FY23 Strategic Initiatives Research and Technology Development (SRTD)

Architecting and Verifying Autonomous Systems using Digital Twins

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Strategic Focus Area: Model Based Assurance of Autonomy | **Strategic Initiative Leader:** Martin S Feather

Objectives

Investigate using automated model-based approaches to test system-level autonomy

Background

On-board autonomy is a key enabler for the next generation of robotic missions.

Autonomy's use is sought to respond appropriately to a wide range of circumstances. The traditional approach of using manual testing as the way to show correct behavior in all circumstances is expensive. The purpose of this task is to develop and demonstrate a combination of techniques - design best practices captured in a model, automated model-based analyses, and smart model-based testing, better suited to provide confidence in autonomy.

Approach and Results

Assume-Guarantee analysis over performance intervals (not single point solutions)
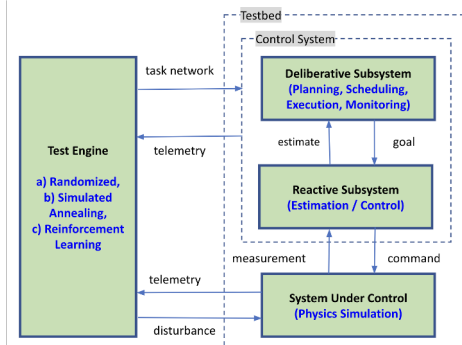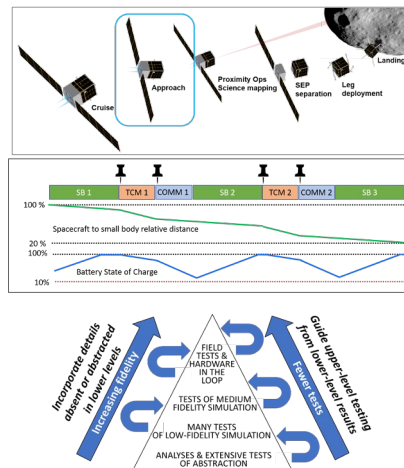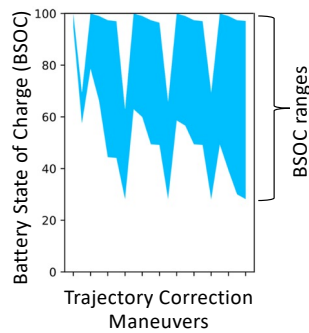
Autonomy Testing Architecture

- *State Analysis guided design* goal-oriented spec of the autonomy at reactive and deliberative level
- *Assume-Guarantee contracts* for system autonomy and mission scenario to enable analysis by reasoners
- *Smart testing* search the space of off-nominal events for sequences that challenge the system in a scenario

Significance/Benefits to JPL and NASA

"Autonomy advancements are required at a system level to integrate and harmonize subsystems to make decisions and execute planned operations on remote, complex and potentially unknown planetary bodies. … Applicable Destinations: All" *

* National Academies of Sciences, Engineering, and Medicine 2022. *Origins, Worlds, and Life: A Decadal Strategy for Planetary Science and Astrobiology 2023-2032*. Washington, DC: The National Academies Press. https://doi.org/10.17226/26522.

Publications:
Maged Elaasar, Nicolas Rouquette, Klaus Havelund, Martin Feather, Saptarshi Bandyopadhyay and Alberto Candela. "Autonomica: Ontological Modeling and Analysis of Autonomous Behavior," 33rd Annual INCOSE International Symposium, Honolulu, HI, 2023, (Vol. 33, No. 1, pp. 1570-1585)

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