CubeSats and Mission Success:

A Look at the Numbers

Michael Swartwout
Parks College of Engineering, Aviation & Technology
Saint Louis University

2016 CubeSat Developers' Workshop
20 April 2016

SAINT LOUIS UNIVERSITY

PARKS COLLEGE OF ENGINEERING,
AVIATION AND TECHNOLOGY

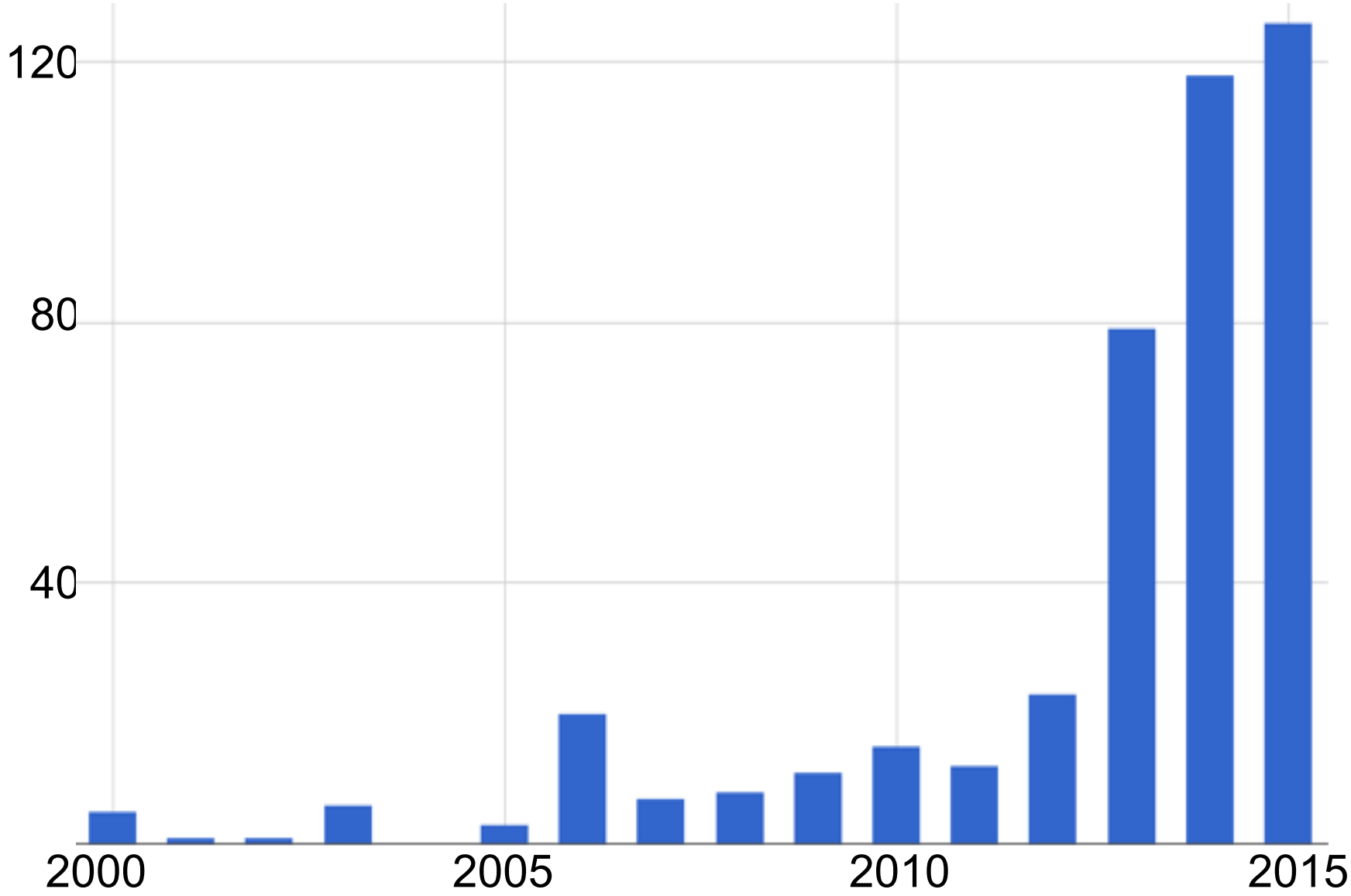
Motivation and Agenda

- CubeSats: Toys, tools or debris cloud?
- Opportunities
  - Missions: Single-instrument science, constellations
  - Schedule: Concept-to-operations in under 24 months
  - Modularity: Form-factor forcing standardized parts
- Risks
  - Capabilities: Reports are confusing, conflated, and/or apocryphal
  - Cost-to-performance: Is it good? What is good?
  - Go Fever: CubeSats viewed as magic solution
- Agenda
  - Define terms
  - Key snapshots
  - Shameless plea for better data

Terms

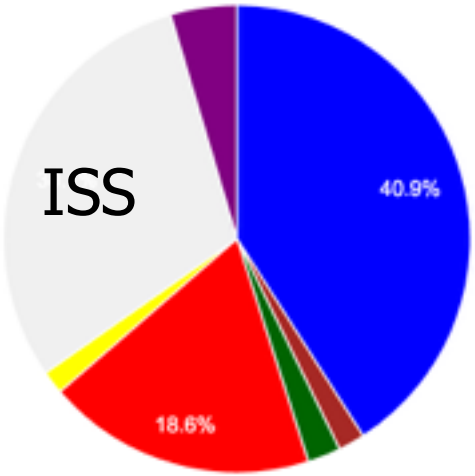
- CubeSat
  - Containerized spacecraft (P-POD >> standardized parts)
  - More-or-less compatible with CubeSat Design Spec
- Organization Types (I need better names!)
  - Hobbyists
  - SmallSatters
  - Traditionalists (e.g., large contractors)
  - Commercial constellations (Planet Labs, SPIRE)

CubeSats Launched (2000-2015)

