The Cubesat Explosion
Jonathan McDowell (Center for Astrophysics)
[Ver.2: Data updated to 2014 Dec 31]
The Cubesat Explosion: STATISTICS 2014 Dec 31
Jonathan McDowell, Center for Astrophysics

Satellite masses 1960-2009

Satellite masses 2010-2014

Orbited TotalFail

A: Academic/nonprofit 112 23?
B: Business/commercial 71 2
C: Civil govt. (e.g. NASA) 19 0
D: Defense/military 43 3+

OPERATED > 2 YEARS: 25
(CUTE-I, XI-IV 11 years and going!)

TOTAL 33 COUNTRIES:
USA 223 Japan 18 Germany 10

SCIENCE 31 (Bio 4, Astron 2) COM 32 IMG 106
TECH 143 CAL 1

http://planet4589.org
In 1960s, only a few dozen sats operating at any one time

Today, over 1000 active satellites and rising
Satellites come in many shapes and sizes...
In the 1950s there were some 1-10 kg sats but in later decades trend was to satellites in the 1000 to 10000 kg range.

No nanosats or picosats
(left of magenta line, 0.1-10 kg)
In the 2010s a dramatic shift to lower satellite masses

- **1990s**: Each Shuttle about 100 tonnes in orbit
- **2000s**:
- **2010s**: Wow! Nanosats!
Cubesats: 1 kg, 10 cm (2 lb, 4 in for the metric impaired)
Standard kit for universities to make students build sats in engineering courses
Can also make '3U' cuboids 30 x 10 cm; '6U' cuboids 30 x 20 cm coming soon
All the Cubesats 1: 2003-2010  [Photo credit to satellite owners, many via Gunter Krebs' excellent space.skyrocket.de page, which see for detailed credits]
All the Cubesats 2: 2010-2013
All the Cubesats 3: More 2013 Cubesats
CUBESAT STATISTICS  2014 Dec 31

LAUNCHED: 313
   48 failed to reach orbit
   20 aboard ISS waiting to deploy

DEPLOYED   245 (includes 5 Pocket Qub 0.1-0.5 kg)

<table>
<thead>
<tr>
<th>Category</th>
<th>Orbited</th>
<th>TotalFail</th>
</tr>
</thead>
<tbody>
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<td>A: Academic/nonprofit</td>
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<td>43</td>
<td>3+ (unknown others?)</td>
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It's hard to define success/fail – many cubesats have vague and minimal goals, others v ambitious (tether deploy, etc). The 'TotalFail' above means that a reliable signal from the satellite was never detected. Even with this minimal success criterion, 20 percent of the student built sats fail. Categories B,C,D tend to be built by professional aerospace companies and fail less often.

STILL IN ORBIT  163
STILL WORKING 111
OPERATED > 2 YEARS:  38   (CUTE-I, XI-IV 11 years and going!)
CUBESAT STATISTICS  2014 DEC 31 – BY COUNTRY
LAUNCHED     313    (including failures to orbit)

USA             223
JAPAN           18
GERMANY     10
DENMARK       6  (surprising!)

By continent:
N AMERICA  225
    Canada 2

S AMERICA  11:
    Argentina 2, Peru 4, Ecuador 2, Colombia 1, Uruguay 1, Brazil 1

EUROPE 27+16 = 43
    Spain 3, Netherlands 4, Italy 3, Norway 3, UK 2, Belgium 2,
    Switzerland 2, Lithuania 2, Estonia 1, France 1, Poland 1, Hungary 1,
    Romania 1, Ukraine 1

ASIA 14 + 18 = 32
    Korea 4, Turkey 2, Vietnam 2, India 1, Pakistan 1, Singapore 3, Israel 1

AFRICA   1
    South Africa 1

NOTE:  Russia 0  (ZERO! - also surprising)

TOTAL 33 COUNTRIES
Cubesats for Science

2003 QUAKESAT (Stanford) VLF from earthquakes
2006 KuteSat (Kansas/Lawrence) Radiation dose [Launch fail]
2006 ICECube-1 (Cornell) Ionosphere scintillation [Launch fail]
2006 MEROPE (Montana State) Radiation belts [Launch fail]
2010 RAX (Michigan) Radio from aurora
2011 Exp 1 Prime (Montana State) Radiation belts [Launch fail]
2011 DICE-1/2 (Utah State) E/B fields in ionosphere
2011 RAX-2 (Michigan) Radio from aurora
2011 HRB E (Montana State) Radiation belts
2012 Goliath (Bucharest) Radiation, meteoroids
2012 CSSWE (Colorado) Space weather
2012 CINEMA (Berkeley) Ionosphere, ring current
2013 SOMP (Dresden) Atomic oxygen
2013 Firefly (GSFC/Siena) Lightning/TGFs
2013 KHUSAT-1,2 (Kyung Hee U) Ionosphere, ring current
2013 FIREBIRD A,B (Montana State) Electron microbursts
2013 CUNYSAT (Medgar Evers,CUNY) Ionosphere with GPS [Fail]
2014 NanoSatBR (Brazil-INPE) Radiation belts
2014 QB50P1/P2 (Von Karman Inst) Atmosphere
2014 MicroMas (MIT) Atmosphere

Astronomy:
2008 AAUSAT-II (Aalborg) GRBs
2012 CXBN (Morehead State) Hard X-ray Background [Fail]

Life Sciences:
2006 Genesat-1 (NASA Ames)
2009 Pharmasat (NASA Ames)
2010 O/OREOS (NASA Ames)
2014 SporeSat (NASA Ames)