

COE CST Fifth Annual Technical Meeting

Task 244: Autonomous Rendezvous & Docking for Space Debris Mitigation

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Agenda

- Team Members
- Task Description
- Schedule
- Goals
- Results
- Conclusions and Future Work

Team Members

- Principal Investigator
 - Norman Fitz-Coy
- Students
 - Bungo Shiotani (PhD student)
 - Kathryn Cason (accepted job with MEI)
 - Takashi Hiramatsu (PhD in 2012 – Keio Univ.)
- Organizations
 - Collaborator: NASA ODPO
 - Matching provided by: Space Florida

Task Description (Original)

- Active debris removal is required
 - Interests in small satellites (e.g., CubeSats) especially by new space entrant leads to:
 - More spacecraft → more failure (debris)
 - Debris likely to be non-cooperative
- Objective
 - Develop strategies to minimize interactions during removal of non-cooperative debris
 - Develop strategies for safe proximity operations / collision avoidance during removal

Task Description (Modified)

- Objectives

- Identify/quantify the global growth trends of CubeSat-class satellite; assess the interests of US and international communities for CubeSat applications and investigate emerging CubeSat products (e.g., Planet Labs constellation of CubeSats).
- Survey the assembly integration and testing practices of these CubeSat developers and utilize that information to investigate the mortality rates of CubeSats
- Assess the space debris mitigation strategies utilized / implemented by these developers