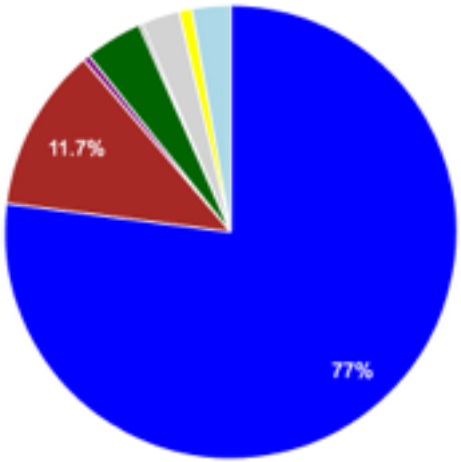


CubeSat By Nation (2000-2015)

Launch Provider

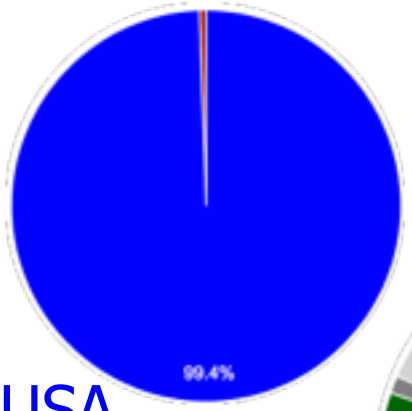


Builder

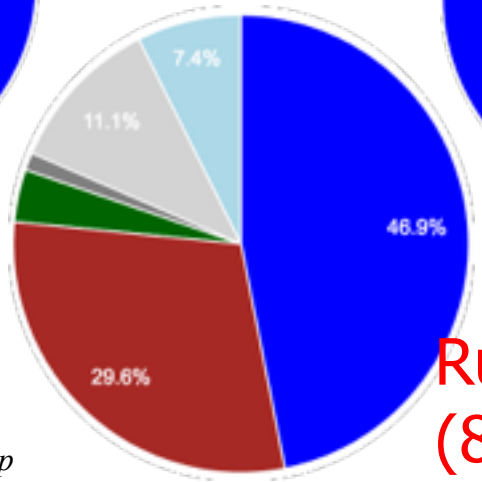


- USA
- Europe
- India
- Japan
- Africa
- Asia
- China
- Russia
- Latin America

CubeSats By Launch Provider

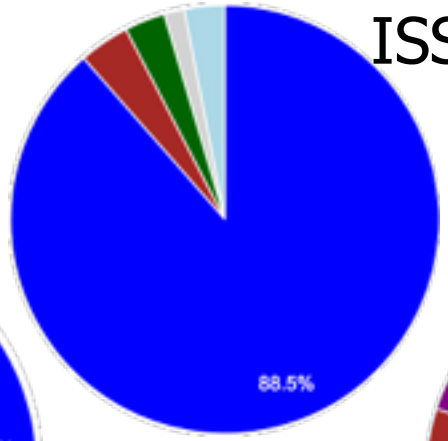


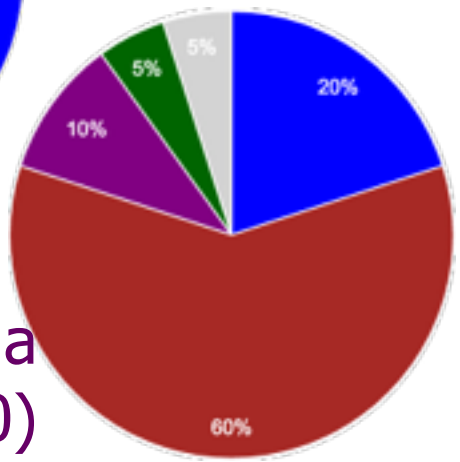
USA (178)



Russia (81)

ISS (131)

