

SSC13-IX-01

The Long-Threatened Flood of University-Class Spacecraft (and CubeSats) Has Come: Analyzing the Numbers

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27th Annual AIAA/USU Conference on Small Satellites
Logan, UT
14 August 2013



Same Song, Sixth Verse?



Fifth revision of this paper *(2004, 2006, 2007, 2009, 2011, 2013)*

- **Why?** *(Besides an excuse to come to Logan, of course)*
- The third watershed is happening
 - First event: UoSat-1 (1981)
 - Second event: JAWSAT (2000)
 - Third event: ORS-3 (2013) *[or OUTSAT (2012) or ...]*
- Agenda
 - Listen to my talk
 - Read my paper (please?)
 - Check out my database
 - Argue!



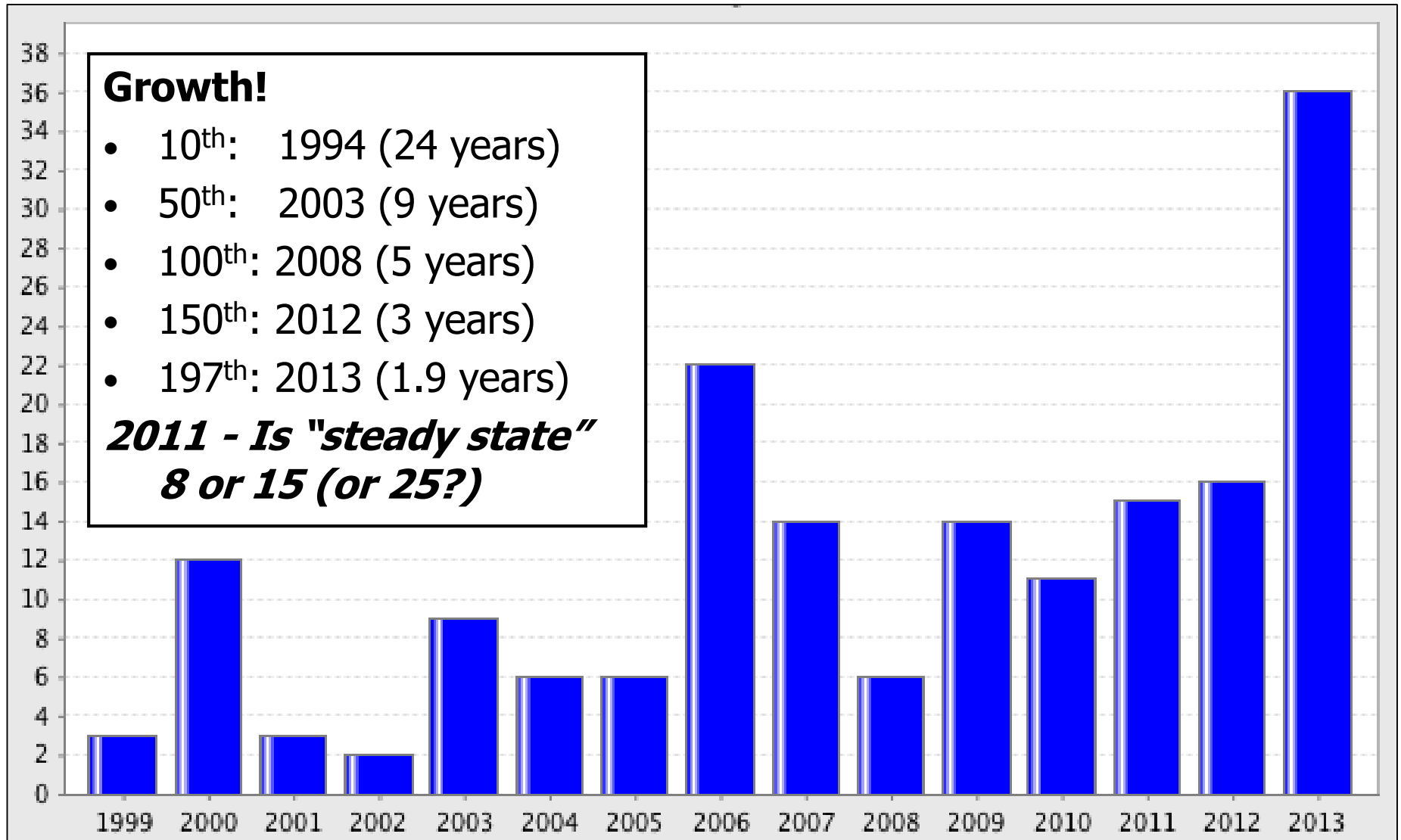
"University-Class Satellite"



- Working definition
 - Self-contained device with independent communications, command & control
 - Untrained personnel (*i.e. students*) have key roles in design, fabrication, integration and operations
 - Training is at least as important as the rest of the mission
- Excluded (by definition)
 - Many, many satellites with strong university participation (especially as science PI)
 - Most Amateur satellites
- Exclusion does not imply lack of educational value!



