Athul P. Girija

PH.D., ASTRODYNAMICS AND SPACE APPLICATIONS

School of Aeronautics and Astronautics, Purdue University, West Lafayette, IN 47907, USA

☐ (+1) 765-476-3703 | ✉ athulpg007@gmail.com | ⌂ athulpg007.github.io | ⬡ athulpg007 | ▥ athulpg007

Summary

Ph.D. in Astrodynamics and Space Applications with expertise in orbital and atmospheric flight mechanics, software development (Python, C++), mission formulation and concept development, aerocapture, deorbit systems, Entry, Descent, and Landing (EDL) systems, and systems analysis for advanced technologies to support LEO and planetary missions. Experience with scientific programming, simulations, software documentation, testing, and command line interface. Experience working with teams to develop mission analysis software for LEO and deep space missions. Developer of the Aerocapture Mission Analysis Tool (AMAT). **Citizenship: India**

Education

School of Aeronautics and Astronautics, Purdue University   *West Lafayette, IN, USA*

PH.D., ADVANCED ASTRODYNAMICS CONCEPTS (AAC) LAB   *Aug. 2016 - Aug. 2021*

- Dissertation: "A Systems Framework and Analysis Tool for Rapid Conceptual Design of Aerocapture Missions"
- Advisors: Dr. Sarag J. Saikia and Dr. James M. Longuski
- Major: Astrodynamics and Space Applications; Minor: Aerospace Systems; GPA: **3.9/4.0**

School of Aerospace Engineering, Indian Institute of Technology (IIT), Madras   *Chennai, India*

DUAL DEGREE (B.TECH.+M.TECH.) IN AEROSPACE ENGINEERING   *Aug. 2011 - Jul. 2016*

- Major: Aerospace Propulsion; Minor: Industrial Engineering
- GPA: **9.16/10.0**; Silver Medal, Class of Aerospace Engineering, 2016
- Graduated with Honors, awarded the Mayan Prize for best academic record and senior design project.

Work Experience

Research Scientist, Pioneer Astronautics   *Lakewood, CO*

ADVANCED STIRLING ENGINE FOR ULTRA-HIGH EFFICIENCY SPACE POWER SYSTEMS   *Aug. 2021 - present*

- Lead systems engineer for the NASA SBIR Phase I contract on ultra-high efficiency space power systems.
- Developed computer codes for trade studies, design, and optimization of various Stirling engine configurations.
- Lead mission analysis of various LEO and deep space planetary missions using the new radioisotope system.

Research Intern, Pioneer Astronautics   *Lakewood, CO*

MAGNETIC SAILS, PLASMA AEROBRAKING, LUNAR MATERIALS PROCESSING   *Aug. 2020 - May 2021*

- Led particle-in-cell (PIC) simulation effort for plasma aerobraking in LEO and planetary atmospheres.
- Led computer modeling efforts and systems analysis to support the mineral processing effort to enrich lunar regolith ilmenite from 8% to 65% in support of the Artemis program to return US astronauts to the lunar surface.

Planetary Science Summer Seminar (PSSS), NASA Jet Propulsion Laboratory   *Pasadena, CA*

MISSION FORMULATION SECTION, TEAM X, JPL   *May. 2018 - Jul. 2020*

- Participant of the 30th NASA PSSS which formulated a New Frontiers mission concept to Uranus.
- Led the mission design and Uranus system tour design to achieve the science within the mission constraints.
- Co-led the magnetosphere science team, led the magnetometer instrument team for the mission study.

Summer Intern, Indian Space Research Organization (ISRO)   *Trivandrum, Kerala, India*
AEROHEATING DIVISION, VIKRAM SARABHAI SPACE CENTER, ISRO   *May. 2013 - Jul. 2013*

- Studied modeling and simulation techniques for entry vehicle thermal protection systems (TPS) materials.
- Implemented a 3-D thermal analysis code to predict the TPS material response during Earth re-entry.

