Adam Nekolny

Ph.D. Student, Aerospace Engineering | University of Arizona

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Education

University of Arizona Aug 2026 – May 2029 (expected)
Ph.D. Student, Aerospace Engineering — Dynamics and Control; Advisor: Prof. Christopher K. Walker Tucson, AZ

- Ph.D. aim: spacecraft-native autonomous algorithms for on-orbit operation — custom neural-network optimization and physics-conditioned update rules (policy gradients / backpropagation) that tune to spacecraft subsystems and the expected environment from LEO through interplanetary and interstellar regimes, rather than applying generic PPO/SAC off the shelf. Quals pending (student, not candidate).
- Near-term base: *ARLAMX* multi-objective deep RL for aerodynamic attitude scheduling in VLEO, moving from off-the-shelf PPO toward flight-software-resident, physics-aware learning.

University of Arizona Aug 2023 – Aug 2026
M.S., Aerospace Engineering — Dynamics and Control; Advisor: Prof. Christopher K. Walker Tucson, AZ

- **GPA:** 3.3/4.0. **Award:** 2024 Outstanding Graduate Teaching Assistant, AME Department.
- Thesis: *Multi-Objective Deep Reinforcement Learning for Aerodynamic Attitude Scheduling in Very Low Earth Orbit* (ARLAMX / ARLAMX 2.0 stack; PPO/SAC/TD3), integrated into SolarCat (Earth Cup RACE 1) and CatSat.
- Selected coursework: Digital Control Systems (ECE 542), Principles of AI (ECE 579), Spacecraft Optimal Estimation (AME 521), Nonlinear and Optimal Control (AME 556), Introduction to Advanced Control Theory (AME 558), Orbital Mechanics, Interplanetary Mission Design, Advanced Dynamics.

University of Arizona Honors College Aug 2020 – May 2024
B.S., Aerospace Engineering (Cum Laude) | *B.S., Mathematics (Cum Laude)* Tucson, AZ

- **GPA:** 3.64/4.0 (both degrees). **Awards:** Highest Academic Distinction (2021); Academic Distinction (2022, 2023).
- Applied-mathematics capstone: match-filtering pipeline and sensitivity analysis for LIGO gravitational-wave detection.

Research

Graduate Research Assistant — Walker Group Aug 2024 – Present
University of Arizona, Dept. of Aerospace and Mechanical Engineering / Steward Observatory Tucson, AZ

- Ph.D. research aim: a spacecraft-native learning stack for autonomous operation in space — not generic deep RL reused from terrestrial benchmarks, but optimization / backpropagation / policy-update rules conditioned on the vehicle's physics subsystems (ADCS, power, thermal, comms, structure) and on the expected disturbance environment from LEO/VLEO through interplanetary and interstellar flight.
- Fall 2026 research assistant to Prof. Christopher K. Walker for superconducting patent work on the Meissner Effect Transistor (MET) / terahertz-transistor line (US 12,290,009 B2). Verified initial device values in a PyTDGL time-dependent Ginzburg–Landau environment and showed simulation viability of a neural-net MET formulation. Current expansion, aimed at an additional provisional, is a custom library for 3-D magnetic-field representation in superconducting material and a neural-net library with a translation layer into superconducting-regime weights. Hardware test is the next gate once the simulation is sufficient; it is not yet built.

- Also co-teaches the practical-application portion of *ASTR 496/596 Small Satellite Systems* (avionics, ADCS, and flight-software exercises).
- M.S. thesis *Multi-Objective Deep Reinforcement Learning for Aerodynamic Attitude Scheduling in Very Low Earth Orbit* (*ARLAMX* / *ARLAMX 2.0*): PPO/SAC/TD3 advisor emitting low-cadence quaternion set-points to a PD inner loop, recruiting drag and SRP as secondary actuation in the 500–300 km corridor. Basilisk + 18-panel Sentman model: median $C_d = 0.045$ vs MinDrag 0.035. Onboard PPO of ∼2,500–3,000 parameters at a 300 s advisor cadence, ∼6× cheaper than a comparable MPC loop; FP32 on the STM32 FPU with B-dot safe-mode, INT8 held if memory tightens. This stack is the starting plant for the Ph.D. optimizer.

