SSC06-I-3

Twenty (plus) Years of University-Class Spacecraft:

A Review of What Was, An Understanding of What Is, And a Look at What Should Be Next

Michael Swartwout

Washington University in St. Louis

20th Annual AIAA/USU Conference on Small Satellites
Logan, UT
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School of Engineering & Applied Science

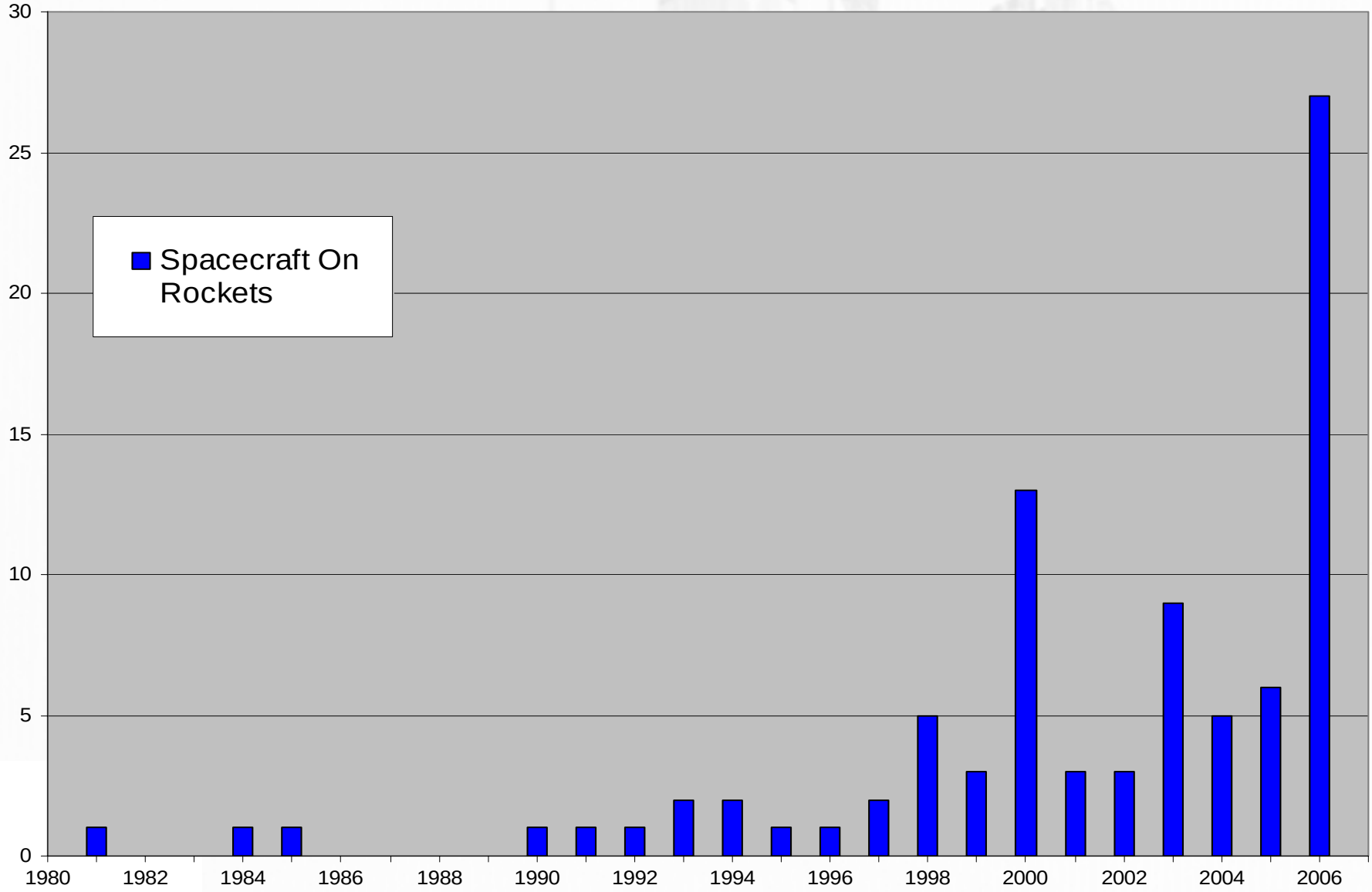
"University-Class Satellite"

- 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!