Replace CubeSats with “Containerized” Satellites

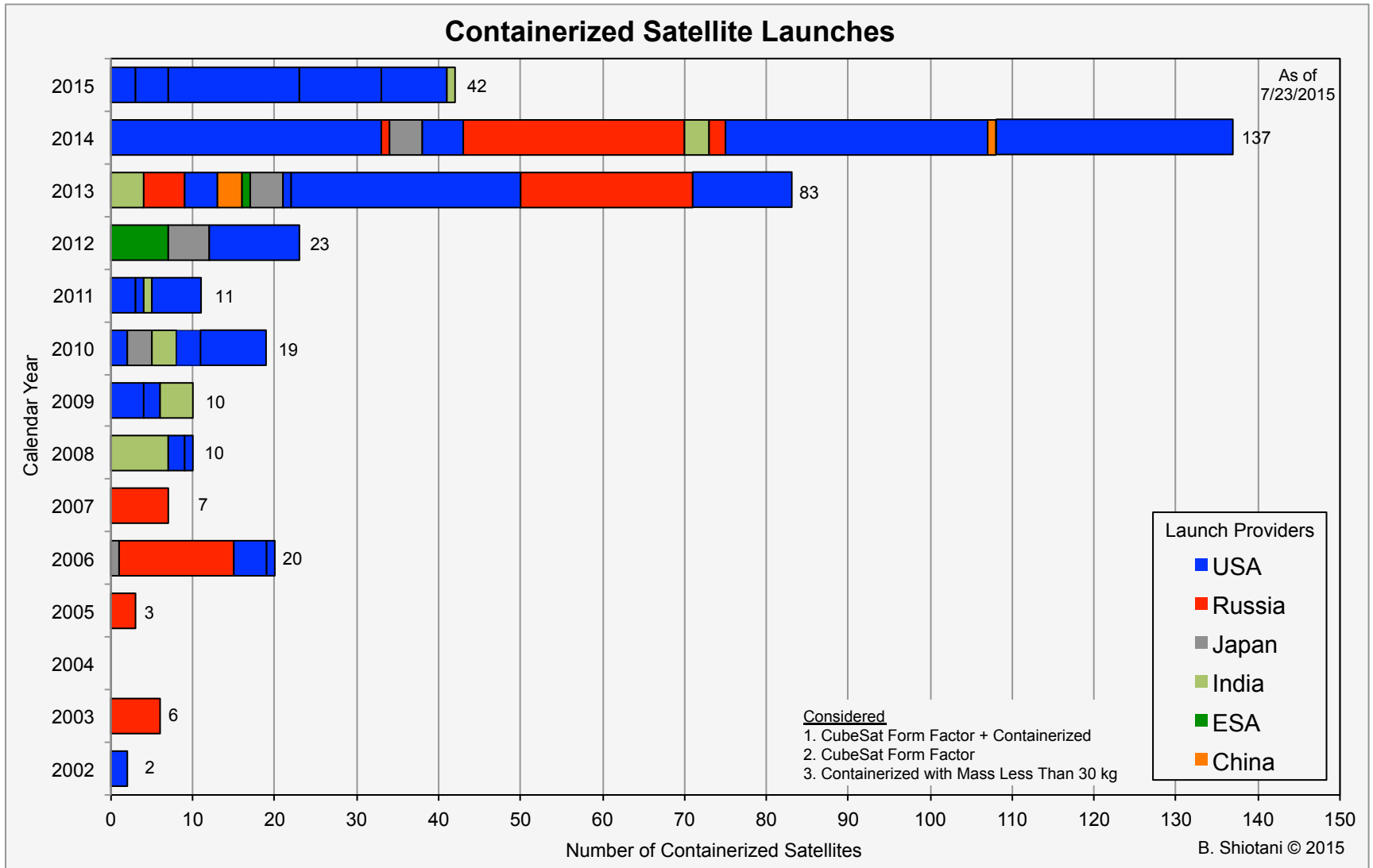
Schedule

- Start date: September 2014
- Develop survey strategy: October 2014
- Pilot test questionnaire: December 2014
 - Reviewed by NASA ODPO
- Disseminated questionnaire: January 2015
- Survey closed: May 2015
- Analyze survey results: June-Aug. 2015
- Finalize/publish results: September 2015

Goals

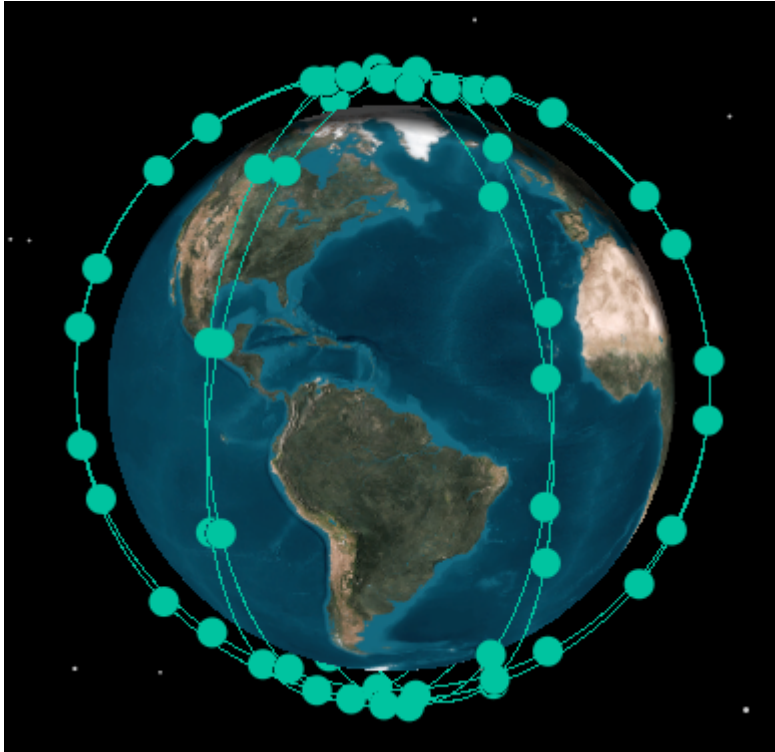
- Outcomes
 - Utilize the growth trends, mortality information, and mitigation strategies to assess the impact of “containerized” satellites to LEO debris
 - Sensitize containerized satellite community of their potential impact on space debris
 - Work with NASA ODPO and IADC to develop protocols to reduce debris growth trend (e.g. modify 25-year rule)
- Relevance to FAA
 - Debris in LEO will re-enter the airspace and could interact with sub-orbital flights and/or air traffic
 - Collision with 5 mm sized debris could be consequential

