Maximizing the Life and Utility of SmallSats in LEO
Using a Network of Robotic Space Stations

Thanks to rapid miniaturization in electronics, sensors, actuators and power systems, we have seen the birth of the smallsat technology revolution. This has led to the explosion of low-cost science and technology missions previously thought impossible. However, some major limitations exist within this paradigm, due to shortened lifetimes of the missions. This results in material waste, waste of launch spots and slower technology development cadence. Most CubeSat missions deployed in LEO only have an operational lifespan of one year or less, as they often do not carry enough propellant to revive their decaying orbits. Imagine the possibilities if these platforms could be retrieved and reused! Persistent platforms may be a solution to this problem. Persistent platforms are robotic spacecraft that are intended for longer missions, are autonomously assembled in space, and receive modular payloads. They will maintain their LEO orbit thanks to onboard propulsion and a regular refueling schedule. This reduces the economic costs of constant launches, enabling a “pay as you go” scheme. The modular payloads offer an interesting approach. If the payloads were smallsats and acted as modular components for the platform, these platforms could be serviced in space and change their objective and science instruments at a moment’s notice. In particular, the addition of payload spacecraft allows for persistent platforms to form an on-orbit virtual railway, where cargo and components can be exchanged. This leads to the concept of the on-orbit railway, with each of the persistent platforms acting as stations. This paper will examine the robustness of this concept in regard to damage mitigation. How does the system respond when several components become damaged over time and need to be replaced? Is there a state where the virtual railway system is unable to function, as too many components are in orbit? Is there an optimal cadence in transferring the component spacecraft? These questions will be examined with a series of experiments. A simulation will be created to examine the scenario at a larger scale, utilizing object-oriented programming to update the health of the station. This will be paired with a lower-fidelity physical model of the on-orbit railway.

Links for further research:

- https://arc.aiaa.org/doi/10.2514/6.2022-2518
- https://arc.aiaa.org/doi/abs/10.2514/6.2022-2464