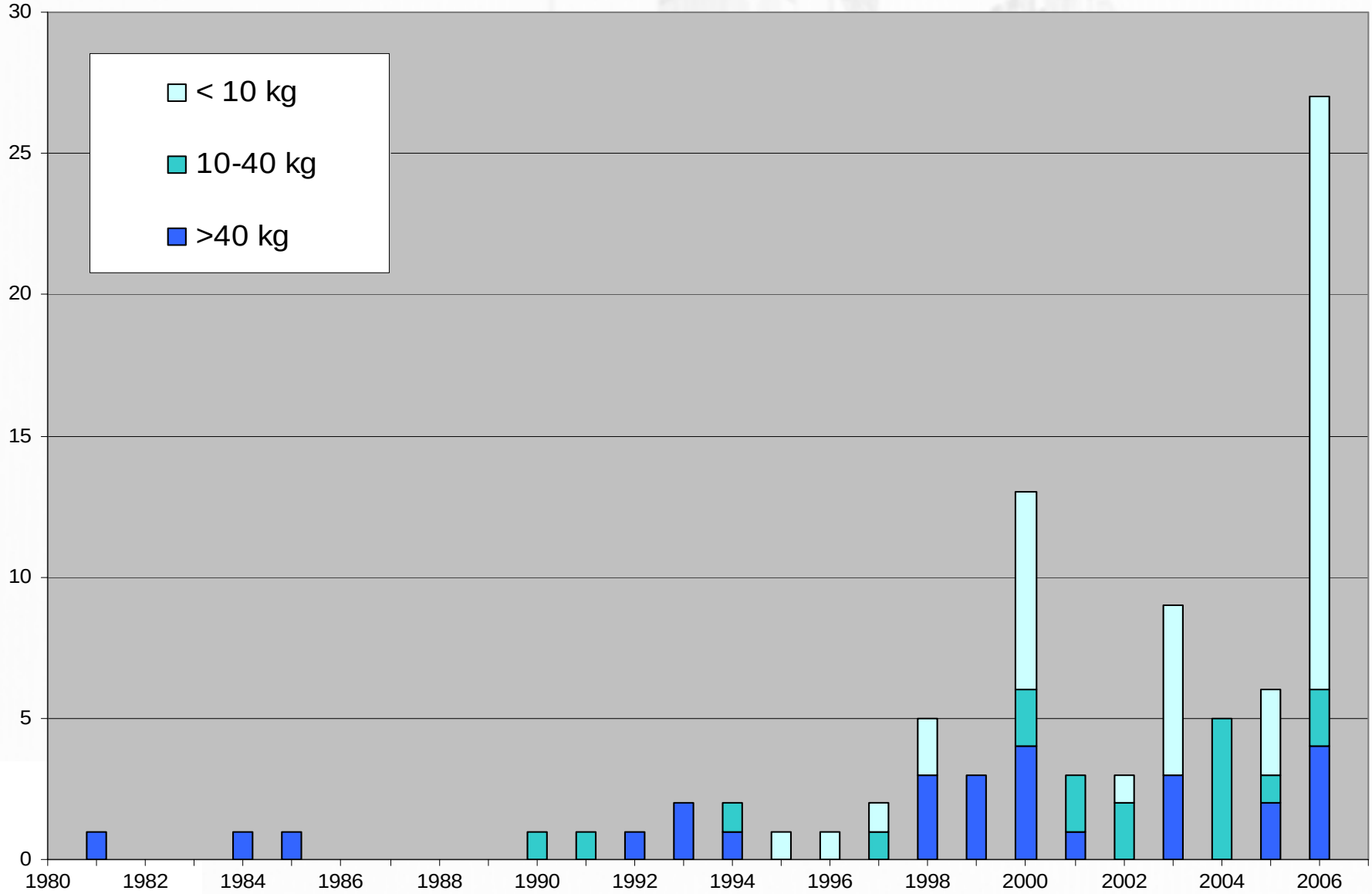
Sneak Preview

- Read my paper (but not ***that*** paper)
- A look at the numbers
  - Reliability
  - Flagship vs. Independent
  - Repeat business
- Two big years: 2000 and 2006
- Building spacecraft is hard work
  - Can we make it easier?
  - Should we do this?
- Indulging my inner soapbox

