

# Rahil Makadia

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## EDUCATION

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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

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**NASA Jet Propulsion Laboratory** Advisors: Steven Chesley, Davide Farnocchia  
NSTGRO Visiting Technologist May 2023 - Aug 2023

- 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- $1\sigma$  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.

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

- Developed simulations to assess performance of celestial navigation 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

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**Astrodynamics and Planetary Exploration Research Group** Advisor: Dr. Siegfried Eggli  
Double Asteroid Redirection Test (DART) Mission May 2020 - present

- 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.
- Produced a post-deflection impact risk assessment for Didymos using parallelized Monte Carlo simulations.
- 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.

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.

## 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

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### University of Illinois at Urbana-Champaign

Instructor: Dr. Siegfried Eggli

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 emphasized on covering Newtonian, Lagrangian, and Hamiltonian mechanics to represent particle motion.
- Assisted 16 student teams with Project Clear Constellation, which called for novel methods to remove orbital debris.

## SKILLS

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Programming Languages Python, C/C++, MATLAB, Fortran

Software Tools  $\LaTeX$ , Git

Prepackaged Tools MONTE, GMAT, FreeFlyer

Operating Systems Linux, MacOS, Windows

Languages English, Gujarati, Hindi, French

## AWARDS AND AFFILIATIONS

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### NASA Space Technology Graduate Research Opportunities Fellow

Aug 2022 - present

NSTGRO award from NASA Space Technology Mission Directorate (STMD)

### 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 (APL)

### 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 Team Project

October 2019

70<sup>th</sup> International Astronautical Congress (IAC), Washington D.C.

### Dean's List

Spring 2019, Spring 2020

University of Illinois at Urbana-Champaign

## JOURNAL ARTICLES

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### PRIMARY AUTHOR

- <sup>4</sup>**R. Makadia** et al., “Measurability of the heliocentric momentum enhancement from kinetic impactors: Applications to the Double Asteroid Redirection Test (DART) mission”, *The Planetary Science Journal* **under review** (2023).
- <sup>3</sup>D. C. Richardson et al., “The Dynamical State of the Didymos System Before and After the DART Impact”, *The Planetary Science Journal* **under review** (2023).
- <sup>2</sup>**R. Makadia** et al., “Heliocentric Effects of the DART Mission on the (65803) Didymos Binary Asteroid System”, *The Planetary Science Journal* **3**, 184 (2022).
- <sup>1</sup>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).

### SECONDARY AUTHOR

- <sup>4</sup>M. Hirabayashi et al., “Kinetic deflection change due to target global curvature as revealed by NASA / DART.”, *Nature Communications* **submitted** (2023).
- <sup>3</sup>N. L. Chabot et al., “Achievement of the Planetary Defense Investigations of the Double Asteroid Redirection Test (DART) Mission”, *The Planetary Science Journal* **in press** (2023).
- <sup>2</sup>J.-Y. Li et al., “Ejecta from the DART-produced active asteroid Dimorphos”, *Nature* **616**, 452–456 (2023).
- <sup>1</sup>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).

## CONFERENCE AND MEETING PROCEEDINGS

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- <sup>12</sup>**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).
- <sup>11</sup>**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).
- <sup>10</sup>**R. Makadia** and S. Eggl, “Heliocentric beta ( $\beta_{\odot}$ ) measurability”, in May 2023 DART Investigation Team Meeting (May 2023).
- <sup>9</sup>**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).
- <sup>8</sup>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).
- <sup>7</sup>**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).
- <sup>6</sup>**R. Makadia** and S. Eggl, “Heliocentric beta ( $\beta_{\odot}$ ) estimation”, in November 2022 DART Investigation Team Meeting (Nov. 2022).

- <sup>5</sup>**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).
- <sup>4</sup>**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).
- <sup>3</sup>**R. Makadia**, S. Eggl, and E. Fahnestock, “Changing the heliocentric orbit of the Didymos system with DART: Implications for  $\beta$  determination”, in June 2021 DART Investigation Team Meeting (June 2021).
- <sup>2</sup>**R. Makadia** et al., “Changing the heliocentric orbit of the Didymos system with DART: Implications for  $\beta$  determination”, in June 2021 DART Investigation Team Meeting (June 2021).
- <sup>1</sup>**R. Makadia** et al., “Changing the heliocentric orbit of the Didymos system with DART”, in [7th IAA Planetary Defense Conference](#) (Apr. 2021).