Undergraduate Researcher — SpaceTREx Laboratory Aug 2022 – May 2024
University of Arizona, Dept. of Aerospace and Mechanical Engineering Tucson, AZ

- Developed MATLAB orbital-mechanics simulation pipelines for spacecraft intercept of interstellar objects (ISOs); produced statistical ΔV and propulsion-trade datasets supporting four conference publications (see Publications).
- Performed subsystem trade studies for an ISO impactor mission concept, including radiation effects, asteroid-surface interaction, and impact-outcome analysis.

Undergraduate Research Intern May 2022 – Aug 2022
University of the Bundeswehr Munich Munich, Germany

- Developed a Wolfram Mathematica simulation of low-friction Tesla-turbine flow; produced an analytical and numerical comparison study under independent research supervision.

EXPERIENCE

Mission Systems Architect — ECE, ADCS & Flight Software Lead 2025 – Present
SolarCat — University of Arizona Earth Cup RACE 1 Team Tucson, AZ

- Mission systems architect and ECE/ADCS/flight-software lead for a hexagonal MembraneSat-class sailcraft (MSat standard, Robonautics) demonstrating autonomous drag-modulated lifetime extension in VLEO. Team placed 3rd in Earth Cup RACE 1 and advanced to a Step 2 flight-hardware build. Presented the mission as part of the Earth Cup RACE 1 panel at the 2026 SmallSat Conference. Co-authored the Step 1 white paper (May 2026).
- Own the electronic, firmware, and flight-software architecture for fully autonomous operation: two-timescale stack (ground-trained PPO advisor at 300 s cadence over a 23-D observation, 10 Hz quaternion-feedback PD inner loop on STM32U575/FreeRTOS, B-dot detumble as the safe-mode fallback), KiCad avionics architecture, and written interface-control documentation that partitions code into clearly defined segments so subsystem teams can communicate through stable contracts rather than implicit coupling. Closed-loop plant is full 6-DoF, with magnetorquer torque checked against a realistic magnetic-dipole model. Onboard RL runs FP32 on the STM32 FPU; INT8 quantization is held as a memory contingency.
- Building one modular flight-software design for both RACE 1 and RACE 0 on FreeRTOS, with architectural patterns drawn from NASA cFS and JPL FPrime (F′), DO-178C-informed software partitioning, and NASA NPR 7150.2D software-engineering practices, so the stack is reviewable against space-program process expectations and is the standard students are trained on. Modules fail over to a golden backup on internal error detection and reporting. STM32 ECC memory modes are enabled, trading capacity for on-orbit SEU tolerance.
- Lead a 9-person student team (2 Ph.D. subsection leads for ADCS and flight software; undergraduates across ECE, structures, systems engineering, ground station/comms, simulation, magnetorquers, and power). Write onboarding documentation so new students can enter the project quickly; delegate execution through subsection leads while retaining architecture and integration ownership. Also co-teach the practical-application portion of *ASTR 496/596 Small Satellite Systems*, feeding course students onto RACE 1 deliverables.

ADCS, Avionics & Flight Software Lead 2026 – Present
Earth Cup RACE 0 — University of Arizona (flight demonstrator) Tucson, AZ

- Lead engineer for the ADCS, avionics, and flight-software stack of a $5,000 chipsat-class technology demonstrator (flight prototype due Oct 2026; competition-funded Spring 2027 launch), on the same modular flight-software

design as RACE 1.

- Designing custom cost-reduced magnetorquers with a bespoke I^2C driver board for PWM torque-rod control; laying out the spacecraft avionics PCB and power subsystem; integrating with a flight-proven chipsat bus for downlink. Magnetorquer behavior is checked against a realistic magnetic-dipole plant rather than an ideal torque source.
- Directing a mixed graduate/undergraduate team (sourced via ASTR 496/596) on ADCS algorithms, avionics, and magnetorquers; fielding FI-ARLAMX (flight-integrated ARLAMX) to collect on-orbit data and validate operational autonomy; benchmarking PPO/SAC/TD3 for STM32U575 deployment in FP32, with INT8 as a memory contingency.

Systems and Automation Engineer Nov 2024 – Present
CatSat — University of Arizona CubeSat Program Tucson, AZ

- Maintain the multi-host Linux ground-station network supporting spacecraft operations, including secure infrastructure, mission-data retention, and automation scripting for deployment and hardware troubleshooting. Stack uses Linux CLI, virtualization, and Docker.
- Deployed ARLAMX as an indirect on-orbit mission planner generating optimized ADCS command sequences; validating the policy against >1 year of CatSat orbital-decay and quaternion telemetry.