Research Projects

JPL-Purdue Outer Planet Aerocapture Studies   *West Lafayette, IN, USA*
FUNDED BY NASA JET PROPULSION LABORATORY (JPL)   *Jan. 2018 - Sept. 2019*

- Led the joint JPL-Purdue end-to-end aerocapture mission study for a Flagship-class Neptune mission.
- Demonstrated for the first time that Neptune aerocapture could be viable using heritage blunt-body aeroshells.
- Coordinated project planning, execution, and delivery with Mission Design and Navigation Section at JPL.
- Presented results to senior JPL program managers and scientists. Link to Final Report and Presentation

Systems Framework for Rapid Conceptual Design of Aerocapture Missions   *West Lafayette, IN, USA*
IN COLLABORATION WITH NASA JET PROPULSION LABORATORY   *Jan. 2017 - Present*

- Formulated an integrated systems framework for rapid conceptual design of aerocapture missions.
- Automated the creation of "aerocapture feasibility charts" unifying interplanetary trajectory and vehicle design.
- Implemented the framework in the open-source Aerocapture Mission Analysis Tool (AMAT), which provides rapid mission analysis capability for aerocapture mission concepts to the planetary science community.

Purdue Single Wheel Test Rig for Ocean World Rovers   *West Lafayette, IN, USA*
FUNDED BY NASA SCIENCE MISSION DIRECTORATE, NASA H.Q.   *Aug. 2017 - Aug. 2019*

- Led the mechanical design (SolidWorks), fabrication (machining, CNC), assembly, and testing of a state-of-the art NASA funded planetary rover wheel-soil interaction test facility for Ocean Worlds at Purdue University.
- Led the testbed and simulant design effort to accommodate large tires (> 1 m dia.) and a range of surface conditions (such as snow, ice, cobblestones, boulders and sharp rock formations). Link to Factsheet, Video.
- Managed a team of five graduate students and coordinated project planning and execution with Robotics and Mobility group at JPL and industrial partners at Thin Red Line Aerospace and Smithers Inc. Link to Presentation

Drag Modulation Enabled Small Satellite Constellations for Mars and Venus   *West Lafayette, IN, USA*
PURDUE UNIVERSITY   *Jan. 2021 - Jun. 2021*

- Led a research effort to assess the feasibility of establishing small satellite constellations at Mars and Venus.
- Studied potential mission architectures such as Synthetic Aperture Radar (SAR) constellations, communications relay, and magnetosphere observation clusters consisting of SmallSats at Mars and Venus.
- Presented results to the scientific community at IPPW 2021. Link to Presentation

Assessment of Aerocapture for Small Satellite Missions to Venus   *West Lafayette, IN, USA*
PURDUE UNIVERSITY   *Jan. 2018 - Sep. 2018*

- Led a comprehensive feasibility and mass-benefit assessment of aerocapture for future Venus missions.
- Demonstrated the viability of inserting small satellites into Venus orbit using drag modulation aerocapture as secondary payload from spacecraft flying to Venus or flying by Venus for gravity assist.
- Presented results to the scientific community at VEXAG meetings in 2017 and 2018. Link Link

Atmospheric Sample Return from the Habitable Zone of Venus   *West Lafayette, IN, USA*
PURDUE UNIVERSITY   *Jan. 2017 - Jun. 2017*

- Analyzed the feasibility of collecting and returning a sample from the habitable zone the Venusian atmosphere.
- Performed trade studies of various entry vehicle systems, ascent vehicles, and sample collectors.
- Presented poster at the Planetary Science Vision (PSV) 2050 Workshop. Link to poster and media coverage.

Journal Publications

1. **A. P. Girija**, S. J. Saikia, J. M. Longuski, Y. Lu, and J. A. Cutts, "Quantitative Assessment of the Aerocapture and Applications to Future Solar System Exploration", *AIAA Journal of Spacecraft and Rockets*, Accepted, October 2021. Pre-print

2. **A. P. Girija**, S. J. Saikia, J. M. Longuski, and J. A. Cutts, "AMAT: A Python package for rapid conceptual design of aerocapture and atmospheric Entry, Descent, and Landing (EDL) missions in a Jupyter environment", *Journal of Open Source Software*. Vol. 6, Number 67. November 2021. DOI: 10.21105/joss.03710

3. **A. P. Girija**, S. J. Saikia, J. M. Longuski, S. Bhaskaran, M. Smith, and J. A. Cutts, "Feasibility and Performance Analysis of Neptune Aerocapture Using Heritage Blunt-Body Aeroshells", *AIAA Journal of Spacecraft and Rockets*. Vol. 57, Number 6. November 2020. DOI: 10.2514//1.A34719

4. **A. P. Girija**, Y. Lu, and S. J. Saikia, "Feasibility and Mass-Benefit Analysis of Aerocapture for Missions to Venus", *AIAA Journal of Spacecraft and Rockets*. Vol. 57, Number 1. January 2020. DOI: 10.2514/1.A34529

