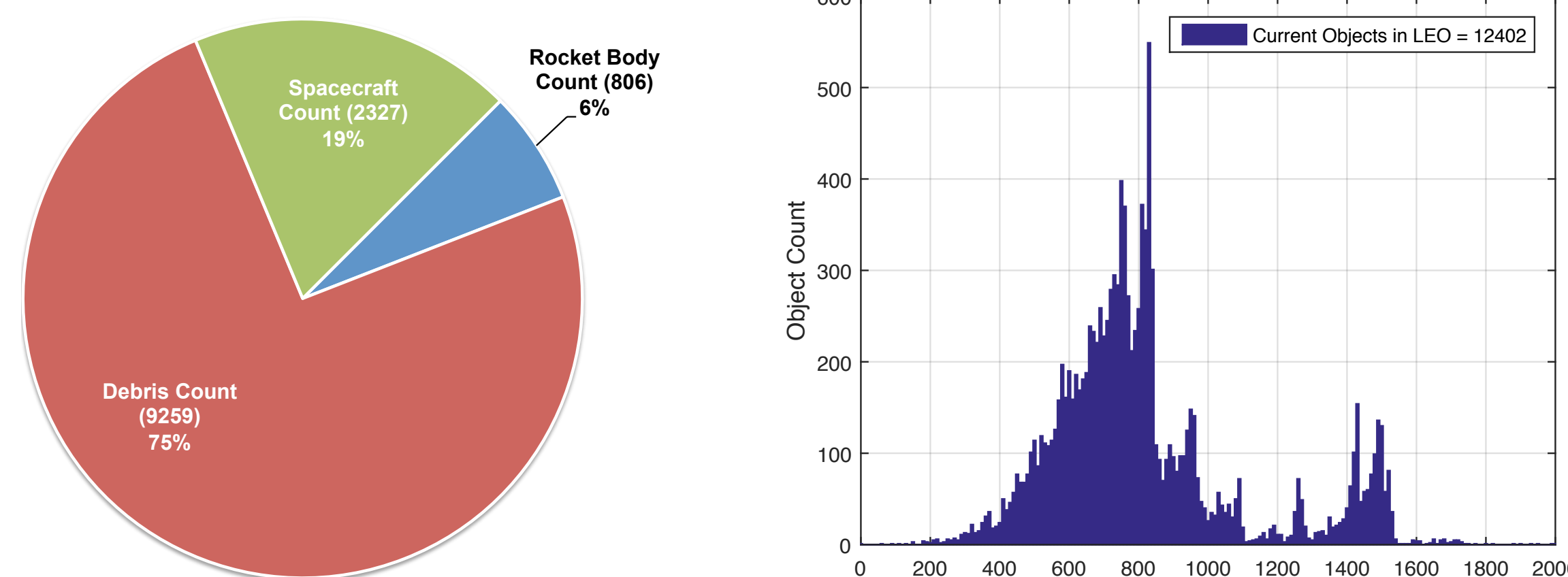


# A Survey of Systems Engineering Activities for Containerized Satellites – Preliminary Results

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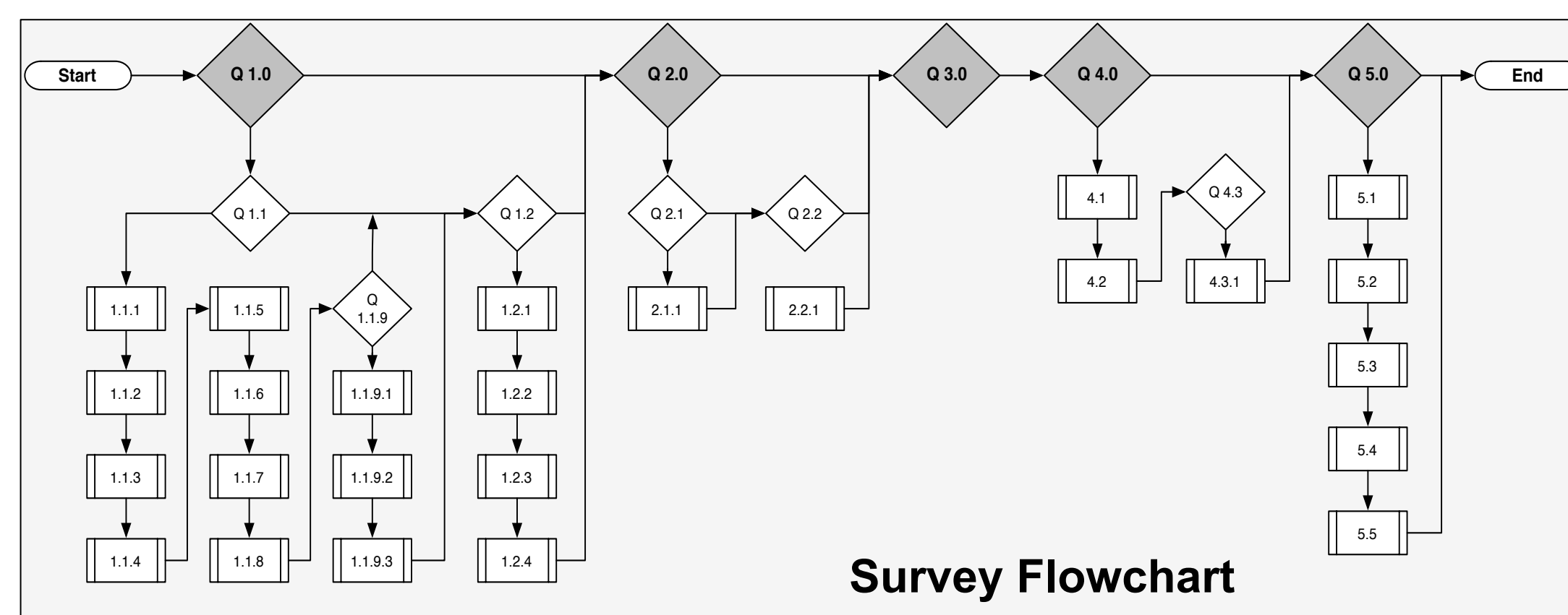
As of July 23<sup>rd</sup> 2015, a total of 40,742 space objects have been cataloged, the first of which was Sputnik. Currently, there are 17,446 cataloged space objects in orbit, 12,402 (71%) of which are in LEO. Three-quarters of the LEO objects are debris while only one in every five are active spacecraft. Space debris are all man-made objects including fragments and elements thereof, in Earth orbit that are non-functional.



