Non-Propulsive Control Systems for Future Planetary Missions

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Abstract

This white paper will present an assessment of control systems as it relates to state-of-the-art hypersonic entry vehicles and addresses technological advances that enable new control systems for future hypersonic entry vehicles. Advancements in deployable entry vehicle (DEV) technology, entry guidance, woven thermal protection systems, and affordable launch services make it possible to conceive of entry vehicles that optimize entry loads, maneuverability, usable payload mass and volume, and operational costs.

NASA's Space Technology Mission Directorate (STMD) is currently funding efforts to investigate non-propulsive entry control systems for precision targeting of mechanical and inflatable DEVs. [1, 2, 3, 4, 5, 6, 7, 8, 9] Ongoing studies indicate the potential for developing entry vehicle designs that can:

1. broaden the tradespace for entry trajectories that maintain entry deceleration and thermal loads low enough for sensitive payload handling,
2. provide aerodynamics modulation hardware, control modulation software, and entry guidance software to achieve precision targeting,
3. combine the propellant mass savings of non-propulsive control systems and payload volume capacity of DEVs to achieve greater payload mass and volume allocations compared to heritage entry vehicles given a particular launch vehicle.

This means instrumentation with low g-load requirements can be delivered safely, precisely, and at reduced cost and the integrity of returned samples can be preserved after acquisition from scientific regions of interest identified by prior orbital missions. Plus, smaller commercial launch vehicles, which are less expensive and more readily available than larger conventional launch systems, can be considered to tailor in situ or sample return mission timelines as needed and affordably enable missions that require deploying multiple exploration platforms on a single launch.

Ultimately, this white paper will propose research, development, and testing needed to close the current gap in non-propulsive control systems to support future planetary science and exploration missions.

White paper status

The white paper is a work-in-progress, and we expect to complete a draft for feedback by mid-May.

Involvement and collaboration

We are seeking immediate feedback from the MEPAG community about the potential needs for this technology, and we welcome reviewers and signatories to commit their support once the draft white paper is complete. Please submit a form to co-sign and contact POCs (antonella.i.alunni@nasa.gov & sarah.n.dsouza@nasa.gov) if you'd like to co-author and provide writing and/or editing support.

Note that we are reaching out to the entry, descent, and landing (EDL) community for similar support at this time, too.

References

[1] Sarah N. D'Souza, et al. Developing an Entry Guidance and Control Design Capability Using Flaps for the Lifting Nano-ADEPT. AIAA AVIATION 2019 Forum. 2019, AIAA, Dallas, TX.

[2] Bryan C. Yount, et al. Pterodactyl: Mechanical Designs for Integrated Control Design of a Mechanically Deployable Entry Vehicle. AIAA SciTech 2020 Forum. 2020, AIAA, Orlando, FL.

[3] Ben E. Nikaido, et al. Pterodactyl: Aerodynamic and Aeroheating Database Development for Integrated Control Design of a Mechanically Deployable Entry Vehicle. AIAA SciTech 2020 Forum. 2020, AIAA, Orlando, FL.

[4] Breanna J. Johnson, et al. Pterodactyl: Development and Performance of Guidance Algorithms for a Mechanically Deployed Entry Vehicle. AIAA SciTech 2020 Forum. 2020, AIAA, Orlando, FL.

[5] Wendy A. Okolo, et al. Pterodactyl: Development and Comparison of Control Architectures for a Mechanically Deployed Entry Vehicle. AIAA SciTech 2020 Forum. 2020, AIAA, Orlando, FL.

[6] Zane B. Hays, et al. Pterodactyl: Thermal Protection System for Integrated Control Design of a Mechanically Deployable Entry Vehicle. AIAA SciTech 2020 Forum. 2020 AIAA, Orlando, FL.

[7] Antonella I. Alunni, et al. Pterodactyl: Trade Study for an Integrated Control System Design of a Mechanically Deployable Entry Vehicle. AIAA SciTech 2020 Forum. 2020, AIAA, Orlando, FL.

[8] Dwyer Cianciolo, Alicia, et al. "Low Lift-to-Drag Morphing Shape Design," AIAA SciTech 2020 Forum. 2020, AIAA, Orlando, FL.

[9] Lugo, Rafael A., et al. "Overview of a Generalized Numerical Predictor-Corrector Targeting Guidance with Application to Human-Scale Mars Entry, Descent, and Landing." AIAA SciTech 2020 Forum. 2020, AIAA, Orlando, FL.