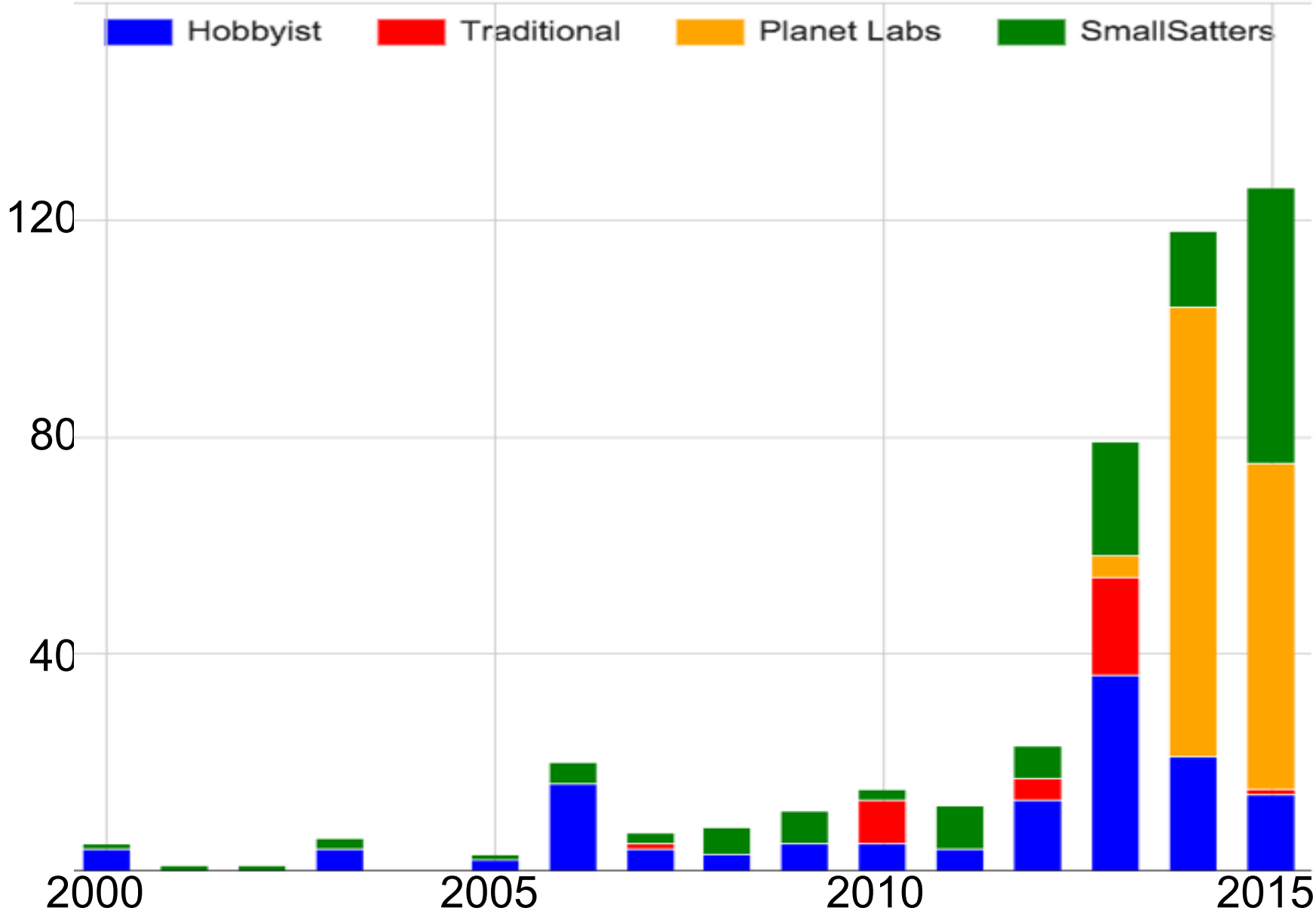




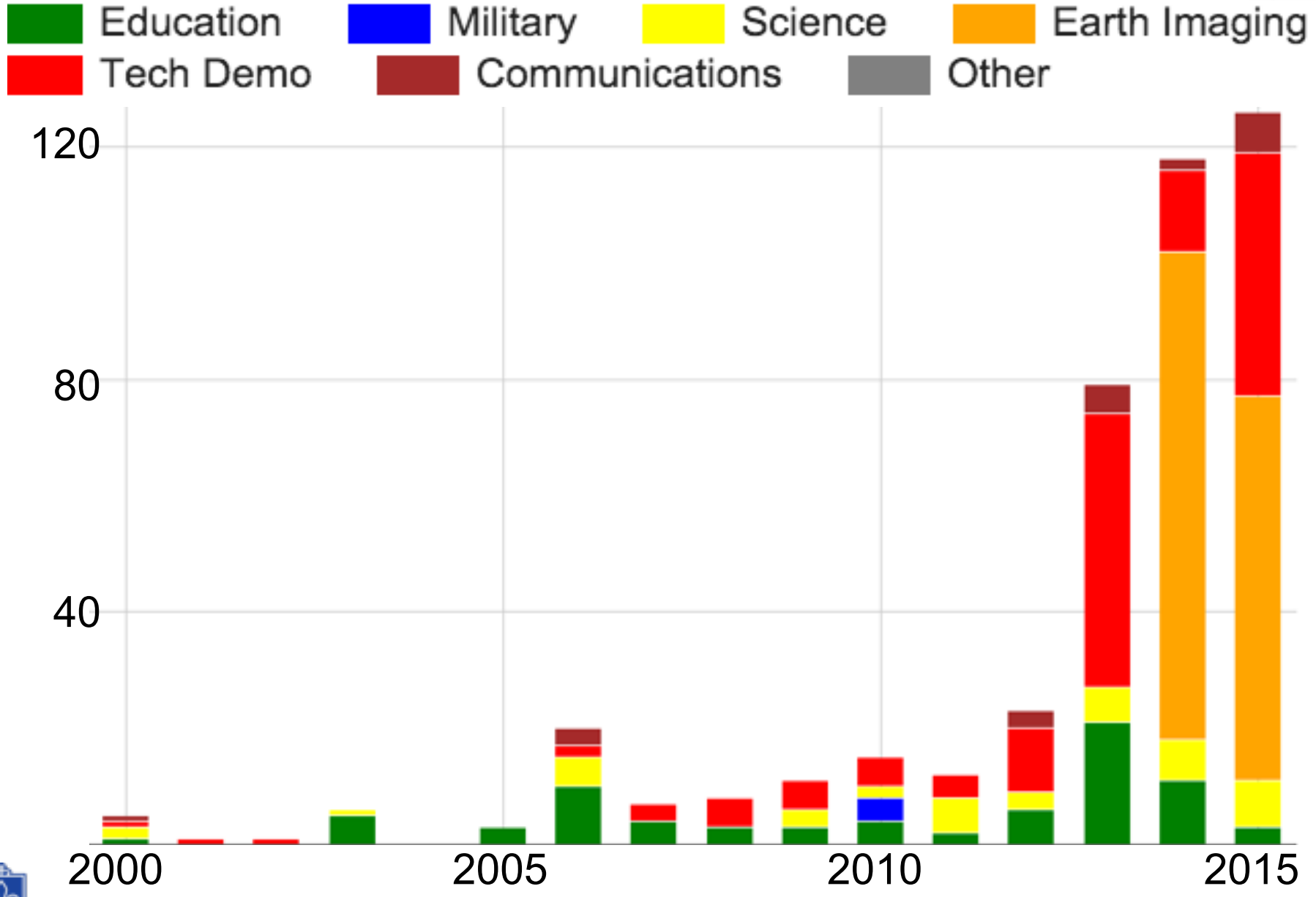
India (20)

Not shown:
Europe (8)
Japan (10)
China (7)