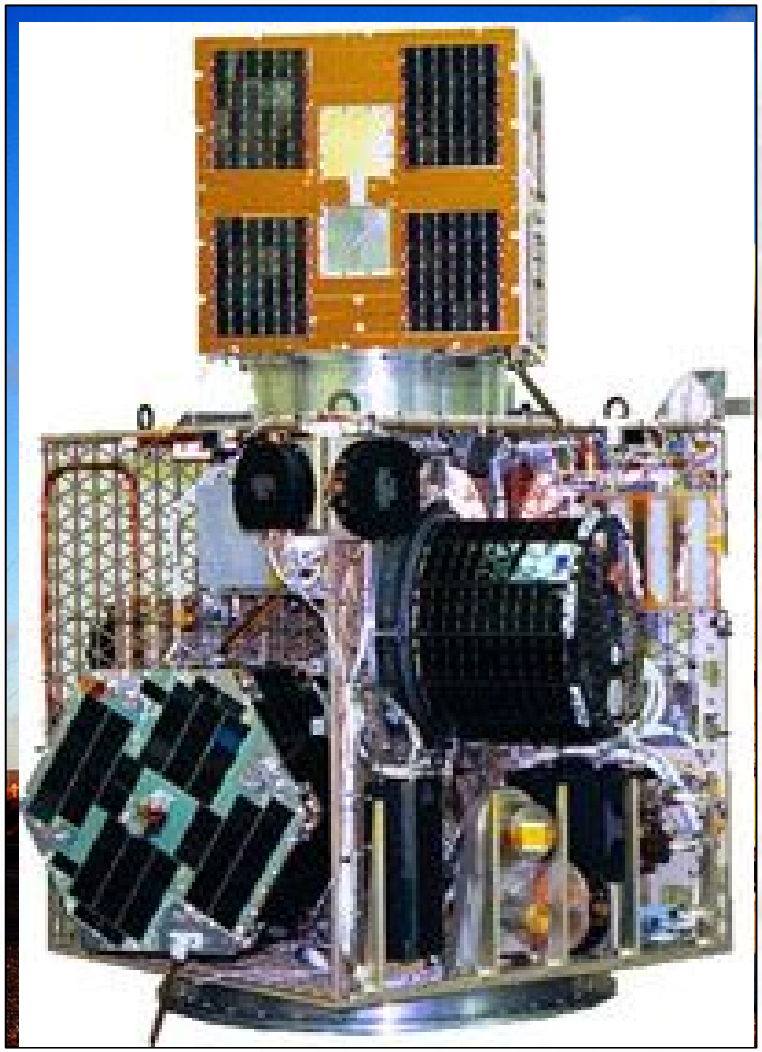
The Numbers


30
25
20
15
10
5
0
Spacecraft On Rockets
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006

