Introduction

Smaller satellites are of increasing interest; growing use in recent years.

Bryce’s *Smallsats by the Numbers* presents historical information on smaller satellites launched 2011 – 2020 (regardless of operational status).

Definition used here, 600 kg and under, reflects the five smallest mass classes defined by the FAA.

‘Smallsat’ or ‘very small satellite’ are often used to refer to smaller satellites.

Due to the large quantity of LEO broadband telecommunications smallsats launched in 2020, this report provides data views that both exclude and include LEO broadband telecommunications smallsat systems that have launched operational satellites as of 2020 to provide insight into trends in other types of systems.

<table>
<thead>
<tr>
<th>Mass Class Name</th>
<th>Kilograms (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femto</td>
<td>0.01 – 0.09</td>
</tr>
<tr>
<td>Pico</td>
<td>0.1 – 1</td>
</tr>
<tr>
<td>Nano</td>
<td>1.1 – 10</td>
</tr>
<tr>
<td>Micro</td>
<td>11 – 200</td>
</tr>
<tr>
<td>Mini</td>
<td>201 – 600</td>
</tr>
<tr>
<td>Small</td>
<td>601 – 1,200</td>
</tr>
<tr>
<td>Medium</td>
<td>1,201 – 2,500</td>
</tr>
<tr>
<td>Intermediate</td>
<td>2,501 – 4,200</td>
</tr>
<tr>
<td>Large</td>
<td>4,201 – 5,400</td>
</tr>
<tr>
<td>Heavy</td>
<td>5,401 – 7,000</td>
</tr>
<tr>
<td>Extra Heavy</td>
<td>&gt; 7,001</td>
</tr>
</tbody>
</table>

From FAA *The Annual Compendium of Commercial Space Transportation: 2018*
2020 Smallsat Highlights

- 1,202 Smallsat launches in 2020

- 40% of all smallsats launched in last 10 years launched in 2020

- 43% of total upmass represented by smallsats in 2020

- 68 launches in 2020 carried smallsats

- 14% of smallsats launched on small/micro launch vehicles in 2020
Smallsats in Context and Operator/Mission Type Trends

Smallsat Mass Trends
Smallsat Launch Trends
Looking Forward
Smallsats Launched and Total Spacecraft Upmass 2011 – 2020

Smallsats in Context and Operator/Mission Type Trends

- **3,968** Spacecraft launched
  - ~4,000 MT Total upmass
  - Femto, Pico each <0.1%
  - Nano 0.1%

- **1,282** Spacecraft launched
  - ~554 MT Total upmass
  - Femto 0%
  - Pico and Nano 0.1%

**Mass Class Name** | **Kilograms (kg)**
--- | ---
Femto | 0.01 – 0.09
Pico | 0.1 – 1
Nano | 1.1 – 10
Micro | 11 – 200
Mini | 201 – 600
Small | 601 – 1,200
Medium | 1,201 – 2,500
Intermediate | 2,501 – 4,200
Large | 4,201 – 5,400
Heavy | 5,401 – 7,000
Extra Heavy | > 7,001

- Smallsats represent 75% of spacecraft launched 2011 – 2020, 9% of total upmass
- Smallsats represent 94% of spacecraft launched in 2020, 43% of total upmass
Spacecraft Launched 2011 – 2020, by Mass Class

Smallsats in Context and Operator/Mission Type Trends

Number of Spacecraft Launched

Starlink and Oneweb smallsats

Other smallsats

Small (601-1,200 kg)

Medium (1,201-2,500 kg)

Intermediate (2,501-4,200 kg)

Large (4,201-5,400 kg)

Heavy (5,401-7000 kg)

Extra Heavy (7,000+ kg)
Smallsats 2011 – 2020, by Mass Class

Smallsats in Context and Operator/Mission Type Trends

- Femto (.01-.09 kg)
- Pico (.1-.1 kg)
- Nano (1.1-10 kg)
- Micro (11-200 kg)
- Mini (201-600 kg)
Smallsats 2011 – 2020, by Mass Class, Starlink and OneWeb Breakout

Smallsats in Context and Operator/Mission Type Trends

Number of Smallsats Launched

- Femto (0.01-0.09 kg)
- Pico (0.1-1 kg)
- Nano (1.1-10 kg)
- Micro (11-200 kg)
- OneWeb (~150 kg)
- Mini (201-600 kg)
- Starlink (~260 kg)
### Share of Smallsats 2011 – 2020, by Mass Class Including Starlink and OneWeb

