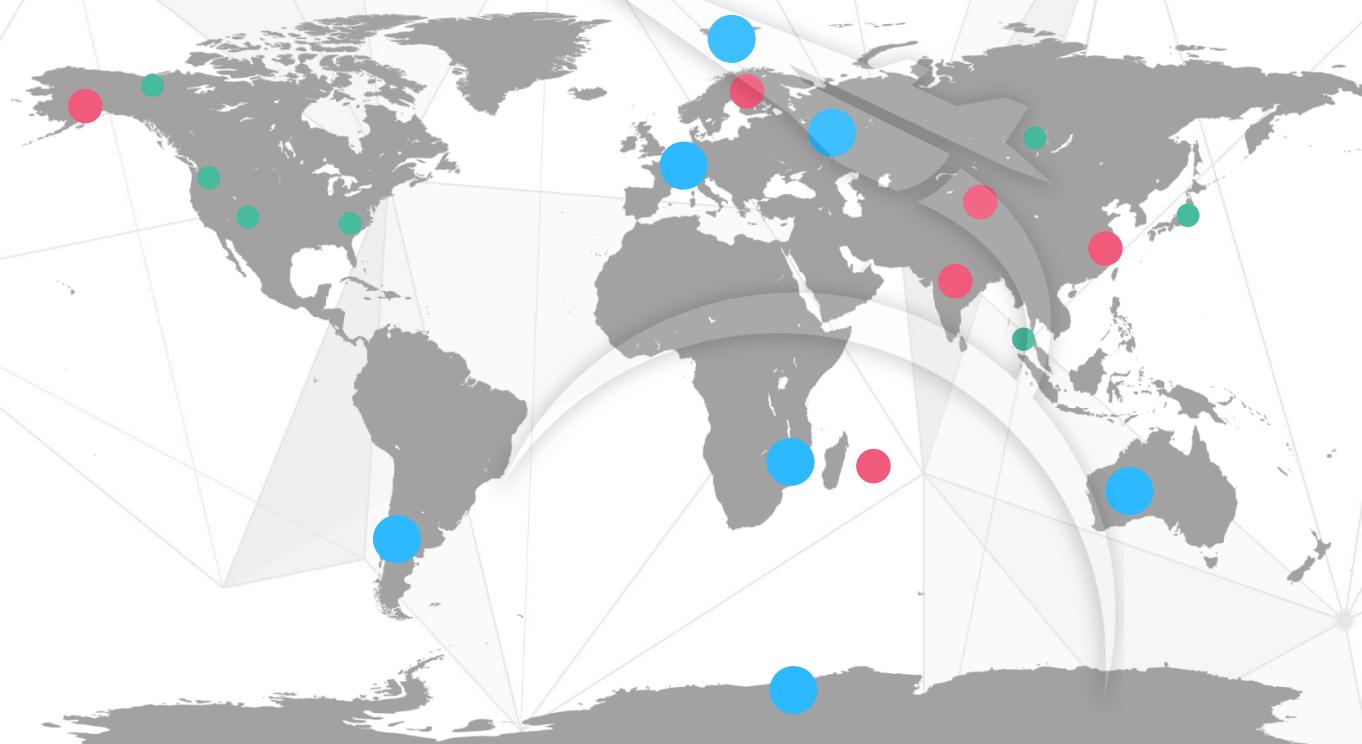


Manned space stations could be worth as much as \$50B between 2030 and 2050 – but is there downstream demand to support it?



INSIDE LOOK! SATELLITE GROUND STATIONS

SpaceWorks maintains proprietary databases on the satellite ground station market



Number of
Antennas¹

¹ Non-exhaustive list, only a subset of ground stations tracked in SpaceWorks Ground Station Database (GSDB) shown





New entrants and technology in the ground station market are gaining ground fast – are optical ground stations the way of the future or just a fantasy?



SPACEWORKS COMMERCIAL SERVICES

Our economic consultants monitor global economic activity across the space sector and combine quantitative modeling with deep industry expertise to answer critical business questions. Our work helps clients to navigate the changing space market landscape, envision the impact of future technologies, under the cost and feasibility of proposed systems, and making sound strategic investment decisions regarding the future of space markets.



Interested in how we can help your business? Contact us today:

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STRATEGIC INSIGHTS



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ECONOMIC ANALYSIS



MARKET FORECASTING &
COMPETITIVE INTELLIGENCE



STRATEGIC ADVISORY &
CONSULTING SERVICES

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/microsatellites
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 and expected launch schedule.
4. Future projects are determined by "best fit" regression with a set market saturation point based on expected downstream demand.
5. The Full Market Potential dataset contains all currently known past and future nano/microsatellites from the SpaceWorks Lddb, with the addition of inflating factor for known unknowns plus assumed sustainment of certain projects and programs and the continued emergence and growth of numerous existing commercial companies. The SpaceWorks Forecast dataset reflects SpaceWorks' expert value judgement on the likely market outcome.
6. Graphs are based on the SpaceWorks Forecast dataset only, and do not include the additional satellites contained in the Full Market Potential dataset
7. Nanosatellites are binned by rounding mass to the nearest whole number. Picosatellites less than 1 kg are not included
8. SpaceWorks' Launcher Maturity Index is a qualitative assessment of Small Satellite Launch Vehicle operators based on a number of factors, including historical performance, funding and licensing status, team composition and completeness, operator potential to capture global market share, and SpaceWorks' overall expert judgement of the operator's credibility for executing their launch plans within their stated IOC targets.
9. SpaceWorks' Ground Station Database includes 200+ entries of historical and planned ground stations, not all of which are presented within this report
10. SpaceWorks wishes to attribute image credits for images not cited inline to the following entities: Planet Labs, Astrocast, Capella Space, Aerial & Maritime Ltd., Satellogic, HawkEye360, Spire Global, SpaceQuest, Astro Digital, OneWeb, EarthI, Iceye, Axelspace, SpaceX, Iridium, UrtheCast, SpaceBelt, Globalstar, AMOS, SES, ABS, Intelsat, Echostar, ArabSat, Hispasat, ViaSat, Turksat, Inmarsat, DigitalGlobe, RocketLabs, China Great Wall Industries, Virgin Orbit, Indian Space Research Organization, Vector Space Systems, PLD Space, US Department of Transportation, US Department of Commerce, and US Director of the Office of National Intelligence