Mass by the Numbers

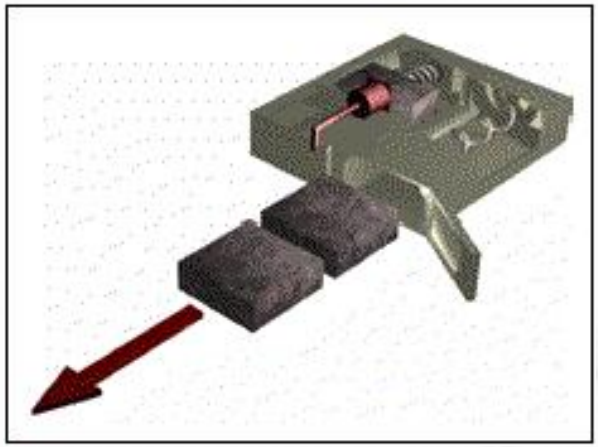


The Class of 2000: JAWSAT Launch



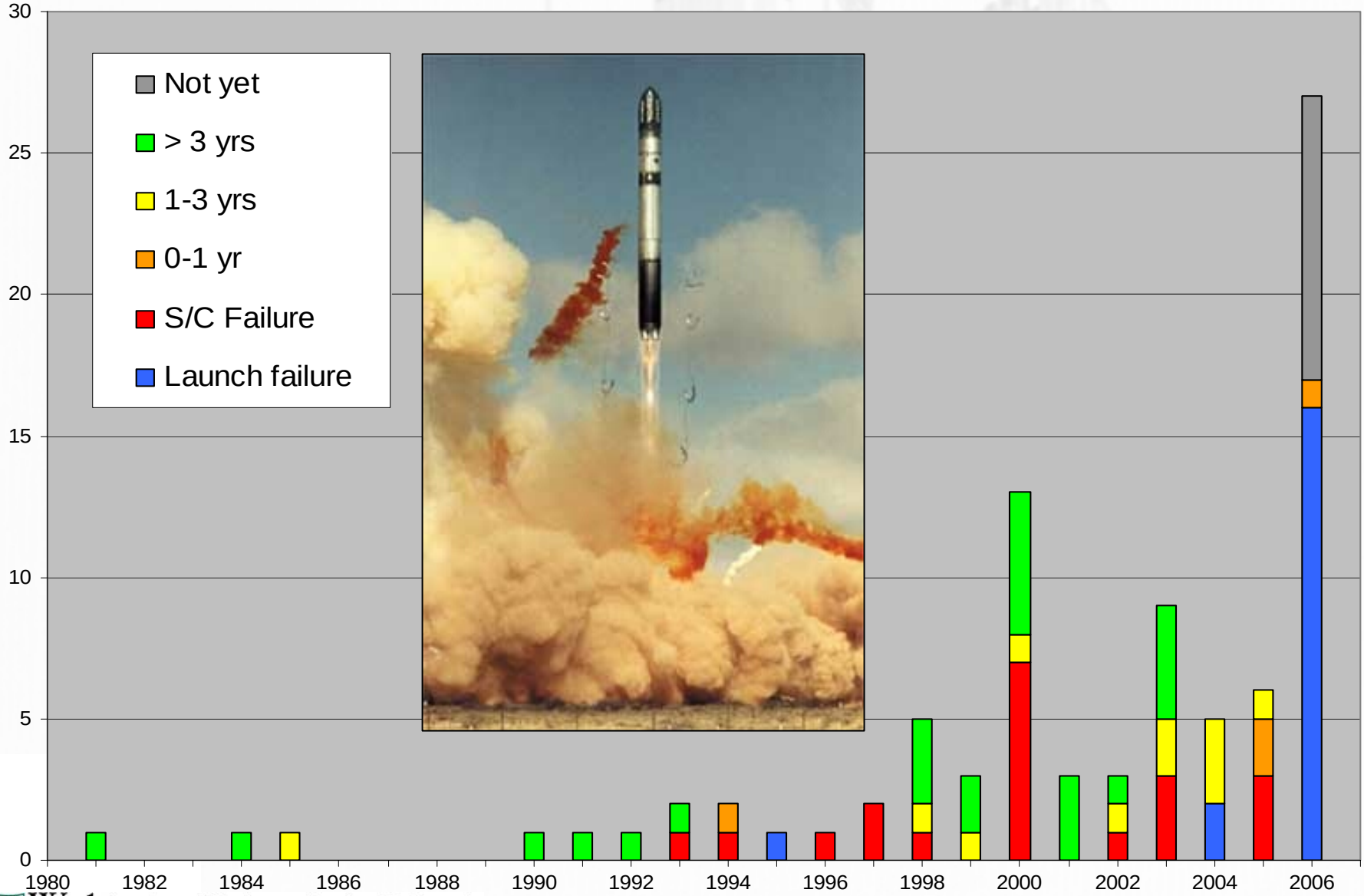
- JAWSAT (Air Force/ Weber)
  - ASUSat-1 (ASU)
  - FalconSat-1 (USAFA)
  - *Optical Calibration Sphere*
  - Opal (Stanford)
    - Thelma, Louise, JAK (SCU)
    - *Stensat (Radio Amateurs)*
    - *PICOSAT 1, 2 (Aerospace)*
- Disproportionate effect on perception of university-class missions