Task Motivation

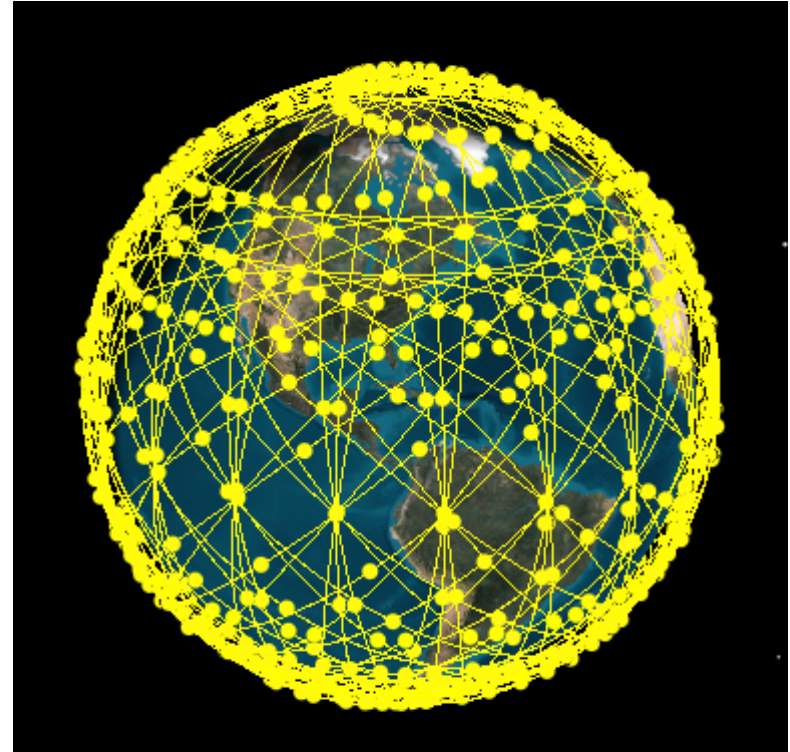


Task Motivation

- Debris growing due to increases launch rate of containerized satellites
- Large constellations (hundreds of satellites) are being “developed”



Constellation of traditional satellites
(e.g., Iridium)



Constellation of containerized satellites
(e.g., OneWeb, SpaceX, PlanetLabs)

