



NEPP Task: CubeSat Database

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June 19, 2014



Overview

- NEPP CubeSat Database
- Sources
- CubeSat Mission Data
- CubeSat Failure Statistics
- Common CubeSat EEE Parts
- CubeSat Manufacturers
- Conclusions/Future



NEPP CubeSat Database

- Approach is to obtain general reliability information and specific EEE parts information for all available CubeSat missions
 - Flight status of CubeSat missions, subassemblies, and associated EEE components
 - Failure rates and modes
 - Screening/qualification performed by common CubeSat manufacturers



Sources

- EOPortal Satellite Directory, European Space Agency
- Space-Track.org
- SpaceflightNow.com
- CubeSat/Small Satellite Conferences
- Mission/University Websites
- CubeSat Manufacturers
- JPL CubeSat Developers

CubeSat Mission Data



CubeSat Missions:

- **Sponsoring Organization**
- **Launch Date, Vehicle, Ejector**
- **Orbit** – Shape, Apogee, Perigee, Inclination, Period
- **Mission Sponsor** - University, Civil, Commercial, Military
- **CubeSat Type** - 1U, 2U, 3U, etc.
- **Mission Status** - Manifested, Launched, Deployed, Checkout, Primary Operations, Mission Success
- **Functional Status** - Pre-launch, Launch/Deployment Failure, Semi-operational, Non-operational, Active, Deorbited
- **Failure/Deorbit Date**
- **Cause of Failure**
- **Mission Lifetime**

CubeSat Components:

- **Subsystem usage:**
 - (ADCS)
 - **Command and Data Handling (C&DH)**
 - **Communications**
 - **Power**
- **Instruments**
- **Interviews with vendors regarding EEE parts policies and procedures**
- **Review of mission specific technical literature**
- **Known technology limitations**

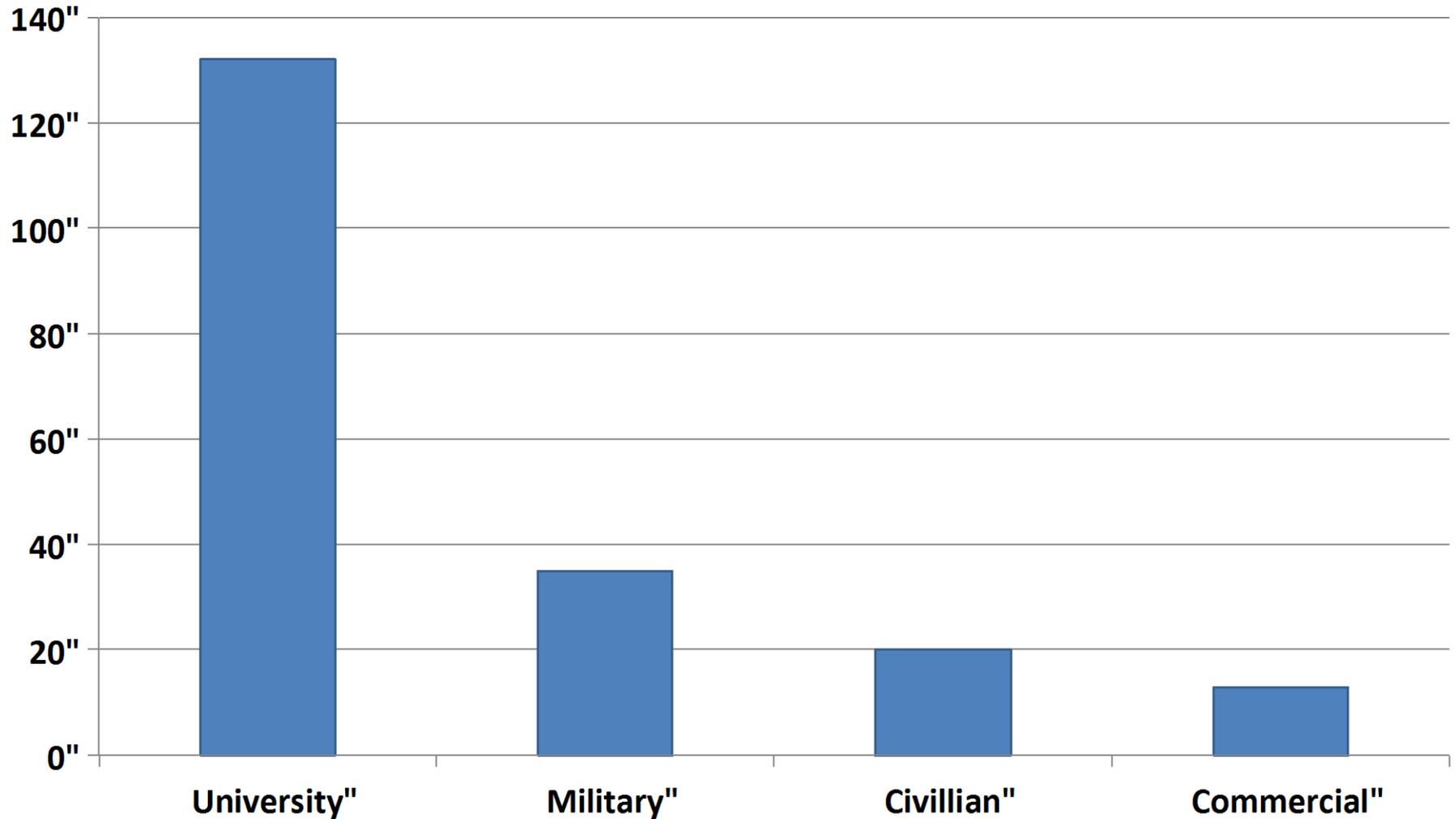


CubeSat Mission Trends

- 200+ CubeSats launched as of June 2014
- 36 CubeSat launches from June 2003 to June 2014
- Three launch failures, destroyed 20 CubeSats
- Number of CubeSats per launch has increased over time
- Launch in November 2013 included 28 CubeSats
- Currently 201 CubeSat missions in our database

