Rahil Makadia

✉ Email | 307 Talbot Laboratory, 104 S Wright St, Urbana IL 61801, USA | 🌐 Website

EDUCATION

Ph.D. in Aerospace Engineering, University of Illinois at Urbana-Champaign   Jan 2021 - present
B.S. in Aerospace Engineering, University of Illinois at Urbana-Champaign   Aug 2017 - Dec 2020

WORK EXPERIENCE

NASA Jet Propulsion Laboratory   Advisors: Dr. Steven Chesley, Dr. Davide Farnocchia
NSTGRO Visiting Technologist   May 2023 - Aug 2023, Mar 2024 - Jun 2024

– Validated an efficient solar system propagator with sub-1 km position accuracy over 250 years compared to JPL's internal small body software.
– Developed an orbit determination submodule alongside the propagator that has sub-1σ agreement with JPL small-body orbit solutions.
– Presented a publicly available Python package, GRSS, to allow the scientific community to accurately propagate and determine the orbits of solar system bodies.
– Implemented ability to compute locations of gravitational keyholes, which are predictors of future asteroid impacts with Earth.

NASA Goddard Space Flight Center   Advisors: Kenneth Getzandanner, Andrew Liounis
OSIRIS-REx/OSIRIS-APEX CelNav Intern   Jun 2022 - Aug 2022

– Developed simulations to assess performance of Celestial Navigation (CelNav) using onboard optical instruments during the OSIRIS-APEX cruise phase.
– Simulated more than 8,000 solar system bodies to obtain optimal observable clusters for the spacecraft.
– Performed covariance analysis using NASA's MONTE software to study the spacecraft's state uncertainty on its way to asteroid (99942) Apophis.

RESEARCH EXPERIENCE

Astrodynamics and Planetary Exploration Group   Advisor: Dr. Siegfried Eggl
Gauss-Radau Small-body Simulator (GRSS)   Nov 2022 - present

– Released an open-source Python library with a C++ binding for use by the planetary defense community.
– Developed a high-accuracy propagator for solar system bodies using Gauss-Radau quadrature.
– Built an orbit determination code for estimating small body orbits using optical and radar observations.

Double Asteroid Redirection Test (DART) Mission   May 2020 - Feb 2024

– Analyzed high-fidelity kinetic impactor simulation results from NASA's Jet Propulsion Laboratory (JPL) for impacts in the (65803) Didymos binary asteroid system.
– Implemented a novel method to impart momentum changes in the Didymos system after the DART impact.
– Generated updated B-plane maps to conclude that the Didymos system will not collide with the Earth after the DART impact.
– Wrote MATLAB and Python parameter estimation packages to assess measurability of the heliocentric momentum enhancement from the DART impact.

Aerospace Mission Analysis Laboratory   Advisor: Dr. Zachary Putnam

Venus Aerogravity Assist Performance Assessment   Aug 2022 - Jan 2023

– Analyzed Venus aerogravity assist missions to significantly reduce transit times to the outer solar system.
– Assessed the performance of blunt-body vehicles and waveriders using a MATLAB pipeline for varying trajectories and vehicle configurations.

Teaching Experience

University of Illinois at Urbana-Champaign   Instructor: Dr. Siegfried Eggl

Teaching Assistant for AE 352: Aerospace Dynamical Systems   Aug 2021 - Dec 2021

– Focused on developing and teaching the curriculum's core dynamics course with aerospace applications.
– Syllabus covered Newtonian, Lagrangian, and Hamiltonian mechanics for rigid body motion.
– Guided 16 student teams with Project Clear Constellation, focusing on methods to remove orbital debris.

Skills

Programming Languages	Python, C/C++, MATLAB, R/RStudio, Fortran
Software Tools	LaTeX, Git
Prepackaged Tools	MONTE, GMAT, FreeFlyer
Operating Systems	Linux, MacOS, Windows
Languages	English, Gujarati, Hindi, French

Awards and Affiliations

NASA Space Technology Graduate Research Opportunities Fellow   Aug 2022 - present

NSTGRO fellowship from NASA Space Technology Mission Directorate

ARCS Foundation Scholar Award   Aug 2023 - present

Achievement Rewards for College Scientists (ARCS) Foundation Illinois Chapter

Double Asteroid Redirection Test (DART) Investigation Team Member   Dec 2020 - Nov 2023

NASA/Johns Hopkins University Applied Physics Laboratory (JHUAPL)

John C. Mather Nobel Scholar   Jul 2022 - Jun 2023

National Space Grant Foundation

Fellowship for Outstanding Academic and Research Achievement   Apr 2023

Aerospace Engineering Department at the University of Illinois at Urbana-Champaign

President's Award   Aug 2017 - Dec 2020

University of Illinois at Urbana-Champaign

Hans von Muldau Team Award for Best Project   October 2019

70th International Astronautical Congress (IAC), Washington D.C.