CubeSat by Mission Developer Type

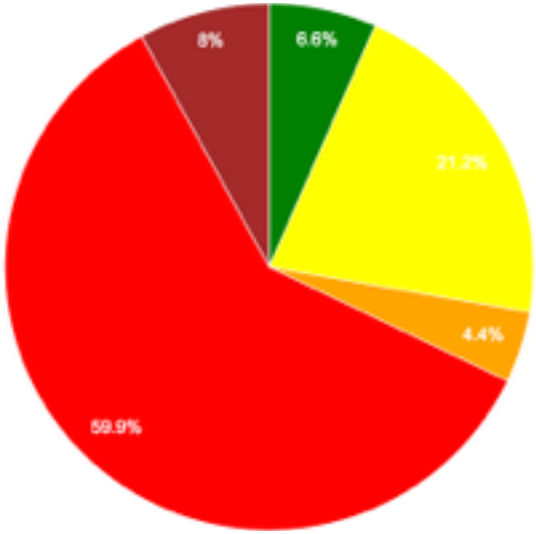


CubeSat by Mission Type

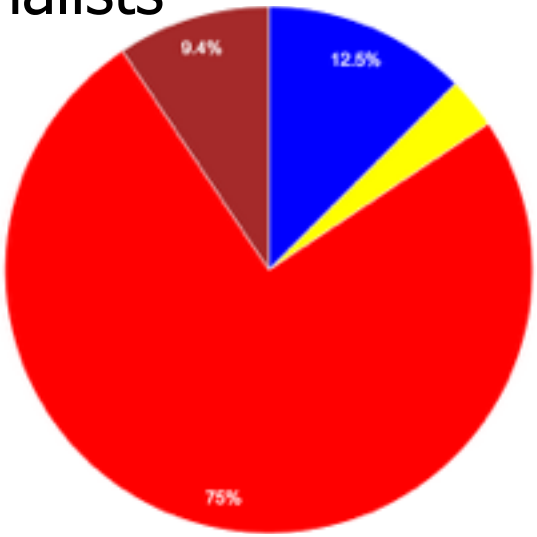


CubeSat Mission Type by Developer Class (2000-2015)

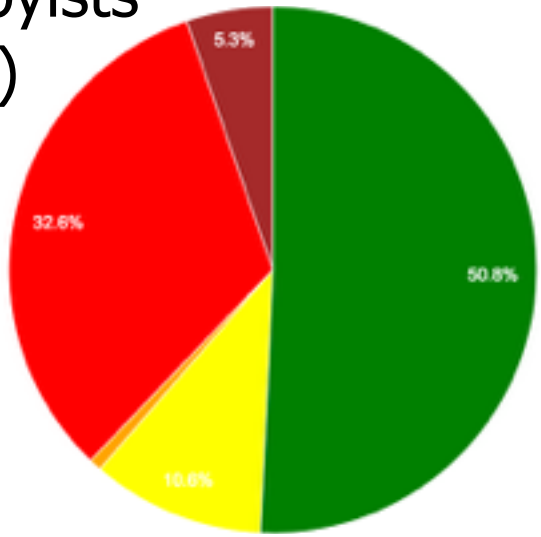
SmallSatters (125)



Traditionalists (32)



Hobbyists (131)



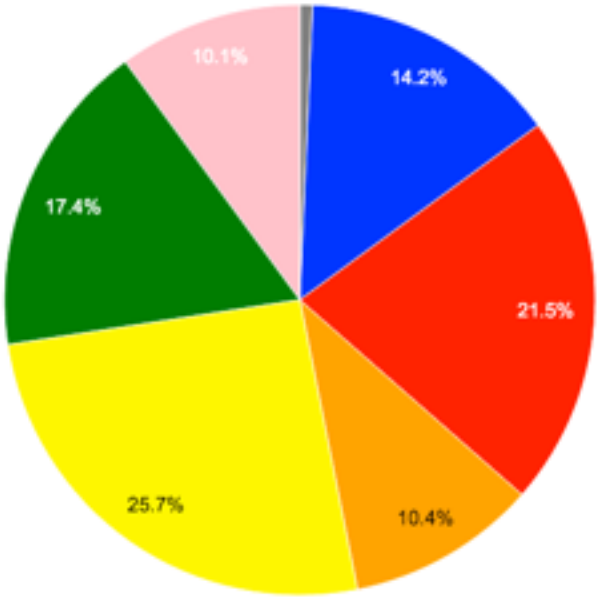
New Definition: Mission Status

- Mission status increments at each milestone
  - **0** Prelaunch (Cancelled)
  - **1.** Launched (Launch failure)
  - **2.** Deployed (Dead on Arrival)
  - **3.** Contacted (Premature Failure)
  - **4.** Commissioned (Partial Mission Success)
  - **5.** Primary mission complete (Mission Success)

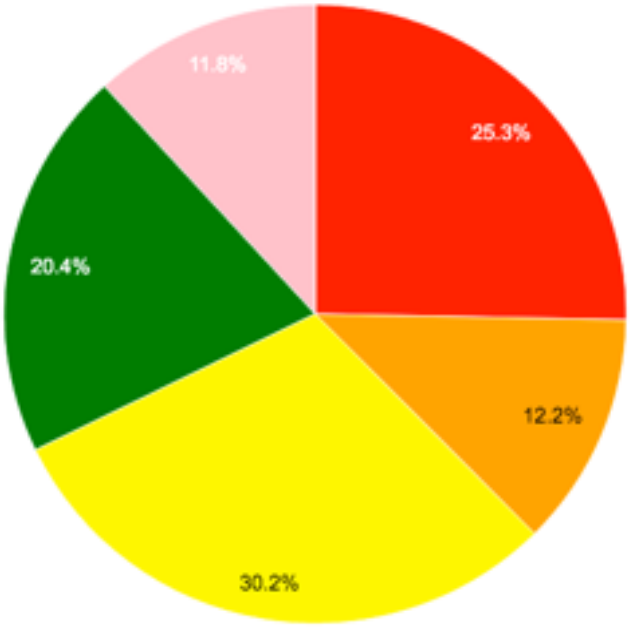
- A mission that stalls at one status is given a success/failure assessment

CubeSat Mission Status, 2000-2015 by Developer Class (Except for Planet Labs)

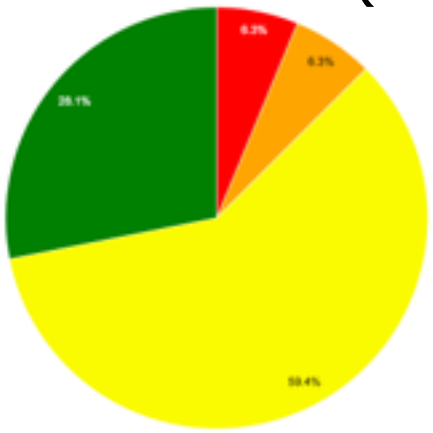
All Missions (288)



