DRONE-BASED PATHFINDER FOR SPACE-BASED INTERFEROMETRY

Prachet Jain [1], John D. Monnier [1], 1: University of Michigan

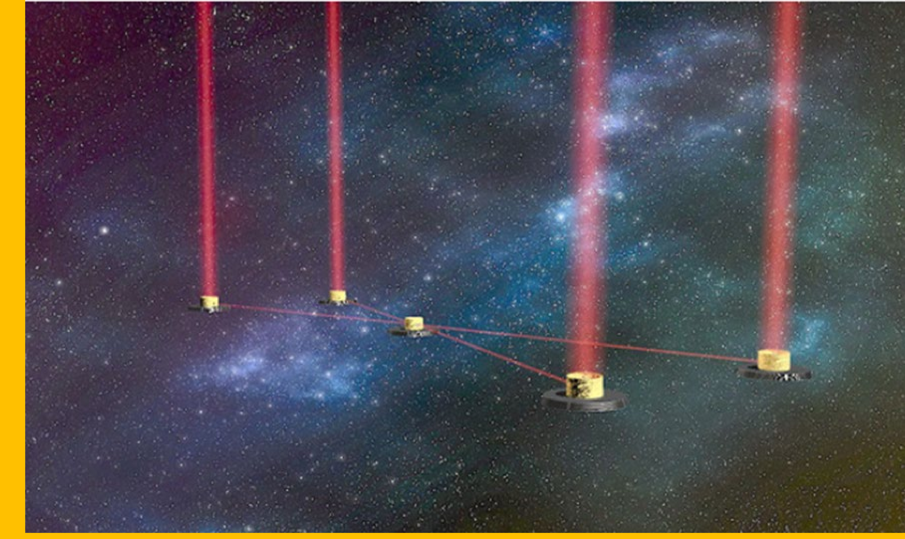


Illustration of a space-based interferometer (LIFE mission)

INTRODUCTION

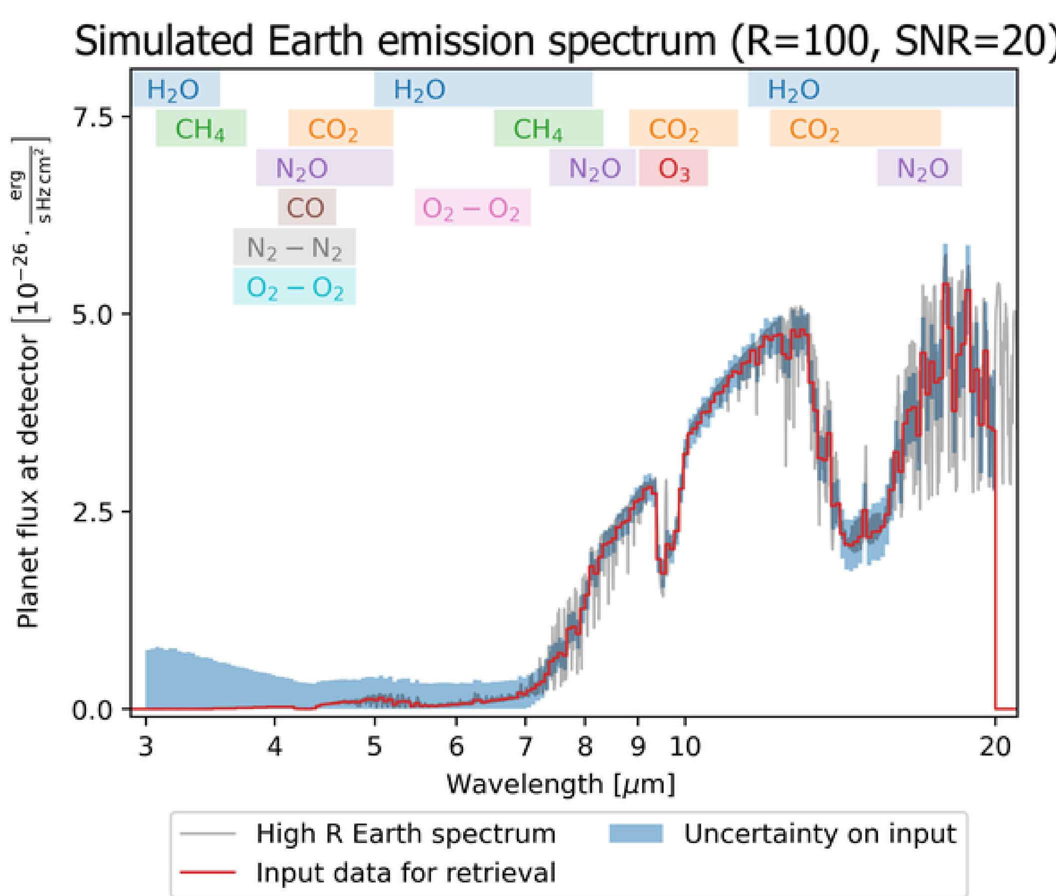
Conventional ground-based interferometer arrays are hindered by atmospheric disturbances and telescope thermal emissions. Additionally, the lack of reconfigurable baselines limits angular resolutions to certain ranges. A suitable alternative to a conventional ground-based interferometer array would be a space-based array of formation-flying satellites, free of atmospheric turbulence and reconfigurable to adjust baselines for any required angular resolution.