Graduate Teaching Assistant Aug 2024 – Present
University of Arizona, AME and Astronomy Departments Tucson, AZ

- **AME 321 Aircraft Controls** (Sp 2026): Office hours, exam-prep authoring, and six LaTeX practice/solution PDFs (including a pgfplots hodograph) adopted into the course bank.
- **AME 557 Orbital Mechanics**: Authored exam preparation materials and MATLAB Lambert-transfer simulation/visualization code.
- **ASTR 496/596 Small Satellite Systems**: co-teach the practical-application portion (avionics, ADCS, and flight-software exercises) alongside the Fall 2026 Walker-group RA appointment.
- **AME 300 Instrumentation Lab, AME 302 Numerical Methods, AME 211 Statics, ASTR 202 Life in the Universe**: Lab section instruction, MATLAB tutorials, grading, and technical concept communication to non-STEM students.

Graduate Summer Intern — AME 300 Laboratory Overhaul May 2025 – Dec 2025
University of Arizona AME Department Tucson, AZ

- Redesigned the first-order-response lab around a YOLO11m machine-vision tracking pipeline (mAP@0.5 $\approx$ 0.99); the new experiment determines viscosity and terminal velocity from Stokes-flow analysis of a falling sphere.

Controls Engineer Contributor Nov 2024 – Apr 2025
University of Arizona & Freefall Aerospace Tucson, AZ

- Contributed to next-generation inflatable RF antenna prototyping under Dr. Aman Chandra and Prof. Walker; developed Arduino C++ firmware for differential pressure sensor interfacing and a Python 3 telemetry recorder.
- Performed assembly and instrumentation work in a Class 10,000 cleanroom and TVAC test chamber.

Graduate Research Assistant — Micro Aerial Vehicle Lab Jul 2024 – Aug 2025
University of Arizona, Dept. of Aerospace and Mechanical Engineering Tucson, AZ

- Troubleshot the ModalAI VOXL autonomous-drone platform under a custom Linux environment; ran flight-simulation regressions and executed wind-tunnel gust-response campaigns with LabVIEW-controlled valve actuation.

Publications and Presentations

Conference Proceedings and Presentations

[1] **A. Nekolny** and **[Co-authors]**, "SolarCat and the Earth Cup RACE 1 MembraneSat mission," in *Annual AIAA/USU Conference on Small Satellites (SmallSat)*, Earth Cup RACE 1 panel presentation; team 3rd-place finish, Salt Lake City, UT, 2026.

[2] **[Co-authors]** and **A. Nekolny**, "Propulsion-technology feasibility study for interstellar object intercept mission architectures," in *75th International Astronautical Congress (IAC)*, Milan, Italy, 2024.

[3] **A. Nekolny** and **[Co-authors]**, "Delta-V distributions for mission requirements towards an interstellar object," in *Interstellar Symposium (ISSC)*, Tucson, AZ, Apr. 2024.

[4] **[Co-authors]** and **A. Nekolny**, "Instrumentation-system constraint analysis for interstellar object exploration spacecraft," in *AAS Guidance, Navigation, and Control Conference*, Breckenridge, CO, 2023.

[5] **[Co-authors]** and **A. Nekolny**, "Orbital simulation and mission-intercept analysis for interstellar objects," in *Interstellar Symposium (ISSC)*, 2023.

[6] **[Co-authors]** and **A. Nekolny**, "Impactor subsystem design for an interstellar object intercept mission," in *AIAA ASCEND*, 2022.

Theses and Technical Reports

[1] **P. Chawdagor**, **A. Nekolny**, **V. Sanisetti**, **E. Dandrea**, **N. Sharma**, **M. M. Cabral**, and **C. K. Walker**, "SolarCat white paper proposal: Earth cup RACE 1 STEP 1 challenge," University of Arizona, Mission White Paper, May 2026.

[2] **A. Nekolny**, "Multi-objective deep reinforcement learning for aerodynamic attitude scheduling in very low earth orbit," In preparation, M.S. Thesis, University of Arizona, Tucson, AZ, 2026.