Missions Manifested Per Year

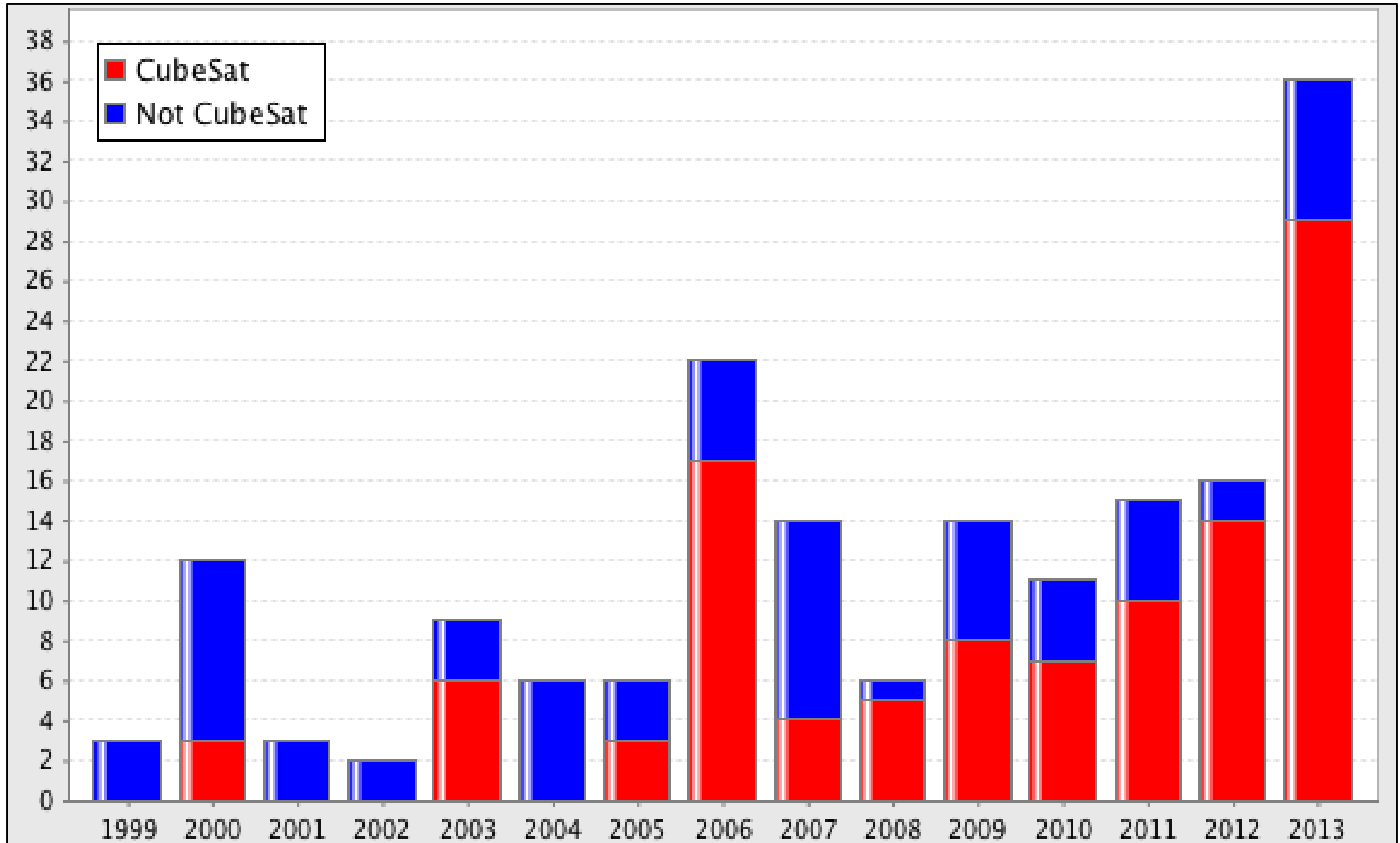


Growth!

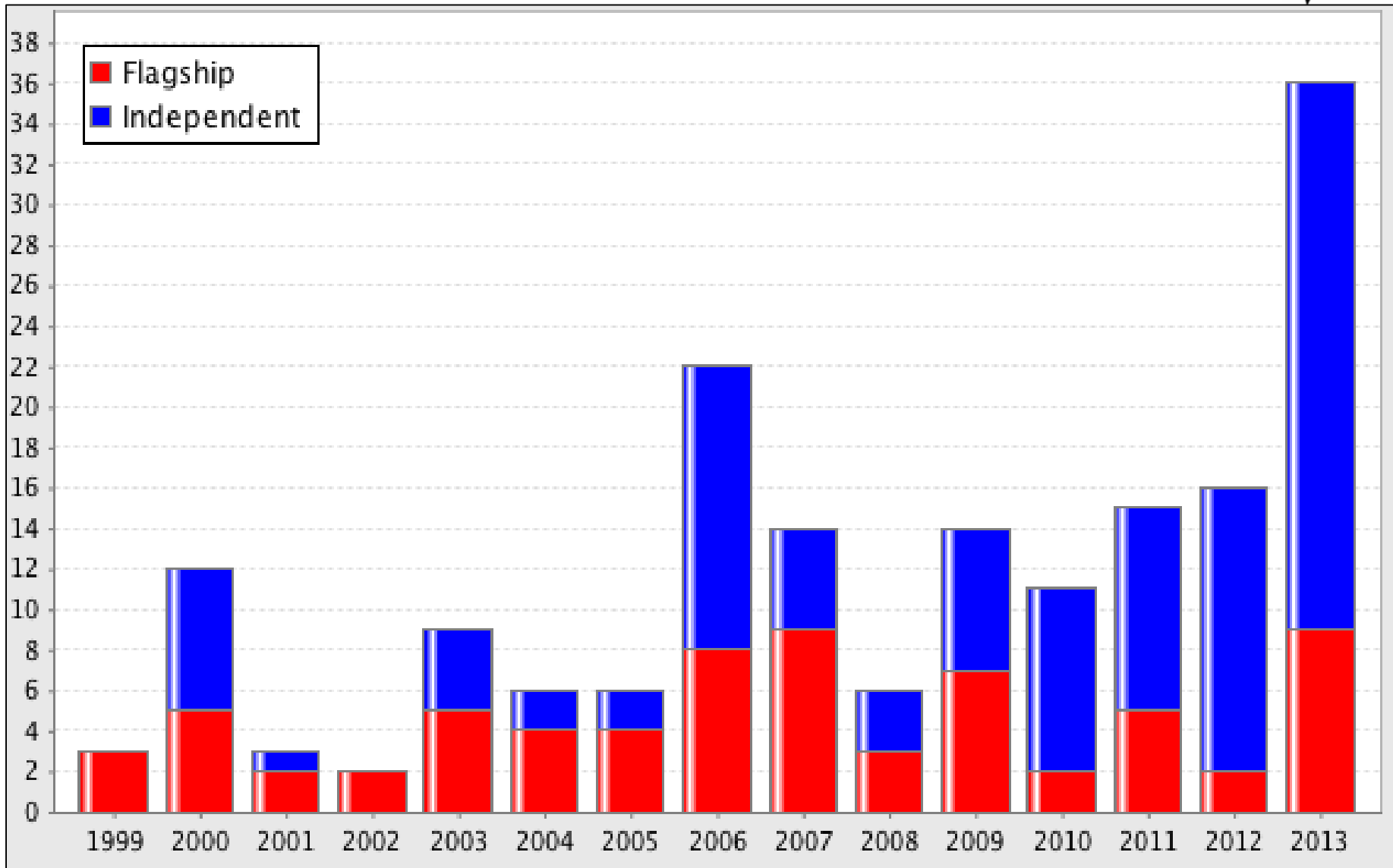
- 10th: 1994 (24 years)
- 50th: 2003 (9 years)
- 100th: 2008 (5 years)
- 150th: 2012 (3 years)
- 197th: 2013 (1.9 years)