Distribution of current objects in LEO

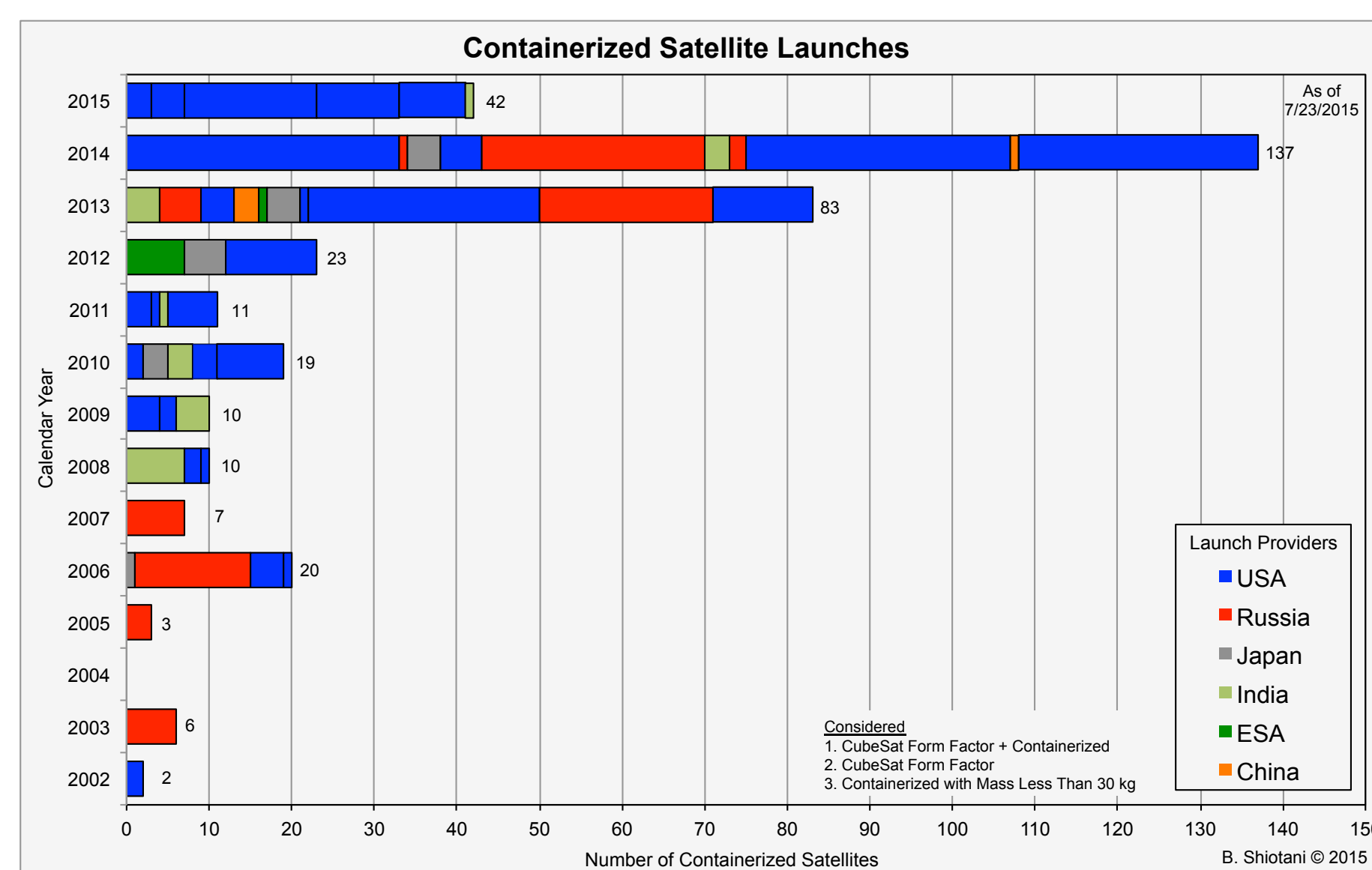
**Motivation:** In recent years, the interest in CubeSat-class satellites have surged worldwide, particularly due to the advancement of deployment containers which resulted in increased launch opportunities. However, there is a perception that these CubeSat-class satellites are contributing or will contribute to debris due to their smaller size, shorter mission lifetime, and being launched in swarms (i.e., multiple spacecraft in a single launch). While verification and validation procedures (i.e., systems engineering activities) may differ depending on the origin of the spacecraft, a systematic mission assurance approach is needed to ensure mission success. A survey was developed and disseminated to the small satellite community to assess the community's standard systems engineering activities.