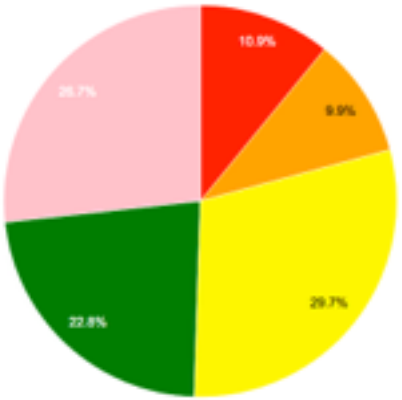
All missions reaching orbit (245)



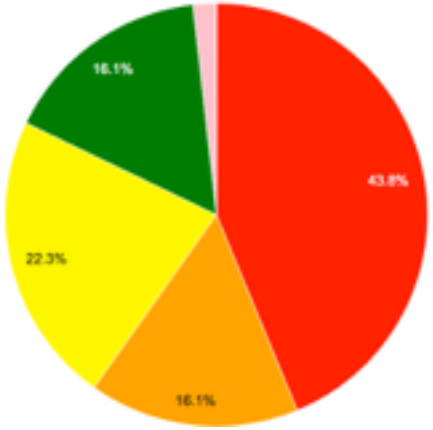
Traditionalists (32)



SmallSatters (101)



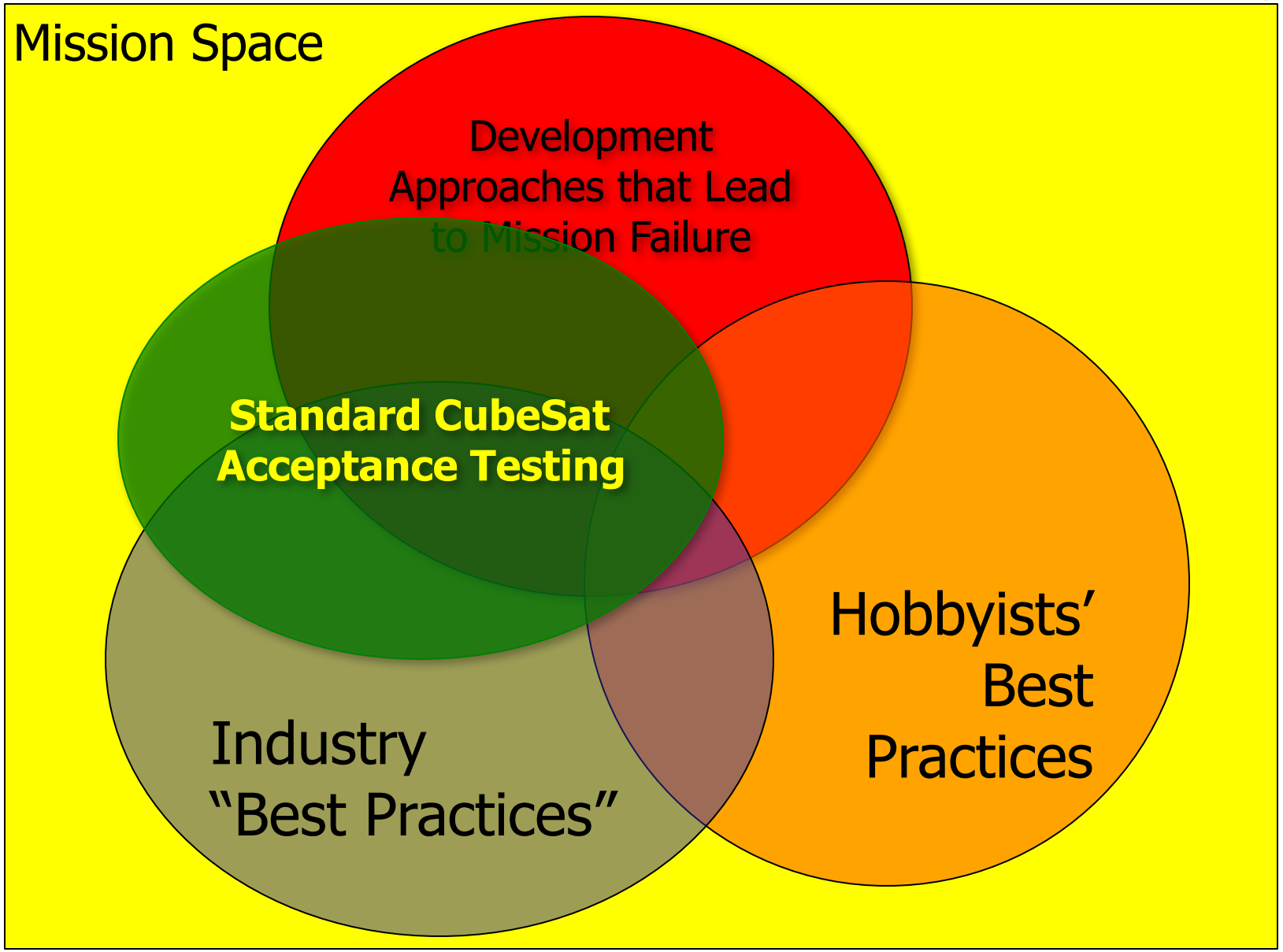
Hobbyists (112)



Why the discrepancy?