Dean's List   Spring 2019, Spring 2020

University of Illinois at Urbana-Champaign

Journal Articles

[8] D. C. Richardson et al., "The Dynamical State of the Didymos System Before and After the DART Impact", The Planetary Science Journal **under review** (2024).

[7] M. Hirabayashi et al., "Kinetic deflection change due to target global curvature as revealed by NASA / DART.", Nature Communications **under review** (2024).

[6] N. L. Chabot et al., "Achievement of the Planetary Defense Investigations of the Double Asteroid Redirection Test (DART) Mission", The Planetary Science Journal **5**, 49 (2024).

[5] **R. Makadia** et al., "Measurability of the Heliocentric Momentum Enhancement from a Kinetic Impact: The Double Asteroid Redirection Test (DART) Mission", The Planetary Science Journal **5**, 38 (2024).

[4] J.-Y. Li et al., "Ejecta from the DART-produced active asteroid Dimorphos", Nature **616**, 452–456 (2023).

[3] T. S. Statler et al., "After DART: Using the First Full-scale Test of a Kinetic Impactor to Inform a Future Planetary Defense Mission", The Planetary Science Journal **3**, 244 (2022).

[2] **R. Makadia** et al., "Heliocentric Effects of the DART Mission on the (65803) Didymos Binary Asteroid System", The Planetary Science Journal **3**, 184 (2022).

[1] D. C. Richardson et al., "Predictions for the Dynamical States of the Didymos System before and after the Planned DART Impact", The Planetary Science Journal **3**, 157 (2022).

Conference and Meeting Proceedings

[16] **R. Makadia** et al., "A novel method for computing state transition matrices using the unscented transform", in Dynamics and Physics in the Solar System – The legacy of Paolo Farinella and Andrea Milani (June 2024).

[15] **R. Makadia** et al., "GRSS: An open-source small-body science tool for planetary defense", in 55th AAS Division for Planetary Sciences Meeting (Oct. 2023).

[14] **R. Makadia** et al., "The DART mission: Measurability of the heliocentric changes to the (65803) Didymos system", in 14th Asteroids, Comets, Meteors Conference (June 2023).

[13] D. C. Richardson et al., "The dynamical state of the Didymos System before and after the DART Impact", in 14th Asteroids, Comets, Meteors Conference (June 2023).

[12] R. Nakano et al., "Mutual orbit perturbations due to Dimorphos's deformation after the DART impact", in 14th Asteroids, Comets, Meteors Conference (June 2023).

[11] **R. Makadia** and S. Eggl, "Heliocentric beta ($\beta_\odot$) measurability", in May 2023 DART Investigation Team Meeting (May 2023).

[10] **R. Makadia** et al., "Measurability of the heliocentric momentum enhancement of the Didymos system from the DART impact", in 8th IAA Planetary Defense Conference (Apr. 2023).

[9] D. Engel, **R. Makadia**, and Z. Putnam, "Assessment of aerogravity assist at Venus using blunt-body vehicles", in 33rd AAS/AIAA Space Flight Mechanics Meeting (Jan. 2023).

[8] **R. Makadia** et al., "Post-impact prediction of changes to the heliocentric orbit of the (65803) Didymos system due to the DART mission", in 2022 AGU Fall Meeting (Dec. 2022).

[7] D. C. Richardson et al., "First Assessment of the Dynamical State of the Didymos Binary Asteroid System Before and After the DART Impact", in 2022 AGU Fall Meeting (Dec. 2022).

[6] **R. Makadia** and S. Eggl, "Heliocentric beta ($\beta_\odot$) estimation", in November 2022 DART Investigation Team Meeting (Nov. 2022).

[5] **R. Makadia**, S. Eggl, and E. Fahnestock, "The Double Asteroid Redirection Test (DART): Expected changes to the heliocentric orbit of (65803) Didymos", in 44th AAS Guidance, Navigation, and Control Conference (Feb. 2022).

[4] **R. Makadia**, S. Eggl, and E. Fahnestock, "Changes to the heliocentric orbit of (65803) Didymos system due to DART: Simulation and momentum enhancement estimation", in 53rd AAS Division for Planetary Sciences Meeting (Oct. 2021).

[3] **R. Makadia**, S. Eggl, and E. Fahnestock, "Changing the heliocentric orbit of the Didymos system with DART: Implications for β determination", in June 2021 DART Investigation Team Meeting (June 2021).

[2] **R. Makadia** et al., "Changing the heliocentric orbit of the Didymos system with DART: Implications for β determination", in June 2021 DART Investigation Team Meeting (June 2021).

[1] **R. Makadia** et al., "Changing the heliocentric orbit of the Didymos system with DART", in 7th IAA Planetary Defense Conference (Apr. 2021).