**Smallsats in Context and Operator/Mission Type Trends**

<table>
<thead>
<tr>
<th>Year</th>
<th>Femto (.01-.09 kg)</th>
<th>Pico (.1-1 kg)</th>
<th>Nano (1.1-10 kg)</th>
<th>Micro (11-200 kg)</th>
<th>Mini (201-600 kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>15%</td>
<td>21%</td>
<td>18%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>17%</td>
<td>33%</td>
<td>24%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>17%</td>
<td>37%</td>
<td>21%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>7%</td>
<td>67%</td>
<td>6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>8%</td>
<td>65%</td>
<td>10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>8%</td>
<td>58%</td>
<td>9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>2%</td>
<td>83%</td>
<td>5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>9%</td>
<td>60%</td>
<td>13%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td>9%</td>
<td>38%</td>
<td>37%</td>
<td></td>
<td>16%</td>
</tr>
<tr>
<td>2020</td>
<td>4%</td>
<td>72%</td>
<td>9%</td>
<td></td>
<td>15%</td>
</tr>
</tbody>
</table>

*Including heavier LEO broadband constellation smallsats, mini smallsats constitute the largest share of smallsats in 2020.*
Excluding heavier LEO broadband constellation smallsats, nano smallsats constitute the largest share of smallsats since 2013.
Share of Smallsats 2011 – 2020, by Application Including Starlink and OneWeb

Smallsats in Context and Operator/Mission Type Trends

Relative share of remote sensing and technology development smallsats has decreased due to launch of LEO communication smallsats.
When excluding Starlink + OneWeb, remote sensing and technology demonstration smallsats historically have largest shares
Number of commercial smallsats launched increased from 3 smallsats in 2011 and 2012 to 1,111 in 2020.
Commercial Smallsat Operators 2011 – 2020

Smallsats in Context and Operator/Mission Type Trends

83% of smallsats launched 2011 – 2020 are owned by 5 operators

![Diagram showing the distribution of smallsats by operator]

### Commercial Operators with more than 5 smallsats*

<table>
<thead>
<tr>
<th>Operator</th>
<th># of Smallsats</th>
</tr>
</thead>
<tbody>
<tr>
<td>SpaceX</td>
<td>955</td>
</tr>
<tr>
<td>Planet</td>
<td>437</td>
</tr>
<tr>
<td>Spire Global</td>
<td>131</td>
</tr>
<tr>
<td>OneWeb</td>
<td>110</td>
</tr>
<tr>
<td>Swarm Technologies</td>
<td>45</td>
</tr>
<tr>
<td>CGSTL</td>
<td>26</td>
</tr>
<tr>
<td>Satellogic</td>
<td>20</td>
</tr>
<tr>
<td>ORBCOMM</td>
<td>19</td>
</tr>
<tr>
<td>Spacety</td>
<td>12</td>
</tr>
<tr>
<td>Astro Digital</td>
<td>10</td>
</tr>
<tr>
<td>Zuhai Orbita</td>
<td>10</td>
</tr>
<tr>
<td>Guodian Gaoke</td>
<td>10</td>
</tr>
<tr>
<td>GeoOptics</td>
<td>8</td>
</tr>
<tr>
<td>BlackSky</td>
<td>7</td>
</tr>
<tr>
<td>Commsat Tech Dev Co.</td>
<td>7</td>
</tr>
<tr>
<td>ICEYE</td>
<td>6</td>
</tr>
</tbody>
</table>

*As of the end of 2020
Smallsats 2011 – 2020, by Operator Country
Smallsats in Context and Operator/Mission Type Trends

Operator Country | # of Smallsats
---|---
USA | 2,027 (955 Starlink)
China | 224
UK | 129
Japan | 82
Russia | 83
Germany | 49
Canada | 29
Argentina | 23
France | 21
India | 18
Australia | 17
South Korea | 17
Italy | 16
Singapore | 14
Spain | 13
Israel | 12
Finland | 10

*OneWeb smallsats included under United Kingdom
Number of Government Smallsats 2011 – 2020, by Country