***2011 - Is "steady state"
8 or 15 (or 25?)***

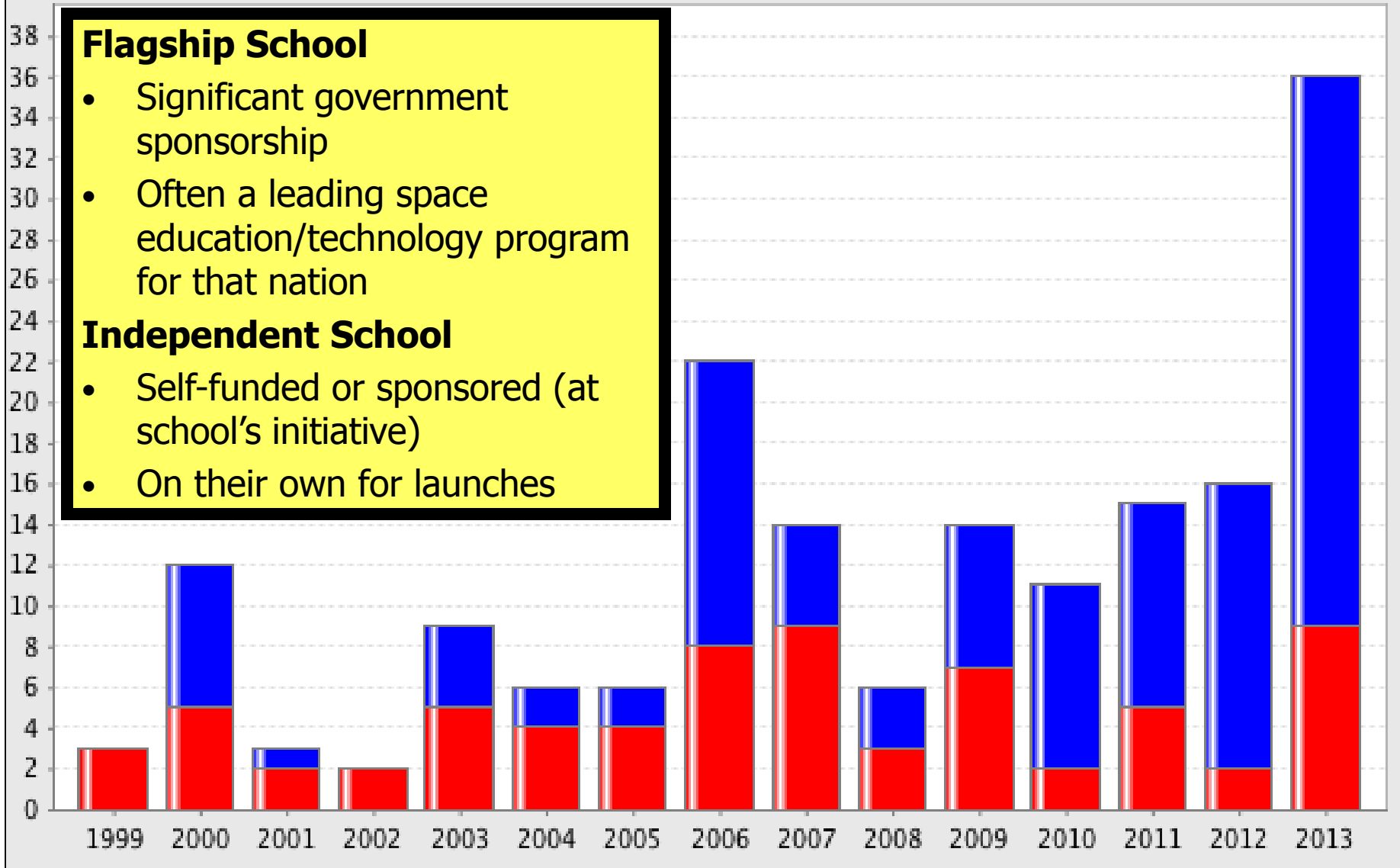
It's Not Just CubeSats! *[Okay, it's mostly CubeSats]*