The Class of 2000: The Good News



- Opal, “father” of CubeSats
  - Concept to launch:
    5 years (Opal),
    18 months (picos)
  - Payload ejector
  - 25 put on rockets (so far)
  - > 75 active schools worldwide
- University Nanosat Program
  - 10 Schools, 10 kg
  - Secondary launch
  - 3CornerSat (NS2, 2004)
  - FASTRAC (NS3, 2007?)
  - A couple dozen in progress

The Numbers, Not So Rosy



What Breaks?

16 of 60 orbited spacecraft "failed"

What Breaks?

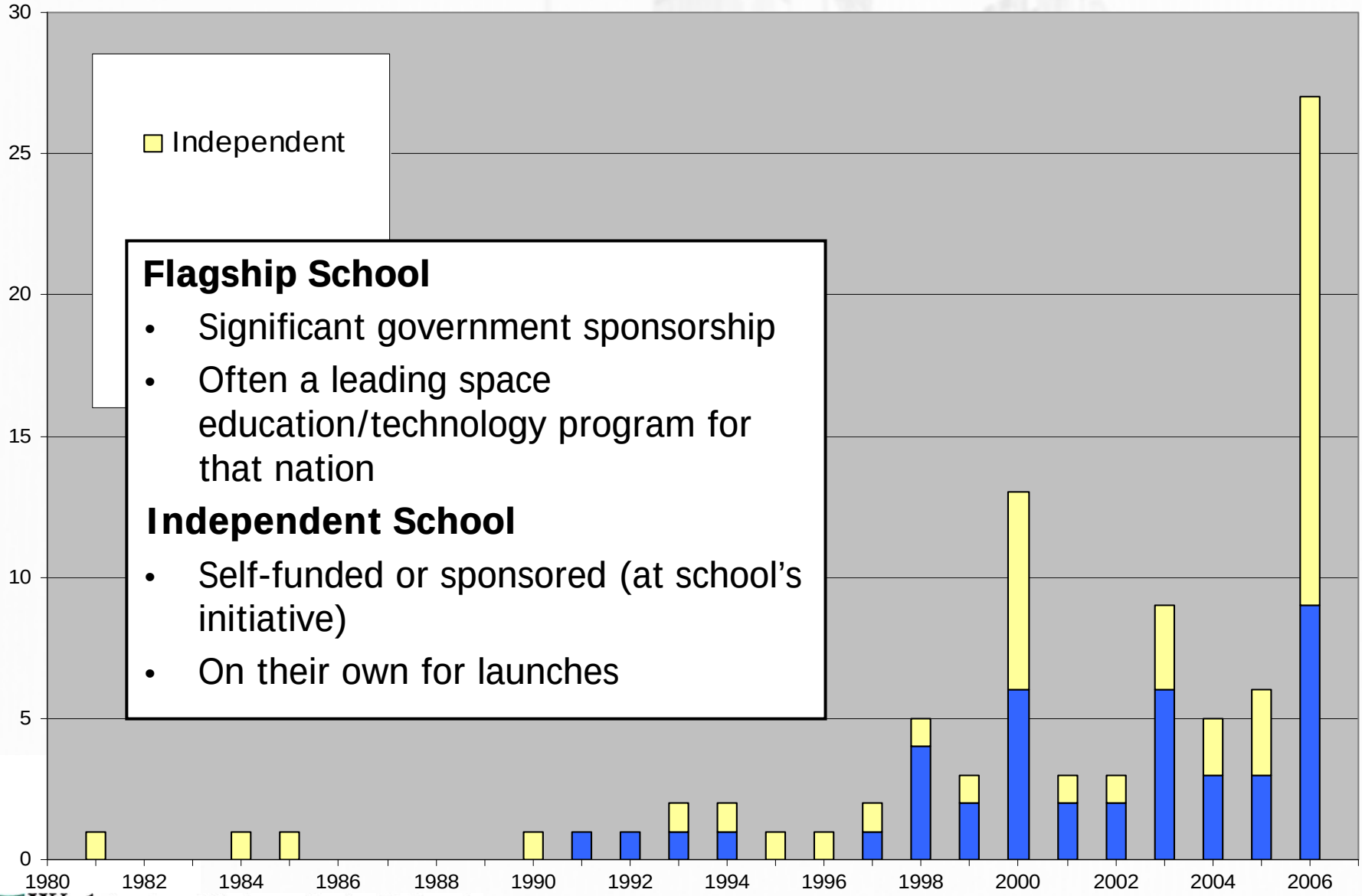
- Radiation: 1*
- Launch interface: 1
- Launch thermal: 1
- Communications: 2½
- Power: 3½
- DOA: 7