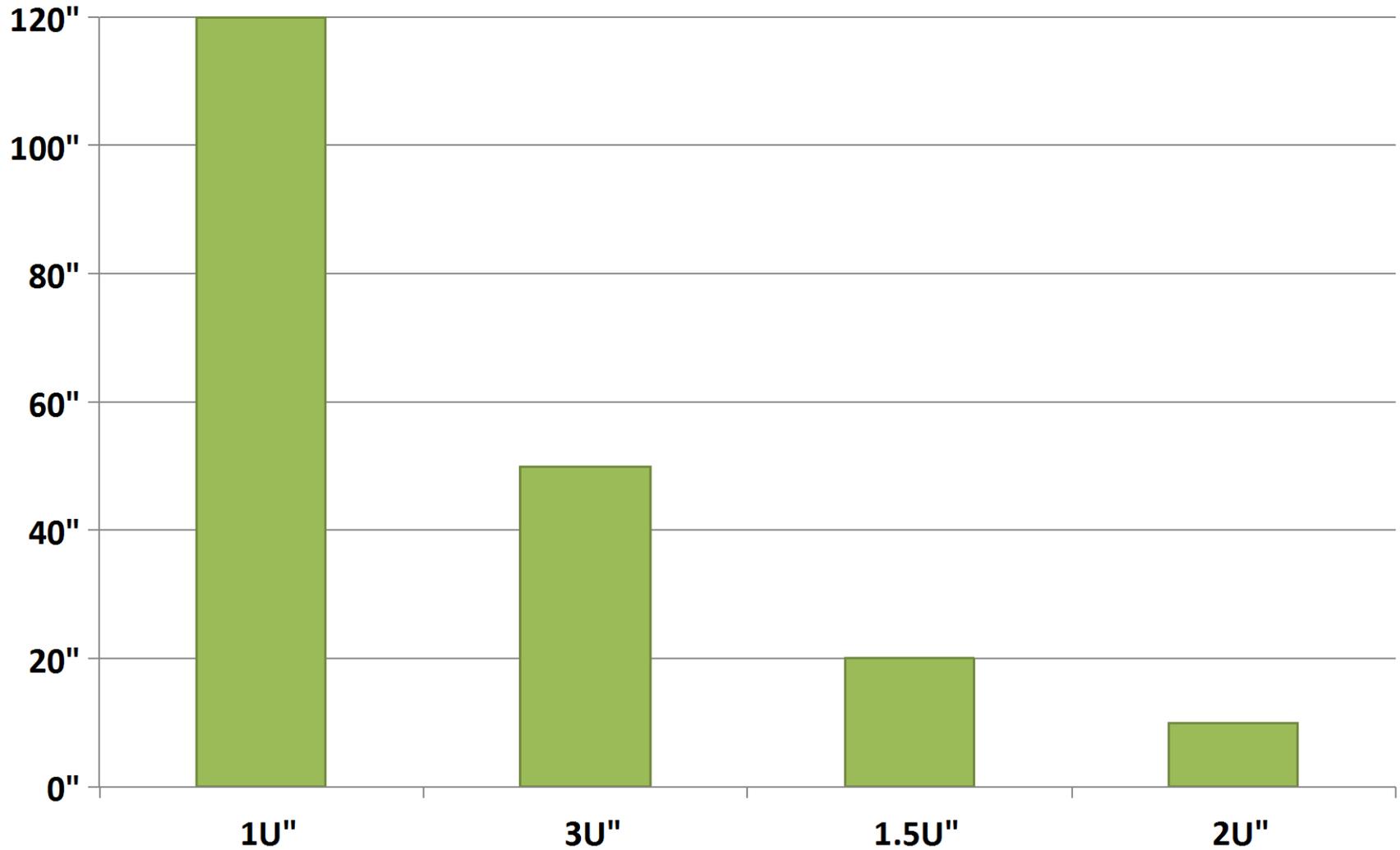


CubeSat Mission Sponsor



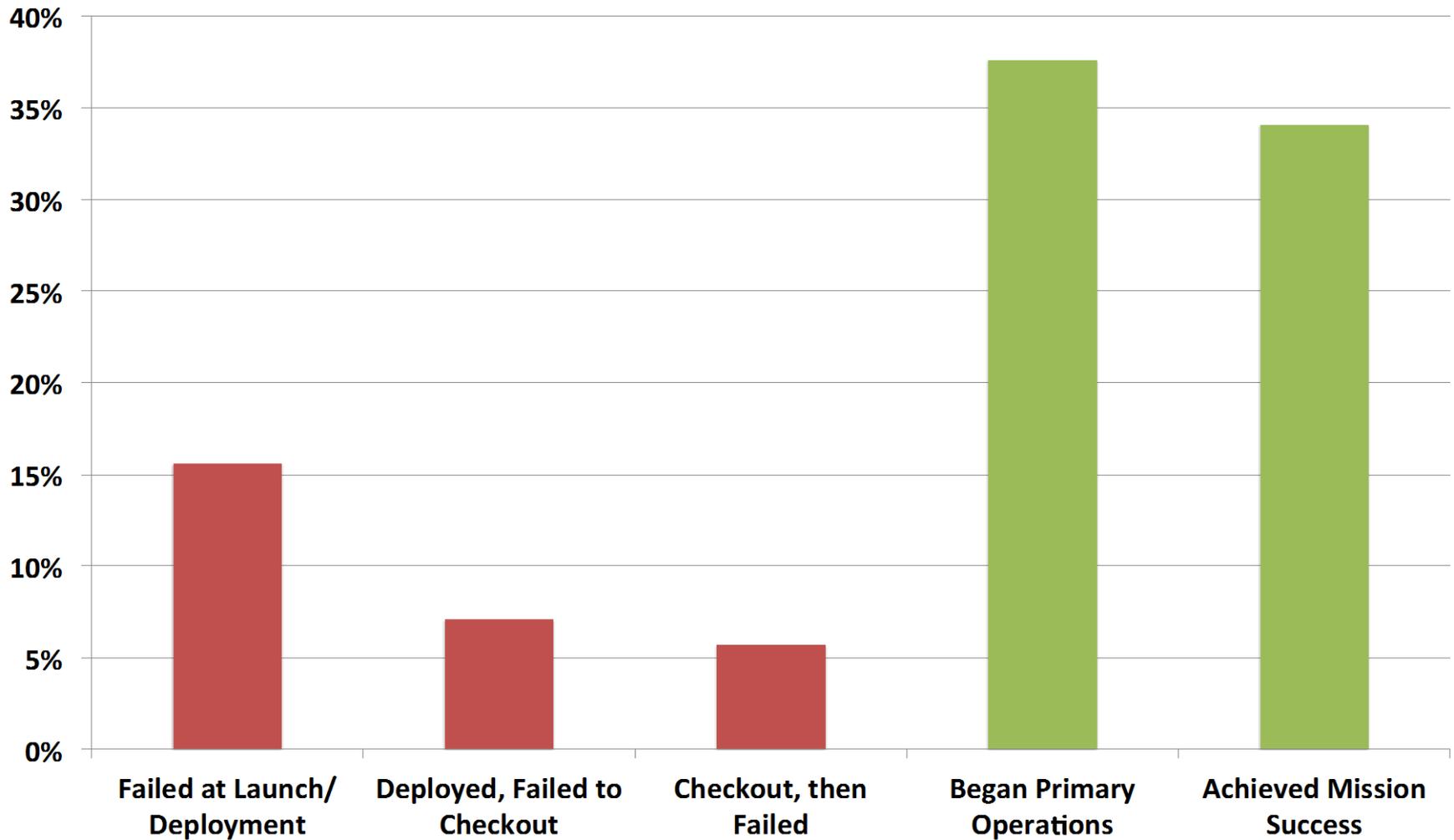