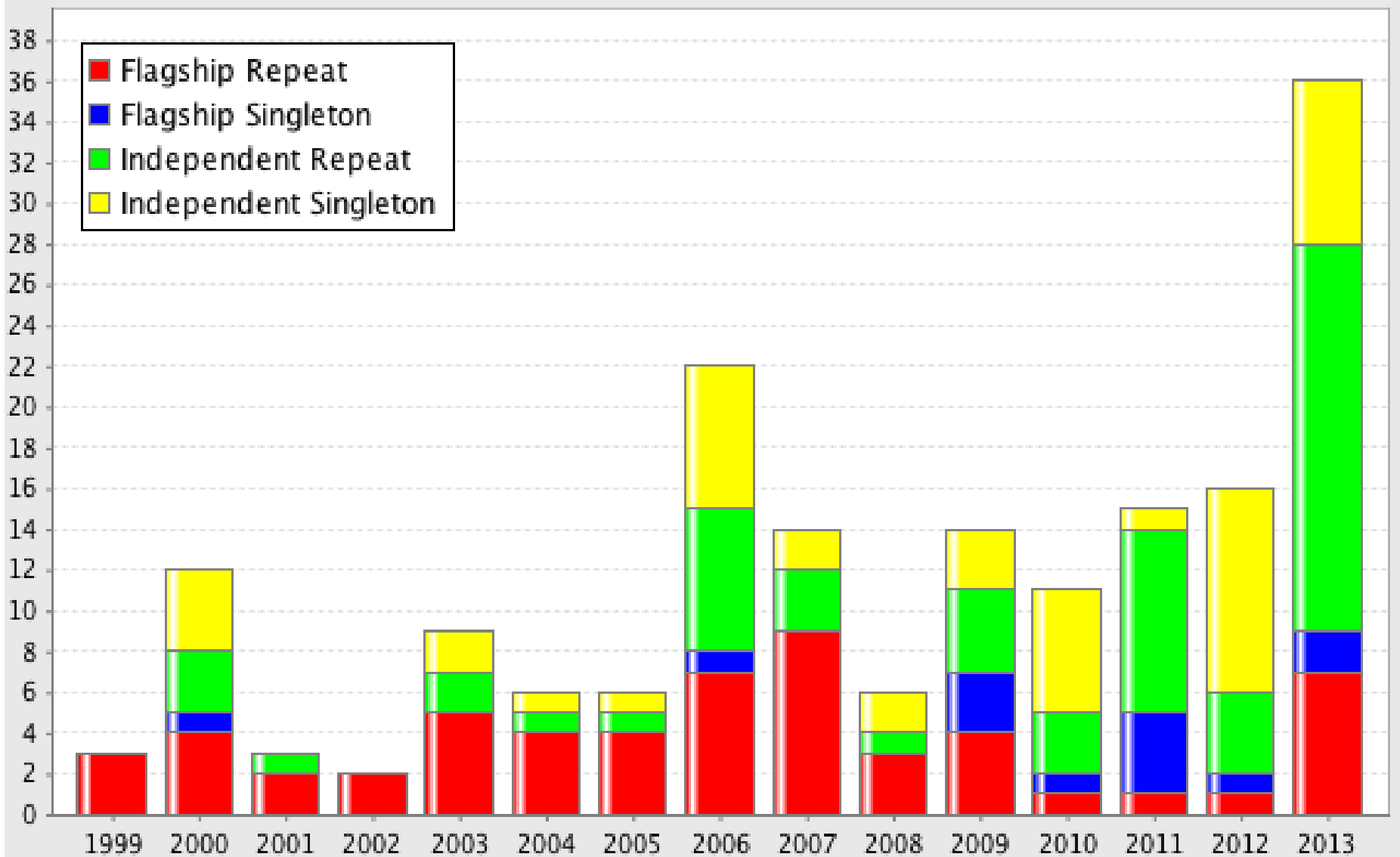
No Flag? No Problem!



No Flag? No Problem!



Thank you for putting this on the exam



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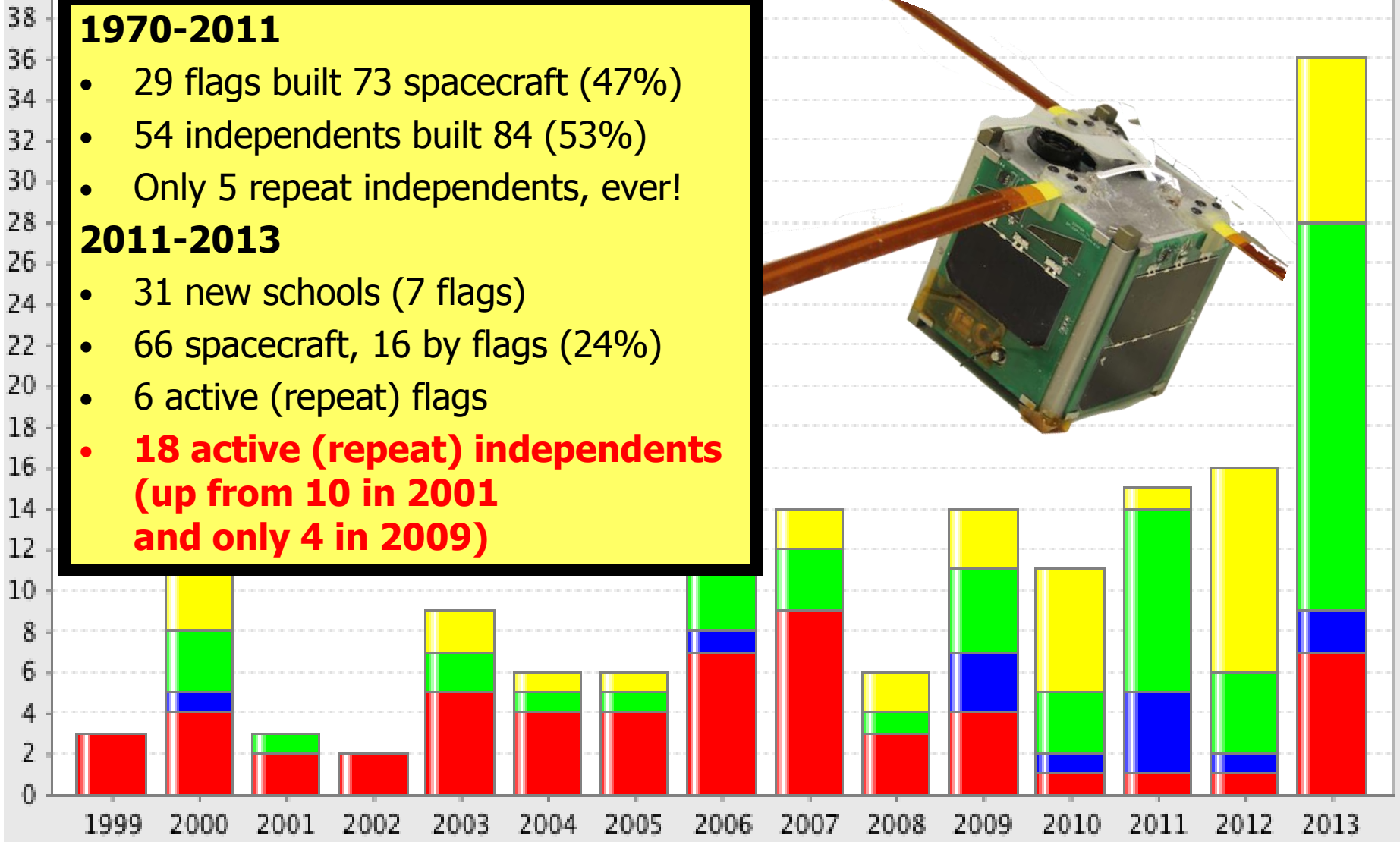
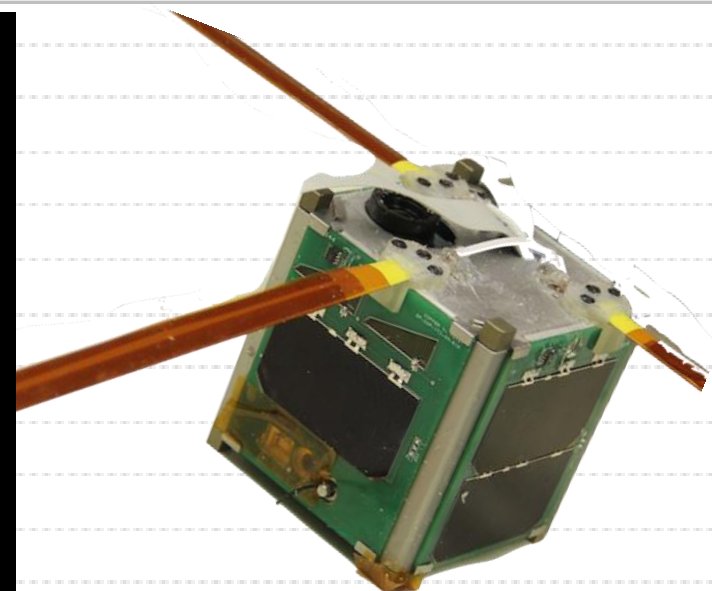


