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PLEXNET - A DISTRIBUTED, VARIABLE-AUTONOMY ARCHITECTURE FOR EXPLORATION OF PLANETARY BODIES

Abstract

While accelerating advancements in launch systems, spacecraft, and artificial intelligence have opened up new opportunities to explore planetary bodies like Mars, Titan, and Europa, mission architectures are still usually restricted to single orbiters or landers with limited scope and little resilience. To expand this opportunity envelope, PLEXNet (PLanetary EXploration Network), a system-of-systems architecture that distributes functions of a single monolithic vehicle across a network of specialized vehicles, could be used in future exploration missions.

In PLEXNet, squads of specialized, variable-autonomy vehicles would be deployed on a planetary body like Titan in conjunction with other squads. These vehicles could include surface and air vehicles and would work alongside a separate squad of power and communications support vehicles. Mission directives sent to PLEXNet would adjust mission goals, but squads would be self-organizing, independently managing and handling tactical functions like path planning, hazard avoidance, power management, and vehicle reallocation. PLEXNet's mobility and scalability would allow it to gradually traverse the planetary body with as many as hundreds of vehicles, potentially exploring large regions of planetary body in a faster and more robust manner than contemporary monolithic systems. Combined with reduced vehicle complexity and decreasing launch and hardware costs, PLEXNet could become financially feasible as commercialization of space progresses.

To study the efficacy of PLEXNet, an agent based model has been developed to simulate asset behavior as they explore a region similar to Titan, with geologically diverse features and uneven distribution of target resources. Vehicle agents are defined by movement class, target research and protocols dictating interactions with other agents and the environment. Support vehicles are also defined by charging and transmission rates, limiting the number of docked assets at any given time. Launch mass is used to limit the number of vehicles deployed in a single landing event. A science point system is used to determine total science output, where certain locations would have an associated point value corresponding to each type of vehicle. Deployment sequence and agent interactions were varied to examine their effects on total science output per unit cost.