5. S. Jarmak, E. Leonard, A. Akins, E. Dahl, D. R. Cremons, S. Cofield, A. Curtis, C. Dong, E. T. Dunham , B. Journaux, D. Murakami, W. Ng, M. Piquette, **A. P. Girija**, K. Rink, L. Schurmeier, N. Stein, N. Tallarida, M. Telus, L. Lowes, C. Budney, K. L. Mitchell, "QUEST: A New Frontiers Uranus Orbiter Mission Concept Study", *Acta Astronautica*. January 2020. DOI: 10.1016/j.actaastro.2020.01.030

6. A. Austin, G. Afonso, S. Albert, H. Ali, A. Alunni .., **A. P. Girija**, .., + 57 co-authors, Enabling and Enhancing Science Exploration Across the Solar System: Aerocapture Technology for SmallSat to Flagship Missions, *Bulletin of the AAS*, Vol. 53, Issue 4, March 2021. DOI: 10.3847/25c2cfeb.4b23741d

7. S. Dutta, M. Perez-Ayucar, A. Fedele, .., **A. P. Girija**, .., + 59 co-authors, Aerocapture as an Enhancing Option for Ice Giants Missions, *Bulletin of the AAS*, Vol. 53, Issue 4, March 2021. DOI: 10.3847/25c2cfeb.e8e49d0e.

8. S. Limaye, N. Abedin, C. Ao, T. Bocanegra, M. A. Bullock,.., **A. P. Girija**, .., + 30 co-authors, Venus Observing System, *Bulletin of the AAS*, Vol. 53, Issue 4, March 2021. DOI: 10.3847/25c2cfeb.7e1b0bf9.

9. I. Cohen, C. Beddingfield, R. Chancia, G. DiBraccio, .., **A. P. Girija**, .., + 84 co-authors, New Frontiers-class Uranus Orbiter: Exploring the feasibility of achieving multidisciplinary science with a mid-scale mission, *Bulletin of the AAS*, Vol. 53, Issue 4, March 2021. DOI: https://doi.org/10.3847/25c2cfeb.262fe20d.

10. **A. P. Girija**, Y. Lu, A. Arora, R. Agrawal, J. Prabha, M. de Jong, B. Aiken, M. Rajapakshe, M. Kent, S. J. Saikia, and J. M. Longuski, "Purdue Single Wheel Test Rig Facility for Ocean World Rovers". In preparation for submission to *Journal of Field Robotics (Expected submission: November 2021)*.

Software

1. **A. P. Girija**, "Aerocapture Mission Analysis Tool (AMAT)". GitHub Docs. AMAT provides rapid mission design capability for aerocapture and EDL mission concepts to all atmosphere-bearing Solar System destinations. AMAT is open-source and is made available under the GNU GPLv3 license.

Conference Publications

1. **A. P. Girija**, S. J. Saikia, J. A. Cutts, and J. M. Longuski, "A Unified Framework for Aerocapture Systems Analysis", AAS 19-811, *AAS/AIAA Astrodynamics Specialist Conference*, Portland, ME, August 2019. engrXiv

2. **A. P. Girija**, S. J. Saikia, J. M. Longuski, S. Bhaskaran, M. Smith, and J. A. Cutts, "Aerocapture Performance Analysis for a Neptune Mission using Blunt-Body Aeroshell", AAS 19-815, *AAS/AIAA Astrodynamics Specialist Conference*, Portland, ME, August 11–15, 2019. engrXiv

3. **A. P. Girija**, S. J. Saikia, and M. de Jong, "Candidate Mechanisms and Fabric Layup Materials for the Mars Surface Tunnel Concept", *IEEE Aerospace Conf.*, Big Sky, MT, March, 2018. DOI:10.1109/AERO.2018.8396720

Oral Presentations

1. **A. P. Girija**, S. J. Saikia, J. M. Longuski "Drag Modulation Aerocapture Enabled Small Satellite Constellation Concepts for Mars and Venus", *18th International Planetary Probe Workshop*, Virtual Event. Link

2. **A. P. Girija**, S. J. Saikia, J. M. Longuski, and J. A. Cutts, "AMAT: A Rapid Design Tool for Aerocapture Missions", *17th International Planetary Probe Workshop*, Invited student speaker for online webinar series. (Originally scheduled to be held in Monterey, CA.) Link

3. **A. P. Girija**, S. J. Saikia, J. M. Longuski, S. Bhaskaran, M. Smith, and J. A. Cutts, "Ice Giant Aerocapture Using Low-L/D Aeroshells: Uncertainty Quantification and Risk Assessment", *16th International Planetary Probe Workshop*, Oxford University, Oxford, United Kingdom, July 8–12, 2019. Link