1970-2011

- 29 flags built 73 spacecraft (47%)
- 54 independents built 84 (53%)
- Only 5 repeat independents, ever!

2011-2013

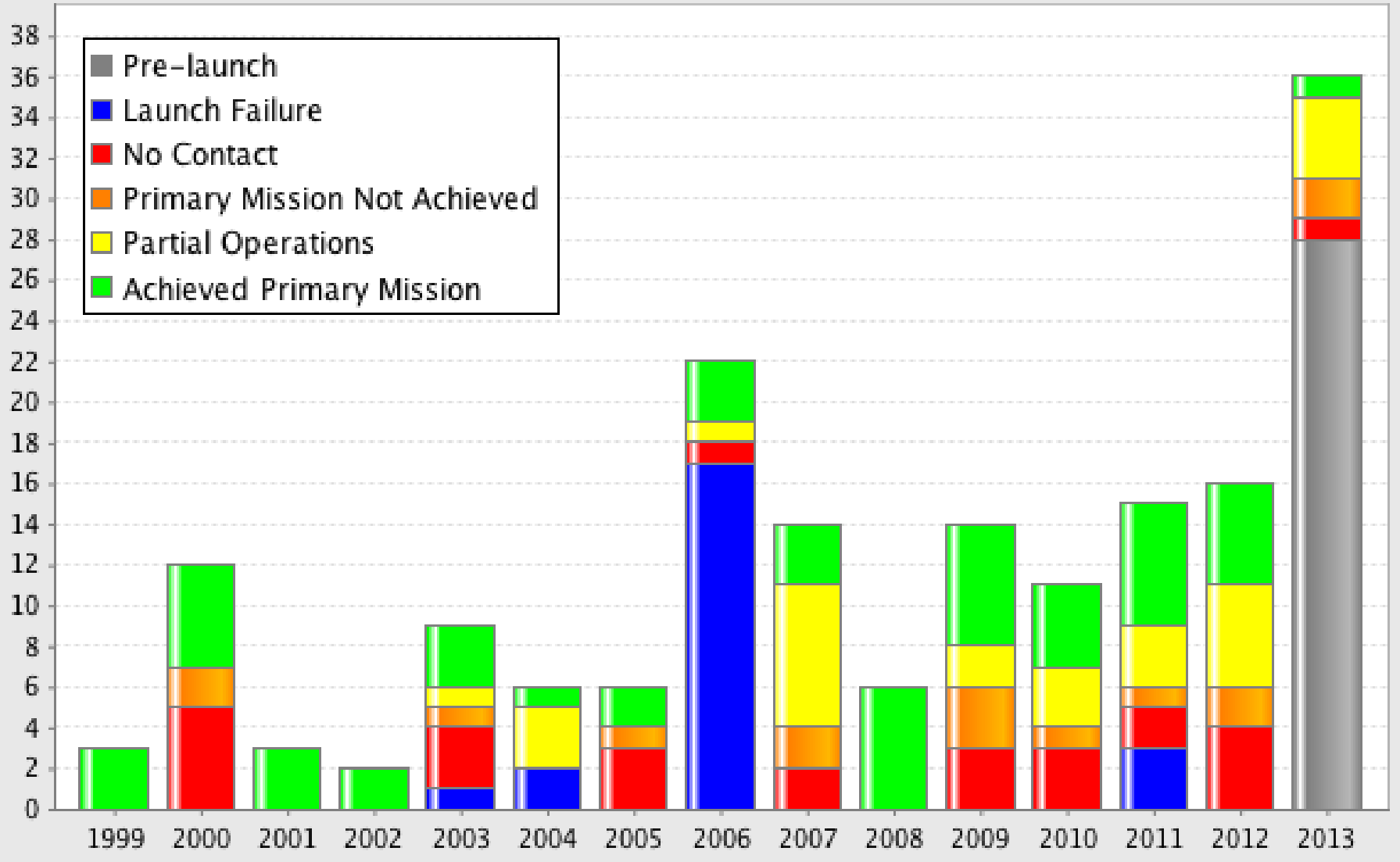
- 31 new schools (7 flags)
- 66 spacecraft, 16 by flags (24%)
- 6 active (repeat) flags
- **18 active (repeat) independents (up from 10 in 2001 and only 4 in 2009)**