We propose developing a technology demonstrator for such a space-based array, utilizing two smallSats to demonstrate various key technologies for a larger concept. Currently, an optical testbed is being developed to be used on a drone to demonstrate actively-controlled light acquisition mechanisms on a moving platform. Additionally, we continue to explore initial mission architecture design choices.

MOTIVATION

A space-based interferometer would revolutionize the search for habitable exoplanets. Earth-like exoplanets emit the bulk of their energy in the mid-infrared range, which also happens to be the part of the spectrum filled with signatures of "biomarker" molecules such as water, methane, and ozone among others.

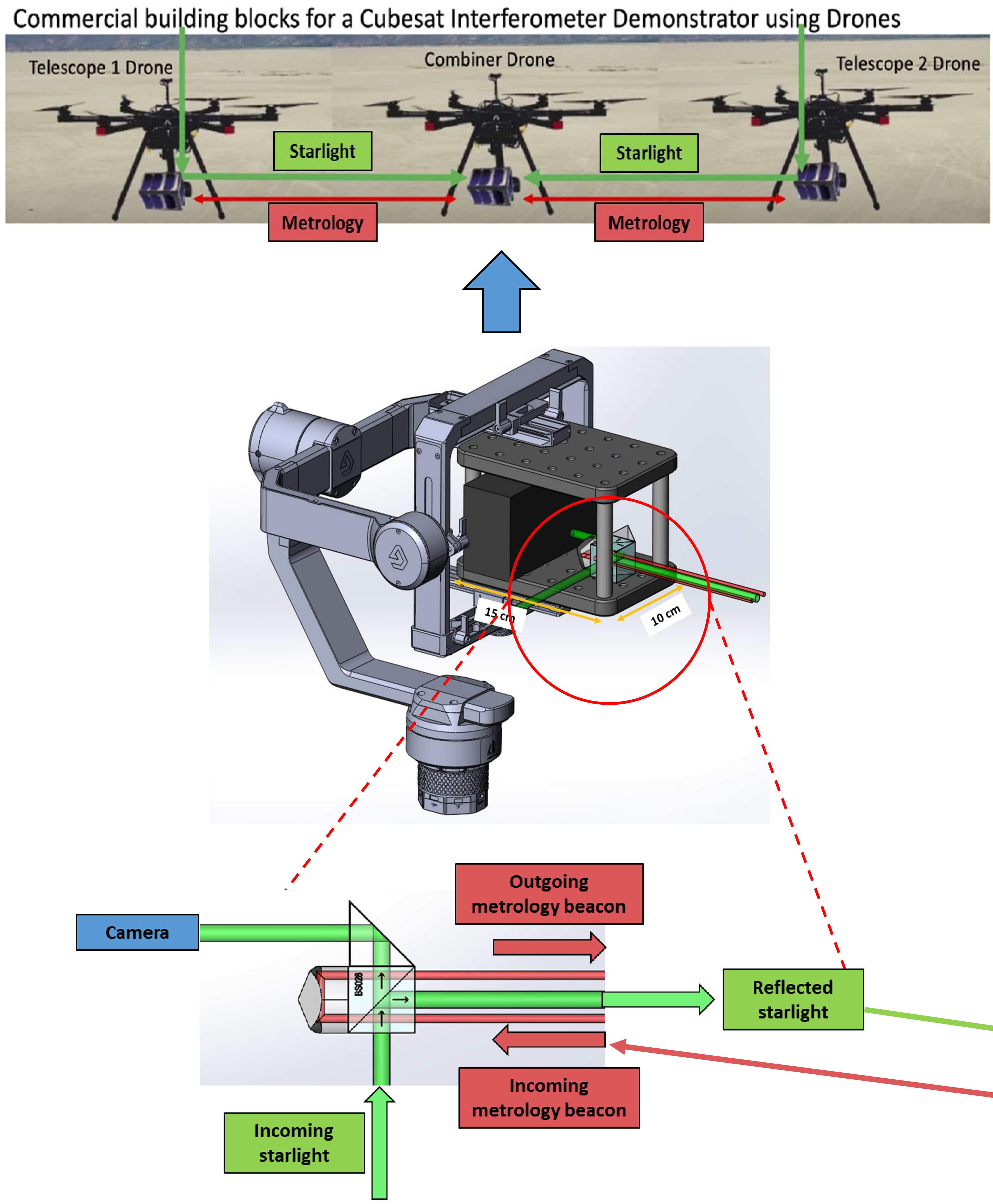
Interferometric capabilities in space would be able to make fundamental discoveries in a wide range of areas. Planetary formation disks can be better understood to discover a wide array of planetary systems. Alongside this, the recycling of carbon and other elements from stars into the interstellar medium and subsequently into forming planets can be studied. Galactic nuclei, black hole accretion disks and galactic evolution can all be studied through this approach as well.



Absorption spectra of key biomarkers such as H_2O and CO_2

CURRENT WORK & SCIENCE GOALS

Currently under development is an optical testbed that substitutes satellites for drones. The drone platform is intended to provide a similar environment to a satellite to test actively-controlled light acquisition and reflection mechanisms. Successful testing of the optical platform will prompt further development work on these mechanisms, including work on controlling optical path lengths through fine-tuned optical platforms.



CAD mock-up of the first iteration of the drone-based optical platform. A beamsplitter, prism and retroreflector form the basis of a passively-controlled reflection mechanism mounted on a gimbal, with work underway for the addition of active-control functionality.