What Doesn't Break?

- Structures
- Thermal
- Commercial Electronics in Radiation Environment

Perhaps we need to worry more about system-level functional testing and less (?) about the space environment

Haves Vs. “Have-Nots”



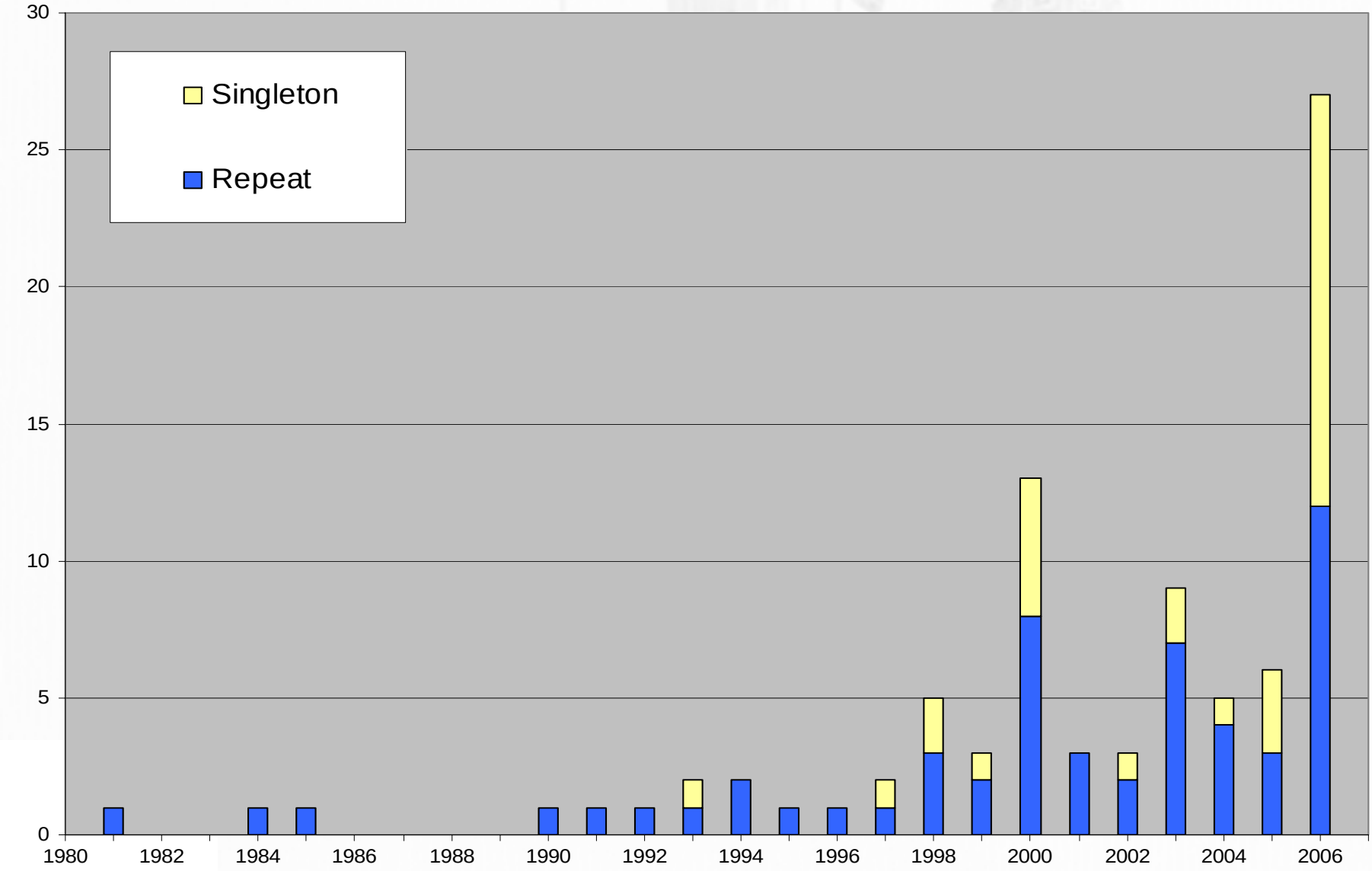
Flagship School

- Significant government sponsorship
- Often a leading space education/technology program for that nation