**Survey:** The survey was organized into five sections: i) past and future launches, ii) "25-Year-Rule", iii) systems engineering activities, iv) COTS and in-house components, and v) voluntary questions. Survey was designed to ask questions regarding containerized satellites.



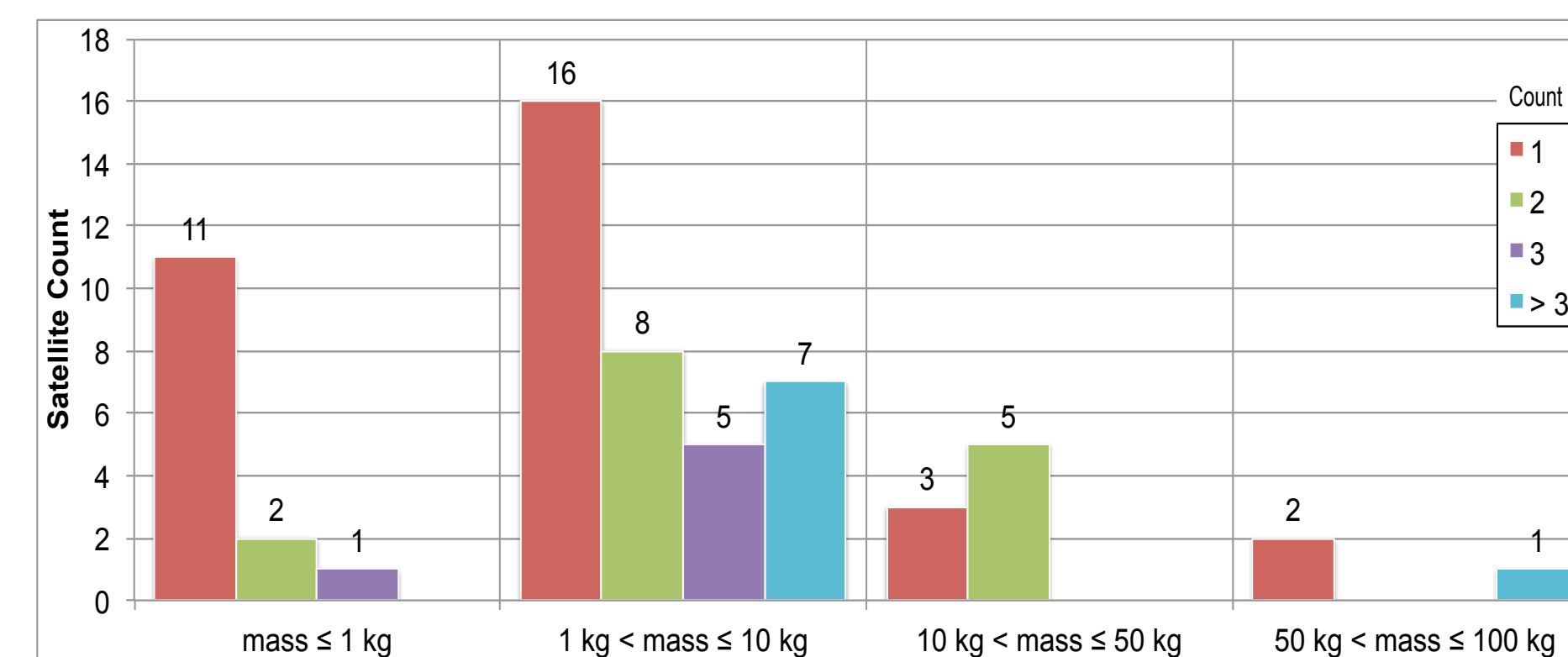
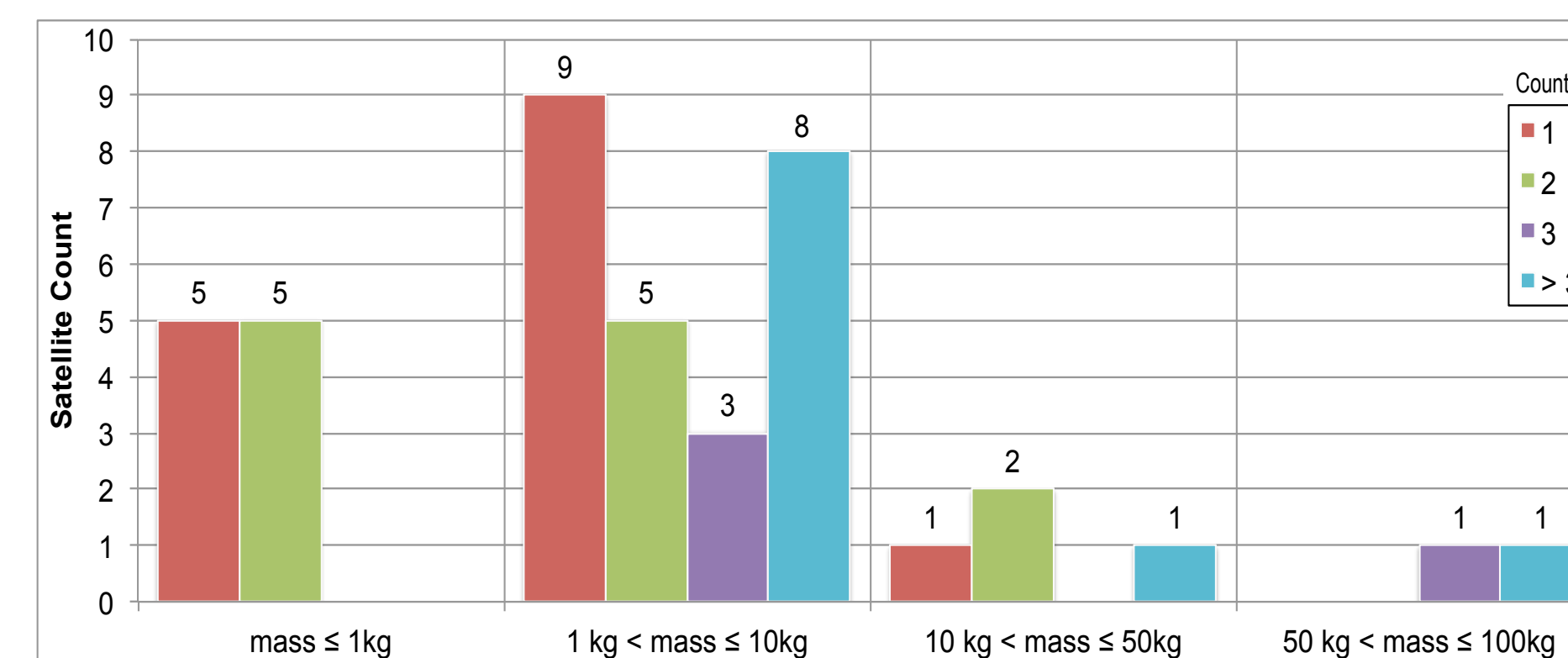
Survey Flowchart

A containerized satellite is any satellite that is enclosed in a container that interfaces the satellite to the launch vehicle. Such a container (e.g., P-POD, X-POD, ISIPOD, etc.) may contain one or more satellites and is designed to prevent harm to the launch vehicle (and other satellites) as well as deploy the containerized satellite(s) into orbit.