CubeSat Mission Size



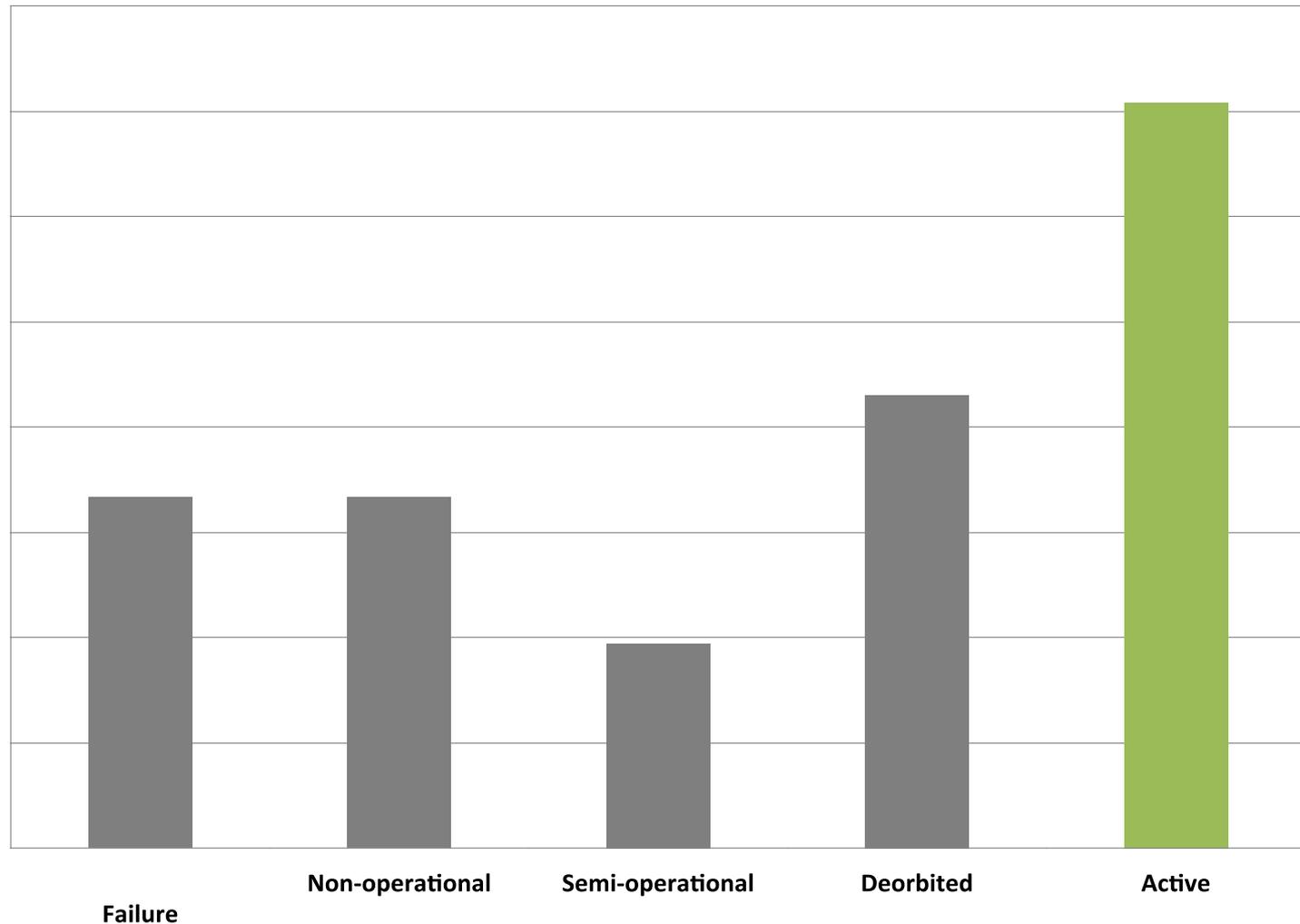


CubeSat Mission Outcome





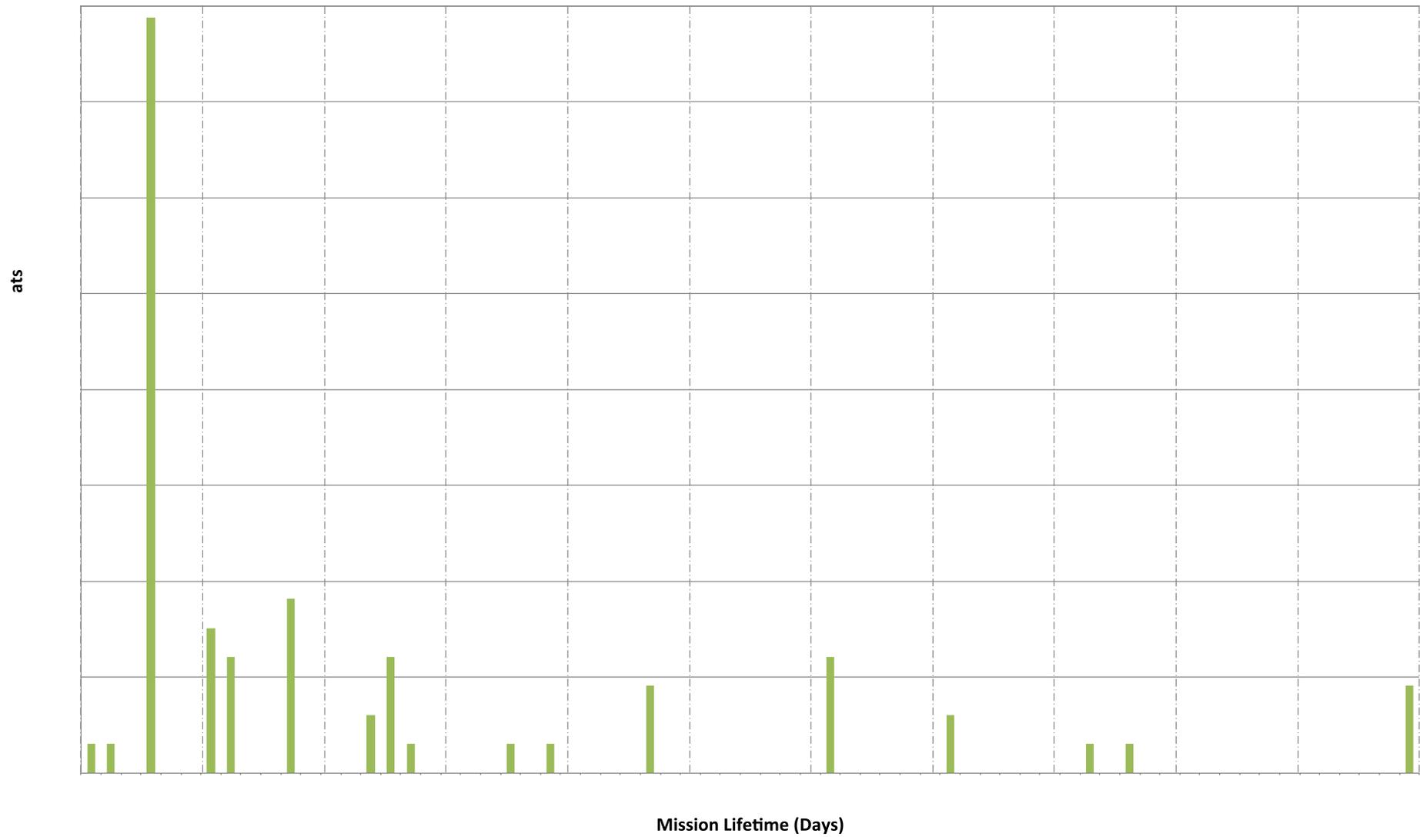