Smallsats in Context and Operator/Mission Type Trends

Countries with More than Five Government Smallsats

<table>
<thead>
<tr>
<th>Five or Fewer Smallsats</th>
<th>Canada</th>
<th>Norway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vietnam</td>
<td>United Kingdom</td>
<td></td>
</tr>
<tr>
<td>South Korea</td>
<td>Algeria</td>
<td></td>
</tr>
<tr>
<td>UAE</td>
<td>Italy</td>
<td></td>
</tr>
<tr>
<td>North Korea</td>
<td>Ecuador</td>
<td></td>
</tr>
<tr>
<td>Poland</td>
<td>The Philippines</td>
<td></td>
</tr>
<tr>
<td>Ethiopia</td>
<td>Turkey</td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>Australia</td>
<td></td>
</tr>
<tr>
<td>Egypt</td>
<td>Nigeria</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>Ukraine</td>
<td></td>
</tr>
<tr>
<td>Belarus</td>
<td>Colombia</td>
<td></td>
</tr>
<tr>
<td>Malaysia</td>
<td>Kazakhstan</td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>Thailand</td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>Pakistan</td>
<td></td>
</tr>
<tr>
<td>Peru</td>
<td>Belgium</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>Rwanda</td>
<td></td>
</tr>
<tr>
<td>Chile</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Largest Government Smallsat Operators 2011 – 2020

Smallsats in Context and Operator/Mission Type Trends

<table>
<thead>
<tr>
<th>Type</th>
<th>15 Largest Government Operators Open-Source Data</th>
<th>Country</th>
<th># of Smallsats Launched</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil</td>
<td>National Aeronautics and Astronautics and Space Administration</td>
<td>USA</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>Los Alamos National Laboratory (LANL)</td>
<td>USA</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Roscosmos</td>
<td>Russia</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Japan Aerospace Exploration Agency (JAXA)</td>
<td>Japan</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Indian Space Research Organisation (ISRO)</td>
<td>India</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)</td>
<td>Germany</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>European Space Agency (ESA)</td>
<td>Europe</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Chinese Academy of Sciences</td>
<td>China</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>National Space Program Office (NSPO)</td>
<td>Taiwan</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Centre National d'Etudes Spatiales (CNES)</td>
<td>France</td>
<td>5</td>
</tr>
<tr>
<td>Military</td>
<td>US Department of Defense</td>
<td>USA</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>Russia MoD/Aerospace Forces</td>
<td>Russia</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>People’s Liberation Army</td>
<td>China</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>National University of Defence Technology (NUDT)</td>
<td>China</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>National Reconnaissance Office</td>
<td>USA</td>
<td>9</td>
</tr>
</tbody>
</table>
Number of Academic Smallsats 2011 – 2020, by Institution
Smallsats in Context and Operator/Mission Type Trends

Academic Institutions with More than Five Smallsats Launched

Nearly 210 academic operators launched smallsats 2011 – 2020
Smallsats in Context and Operator/Mission Type Trends

Smallsat Mass Trends
Smallsat Launch Trends
Looking Forward
Spacecraft Upmass by Spacecraft Mass Class, 2011 – 2020

Smallsat Mass Trends

- Total Mass Launched by Spacecraft
- Mass Class

- Femto + Pico (.01-1kg)
- Nano (1.1-10kg)
- Micro (11-200kg)
- Mini (201-600kg)
- Small (601-1,200 kg)
- Medium (1,201-2,500 kg)
- Intermediate (2,501-4,200 kg)
- Large (4,201-5,400 kg)
- Heavy (5,401-7000 kg)
- Extra Heavy (7,000+ kg)

- Smallsats (≤ 600kg)
Smallsats as a Share of Total Upmass 2011 – 2020

Smallsat Mass Trends

- **Total spacecraft upmass 2020**: 554,277 kg
- **Total smallsat upmass 2020**: 239,150 kg

<table>
<thead>
<tr>
<th>Year</th>
<th>Share of Total Mass Launched</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>1%</td>
</tr>
<tr>
<td>2012</td>
<td>1%</td>
</tr>
<tr>
<td>2013</td>
<td>2%</td>
</tr>
<tr>
<td>2014</td>
<td>2%</td>
</tr>
<tr>
<td>2015</td>
<td>2%</td>
</tr>
<tr>
<td>2016</td>
<td>2%</td>
</tr>
<tr>
<td>2017</td>
<td>2%</td>
</tr>
<tr>
<td>2018</td>
<td>5%</td>
</tr>
<tr>
<td>2019</td>
<td>11%</td>
</tr>
<tr>
<td>2020</td>
<td>43%</td>
</tr>
</tbody>
</table>
Average Mass, Smallsats 2011 – 2020

Smallsat Mass Trends

Smallsats on average are increasing in mass

Average Smallsat Mass
Excluding Starlink + OneWeb
Average spacecraft mass overall is decreasing, driven by deployment of large numbers of smallsats.
Smallsats in Context and Operator/Mission Type Trends

