Cody J. Karcher

Post-Doctoral Research Fellow
University of Michigan
Department of Aerospace Engineering
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EDUCATION

Doctor of Philosophy, Aeronautics and Astronautics
Massachusetts Institute of Technology
Thesis: *An Optimization Centered Approach to Multifidelity Aircraft Design*
Completed: August 2022
Advisors: Bob Haimes and Mark Drela

Master of Science, Aeronautics and Astronautics
Massachusetts Institute of Technology
Thesis: *A Heuristic for Including Black Box Analysis Tools into a Geometric Programming Formulation*
Completed: June 2017
Advisor: Warren Hoburg

Bachelor of Science, Aerospace Engineering
University of Maryland, College Park
Completed: May 2014

POSITIONS AND WORK EXPERIENCE

University of Michigan — *Sept 2022–Present*
Post-Doctoral Research Fellow — Ann Arbor, MI

Massachusetts Institute of Technology — *Aug 2019–Aug 2022*
Graduate Research Assistant (PhD) — Cambridge, MA

MIT Lincoln Laboratory — *Sept 2017–July 2019*
Associate Technical Staff — Lexington, MA

Massachusetts Institute of Technology — *Aug 2014–Aug 2017*
Graduate Research Assistant (MS) — Cambridge, MA

Boeing Research and Technology — *Summer 2015, Summer 2016*
Student Intern — Huntington Beach, CA

Boeing Commercial Airplanes — *Summer 2014*
Student Intern — Mukilteo, WA

University of Maryland, College Park — *Aug 2011-May 2014*
Undergraduate Research Assistant — College Park, MD

NASA Armstrong Flight Research Center — *Summer 2013*
Student Intern — Edwards, CA

RESEARCH ACTIVITIES

Design and Analysis of Sustainable Aircraft — *Sept 2022–Present*
Multidisciplinary Design Optimization Laboratory—Funded by NASA — Ann Arbor, MI

- Developing models for hydrogen combusting and hydrogen fuel cell powered aircraft
- Studying the fundamental tradeoffs that drive the design of these sustainable power sources
- Evaluating new technologies from NASA, including a novel thermoacoustic chiller

Efficient Optimization Algorithms for Aircraft Design — *Sept 2019–August 2022*
Aerospace Computational Design Laboratory—Funded by AFRL — Cambridge, MA

- Developed new algorithms for aircraft design that are 50-80% faster than current state of the art
- Implemented these algorithms in a new software tool, available on request
- New algorithms exploit log-convexity and can effectively utilize existing analysis tools

Design of Axial Flux Electric Motors *Sept 2019–Sept 2020*
Aerospace Computational Design Laboratory—Funded by DARPA Cambridge, MA
- Developed a model for axial flux electric motor design and integrated with geometry software

Framework for the Analysis and Design of UAVs *Aug 2017–July 2019*
MIT Lincoln Laboratory—Funded by MITLL Lexington, MA
- Created a MDAO framework that enabled rapid design and trade studies of UAV concepts
- Demonstrated analysis capability on multiple vehicle concepts for MITLL and DoD customers
- Successfully captured and oversaw $50k in IRAD funding to develop these tools

Applications of Geometric Programming Optimization Methods *Aug 2014–Sept 2017*
International Center for Air Transportation—Funded by MIT and DoD Cambridge, MA
- Formulated various aircraft design problems to be solved using geometric programing
- Assisted in the development of GPkit, a tool used to formulate and solve geometric programs

Jungle Hawk Owl Long Endurance UAV *Sept 2016–May 2017*
International Center for Air Transportation—Funded by MIT Lincoln Lab Cambridge, MA
- Designed, build, and flew a 24ft wingspan mid-altitude long endurance UAV for ISR
- Oversaw a team of approximately 50 undergraduate students over the course of two semesters
- Managed a $250k budget for design and manufacture of the vehicle

MDAO Tool for Blended Wing Body Aircraft *May 2015–May 2017*
International Center for Air Transportation—Funded by Boeing Cambridge, MA
- Developed a framework for MDAO and worked with discipline experts to integrate their tools
- Ran performance calculations for a BWB on a nominal commercial transport mission

Multi-Rotor Vertical Lift Aircraft *May 2015–Aug 2015*
Boeing Research and Technology—Funded by Boeing Huntington Beach, CA
- Assisted in developing a multi-rotor helicopter design tool for an internal Boeing customer

Gamera Human Powered Helicopter *Aug 2011–May 2014*
Alfred Gessow Rotorcraft Center—Funded by UMD College Park, MD
- First human powered helicopter to demonstrate a 60 second controlled flight
- Led both the Stability and Control Team and the Cockpit and Transmission Team
- Design and manufactured novel, highly efficient composite structures

Design and Construction of Small Underwater Vehicles *Sept 2011–May 2014*
Collective Dynamics and Control Laboratory—Funded by UMD College Park, MD
- Designed underwater vehicles used as testbeds for collective control demonstrations
- Developed a vehicle with minimal control inputs for a limited bandwidth environment

PRANDTL-D Experimental Aerodynamic Platform *Jun 2013–Aug 2013*
NASA Armstrong Flight Research Center—Funded by NASA Edwards, CA
- Created a model of aerodynamics and flight dynamics for an experimental flight vehicle
- Analyzed the flight data and showed the existence of proverse yaw
- Validated theories of Ludwig Prandtl and Max Munk from the 1920s and 1930s

