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Using Flexible Execution, Replanning, and Model Parameter Updates to Address Environmental Uncertainty for a Planetary Lander

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Planning for unknown environments presents a number of technical challenges. The planner must ensure robustness to unknown phenomena and manage unpredictable variation in execution, all while operating in a capacity that maximizes its objective. Productivity in the face of these challenges requires an integrated approach to planning and execution that is capable of accomplishing goals, reacting to variation, and maximizing overall utility. We examine this problem in the context of a Europa Lander concept mission. We model the problem as a hierarchical task network, framing it as a utility maximization problem constrained on a depletable energy resource. We propose a planning and execution framework that responds to feedback using three techniques: (1) flexible execution, (2) periodic replanning, and (3) online model parameter and utility updates. The efficacy of each of these techniques is examined through simulation of a Europa Lander concept mission, showing higher utility achievement compared to baseline approaches. We demonstrate that an integrated approach to planning and execution that is grounded in replanning, utility maximization, and model parameter updates will be an enabling technology for future tightly-constrained planetary surface missions.