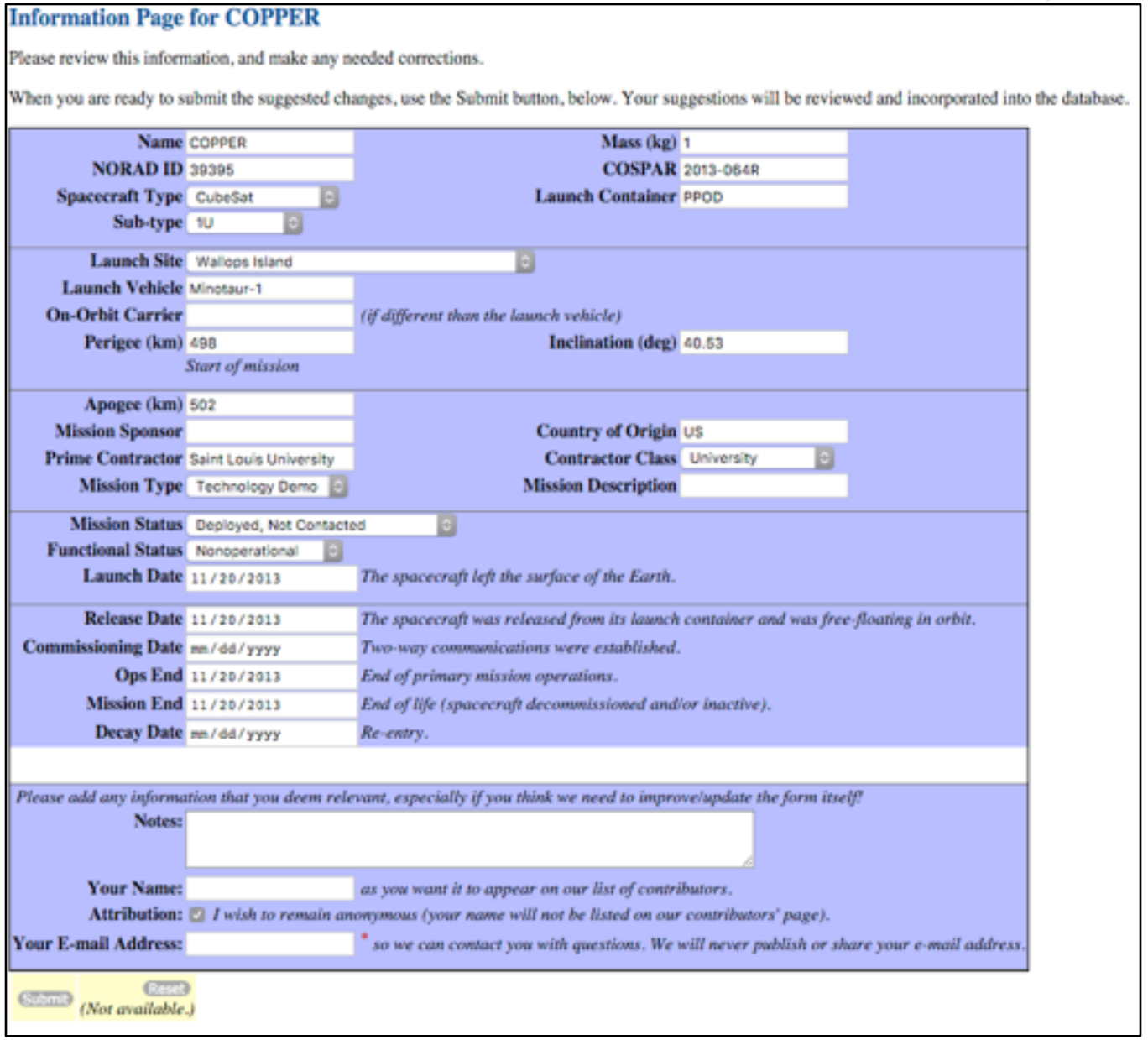
- Traditionalists: You get what you pay for!
- SmallSatters: Failures appear to be a result of ambitious technology infusion (i.e., acceptable losses)
- Hobbyists: [My reckless, semi-informed speculation]
  - Lack of time spent on integration & test
  - Workmanship (?)
  - Uncaptured best practices?

QA Approach: "Because I Said So!"



Please, tell your friends

… or tell me, so I can ask them!



Information Page for COPPER

Please review this information, and make any needed corrections.

When you are ready to submit the suggested changes, use the Submit button, below. Your suggestions will be reviewed and incorporated into the database.

Name	COPPER	**Mass (kg)**	1
NORAD ID	39395	**COSPAR**	2013-064R
Spacecraft Type	CubeSat	**Launch Container**	PPOD
Sub-type	1U		
Launch Site	Wallops Island		
Launch Vehicle	Minotaur-1		
On-Orbit Carrier		*(if different than the launch vehicle)*	
Perigee (km)	498	**Inclination (deg)**	40.53
Start of mission			
Apogee (km)	502		
Mission Sponsor		**Country of Origin**	US
Prime Contractor	Saint Louis University	**Contractor Class**	University
Mission Type	Technology Demo	**Mission Description**	
Mission Status	Deployed, Not Contacted		
Functional Status	Nonoperational		
Launch Date	11/20/2013	*The spacecraft left the surface of the Earth.*	
Release Date	11/20/2013	*The spacecraft was released from its launch container and was free-floating in orbit.*	
Commissioning Date	mm/dd/yyyy	*Two-way communications were established.*	
Ops End	11/20/2013	*End of primary mission operations.*	
Mission End	11/20/2013	*End of life (spacecraft decommissioned and/or inactive).*	
Decay Date	mm/dd/yyyy	*Re-entry.*	

Please add any information that you deem relevant, especially if you think we need to improve/update the form itself!

Notes:

Your Name: *as you want it to appear on our list of contributors.*

Attribution: ☑ *I wish to remain anonymous (your name will not be listed on our contributors' page).*

Your E-mail Address: * *so we can contact you with questions. We will never publish or share your e-mail address.*

Submit Reset *(Not available.)*

Acknowledgements

- Census Data Sources
  - Public: Gunter's Space Page (international launch log)
  - Public: Jonathan's Space Report (orbital elements)
  - Public: DK3WN Satblog (university/amateur operations)
  - Public: Union of Concerned Scientists (operational status)
  - Public: Bryan Klofas
  - Public: Program websites, conference presentations
  - Private: Personal communications
- Support
  - AFOSR / UNP (original work)
  - NASA NEPP (ongoing)

CubeSats and Mission Success:

A Look at the Numbers

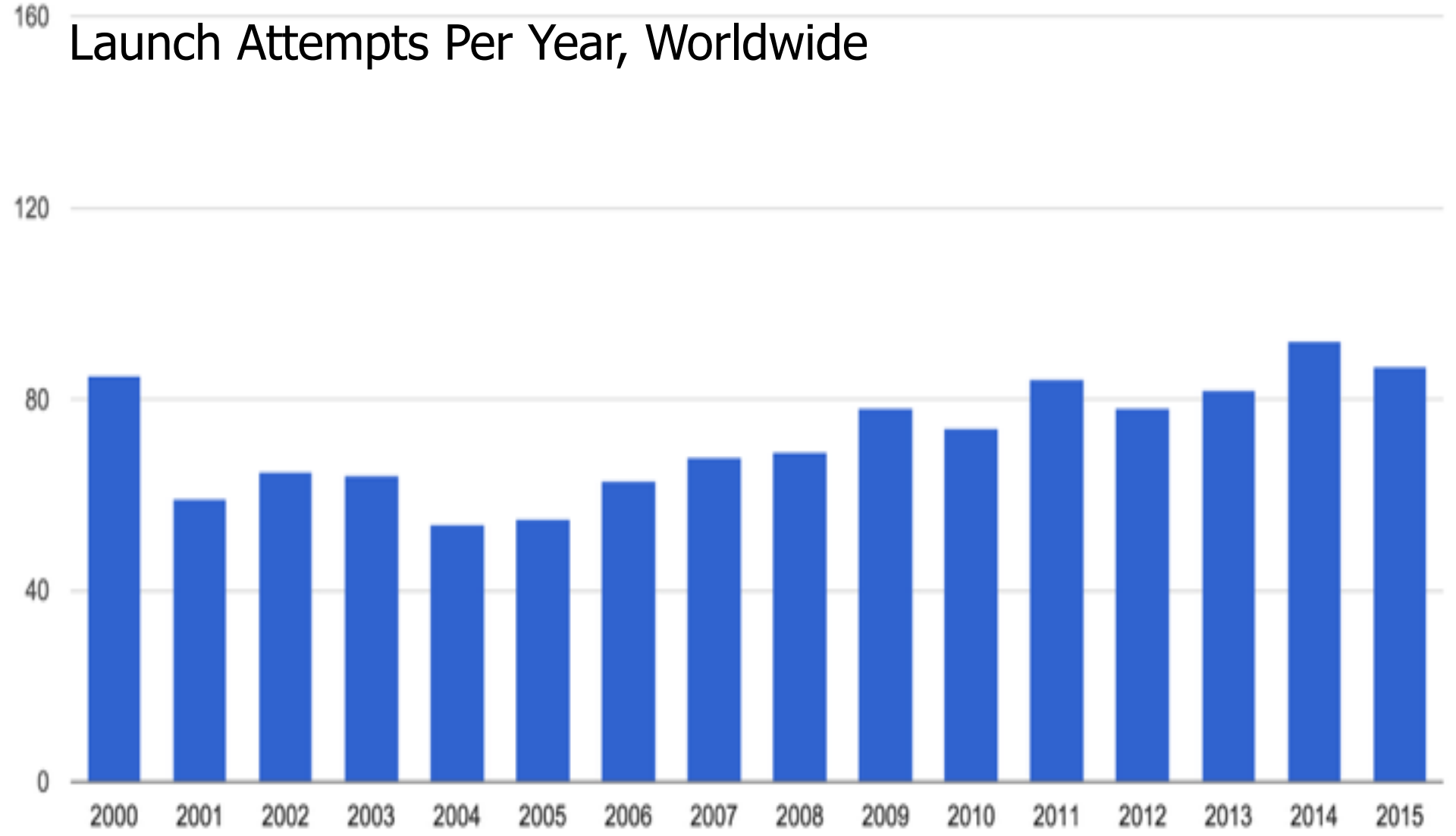
Michael Swartwout
Parks College of Engineering, Aviation & Technology
Saint Louis University

