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Nanosats and Microsats in Deep Space – on track for exponential growth?

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In 2012 a small group at JPL started to meet to discuss the future of cubesat projects at the laboratory. At the time, we had a couple of low-cost cubesat projects in development – both were Earth orbiters whose primary aim was to demonstrate technologies for future Earth science missions. The "cubesat kitchen cabinet" as we half-humorously named ourselves, imagined a very different scenario, in which at least 10 deep space cubesats would be engaged in exploration of our solar system by 2020, with a 100 such spacecraft by 2030. All would be science-driven, or at the very least science-enabling.

So are we on track to achieve this projected exponential growth? With two INSPIRE spacecraft already built and flight-qualified at JPL, and two MARCO spacecraft being assembled in time to make the Insight launch opportunity in 2016, the answer is probably yes. This is affirmed by ongoing pre-phase A and Phase A studies for lunar exploration and asteroid rendezvous missions, and multiple concepts that have been proposed for deep space cubesats to NASA. The Europa Clipper project has 11 academic institutes under contract to study cubesats that would ride along with the main spacecraft to enable it to touch the surface of Jupiter's most intriguing moon. ESA's recent announcement that its AIM asteroid probe will carry a small number of cubesats when it launches in 2020 reinforces the projection. There's actually some reason to think we underestimated the 2020 number.

So what will it take to realize the projected growth in the decade that follows? The simplest step towards realizing this future is if all space agencies engaged in planetary exploration agreed to allocate real estate and mass for one or more cubesats, nanosats or microsats as ride-along payloads on each of their future medium- to flagship-class planetary missions. Another significant development is the advent of low-cost launch capabilities that can throw a nanosat or microsat on an Earth escape trajectory with a reasonable C3, so the spacecraft can make its own way to its destination. Next on the list are Micro-Electric Propulsion (MEP) units which can deliver up to 2 km/s of Delta-V. Communications standards and navigation approaches follow. Next are instruments that fit within volumes ranging from 1U to 4U. Currently we can field simple cameras, magnetometers, mm-wave radiometers, and of course radio science. In the very near future we expect to see: insitu instruments such as mass spectrometers; optical/NIR spectrometers; and even short wavelength radars demonstrated in Earth orbit. Self-assembling telescopes in which multiple cubesats combine to form a larger aperture are within reach. Bandwidth of course is limited so onboard data processing/reduction has also been emphasized.

This paper will provide an overview of the cubesat kitchen cabinet's view of deep space cubesats, and describe how we formulate science-driven cubesat/nanosat investigations within the Innovation Foundry at JPL.

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