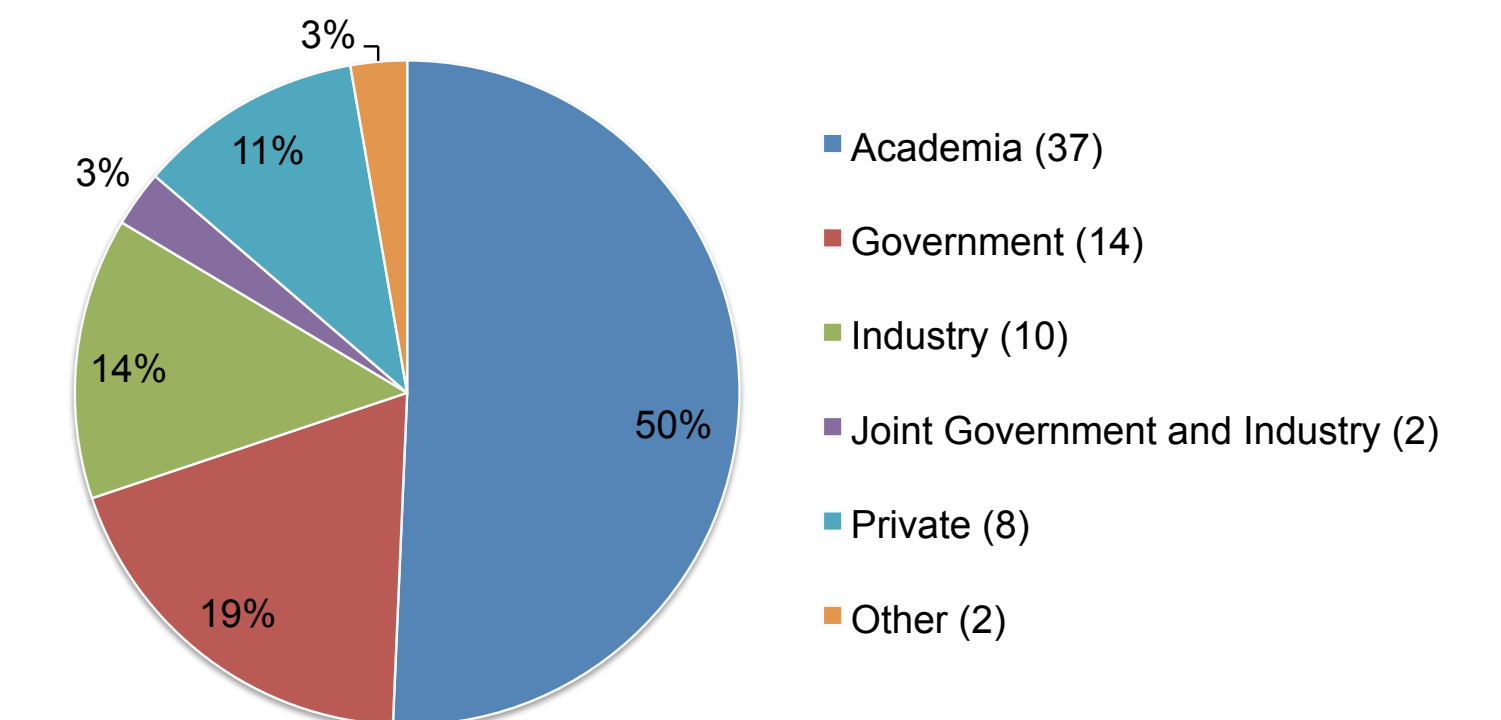


History of containerized satellite launches

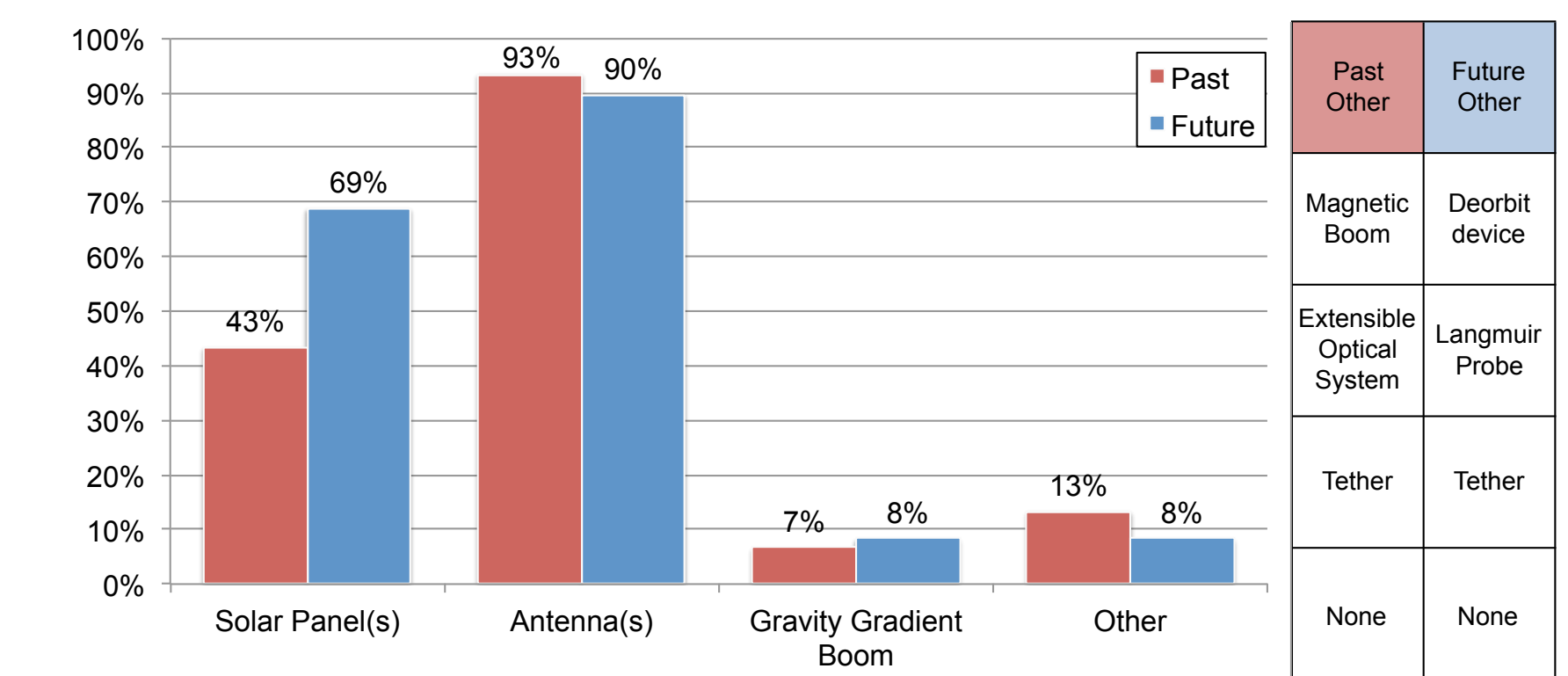
## Survey Results



Past (top) and future (bottom) masses

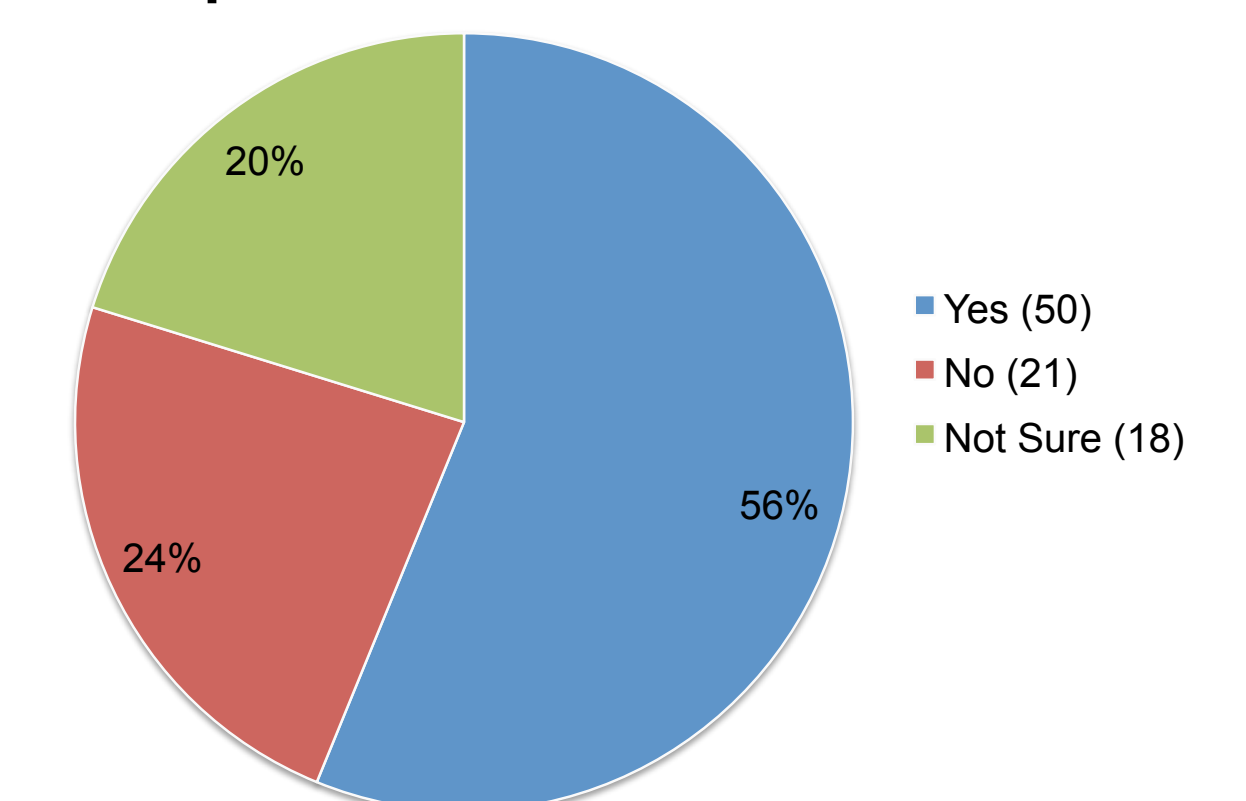


Participant affiliations



Past and future deployable appendages

Does your organization have procedure(s) in place to be in compliance with the "25-Year-Rule"?



### Summary

- Results from the past and future launches show a healthy continuous growth of containerized satellites including newer specifications (6U, 12U, and 27U).
- Organizations acknowledge the debris issue and either have procedures or are developing in place to be in compliance with the "25-Year-Rule."
- Mission assurance (i.e., systems engineering) activities and satellite statuses varies depending on affiliation.
- Significant number of organizations have performed hardware and software verification and validation, however, the number for simulations and analysis needs improvement.

