

A 200 Year CubeSat That Sings With Trees. S. E. Matousek¹, A. Babuscia¹, J. Christensen², A. Freeman¹, R. W. Klemm¹, and J. Lai-Norling¹. ¹ Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, United States, ² Oberlin College, Oberlin, OH, United States Contact: steve.matousek@jpl.nasa.gov.

Introduction: During the coming decades of robotic space exploration it is very likely that humans will be able to send a probe on an interstellar mission to a nearby solar system. To accomplish this feat, it will be necessary to learn how to reliably make small space systems that last for decades. One way to make near-term progress is to build and launch one or more CubeSats that are designed to last 200 years. The 200-year CubeSat is part of a system designed to merge science, engineering, design, and art. The 200 year CubeSat could communicate with trees properly equipped with sensors and an antenna. Trees routinely live over 200 years. Tree measurements recorded over long periods of time tell a story. If sonified, the tree measurements sound like a song. The CubeSat environment in Earth orbit can also be measured and sonified. Transmitted back-and-forth between the tree and CubeSat, this song is a demonstration of the type of longevity, design, and creativity required for an interstellar probe mission.

200 Year CubeSat: For a CubeSat to last 200 years several basic principles hold. 1) Keep the CubeSat as simple as possible. 2) Operate the CubeSat as little as possible per day while still maintaining periodic contact with one or more trees. 3) Maximize the outer surface area and minimize the mass.

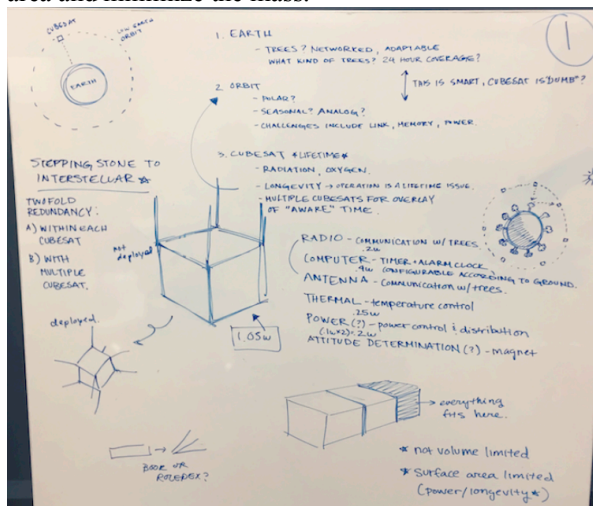


Fig. 1: Notional layout of the 200-year CubeSat

1) *Keep the CubeSat as simple as possible.* Simple systems have less ways to fail. Eliminating attitude control and propulsion means those subsystems won't fail. If the greater external surface area is populated by more solar cells than needed, than the

CubeSat can tolerate 35% - 50% degradation over 200 years. Operation only while in sunlight means no batteries are required. Placing the CubeSat in a 1000 km altitude orbit ensures that both radiation and drag are minimized. A low power UHF telecommunications subsystem communicates with the tree. Command and data handling are accomplished by one or two on-board simple processors that operate as little as possible. As little as one hour of operation every 24 hours seems feasible. Thermal control is passive with large surface areas.

2) *Operate the CubeSat as little as possible per day while still maintaining periodic contact with one or more trees.* From the 1000 km altitude orbit the CubeSat passes over one or more trees per day. Simple timing or "ping" based operations give sufficient communication opportunities while keeping the operating time to a minimum. Thick aluminum shielding minimizes electronics radiation exposure. Note that a 2 to 3 year accelerated ground test could prove out the concept and aid the design process for the flight of a 200-year CubeSat.

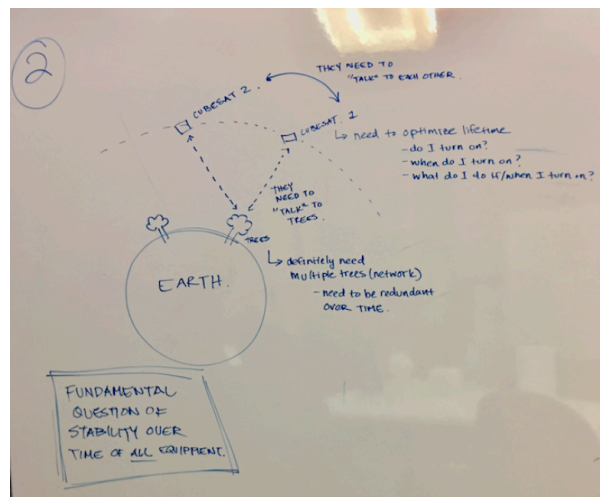


Fig. 2: Notional 200-year CubeSat 1000 km altitude orbit and tree communication (not to scale).

3) *Maximize the outer surface area and minimize the mass.* Unlike most CubeSats, the 200-year CubeSat has a large "cube," likely at least 1 m³, populated only with 2 - 3 U of simple redundant electronics.

This low mass to surface area keeps things simple and helps design for longevity.

The 200 Year CubeSat could be designed and flown within a few years. This part of the tree – CubeSat communication “song” is a step towards the larger goal of an interstellar probe. The 200-year CubeSat can and should be launched. Learning how to create longevity while exercising science, engineering, design, and art will yield benefits beyond what any of us can imagine.

Acknowledgements: This work is conducted at the Jet Propulsion Laboratory, California Institute of Technology, under contract to NASA. Government sponsorship acknowledged. The information presented about this mission concept is pre-decisional and is provided for planning and discussion purposes only.