2016 CubeSat Developers' Workshop
20 April 2016

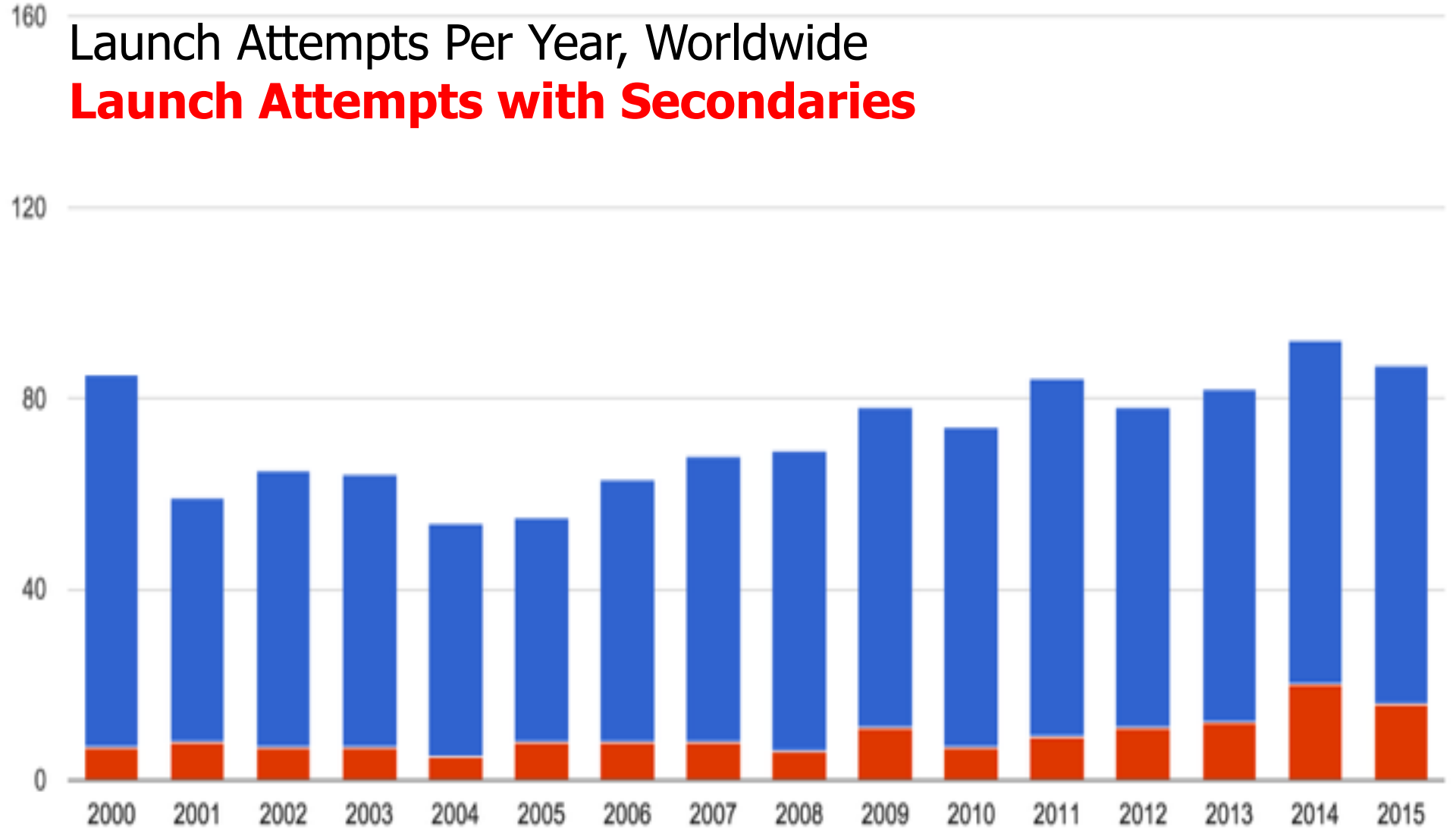
SAINT LOUIS UNIVERSITY

PARKS COLLEGE OF ENGINEERING,
AVIATION AND TECHNOLOGY

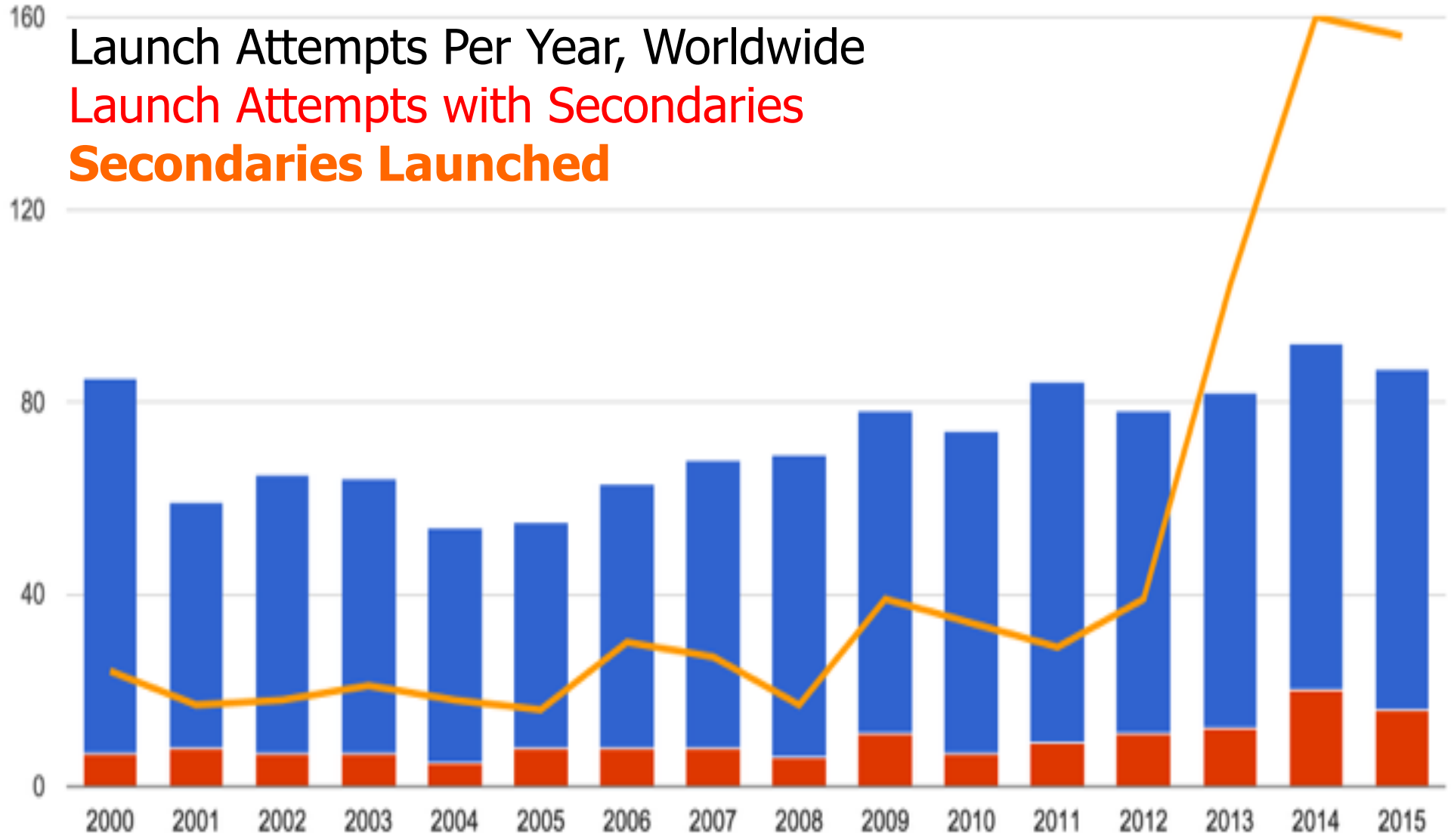
How are they reaching orbit?



How are they reaching orbit?



How are they reaching orbit?



That's a Lot of Secondaries…

- … a whole lot of secondaries!
  - More secondaries than primaries in 2014-2015
  - ISS is capable of releasing 100+ per year
  - ULA, others making 24U standard for launches
  - We haven't seen the peak
- Is there a business case for a dedicated launcher?
  - Lots of CubeSats are freeloaders
  - Would you rather have control over a 24-month launch schedule, or pay (much?) less for a ride 6 months out?