**Development of an automated decision support system for space missions operating in harsh and uncertain environments.**

Future NASA space exploration missions, both manned and unmanned, will often operate in harsh, dangerous, and uncertain environments. Adding to the challenges, communication delays may make it difficult to rely on Earth-based controllers and engineering analysis teams for operational support. System Health Enabled Real-time Planning Advisor (SHERPA) is an automated decision support system being developed to provide optimized real-time action recommendations for such missions. SHERPA is adaptable to different mission types and use cases within missions (such as planetary rover traverse planning or lander science activity sequencing). It is based on the latest methods in the field of decision making under uncertainty, in particular making use of advanced solvers for partially observable Markov decision processes. Under the proposed research opportunity, students will extend SHERPA’s current capabilities. Examples of specific projects include (but not limited to): (1) development of additional use cases (such as mission design optimization, vehicle design optimization, or landing site selection); (2) development of methods for automated result explanation; (3) development of methods for real-time model learning and/or refinement; (4) development of multi-agent and decentralized solution approaches. Students attending academic institutions in the SF area are preferred.

1. Autonomous Maneuvering for On-Orbit Servicing
   1. Every year, hundreds of satellites are decommissioned due to end-of-life, orbital debris impact, faulty subsystems, radiation damage, or solar panel degradation. As the cost of launch continues to decrease and on-orbit manufacturing continues to improve, significant opportunity exists to repair these satellites rather than replace them. NASA missions like Restore-L and DARPA missions like (whatever their one was that SSL pulled out of) will evaluate the technical validity of on-orbit servicing, but more work is required to enable the autonomous work being done by the service satellite. Due to either large time delays or line-of-sight concerns, autonomous servicing is a necessary requirement for these missions, where the satellite must constantly monitor and control its location and attitude under changing mass and inertial conditions. SHERPA presents a solution to this problem, allowing the servicing satellite to optimize its maneuvers under sever uncertainty to changing dynamics.
2. Autonomous Orbital Debris Guidance and Control
   1. The U.S. Space Surveillance Network is currently tracking more than 22,000 objects larger than about 10 centimeters (cm). Additional optical and radar data indicate that there are approximately 500,000 pieces of debris larger than 1 cm, and more than 100 million pieces of debris larger than 1 millimeter (mm) in the environment. Lack of direct sunlight and line-of-sight for communication create an environment populated with unknowns for any orbital debris mission. Based on incomplete or inaccurate debris characterization, orbital debris satellites will need to autonomously characterize and interact with prospective space objects without knowledge of their density, inertial characteristics, or total size. In order to ensure stable attitude control systems and orbit control, the SHERPA program can be used to assist satellite mating and interaction with debris.
3. Interplanetary Autonomous Small Satellite Control
   1. As displayed by the (Mars cubesats I forget what they’re name is exactly), small satellite technology has distinct applications to planetary science and exploration. At a fraction of the cost and enhanced flexibility, small satellites show the potential to enable science missions with reduced timelines and specific purposes, providing scientific dividends much faster with less impact to budgetary planning. When navigating deep space, satellites cannot rely on Earth-based commands to operate in dynamic environments, but small satellites often do not have the size or power to enable the traditional autonomy of high-class robotic exploration missions. Novel approaches to autonomy are needed to facilitate small satellite exploration in the face of unknown magnetic fields, solar irradiance, and other perturbations.