Active CubeSat Missions



Active – fully operational and currently in orbit

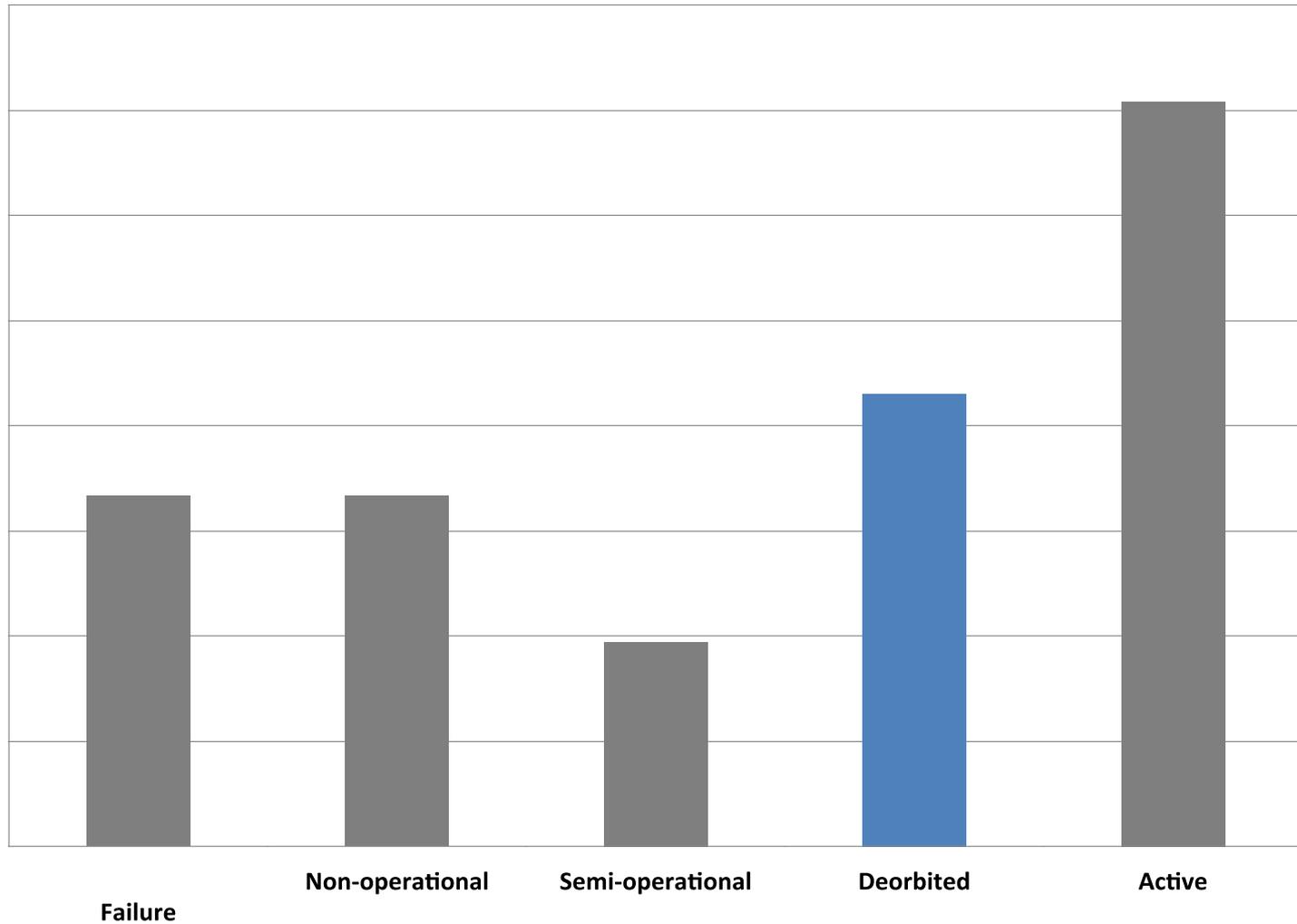


Active CubeSat Mission Lifetime



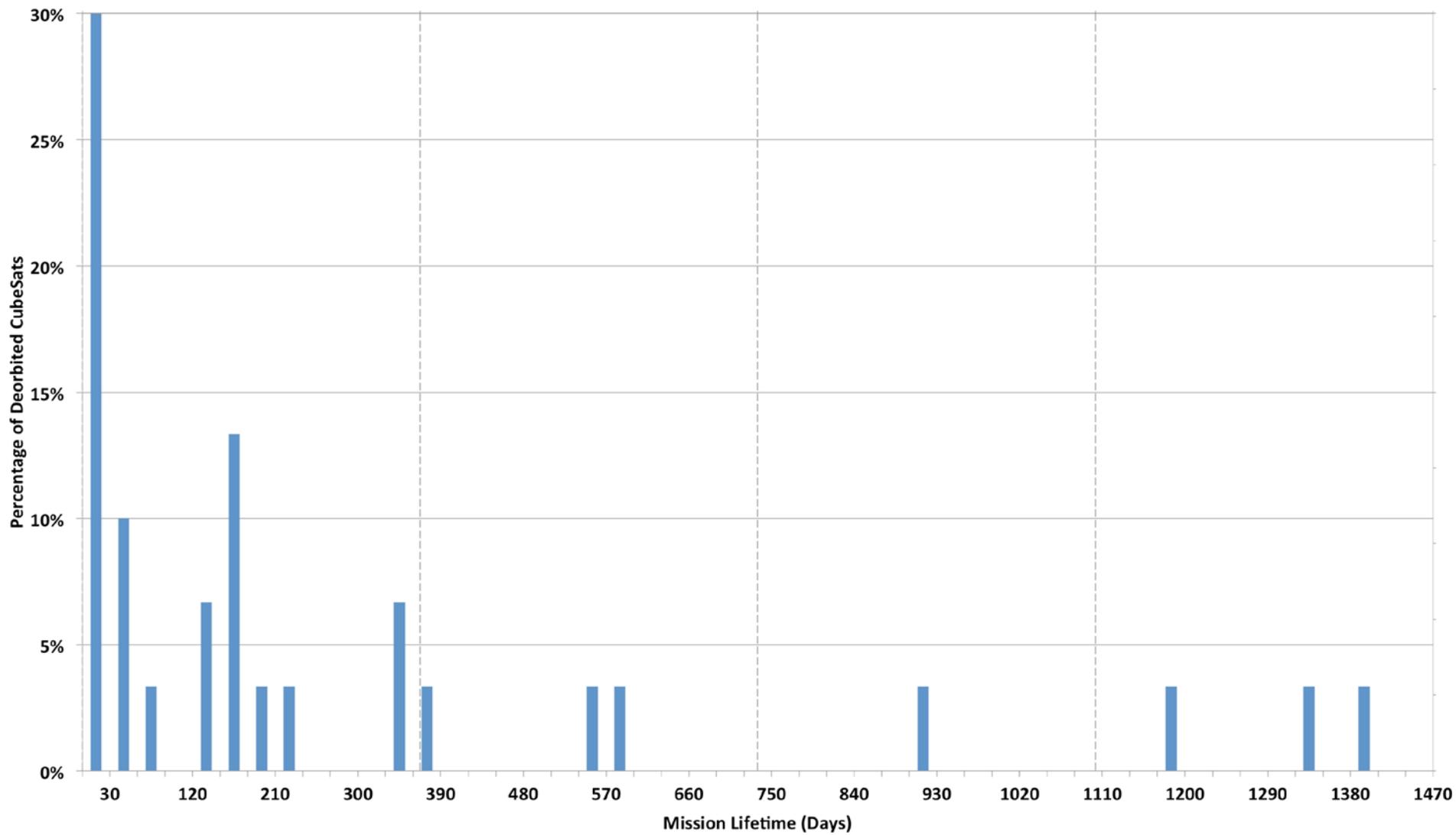