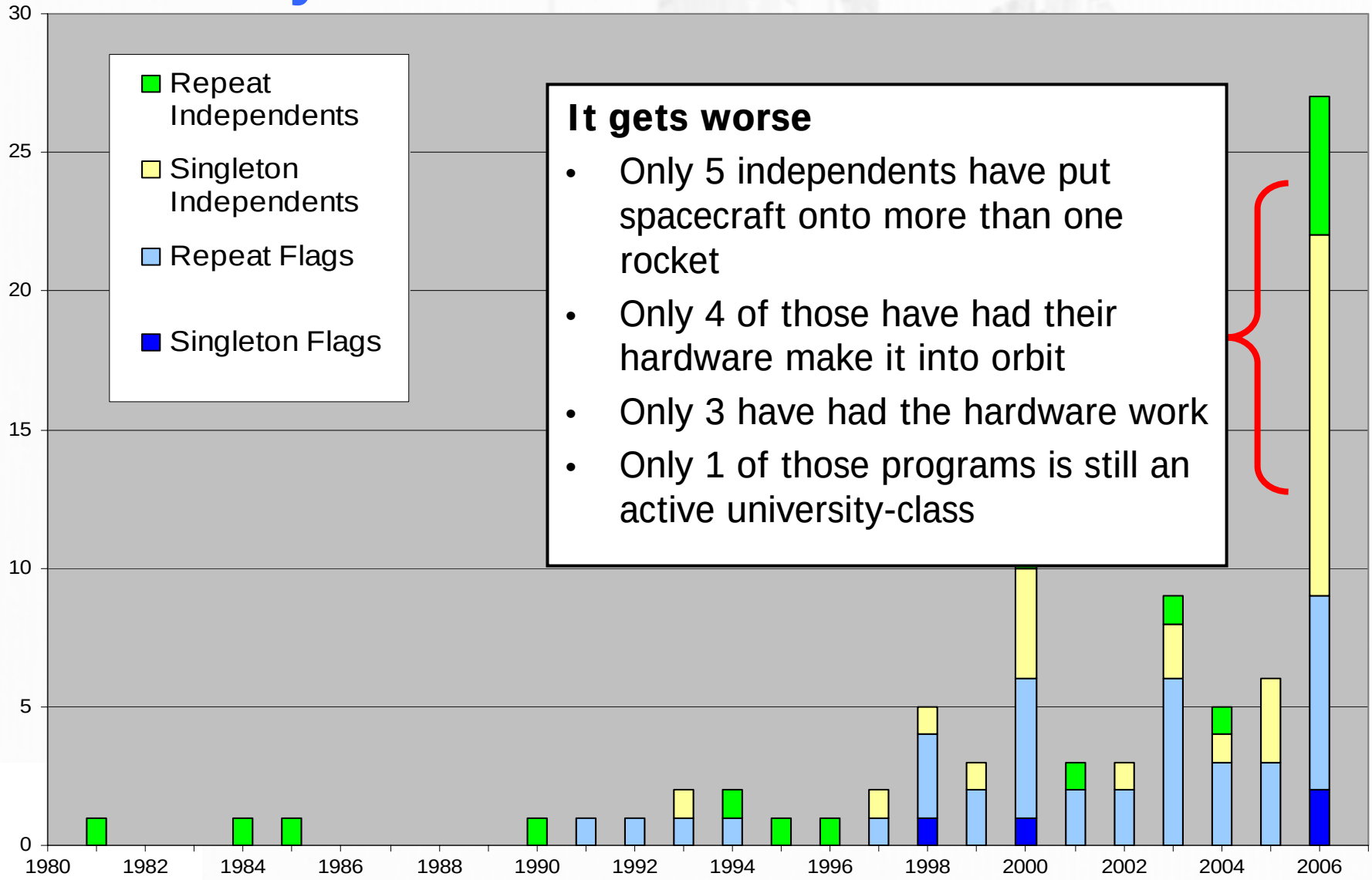
Independent School

- Self-funded or sponsored (at school’s initiative)
- On their own for launches

Sustained Program or One-Time Shot?



Repeat Business: You Gotta Be Somebody



It gets worse

- Only 5 independents have put spacecraft onto more than one rocket
- Only 4 of those have had their hardware make it into orbit
- Only 3 have had the hardware work
- Only 1 of those programs is still an active university-class

The Slide Nobody Wants to Read

- Since 1981, 78 university-class spacecraft have been placed on a rocket
  - 59 made it to orbit
  - 27 of those were built by “independent” schools
  - 5 of those were a second (or third) independent manifest
- This doesn’t even account for the dozens of missions that never made it to the rocket
- Example: University Nanosat
  - 10 “founding schools”
  - Only 2 of the 10 satellites were placed on a rocket
  - Only 1 of the 10 schools has any functional hardware in space, and it wasn’t their Nanosat
  - Nanosat-3 had ~25-to-1 applicant-to-manifest ratio
- Existential dilemma, anyone?

What's an Independent School to Do?

- Be ambitious in your mission
  - Wild and crazy ideas
  - AMSAT Oscar repeaters
- Be modest in your design
  - Small spacecraft
  - Common interfaces
  - Very short duration missions.
  - Large operational margins.
  - Rigorous, <u>system-level</u> functional/operational testing

Soapbox Time

- "Micro" vs. "Nano" vs. "Pico": Missing the point
  - Launch providers are insensitive to 5-20 kg changes in payload mass
  - Volume is the true discriminator
  - If not volume, then launch interface (P-POD vs. ESPA)
- How big should our satellites be?
  - CubeSat (P-POD, 1-5 kg): Affordable launch, unaffordable performance (only 1 orbiting university CubeSat does more than beep, and it had help)
  - Nanosat (ESPA, 10-40 kg): Affordable performance, unaffordable launch
  - Something's gotta give

Acknowledgments

- Christopher Kitts, Freddy Pranajaya, James Cutler, Brian Engberg, Jonathan Chow
- The design teams for all 88 university-class spacecraft (and counting!)
- Launch providers (e.g. Space Test Program)

- *Any errors in university-class satellite descriptions or classification are mine*

Shameless, Off-Topic Plug

- Last year, I promised a rapid integration demonstration using a ‘standardized’ command & data handling system
- This year, we have that demonstration using two university Nanosats (Santa Clara’s ONYX and Washington University’s Akoya)
- Tuesday, 10:25am (during the break) in the conference room (upstairs, 313)

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