Additional details of the survey will be published in the Journal of Small Satellites (JoSS).

### Acknowledgement

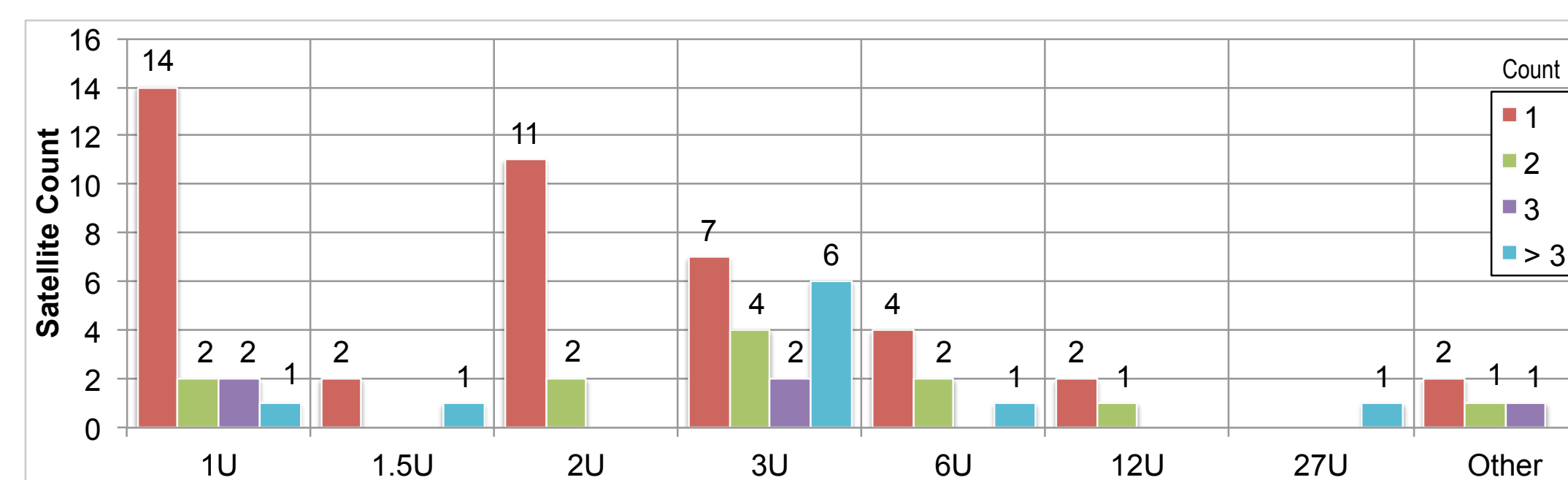
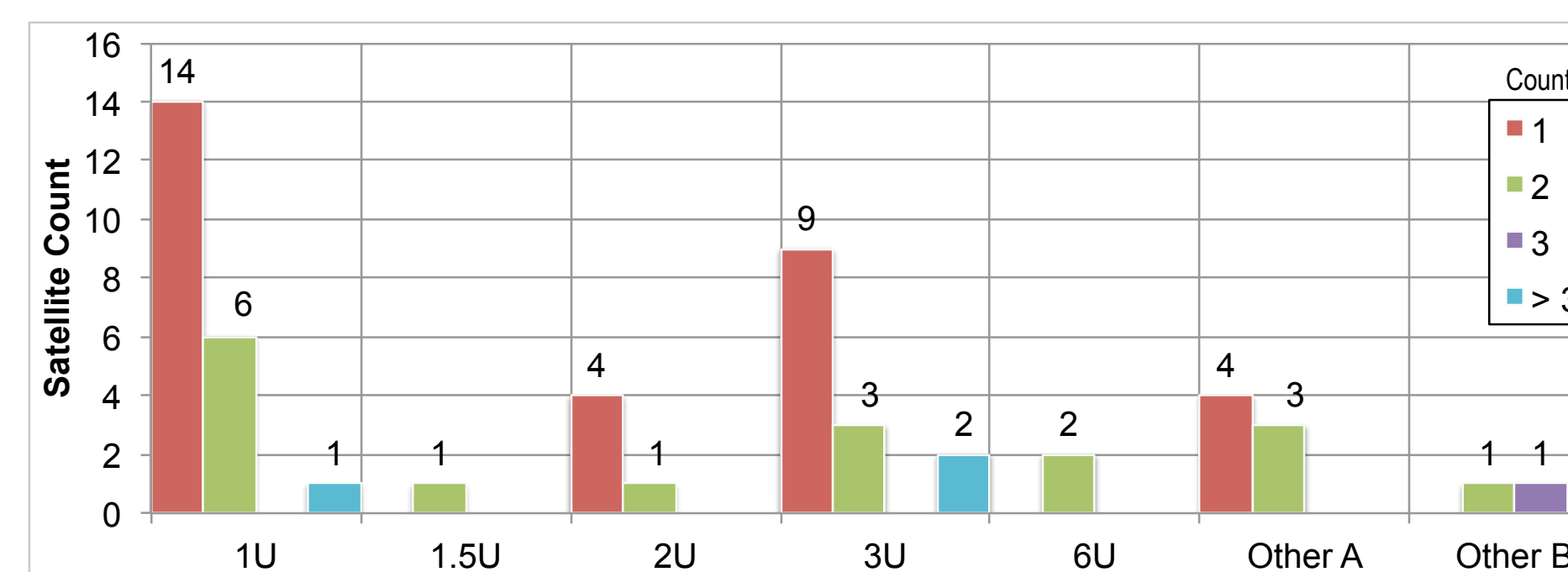
The authors would like to express their sincere thanks to all participants that provided input to this survey.