Deorbited CubeSat Missions



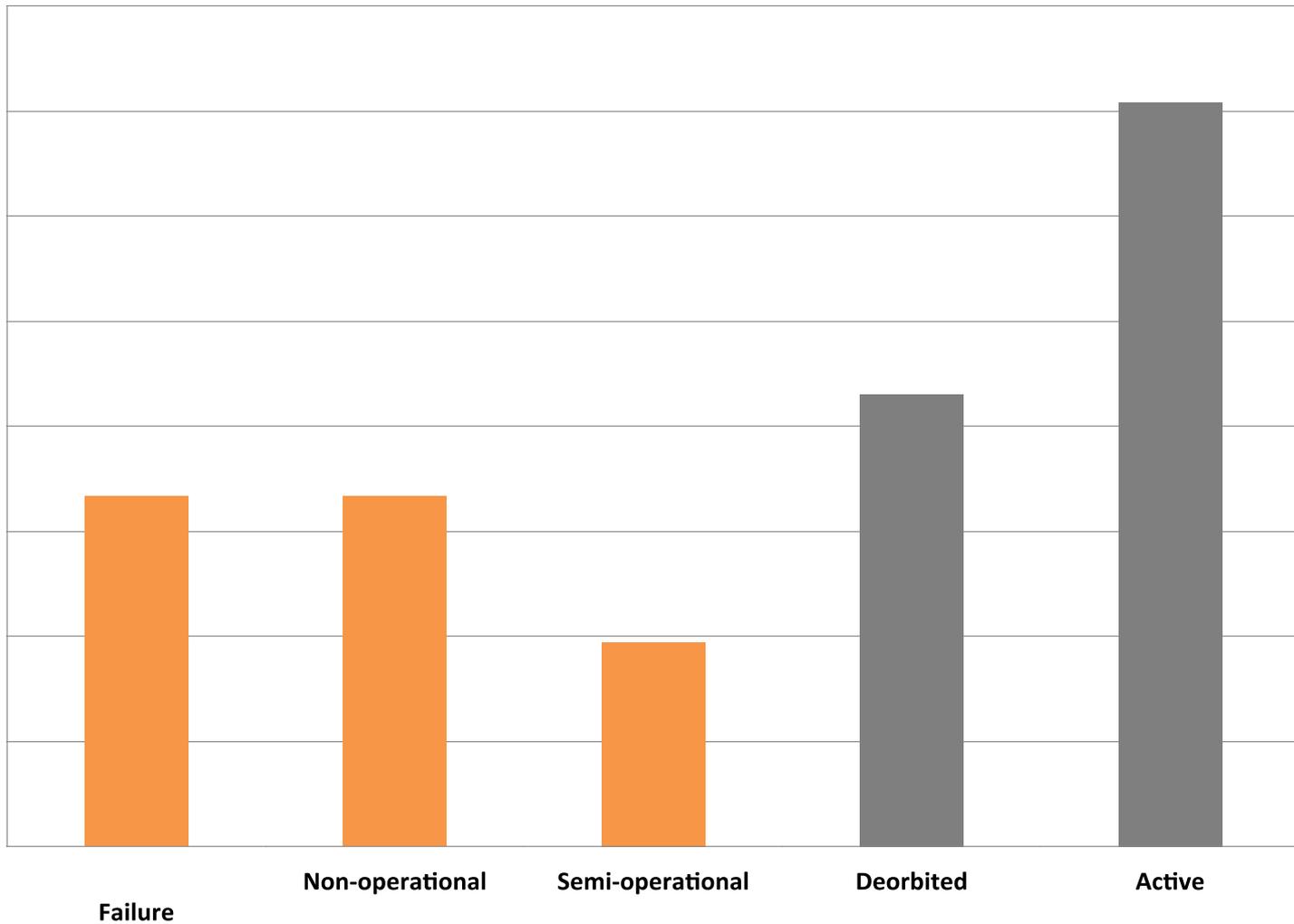
Deorbited – deorbited while fully operational (no failure)