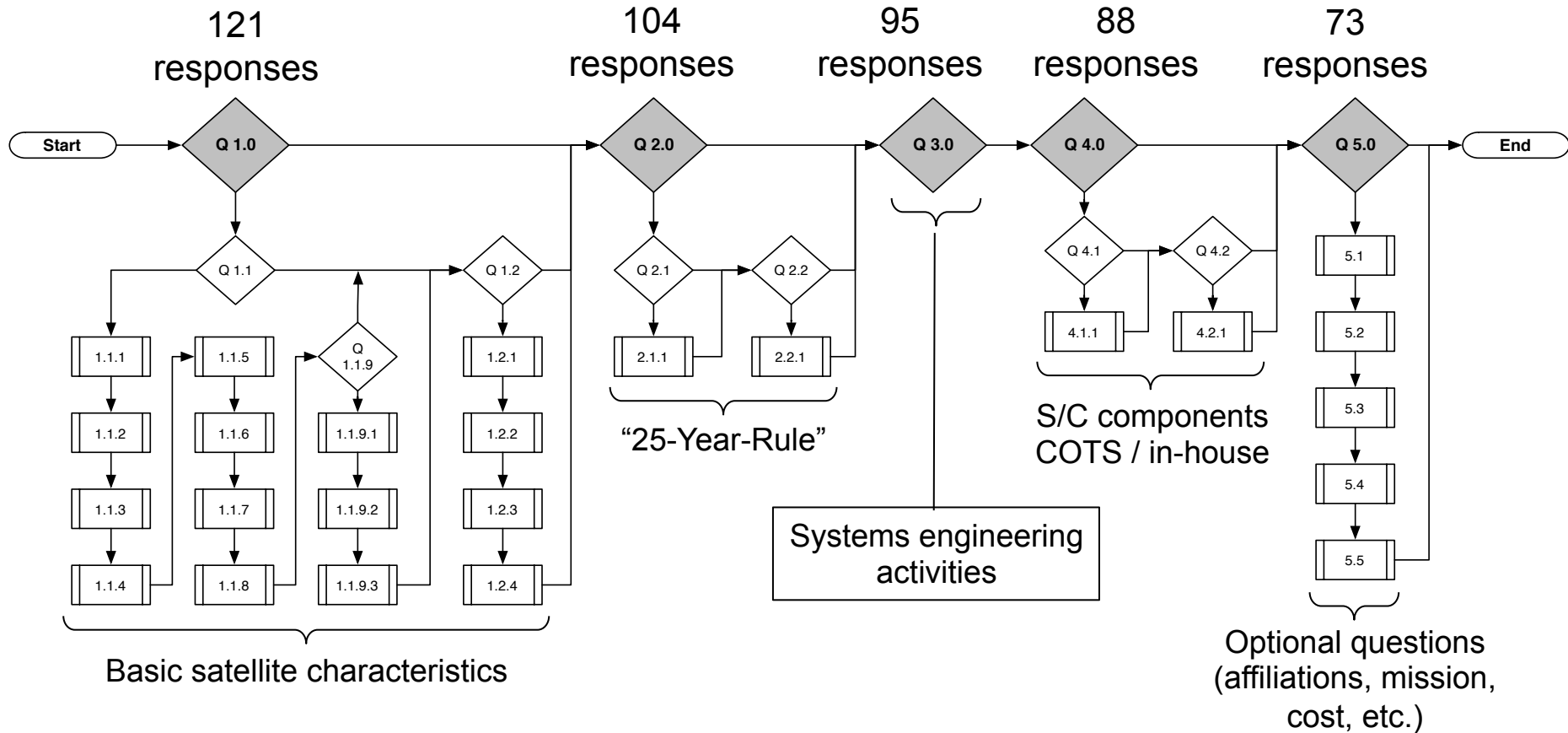
Containerized Satellite Survey



- Survey disseminated to small satellite community through mailing lists (e.g., CubeSat, AMSAT, and working groups of INCOSE and IAA) and personal contacts worldwide.