FUTURE WORK

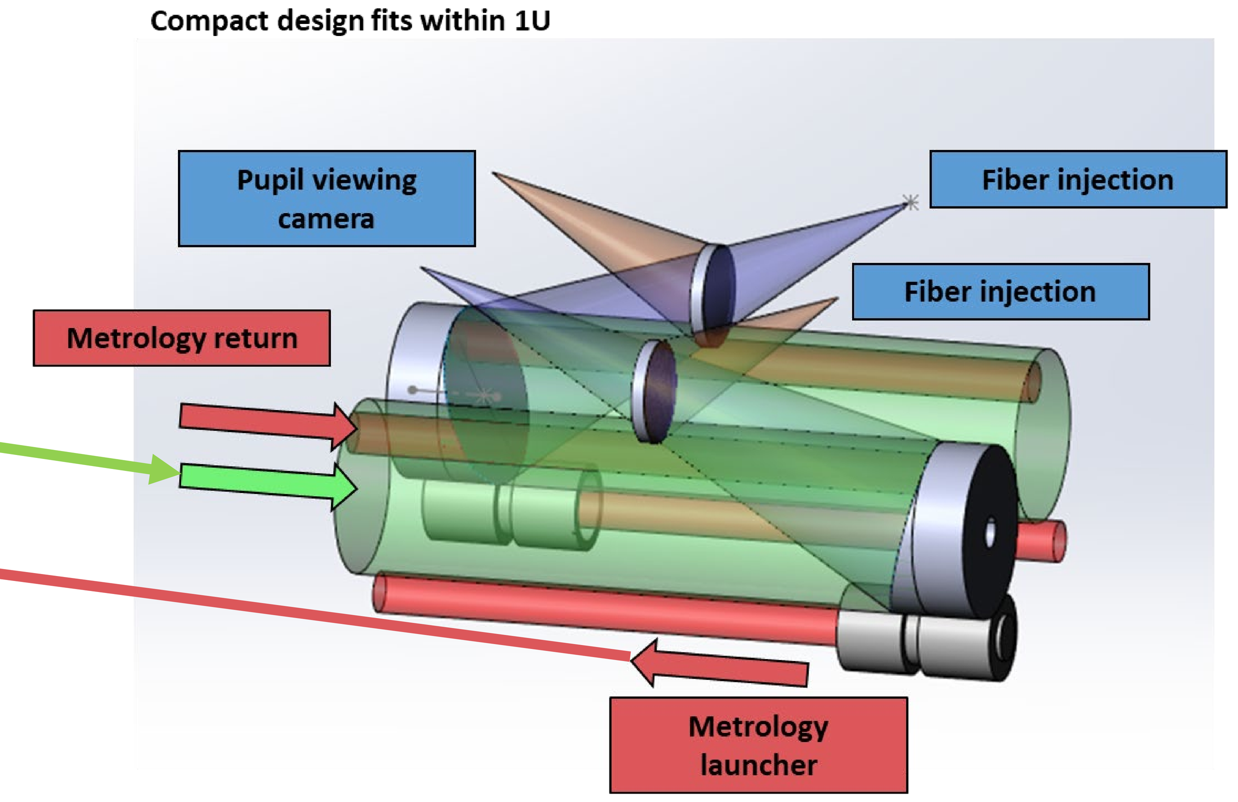
The two-satellite technology demonstrator mission will demonstrate concepts such as reflection of starlight from one satellite to another, inter-satellite metrology, and the ability to "re-form" the geometry of the formation to acquire new stars, which are crucial elements of any potential space-based interferometer. The project will include the development of analogous ground-based metrology, communications and optical systems, which will then be miniaturized for use in cubeSats.

This concept will be developed over the course of two years in a collaboration with the College of Engineering and the Aerospace Department.

CONCLUSIONS

The aim of this research project is to develop a technology demonstrator for a space-based formation-flying interferometer. Such an interferometer would improve the search for habitable exoplanets, which emit the bulk of their energy in the mid-IR wavelength range. Currently, a drone-based optical platform is being developed to simulate the dynamic environment of a satellite in order to fine-tune actively-controlled optical systems. Successful testing of the drone-based platform will lead to further development of optical systems suitable for integration into cubeSats. A two-cubeSat mission will demonstrate concepts such as starlight acquisition and reflection, inter-satellite metrology, and reformation of geometry.

Beam injection and Metrology
Compact design fits within 1U



Proposed designs for the Metrology unit for a cubeSat platform

REFERENCES

Monnier, J. D., "A Realistic Roadmap to Formation Flying Space Interferometry". 2019.

Quanz, S. P., "Large Interferometer For Exoplanets (LIFE)…". 2021. (https://www.life-space-mission.com/)