4. **A. P. Girija**, Y. Lu, S. J. Saikia, J. M. Longuski, and J. A. Cutts, "Feasibility and Mass-Benefit Analysis of Aerocapture for SmallSat Missions to Venus", *16th NASA Venus Exploration Group (VEXAG) Meeting*, Johns Hopkins University Applied Physics Lab (APL), Laurel, MD, November 5–8, 2018. Link

5. **A. P. Girija**, A. Arora, S. J. Saikia and J. A. Cutts, "Hybrid Aerocapture using Low L/D Aeroshells for Ice Giant Missions", *15th International Planetary Probe Workshop*, Boulder, CO, June 11–15, 2018. Link

6. Y. Lu, **A. P. Girija**, S. J. Saikia, and J. A. Cutts, "Venus Aerocapture Assessment", *15th NASA Venus Exploration Group Meeting*, Johns Hopkins University APL, Laurel, MD, November 14–16, 2017. Link

7. **A. P. Girija**, E. Shibata, Y. Lu, S. J. Saikia and J. A. Cutts, "Considerations for Atmospheric Sample Return from Venus", *14th International Planetary Probe Workshop*, The Hague, Netherlands June 12–17, 2017. Link

Poster Presentations

1. S. Jarmak, E. Leonard, A. Akins, E. Dahl, D. R. Cremons, S. Cofield, A. Curtis, C. Dong, E. T. Dunham , B. Journaux, D. Murakami, W. Ng, M. Piquette, **A. P. Girija**, K. Rink, L. Schurmeier, N. Stein, N. Tallarida, M. Telus, L. Lowes, C. Budney, K. L. Mitchell, "QUEST: A New Frontiers Uranus Orbiter Mission Concept Study", *50th Lunar and Planetary Science Conference*, The Woodlands, TX, March 18–22, 2019. Link

2. Y. Lu, **A. P. Girija**, M. Rajapakshe, J. M. Longuski, and S. J. Saikia, "A Single-Wheel Test Rig for Ocean Worlds", *NASA Outer Planets Assessment Group Meeting*, Pasadena, CA, Sept. 11–12, 2018. Link

3. R. Agrawal, B. Aiken, M. de Jong, **A. P. Girija**, J. M. Longuski and S. J. Saikia, "A Surface Mobility System with Large Deployable and Conformal Tires for Ocean Worlds Exploration, *15th International Planetary Probe Workshop*, Boulder, CO, June 11–15, 2018. Link

4. **A. P. Girija**, R. Agrawal, Y. Lu, B. Aiken, M. de Jong, and S. J. Saikia, "A Novel Surface Mobility System for Ocean Worlds", *NASA Outer Planets Assessment Group Meeting*, Hampton, VA, February 21–22, 2018. Link

5. Y. Lu, M. Rajapakshe, R. Agrawal, **A. P. Girija**, and S. J. Saikia, "A Single Wheel Test Rig for Ocean World Rover", *NASA Outer Planets Assessment Group Meeting*, Hampton, VA, Feb. 21–22, 2018. Link

6. E. Shibata, Y. Lu, **A. P. Girija**, J. A. Cutts, and S. J. Saikia, "A Venus Atmospheric Sample Return Mission Concept: Feasibility and Technology Requirements", *Planetary Science Vision 2050 Workshop*, NASA Headquarters, Washington D.C., February 27–28, 2017. Link

Scholastic Achievements

- **Mayan Prize** for best academic record in Aerospace Engineering, Class of 2016, IIT Madras.
- **Silver Medal** for academic excellence, Class of Aerospace Engineering (B.Tech + M.Tech), 2016, IIT Madras.
- **First Rank** in Infant Jesus High School, Indian School Certificate Examination (ICSE), 2009.
- **Top 1 percent** of students in the state of Kerala, India who took the Junior Astronomy Olympiad (2008).

