National Aeronautics and Space Administration

Resilient Autonomous Flight System Control

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Program: FY22 R&TD Strategic Initiative
Strategic Focus Area: Intrinsic Autonomy - Resilient Flight System Control - Strategic Initiative
Leader: John C Day

Objectives

To develop **multi-mission foundational control structures** for **reasoning about cross-domain uncertainties for core survival functions under adverse conditions**: coupled thermal, power, and communication constraints under large positional and attitude uncertainties due to external (environmental) and internal factors (spacecraft degradation). The objectives for FY22 are:

1. Understand the autonomy-pull in the recently released 2023–2032 Planetary Science and Astrobiology Decadal Survey (PSDS)
2. Develop an adequately detailed concept of operations for a representative spacecraft exploration scenario
3. Assess via simulation the degree of resilience that can be achieved by state-of-the-art technologies

Background

Autonomous systems need to *reason* about and *reconcile* onboard information to establish ***situational awareness*** before taking actions. This work establishes onboard and real-time knowledge for a traditionally ground-intensive operation that uses old information: the approach of and landing on a small unexplored body.

Results

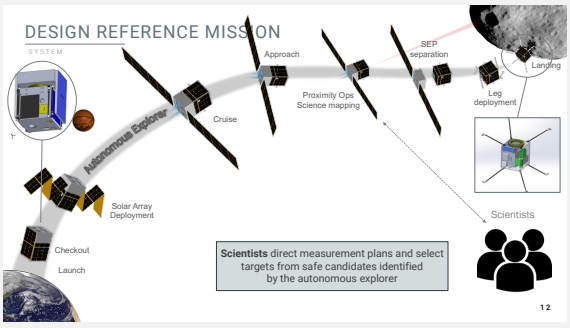
Autonomy Pull in the 2023–2032 Planetary Science and Astrobiology Decadal Survey (PSADS)

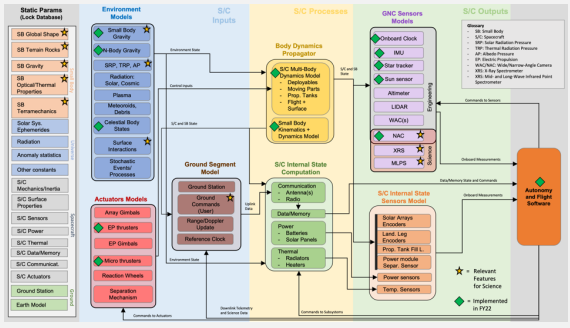
Mission Name	Study Center	Power Source	Average Distance from Earth (AU)	Average Time for Communication to/from Earth* (minutes)	Length of the Science Phase (Duration)	Science: Autonomous Science Data Collection	Science: Autonomous Response to Events	Science: Onboard Science Data Analysis and Action	Motion: Cruise	Motion: ** SC Navigation + Station Keeping + Proximity Operations	Motion: Precision Landing + TRN + Landing Hazard Avoidance	Motion: Sampling + Sample Handling	Motion: Surface Instrument Placement (Manipulation)	Motion: Rover Surface Navigation	Management: Activity Planning/Execution	Management: Fault/Health Management (FDIR)	Management: Thermal Management	Management: Power Management	Management: Data Management	Management: Communication Management with Earth	Management: Communication Management with Other Spacecraft
Endurance-A 2,000 km farside lunar rover to South Pole	JPL	RTG	0.002	0.03	4 years surface	✓				✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Enceladus Orbilander Orbiter and lander with sampling arm	APL	RTG	9.5	79	1.5 years orbital phase 2 years surface phase	✓		✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	
UOP Uranus orbiter and probe	APL	RTG	19	158	4 years orbital tour	✓	✓	✓		✓						✓	✓		✓	✓	
CORAL Centaur orbiter and lander	GSFC	RTG	8.7	113	4 years orbital phase 8 weeks surface phase	✓		✓		✓	✓	✓				✓		✓	✓	✓	
CERES + Asteroid (dwarf planet) sample return	JPL	Solar	2.7	22	16 months orbital phase 2 month surface phase	✓		✓		✓	✓	✓				✓				✓	

✓ Direct Mention
✓ Inferred (Subject to Interpretation)

* (Light takes 8.3 min to travel 1AU)
\+ Likely to have more green checkmarks after completion of the study
** Long cruise is included in SC navigation column (will be separated into its own column in the next revision)

Example: Integrated Simulation Testbed for an Autonomous Spacecraft Approaching an Unexplored Small Body





Significance/Benefits to JPL and NASA

This research enables operations in new environments where *a priori* knowledge is limited. The PSDS recommendation to include Phase E/F costs within the Discovery cost cap underscores the need for more productivity and cost-effective operations, which autonomy enables once it has been developed, matured, and demonstrated sufficiently in flight.

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