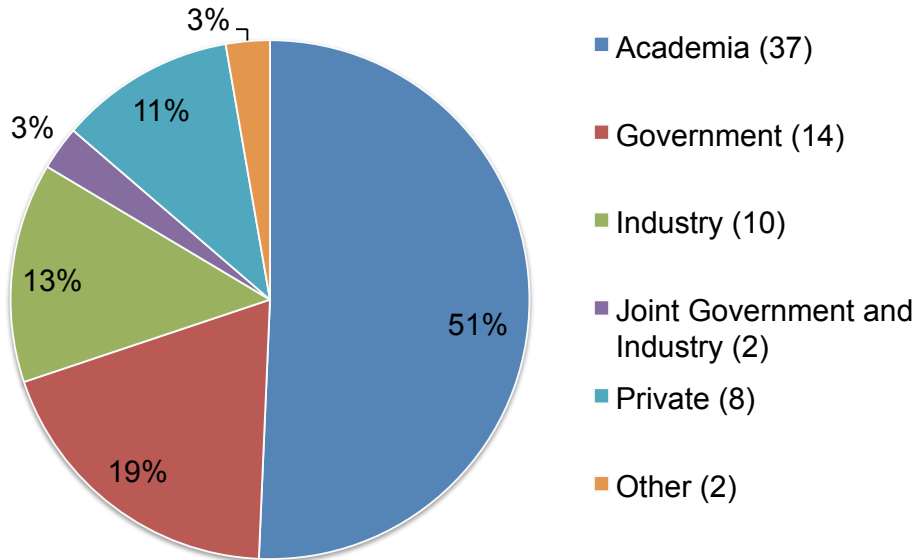
Survey Results

- 200 survey links opened

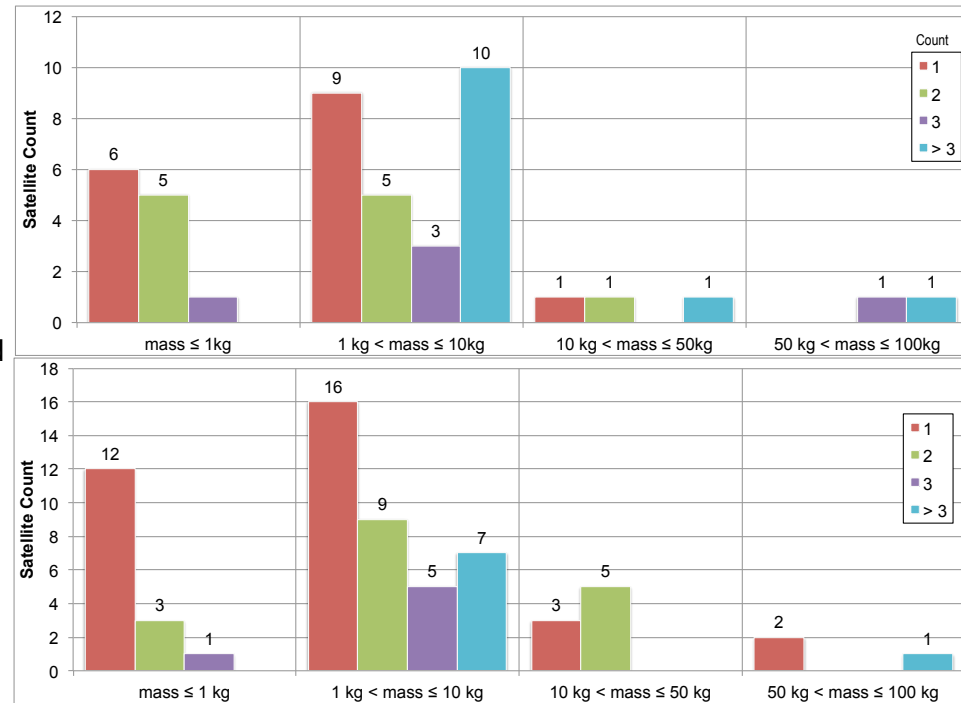


