FY23 Strategic University Research Partnership (SURP)

Applying Disruption Tolerant Network (DTN) Standard to Flight Projects

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OBJECTIVES/APPROACH: The primary objective is to enable Delay Tolerant Networking (DTN) as a communication protocol for future missions. We leveraged the flight-proven, open-source F Prime Flight Software Product Line and the Interplanetary Overlay Network (ION) software implementation of DTN to demonstrate a reference application for future missions that execute flight-like DTN capabilities. Our multi-year phased effort begins with a concept study, followed by a 2-node prototype in year 2, and a final multi-hop end-to-end DTN networking demonstration in year 3.

RESULTS IN FY23: At the University of Michigan, students in the **CubeSat Flight Lab (CFL)** are developing a multi-node, stratospheric testbed (Figure 1) with balloons. A portable ground station node, shown in Figure 2, provides UHF and S-Band communication links to the balloons. Figure 4 shows an upgraded mobile tracking station with dual dish tracking (multi-band), internet connectivity with a mobile Starlink node, and solar-based power. Lastly, Figure 5 provides a summary concept of operations showing a single flight node communicating with a mobile chase car.

During the summer of 2023, we developed a prototype F'-based data collection and command capabilities on our stratospheric testbed Raspberry Pi flight nodes and Linux-based ground simulators. Additional F' support tools such as **U Prime** (the U standing for "Utilities") were developed to provide command-line utilities that enhance the development experience for an F Prime project. We also developed **cmdGen** (read "command gen"), a standalone tool for generating command packets by operators on the ground that offers 1) rapid prototyping of commands under one component, 2) custom data types within the built packet, 3) instant framing of the packet to MXL's format for transportability to other internal software. In 2024, we will begin the installation of the ION-enabled F' into the testbed and map our mission concepts to the testbed.

Benefit to NASA/JPL: DTN enables new inter-networking methods for advanced missions. Demonstrating DTN-enabled F Prime in a mission prototype will rapidly accelerate mission adoption, enable mission design/formulation activities incorporating DTN capabilities, and make JPL mission proposals more competitive with expanded interoperability and multi-mission collaborations with other space assets.

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Figure 1 – The Fall 2022 class in the CubeSat Flight Lab with four stratospheric test beds ready for flight. [**left**] A testbed node takes flight. [**right**]

Figure 3. An **upgraded mobile ground station** with internet connectivity. Two dishes on the right track and provide multi band connections. A solar panel system in the middle provides up to 200 W average power. On the left, a StarLink system is mounted in the black Pelican case, providing internet connectivity.

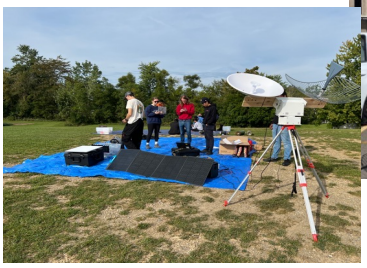
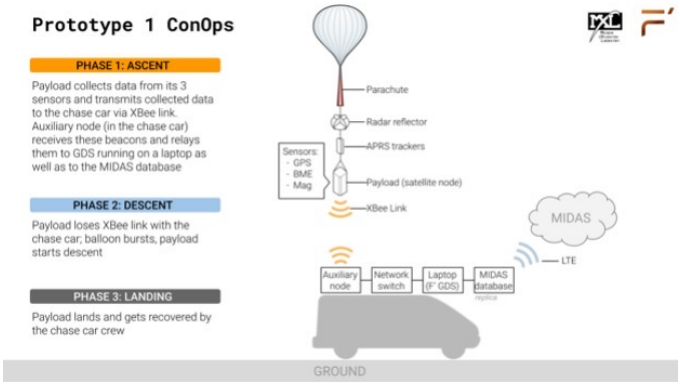


Figure 2 – A portable S-Band and VHF communication ground station.

Figure 5 – A concept of operations diagram a single flight node communicating with a mobile chase node.



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