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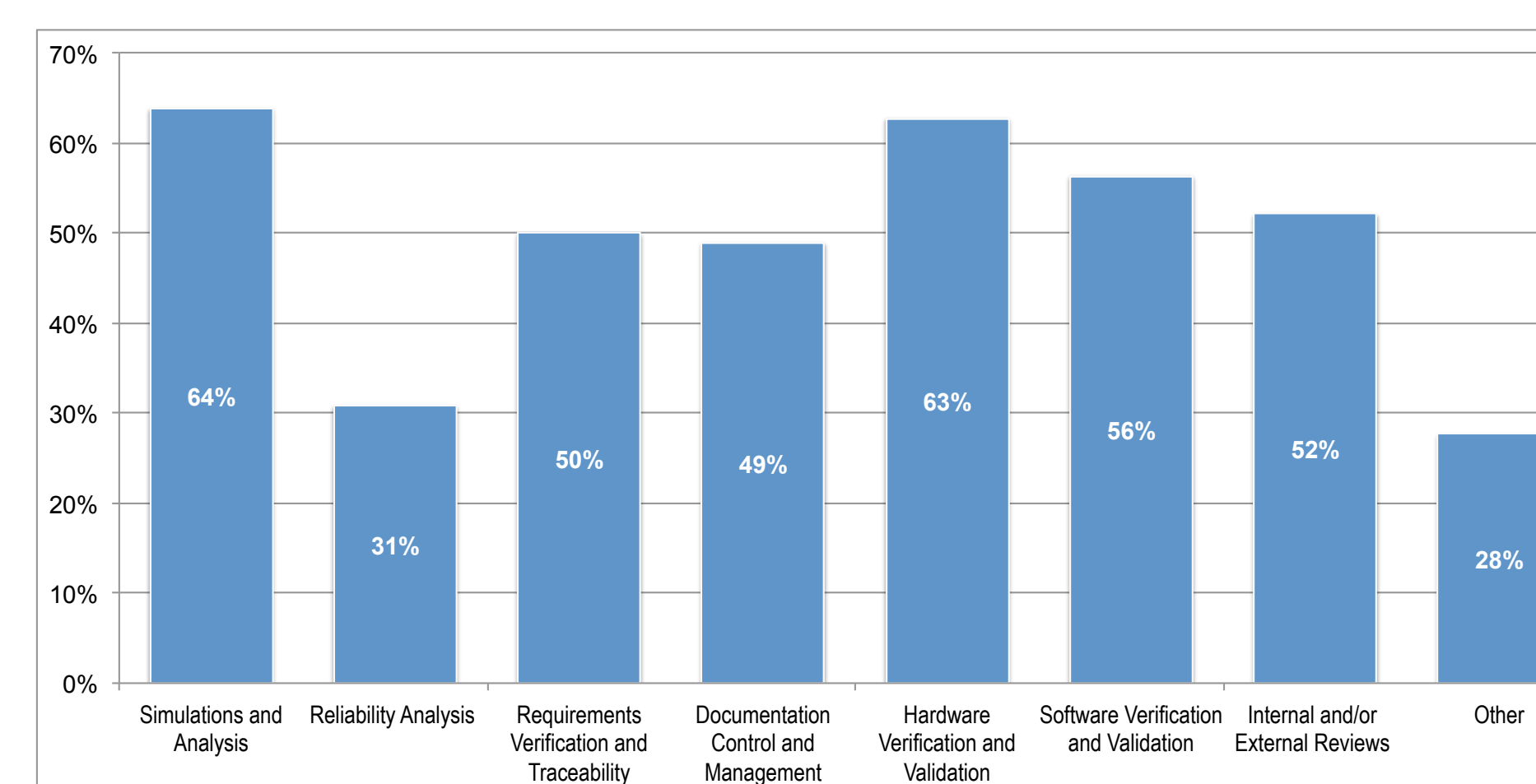
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Past (top) and future (bottom) containerized satellite sizes



Small satellite community's systems engineering activities