Survey Results

Participant affiliation

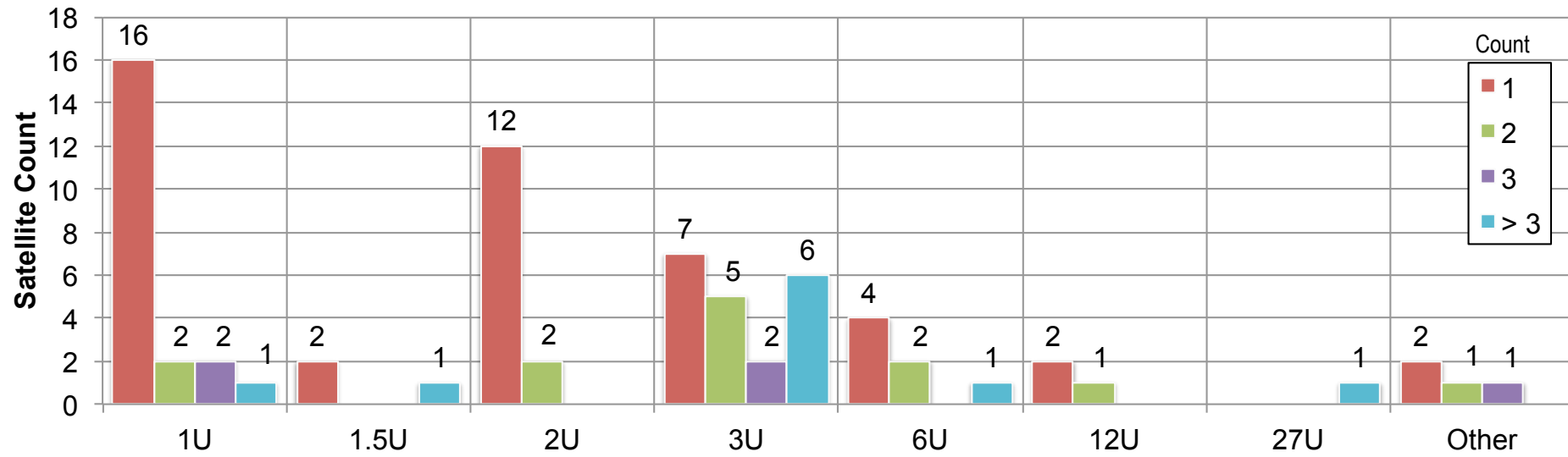
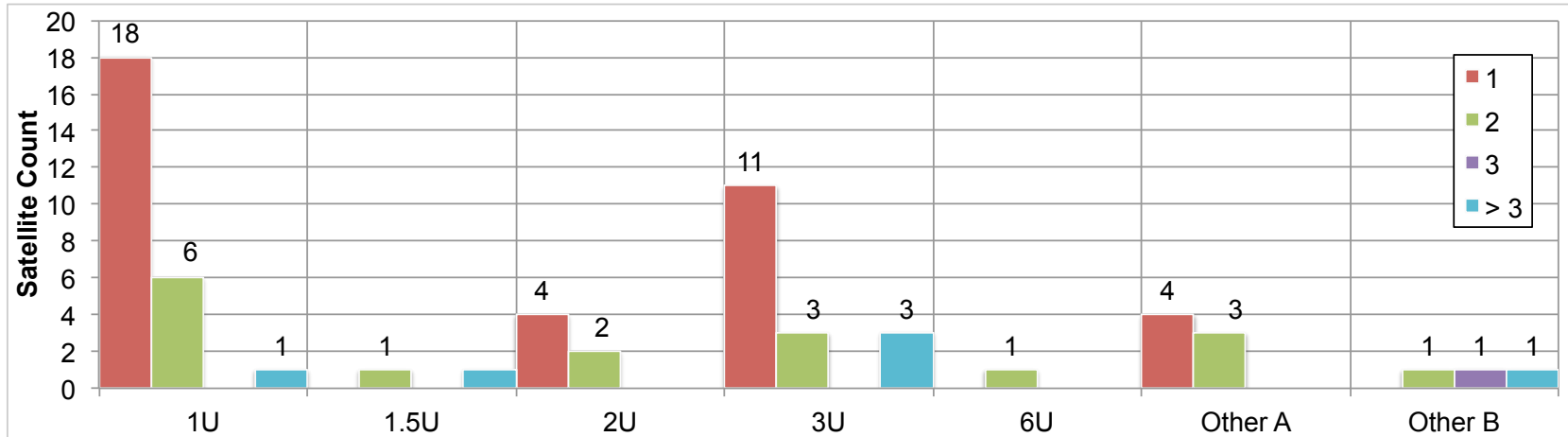