Is this good? You tell me! *(Please?)*



Mission Status



What The CubeSat Hath Wrought

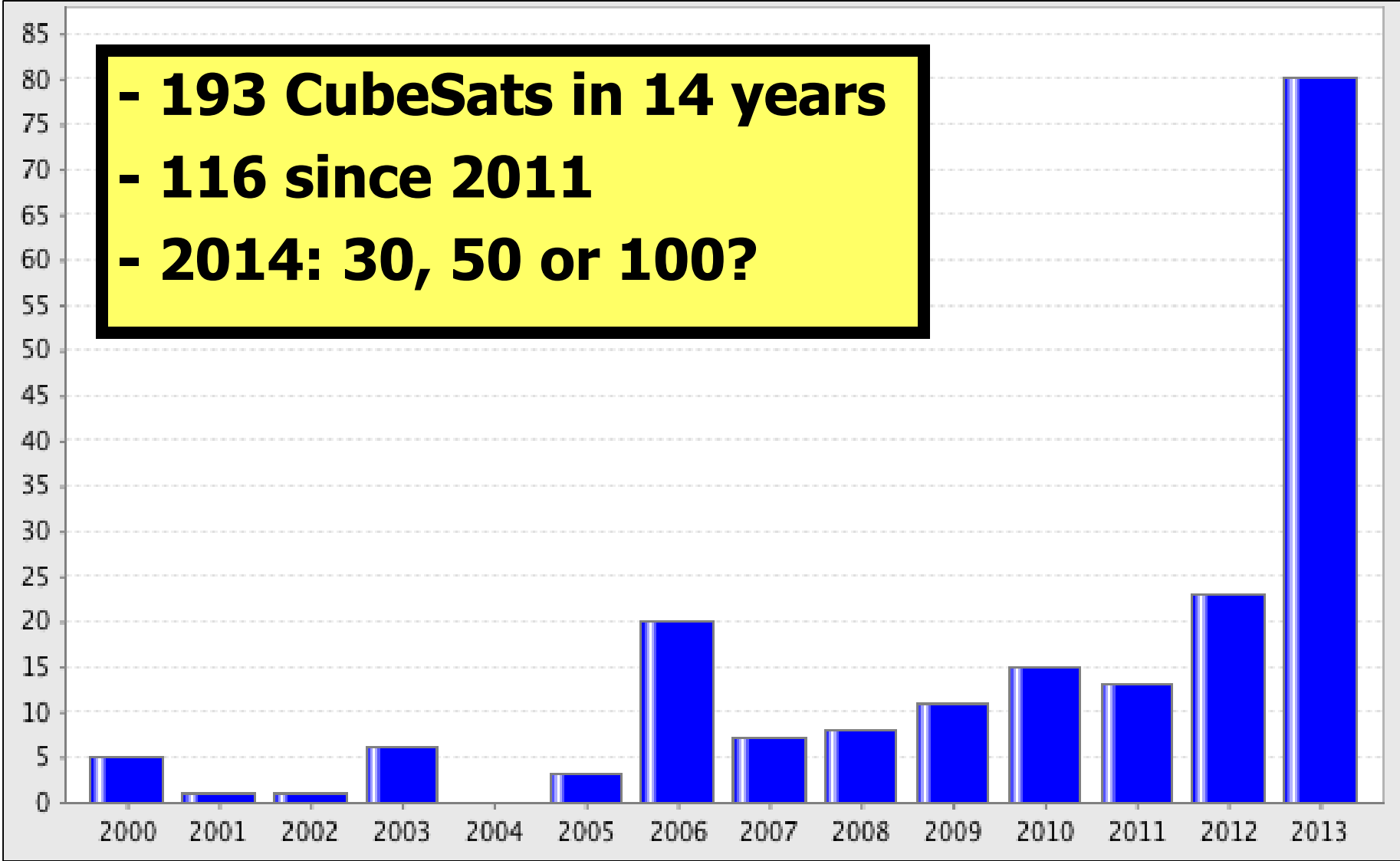


- Leveled the playing field
- Hit (close to) the sweet spot
 - Enough capability to fly real-ish missions
 - Not so much capacity that students' reach exceeds their grasp
- Created two standards
 - The containerized spacecraft carrier
 - COTS spacecraft parts
- Raised expectations (thanks to NSF, NRO, NASA and ESA)

