SPACE SYSTEMS SYMPOSIUM (D1)
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AUTOMATED DESIGN OF CUBESATS AND SMALL SPACECRAFTS

Abstract

The miniaturization of electronics, sensors and actuators has enabled the growing use of CubeSats and sub-20 kg spacecraft. Their reduced mass and volume has the potential to translate into significant reductions in required propellant and launch mass for interplanetary missions, earth observation and for astrophysics applications. However, their low mass, volume and low power typically mean reduced capabilities that prevent them for use in science-led missions. There is an important need to optimize the design of these spacecraft to better ascertain their maximal capabilities by finding optimized solution, where mass, volume and power is a premium.

Current spacecraft design methods require a team of experts, who use their engineering experience and judgement to develop a spacecraft design. The initial identification of candidate designs is based on individual judgement and is often limited to dozens of designs. There is typically no systematic approach to evaluate the whole design space that can meet the defined goals and satisfy the constraints. The principle limiting factor is the ability for a team to fully evaluate a candidate spacecraft design and quantitatively determine its strengths and limitations. Such an approach can miss innovative designs not thought of by the design team. In this work we present a compelling alternative approach that extends the capabilities of a spacecraft engineering design team to search for and identify near-optimal solutions that may not be thought of by the design team. The approach enables automated design of a spacecraft that requires specifying quantitative goals, requiring reaching a target location or operating at a predetermined orbit for a required time. Next a virtual warehouse of available components is specified that be selected to produce a candidate design. Candidate designs are produced using an artificial Darwinian approach, where fittest design survives and 'reproduce', while unfit individuals are culled off. Our past work in space robotic has produced systems that solve tasks superior to human designers.

Finding a near-optimal solution presents vast improvements over a solution obtained through engineering judgment and point design. Through this design approach, we evaluate a LEO- deployed 6U CubeSat that uses onboard propulsion to get into lunar orbit and carry a payload of science instruments. The approach identifies credible solution that will need further study to determine its implementation feasibility. The approach shows a credible pathway to identify and evaluate many more candidate designs than it would be otherwise possible with a human design team alone.