Deorbited CubeSat Mission Lifetime





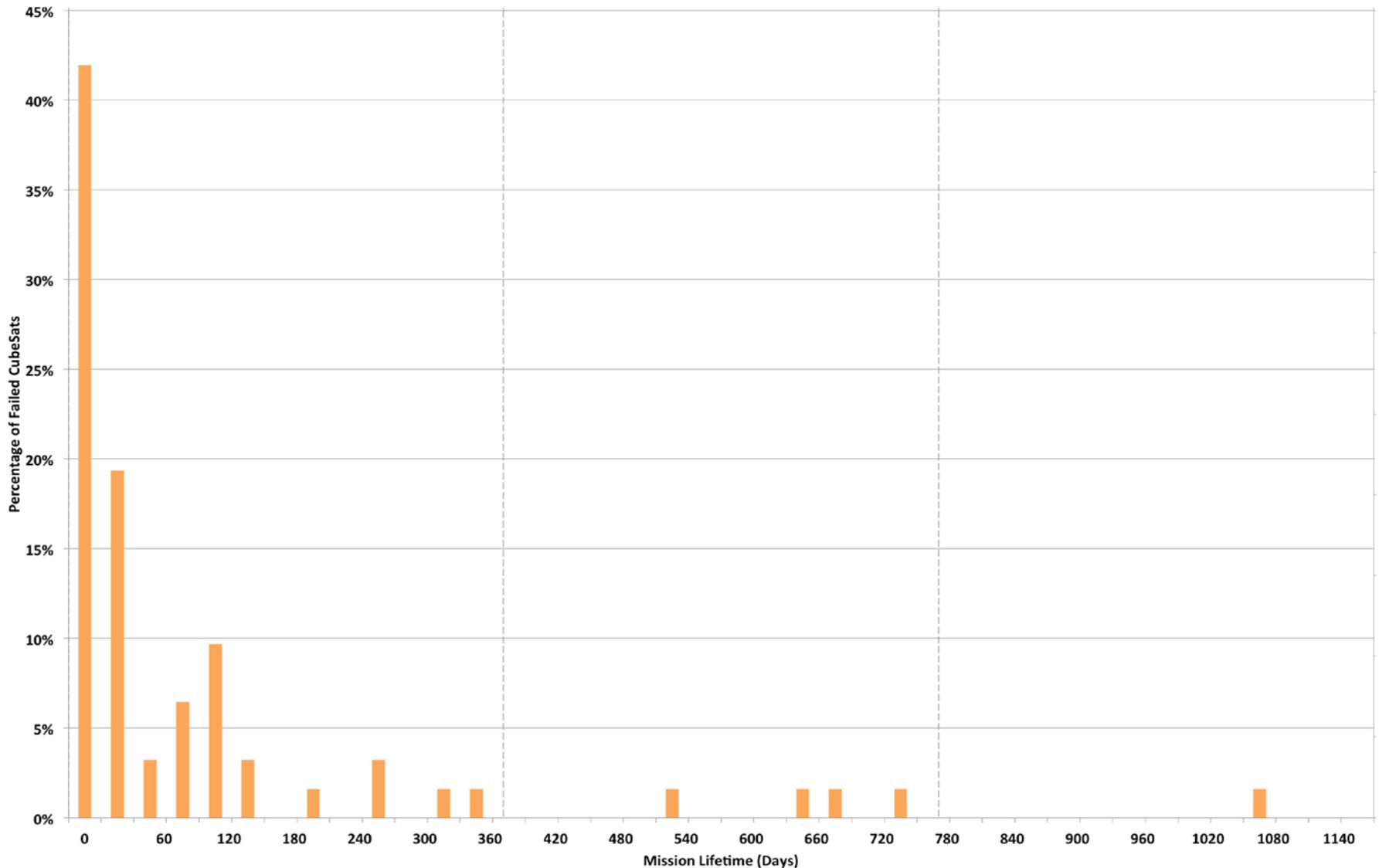
CubeSat Mission Failures



Failure - CubeSat is not fully operational



Failed CubeSat Mission Lifetime



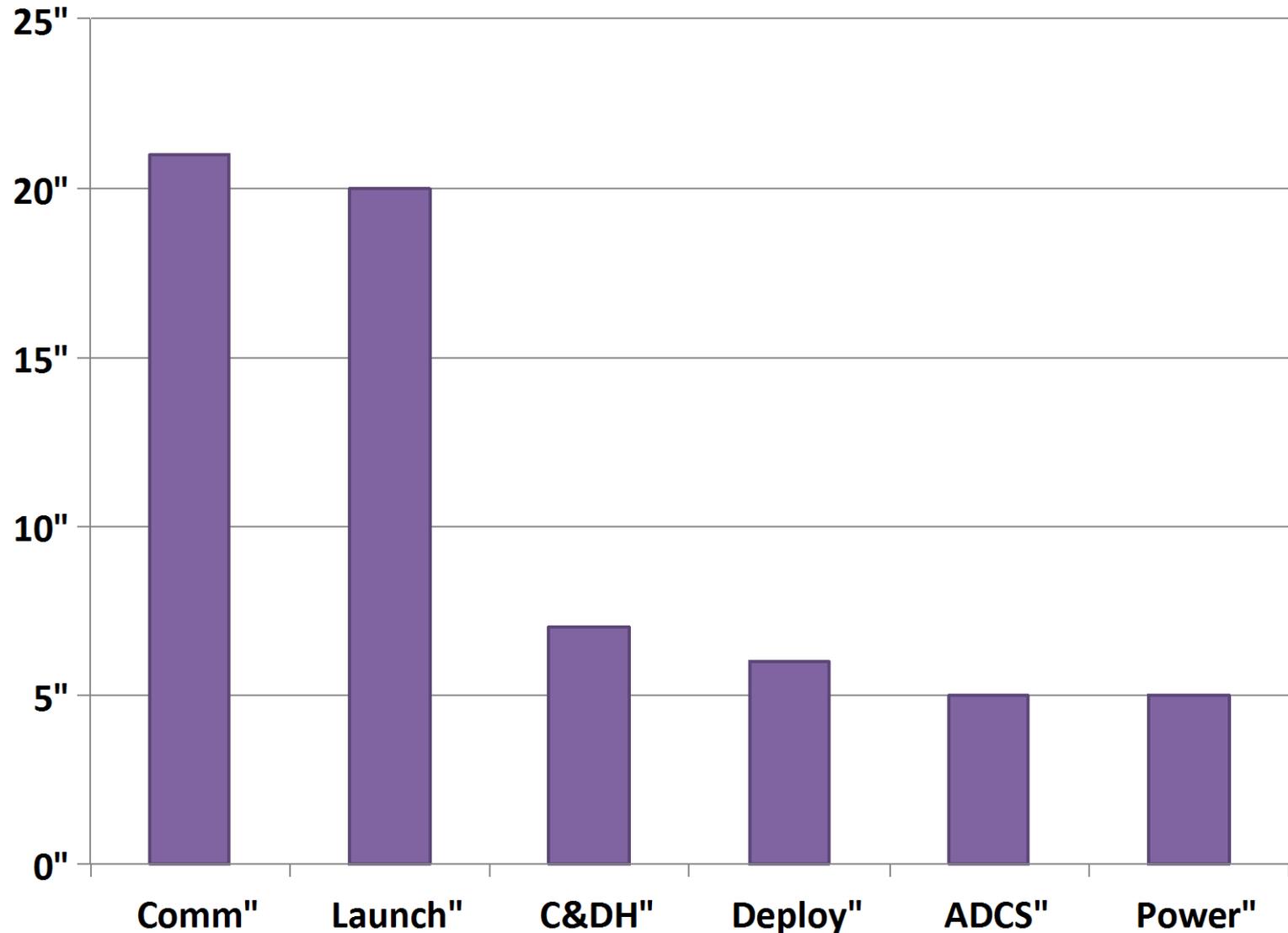


CubeSat Failure Details

Name	Cause of Failure
Dove-1	Low orbital altitude caused reentry into the atmosphere
GOLIAT	Satellite did not settle into orbit properly and tumbled uncontrollably
ESTCube-1	Strong magnetic disturbance inside the satellite causing problems with ADCS
E-ST@R	Tumbling couldn't be stopped, could not operate normally
PW-SAT-1	Turned silent due to power budget problems
KySat-2	A radiation-induced latchup drained the batteries & caused the C&DH + radio to reset, satellite has not returned to normal operations
CP4	C&DH processor lock-up issue
BeeSat-1	Detected telemetry data anomalies, switched to backup computer
PhoneSat 2.4	Experienced recurring upsets that made the software unable to function
First-MOVE	Irreparable damage to onboard software
AAUSat-2	Spacecraft reboots frequently, most likely due to heat of C&DH processor
KickSat-1	Timer to deploy Sprite satellites (payload/instruments) was reset due to high dose of radiation, spacecraft re-entered before timer finished counting down the second time
STARE-A (Re)	Communications issues prevent operations
OSSI-1	Could not communicate with satellite
CAPE-1	Could not communicate with satellite
COPPER	Could not receive signals, small possibility of recovery
F-1	Failed to confirm communications
ROBUSTA	Initial weak signal, later satellite could not be heard; fabrication defect prevented the batteries from being charged
HITSat-1	Intermittent communications



CubeSat Failures by Subsystem





Common CubeSat EEE Parts

- Conservative designs and EEE parts
 - SDRAMs
 - 12 bit/1Msps ADC
 - 8/16-bit microcontrollers
 - Low Frequency ($\leq 32\text{MHz}$ often)
- Significant use of non-historical spacecraft interfaces