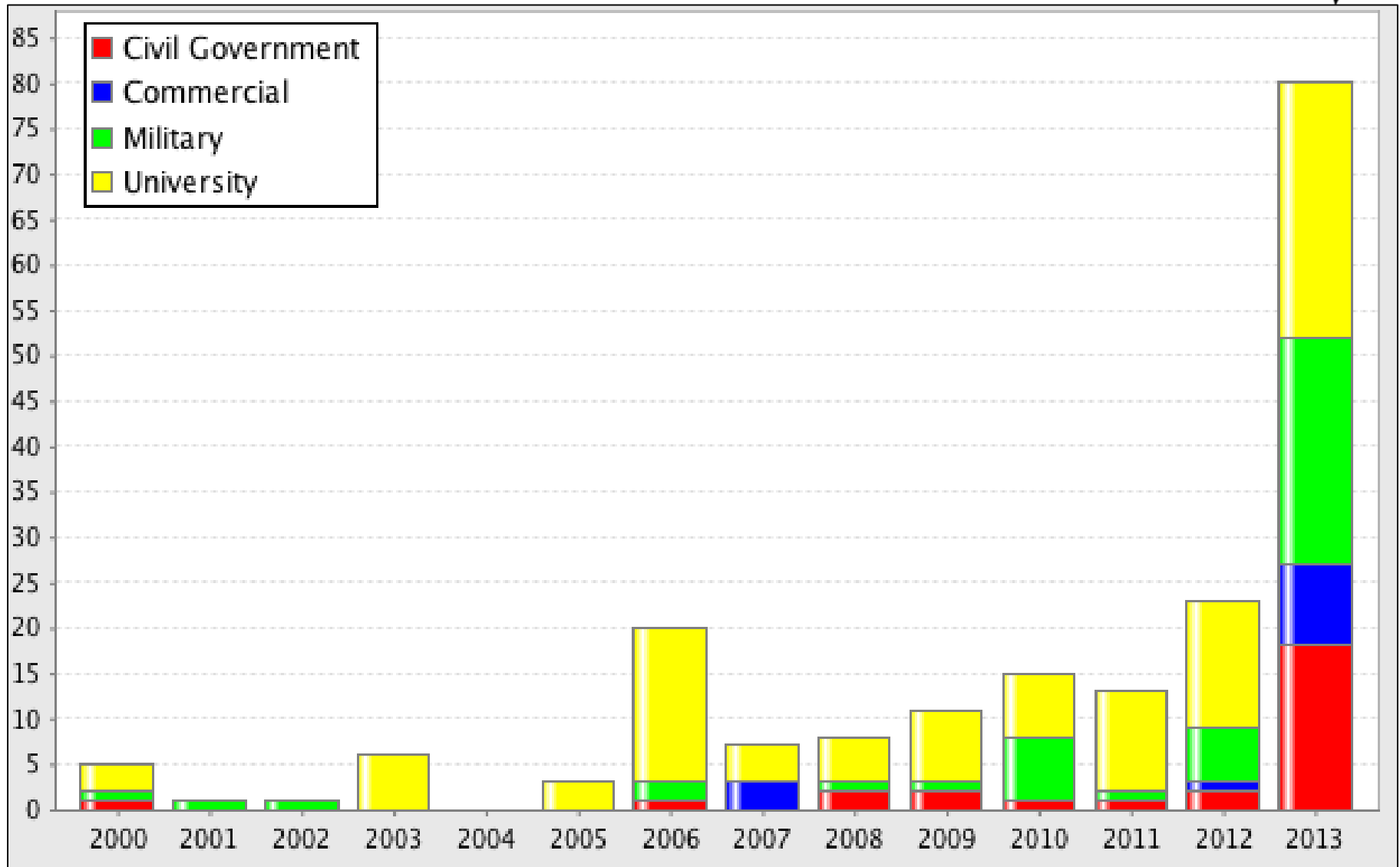
Speaking of CubeSats...



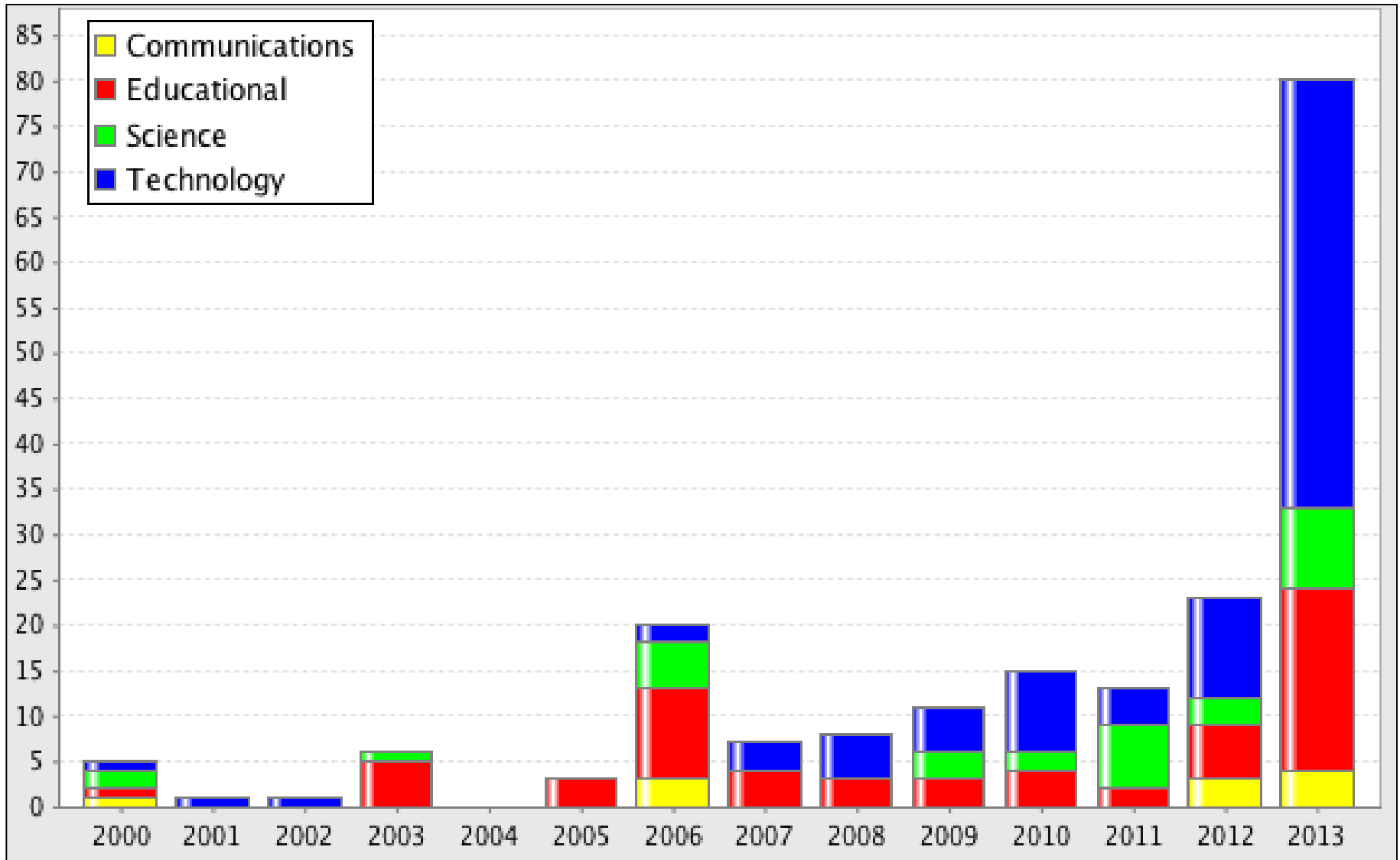
- **193 CubeSats in 14 years**
- **116 since 2011**
- **2014: 30, 50 or 100?**