Smallsat Mass Trends

**Smallsat Launch Trends**

Looking Forward
<table>
<thead>
<tr>
<th>Year</th>
<th>Share of Smallsat Launched</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>41%</td>
</tr>
<tr>
<td>2012</td>
<td>25%</td>
</tr>
<tr>
<td>2013</td>
<td>42%</td>
</tr>
<tr>
<td>2014</td>
<td>55%</td>
</tr>
<tr>
<td>2015</td>
<td>58%</td>
</tr>
<tr>
<td>2016</td>
<td>40%</td>
</tr>
<tr>
<td>2017</td>
<td>27%</td>
</tr>
<tr>
<td>2018</td>
<td>43%</td>
</tr>
<tr>
<td>2019</td>
<td>57%</td>
</tr>
<tr>
<td>2020</td>
<td>78%</td>
</tr>
</tbody>
</table>

*Smallsat Launch Trends: 2011 – 2020, by Country of Launch Provider*
Number of launches per year with smallsats has generally increased over the 10-year period.
Number of Launches with Smallsats 2011 – 2020, by Launch Vehicle Category

Smallsat Launch Trends

Launch Vehicle Category | Capacity (kg) to LEO
--- | ---
Micro | ≤500
Small | 500 – 2,268
Medium | 2,269 – 5,443
Intermediate | 5,444 – 11,340
Heavy | 11,341 – 30,000
Super Heavy | >30,000
Share of Smallsats 2011 – 2020, by Launch Vehicle Category

Smallsat Launch Trends

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Number of Smallsats 2011 – 2020, by Launch Vehicle Category

Smallsat Launch Trends

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Intermediate | 5,444 – 11,340
Heavy | 11,341 – 30,000
Super Heavy | >30,000
Smallsats 2016 – 2020, by Launch Vehicle

Smallsat Launch Trends

Number of Smallsats Launched by Launch Vehicle

- Falcon 9
- PSLV
- Soyuz 2.1a/b
- Starlink
- OneWeb
- Antares 230
- Atlas V
- Vega
- 42 other vehicles (<70 smallsats launched)
Smallsats in Context and Operator/Mission Type Trends
Smallsat Mass Trends
Smallsat Launch Trends
Looking Forward
Number of Spacecraft Launched 2011 – First Half 2021

Looking Forward

# of spacecraft launched in first 6 months of 2021 (97% smallsats) already surpasses 2020 record

- Spacecraft (>600kg) launched
- Smallsats (≤ 600kg) launched

Number of Spacecraft Launched (H1 2021)
Looking Forward

### Commercial Smallsat Operators with the Largest Deployments First Half 2021

**100+ Smallsats Launched**
- SpaceX: 785 satellites
- OneWeb: 108 satellites

**10+ Smallsats Launched**
- SWARM: 76 sats
- Planet: 48 sats
- Spire: 16 sats
- Astroscale: 10 sats
- Kepler: 10 sats

**3+ Smallsats Launched**
- HawkEye³⁶⁰
- ICEYE
- Axelspace: 6 satellites each
- KLEOS: 4 satellites each
- BlackSky: 3 satellites each

### Notes
- Commercial smallsat operators made significant deployments in first half of 2021
Looking Forward: Areas To Watch

Looking Forward

**Business Outcomes**

Smallsat business ventures of all types continue efforts to prove both their business models and their ability to generate significant revenue. Financial outcomes of today’s smallsat companies will impact the long-term smallsat market.

**Communications Constellations**

Smallsat telecommunications operators dominated smallsat activity in 2020 and are continuing deployments in 2021. Launch of these large constellations will influence smallsat activity in the next few years.

**Smallsat Launch Options**

Smallsat operators have an increasing number of launch options including small launch and rideshare. Dozens of new small launch vehicles (many <500kg capacity) are in development to launch smallsats. Launch providers, especially medium – super heavy are increasing rideshare opportunities/initiatives to capture demand from smallsat customers.

**Government use of Smallsats**

Governments are increasingly seeking to leverage smallsats including in architecture planning to augment existing capabilities.

- Space Development Agency deployed first smallsats in 2021, preparing tranches of smallsats in support of National Defense Space Architecture
- DARPA continuing development of Blackjack constellation to demonstrate network of smallsats for military comms, missile warning, and navigation
- NASA supporting smallsat launch through ELaNa, other initiatives
- NOAA exploring use of smallsats for weather forecast modeling
- France launching Composante Optique 3D (CO3D) system for civil and government remote sensing applications
- JAXA RAPIS/RAISE technology demonstration systems
- Several Chinese smallsat systems, various stages development/operation