 - I2C
 - SPI
- Use of passives significant
 - 3-4X number of passives vs. active IC's per board
 - 0603 most common, some smaller
 - Base metal electrodes
- Enough non rad-hard non-volatile memory (32MB) to run Linux based software
- >90% of missions use UHF band comms
 - Data rates usually 9.6kbps



CubeSat Manufacturers

- Contacted numerous manufacturers for reliability information
 - *Does the company buy prescreened/qualified parts?*
 - *Are parts bought from commercial vendors such as Digikey and Avnet*
 - *Does the company look for specific grade parts or buy based solely on performance?*
 - *Does the company do any screening to parts received?*
 - *How does the company assure their parts?*
- Automotive grade is specified by most companies
 - “Whatever is available” also reported
- Digikey is used most frequently
- EEE-INST-002 was referenced in two cases
- Most boards only receive one-time/room temp system level operational test prior to shipment
 - Board level temperature testing only done during development phase



CubeSat Manufacturers (cont.)

- A few companies have an Approved Supplier List
 - GIDEP, approval of certifications, monitor performance, address issues, high reliability, screening
- Mixture of RoHS and non-RoHS
 - Some companies specifically mention additional solder dip processes
- Small number of vendors have ability to trace EEE parts throughout entire manufacturing process
 - Formal/custom BOM software



Conclusions/Future

- EEE Parts used in CubeSats contribute to degraded mission performance
- CubeSat board level development practices often do not completely stress EEE part temperature and voltage margins
- The impact of variations in CubeSat EEE part performance on CubeSat vendor supplied software has yet to be quantified
- Many of the IC's used for CubeSats will be problematic in deep space radiation environments without further qualification/screening