Past and future launch masses



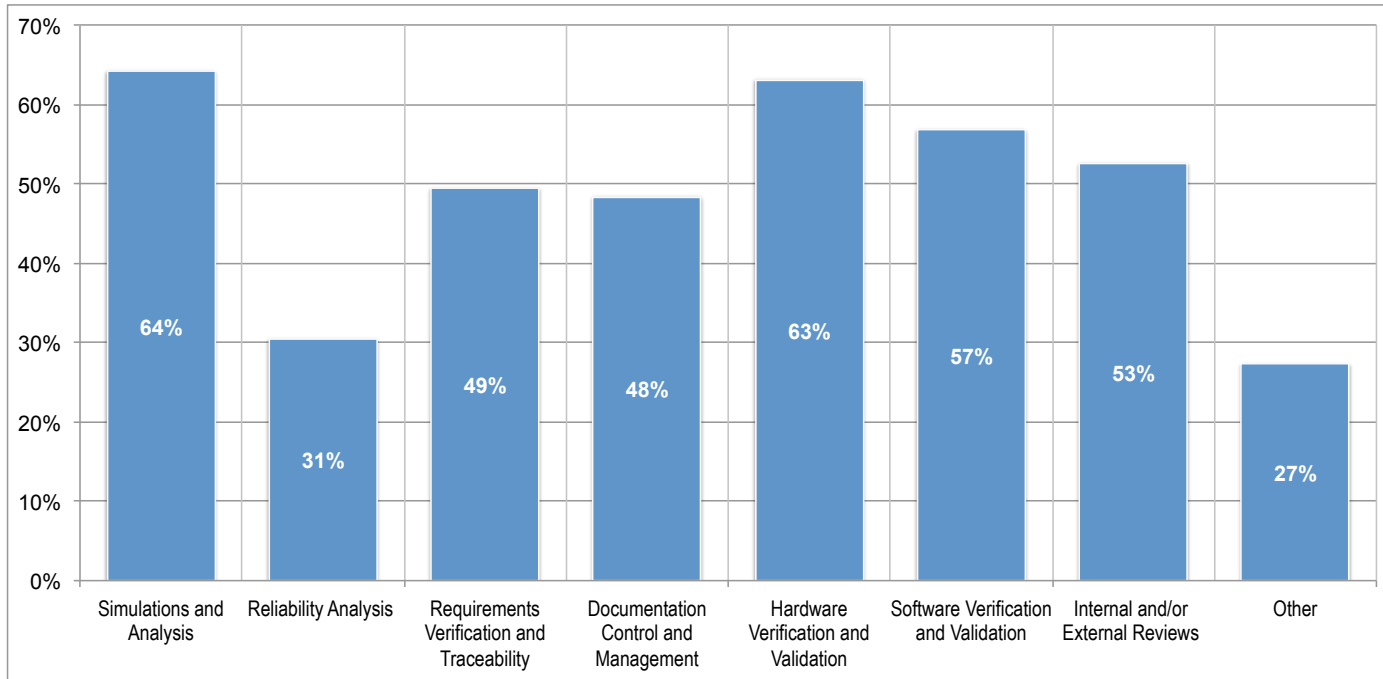
Survey Results

Past and future sizes



Survey Results

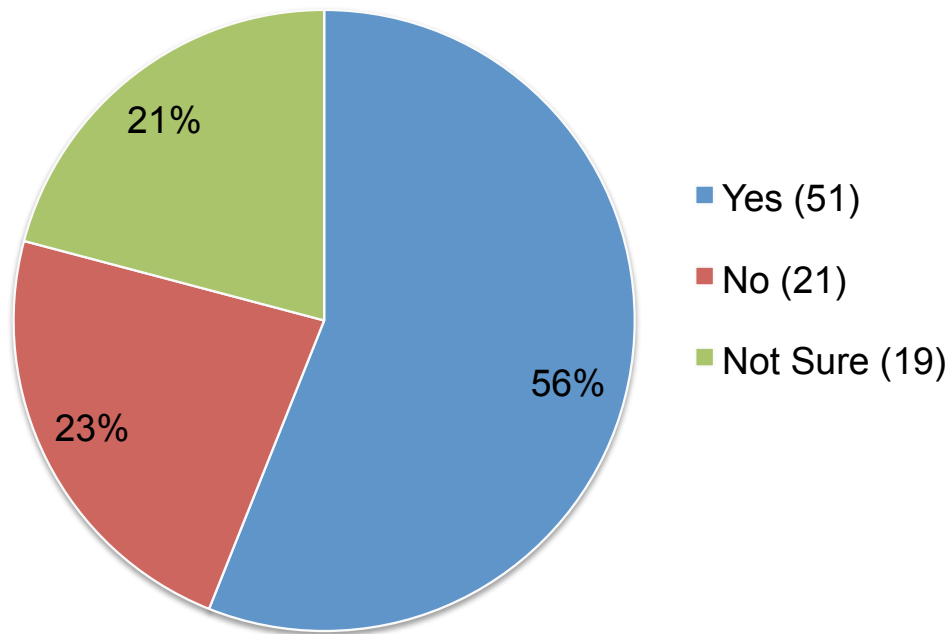
Systems Engineering Activities



Simulation & Analysis	Orbital, thermal, and structural	Hardware V&V	Environmental (thermal, vacuum, vibrate)
Reliability Analysis	FTA	Software V&V	Hardware & software in-the-loop
Requirements	AES9100 QA, ICDs, QA plans	Reviews	Working groups, subject matter experts
Documentation	Versioning, server system, and software	Other	No SE activities

Survey Results

- 91 respondents familiar with the “25-Year-Rule”
 - 56% of these respondents have procedures in place to satisfy the “25-Year-Rule”



Selected Procedures
Orbital simulations and analyses
Reports and documents to governing administration
Active deorbit devices
Passive deorbit devices
By design (consider area-to-mass ratio)
Rely on launch providers to put us in low orbit
Purchase/request launch to low perigee altitudes

- Further details to be published in Journal of Small Satellites

Conclusions and Future Work

- Survey results show a healthy continuous growth of containerized satellites
- Small satellite community acknowledge the debris issue and either have procedures in place or are developing procedures to be in compliance with the “25-Year-Rule”
- Statuses vary depending on mission assurance (i.e., systems engineering) activities and affiliation
- The small satellite community is capable of becoming/being responsible users of space

Conclusions and Future Work

- Observations from the study
 - Lack of survey responses leads to inconclusive assessments (e.g., mortality rates)
 - Some participants thought the survey asked proprietary information and refused to answer
- Future work
 - Disseminate results (paper to be submitted)
 - Work with NASA Orbital Debris Program Office to develop protocols and continue assessment of debris
 - Work with INCOSE SSWG to develop a CubeSat reference model utilizing MBSE
 - Further assess mission assurance (i.e., systems engineering) activities

Acknowledgement

- We would like to express sincere gratitude to:
 - All participants that responded to the survey
 - NASA ODPO for their guidance

- Contact information
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