Scholarships and Awards

- **IPPW Student Scholarship** to attend the International Planetary Probe Workshop (IPPW)
    — Awarded in 2017, 2018, and 2019
- **IPPW Student Poster Award** - 3rd place on co-authored poster, 15th IPPW, Boulder, CO.
- **NASA Planetary Science Summer Seminar Stipend** to attend the 30th annual NASA Planetary Science Summer Seminar (PSSS) at NASA Jet Propulsion Lab, Pasadena, California, August 6-10, 2018.
- **VEXAG Student Travel Grant** to attend NASA Venus Exploration Group (VEXAG) Meetings (2017, 2018)

Software Skills

- **Programming Languages:** Python and C++ (Advanced), MATLAB, Mathematica
- **Operating Systems:** Linux, Windows
- **Cloud Computing:** Amazon Web Services Elastic Cloud Compute (EC2)
- **Packages:** tensorflow and keras (deep learning), pandas (dataframes), seaborn and matplotlib (visualization)
- **Code development**: Git, GitHub
- **Presentation Software:** Microsoft Office, Libre Office, LaTeX, Adobe InDesign, Adobe Illustrator
- **Astrodynamics Software and Packages:** STK, GMAT, AstroPy, jplephem, spicepy
- **CAD and Visualization Software:** Blender, Autodesk Inventor, SolidWorks, matplotlib

Research Experience

Research Assistant (RA) - Purdue-JPL Aerocapture Studies *West Lafayette, IN, USA*
SUPERVISORS : PROF. SARAG SAIKIA AND PROF. JAMES LONGUSKI *Jan. 2018 - Dec. 2018*

- Assessment of aerocapture for outer planet missions, guidance, navigation and control (GNC) algorithms

Research Assistant (RA) - NASA COLDTech Program *West Lafayette, IN, USA*
SUPERVISORS : PROF. SARAG SAIKIA AND PROF. JAMES LONGUSKI *Jun. 2018 - Aug. 2019*

- Design, fabrication, assembly, and validation of planetary rover wheel test rig for Ocean World surfaces
- Design of test methods and selection of simulants or planetary surfaces

Teaching Experience

Teaching Assistant (TA) for AAE450 (Spacecraft Design) - Purdue University *West Lafayette, IN, USA*
INSTRUCTOR : PROF. JAMES LONGUSKI, SCHOOL OF AERONAUTICS AND ASTRONAUTICS. *Jan. 2020 - May 2020*

- Capstone aerospace engineering course where students learn spacecraft systems engineering, conceptual design, technical communication, and project management. Project Website

Teaching Assistant (TA) for AAE340 (Dynamics) - Purdue University   *West Lafayette, IN, USA*
INSTRUCTOR : PROF. CAROLINE FRUEH, SCHOOL OF AERONAUTICS AND ASTRONAUTICS.   *Jan. 2018 - May. 2018*

- AAE340 is an undergraduate dynamics course where students learn the basic principles of rigid body dynamics, vibrations, and orbital mechanics and is a prerequisite for many advanced courses in dynamics and control.

Course Projects

Impact of Anthropogenic Aerosols on Climate   *West Lafayette, IN, USA*
ATMOSPHERIC PHYSICS (EAPS 531): PROF. D. T. DAWSON   *Jun. 2019*

- Studied the "whitehouse efffect", by which anthropogenic aerosols on Earth's radiative transfer budget leading to a cooling effect and offsetting some of the warming caused by the greenhouse effect.

Extras

- **Languages:**
    - English
    - Hindi
    - Malayalam (native proficiency)
    - Chinese (basic proficiency)
    - Russian (elementary proficiency)

References

1. **Dr. Sarag J. Saikia**
   Research Assistant Professor, School of Aeronautics and Astronautics, Purdue University
   E-mail: saragjs@gmail.com, Phone: 765-203-1236

2. **Dr. James M. Longuski**
   Professor, School of Aeronautics and Astronautics, Purdue University
   E-mail: longuski@purdue.edu, Phone: 765-494-5139

3. **Dr. James A. Cutts**
   Program Manager, Solar System Exploration Directorate, NASA Jet Propulsion Laboratory
   E-mail: james.a.cutts@jpl.nasa.gov, Phone: 818-354-4120

4. **Dr. Robert Zubrin**
   Founder and President, Pioneer Astronautics
   E-mail: zubrin@aol.com, Phone: 303-437-7834

5. **Alexander Austin**
   Systems Engineer, Advanced Design Engineering Group, NASA Jet Propulsion Laboratory
   E-mail: alexander.austin@jpl.nasa.gov, Phone: 818-393-7521

6. **Dr. Soumyo Dutta**
   Aerospace Engineer, Atmospheric Flight Mechanics and Entry Systems, NASA Langley Research Center
   E-mail: soumyo.dutta@nasa.gov, Phone: 757-864-3894

7. **Dr. Ethiraj Venkatapathy**
   NASA's Senior Technologist for Entry System Technologies, NASA Ames Research Center
   E-mail: ethiraj.venkatapathy-1@nasa.gov, Phone: 650-248-15963