Who's Building Them?



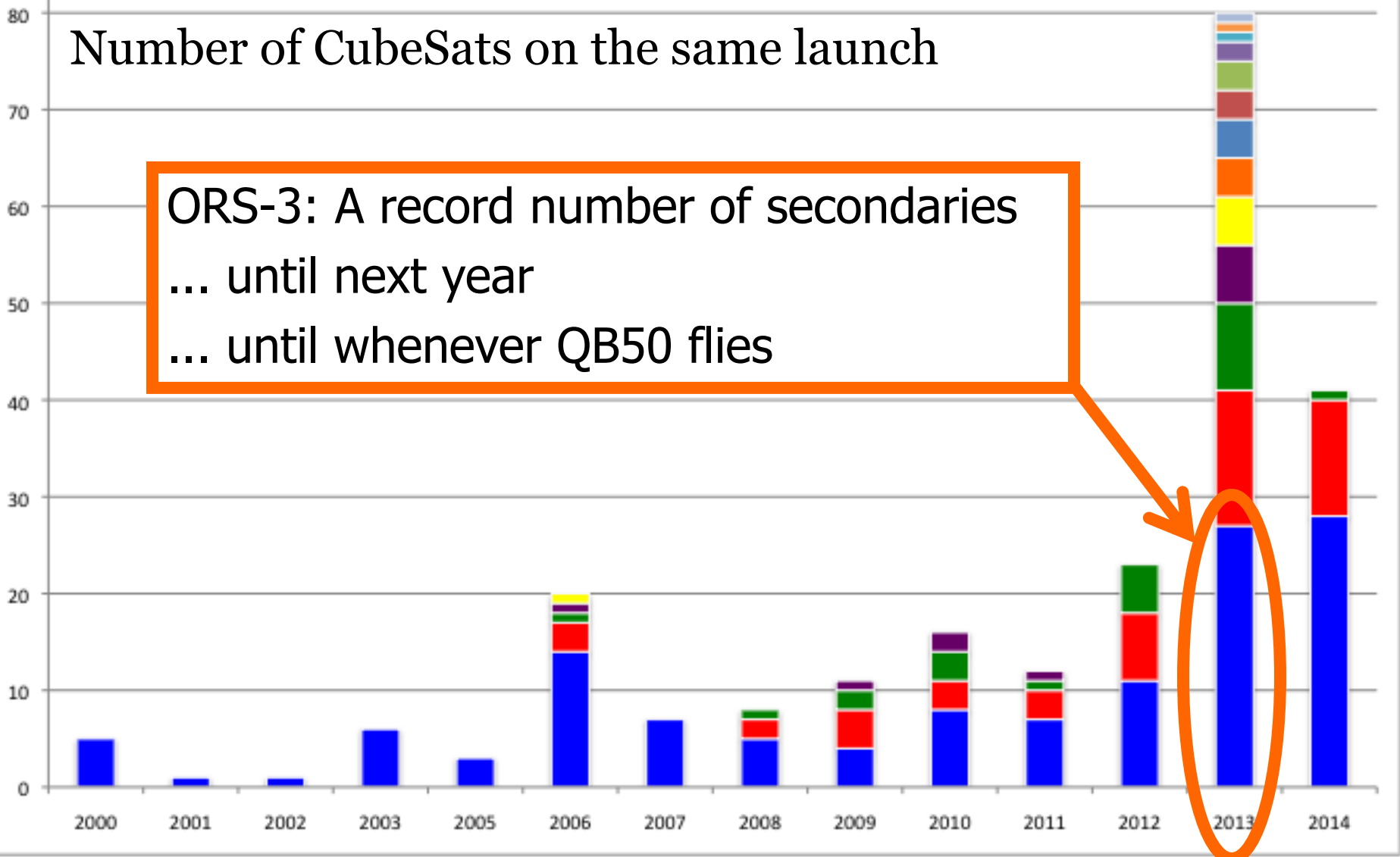
Toy, Tool, or Debris Cloud?



Are We Ready?

Number of CubeSats on the same launch

ORS-3: A record number of secondaries
... until next year
... until whenever QB50 flies



Are We Ready? (Probably Not.)



- It's hard enough to build, integrate & launch 27 CubeSats...
 - Tracking / deconfliction
 - Recontact
 - Uplink / downlink management
 - Unexpected behaviors from common subsystems on different platforms
 - The unwanted attention if 40% don't meet their mission
- The snowball effect
- What happens if/when we have another JAWSAT event?



Acknowledgements



- Sponsors
 - Saint Louis University (President's Research Initiative)
 - AFOSR (University Nanosat-5, 6, 7)
- Research assistant: Marie Kendrick
- Sources
 - Smallsat Conference Proceedings / Conversations
 - Gunter's Space Page
 - Encyclopedia Astronautica
 - Mike Rupprecht (DK3WN Satblog)
 - FlightGlobal SpaceTrak
- My database:

<http://astrolab.slu.edu/AstroLab/Research.html>



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