Dynamic Modeling of the DROID Flight Research Platform *Jun 2013–Aug 2013*
NASA Armstrong Flight Research Center—Funded by NASA Edwards, CA
- Created a dynamic model of an existing UAV research platform using flight and simulation data
- Validated the model with flight tests and implemented it in a virtual simulation environment

JOURNAL PAPERS

J3. Karcher, C., and Haimes, R., *A Method of Sequential Log-Convex Programming for Design Optimization*. Journal of Optimization and Engineering, July 2022. DOI: https://doi.org/10.1007/s11081-022-09750-3

J2. Karcher, C., *Data Fitting with Signomial Programming Compatible Difference of Convex Functions*, Journal of Optimization and Engineering, April 2022. DOI: https://doi.org/10.1007/s11081-022-09717-4

J1. Karcher, C., *Logspace Sequential Quadratic Programming for Design Optimization*, AIAA Journal, February 2022. DOI: https://doi.org/10.2514/1.J060950 PDF: https://arxiv.org/abs/2105.14441

CONFERENCE PAPERS

C3. Lee, D., Karcher, C., Haimes, R., Galbraith, M., and Dannenhoffer, J., *A Parametric Design Process Based on Optimization-Guided Incremental Design Decisions*, AIAA SciTech Conference, Washington DC, January 2023. (Accepted for Publication)

C2. Karcher, C. and Paley, D., *Development of a Prototype Underwater Vehicle for the Low Reynolds Number Regime*, AIAA Region I Conference, Ithaca, NY, April 2014. PDF: http://codykarcher.io/linked_files/Underwater_MAV.pdf

C1. Staruk, W., Schmaus, J., Sridharan, A., Karcher, C., *Control and Stability Characteristics of* Gamera II*: A Human Powered Helicopter*, 69th Annual AHS Forum, Phoenix, AZ, May 2013. *Awarded Best Paper in Session.* PDF: http://www.agrc.umd.edu/gamera/docs/pubs/2013-Control-Stability-of-GameraII.pdf

TEACHING

MIT Aero Astro Senior Design Capstone (16.82) — *Sept 2016–May 2017*
Teaching Assistant — Massachusetts Institute of Technology

Introduction to Aerospace (ENAE100) — *Aug. 2012–Dec. 2012*
Research Mentor — University of Maryland

MENTORING

Quantifying Uncertainty in Aerodynamic Analysis Tools — *Spring 2020-Fall 2021*
Undergraduate Research Project, MIT — Student: Joules Ferguson

High Speed UAV Design — *Summer 2018*
MIT Lincoln Laboratory Internship — Students: Jared Ham and Rosalind Shinkle

Quadrotor Design with Geometric Programming — *Spring 2015*
Undergraduate Research Project, MIT — Student: Janelle Mansfield

AWARDS AND HONORS

Individual:

MIT Aero Astro Teaching Assistantship Award — 2017
NDSEG Fellow — *2015-2017*
MIT Presidential Fellow — *2014*
Magna Cum Laude, A. James Clark School of Engineering — *2014*
NSF Fellowship Awardee — *2014*
Hertz Fellowship Finalist — *2014*
NASA Aeronautics Scholar — *2012-2014*
University of Maryland, Aerospace Departmental Scholarship — *2012-2014*
Best Paper in Session—69th American Helicopter Society Forum — *2013*
AHS Vertical Flight Foundation Scholar — *2013*
First Place Undergraduate Presentation—AIAA YPSE Conference — *2012*
USS Houston Survivors Association Scholarship — *2012*
Eagle Scout — *2011*

With Team Gamera:

Collier Trophy Finalist — *2014*
FAI Certified World Record for Human Powered Rotorcraft-General Duration — *2013*
97.5 seconds - Gamera II

RESEARCH INTERESTS

Aircraft Design, Numerical Optimization, Physics Based Model Development, Mathematical Modeling, Surrogate Modeling, Uncertainty Quantification, Model Verification and Validation, Novel Aircraft Configurations and Powertrains, Unmanned Aerial Vehicles, Sustainable Aviation

SKILLS

Advanced Computer: Python, MATLAB, SolidWorks/CAD, XFOIL, AVL, MSES, ESP/CAPS
Competent Computer: C++, HTML, Javascript, SUAVE
Basic Computer: Fortran, Julia, Raspbery Pi, Arduino, ANSYS CFD
Manufacturing: Composite lay-ups, 3D printing, Manual mill/lathe operation, CNC mill operation, RC electronics, Electrical wiring
Language: Basic Mandarin Chinese
Piloting: FAA Certified Private Pilot (not current), Hobby RC Pilot (beginner)

PROFESSIONAL MEMBERSHIPS AND ACTIVITIES

American Institute of Aeronautics and Astronautics	2014-Present
American Helicopter Society International	2013-Present
Reviewer, AIAA Journal	2022
Reviewer, The Aeronautical Journal	2014

REFERENCES (AVAILABLE ON REQUEST)

Joaquim R. R. A. Martins – *Professor of Aerospace Engineering, University of Michigan*
Robert Haimes – *Principal Research Engineer, MIT*
Mark Drela – *Professor of Aeronautics and Astronautics, MIT*
R. John Hansman – *Professor of Aeronautics and Astronautics, MIT*
Justin Gray – *Research Engineer, NASA Glenn Research Center*
Robert Liebeck – *Senior Technical Fellow, Boeing Research and Technology (Ret.)*
Keith Doyle – *Assistant Division Head for Engineering, MIT Lincoln Laboratory*