Prioritized Technology: System Autonomy – Autonomous Planetary Exploration

Technical Goal ("Fire and Forget")

- Develop key technical capabilities that will enable a robotic spacecraft to reach, orbit, map, and explore a range of planetary bodies (solar system and beyond). Achieve autonomous:
    - Trajectory correction maneuvers
    - Approach, orbit insertion, mapping
    - EDL, DDL, probe delivery
    - Atmospheric and sub-surface sampling
    - Mobility (aerial, deep sub-surface, …), Reactive Science
    - Coordination and collaboration

Major challenges:

- Ground-in-the-loop control results in delayed responses based on stale knowledge of spacecraft and environment, in particular when dynamic changes occur. Scalability. V&V.

Technology advances:

- **Situational/self awareness:** sensing, perception, state estimation, knowledge and model building, anomaly/event detection
- **Reasoning/acting:** goal-based planning, task execution, system health management

Mission Applications

- **New Science:** access hard-to-reach destinations (exploring comet and asteroid surfaces, sampling of Enceladus' plumes, exploring lunar pits, and visiting an exoplanetary system)
- **More Science:** increase science yield (diversity, quality and quantity) of samples from planetary bodies, efficiently identify and access science targets on or below planetary surfaces
- **Guaranteed Science:** enable robust exploration of harsh environments in the presence of spacecraft degradation (Venus) or unknown environment (Europa, Enceladus)
- **Cost-effective Science:** affordable missions to outer planets (Uranus, Neptune, Pluto), efficient operations on planetary surfaces, multi-spacecraft missions (assuming advances in propulsion and avionics that lead to smaller crafts)

Technical Status

- Heavy reliance on ground for all decisions: navigation, approach, mapping, probe delivery, and sampling. Ground-based coordination among spacecraft. Information sharing via ground operations.
- Low-efficiency operations when exploring new destinations (e.g. Mars surface)
- Autonomous capabilities are sequenced (static, point solutions)
- Pockets of technical capabilities demonstrated on terrestrial prototypes: single-sol autonomous rover sampling (TRL 5), long-range mobility, and autonomous science (TRL 5)

Development Cost and Schedule