SELECTED PROJECTS

Spacecraft-Native Learning and Optimization (Ph.D. thrust) 2026 – Present

Physics-conditioned policy updates for on-orbit autonomy; LEO to interstellar

- Designing a learning / optimization method aimed at spacecraft rather than generic deep RL: update rules that ingest subsystem physics (attitude, aero/SRP, power, thermal, comms) and the expected environment, so the same advisor family can retune from VLEO drag corridors to quieter deep-space dynamics.
- Builds on the flown-path *ARLAMX* PPO/SAC/TD3 stack and the AstroChymera plant so new backpropagation and policy-gradient variants can be trained against a geometry-true spacecraft instead of a toy Gym environment.

AstroChymera — Flexible-Body Smallsat Astrodynamics (in development) 2026 – Present

C++ / Python; membrane solar sails and other spacecraft from STL/OBJ

- Designing an astrodynamics framework with flexible-body dynamics in mind for membrane solar sails and other spacecraft, built from STL/OBJ meshes with controlled simplification for runtime speedup. Not a finished product; target is a geometry-true plant for ARLAMX rather than a generic Gym task.
- Implements free-molecular-flow aerodynamics, solar radiation pressure, per-facet material assignment, and a stacked perturbation model (drag, SRP, and higher-order gravitational terms) so sailcraft and chipsat cases can be exercised under the same plant. Next build target is mixed-precision orbit plus reduced-order flexible modes.

Student Free-Flyer Library and Onboard ARLAMX 2.0 2026 – Present

Lighter teaching/ops stack built on the ARLAMX 2.0 thesis line

- Building a smaller library segment so students can fly a simpler free-flyer workflow than full AstroChymera, while still attaching the same drag/SRP plant used in research.
- Training onboard-scale deep RL (PPO/SAC/TD3) for autonomous ADCS: target flight policy is a PPO of ∼2,500–3,000 parameters at a 300 s advisor cadence, about 6× more computationally efficient than a comparable MPC controller at runtime, running FP32 on the STM32 FPU with B-dot detumble fallback. INT8 quantization is a contingency if memory tightens. Closed-loop checks use a full 6-DoF plant.

Hardware-in-the-Loop ADCS Testbed for the SolarCat Sailcraft Fall 2025 – Spring 2026
STM32U575 (Cortex-M33) + Python plant over USB-UART; ECE 542 Digital Control Systems

- Implemented a real-time closed-loop ADCS testbed: Jacobian-linearized 6-DoF quaternion plant, closed-form ZOH discretization (exact since $A^2 = 0$), and a discrete full-state feedback gain placed via Kautsky-Nichols-Van Dooren on the z-plane.
- Swept sample rate over a $40\times$ range (5 ms – 200 ms); confirmed BIBO stability across all six rates and near-invariant step response (15 s settling, $\sim$5% overshoot) when the continuous targets are preserved through $z = e^{sT_s}$.
- Validated on hardware: 1000/1000 bit-exact UART round-trip, 512/512 CRC-16/CCITT bit-flip rejection, and B-dot detumble of a $[5, -3, 4]^\top$ deg/s tumble.

Superconducting Intelligent-Structures Research — Provisional Patent Development Summer 2026 – Present
Steward Observatory / Walker Group Tucson, AZ

- Recreated and independently verified initial values of Prof. Walker's Meissner Effect Transistor (MET) line (US 12,290,009 B2; earlier publication US 2020/0259067) in a PyTDGL time-dependent Ginzburg–Landau environment, and showed simulation viability of a neural-net MET formulation. Expanding an additional provisional with custom libraries for 3-D magnetic-field representation on superconducting material and a neural-net translation layer into superconducting-regime weights. Hardware test follows only after the simulation is sufficient.

TAVIS — Tracking and Viscosity Inference System 2025 – 2026
Computer-vision Stokes-flow viscometer; AME 300 Lab Overhaul

- Trained a YOLO11m ball-tracking model on >1,100 labeled frames (mAP@0.5 $\approx$ 0.99); fused detections with a Kalman filter for stable velocity estimates over noisy numerical derivatives.
- Applied Faxén wall corrections ($K = 0.282$ for 1 in. Delrin in 2.5 in. cylinder); shipped a calibration GUI with multi-dataset management.

Sequential Orbit Determination Suite Fall 2025
AME 521 final project (Optimal Estimation)

- Implemented EKF, IEKF, batch least-squares, and an RTS smoother for range/range-rate observations under J2/J3 perturbations.
- RTS smoother reduced position error by 85.4% and velocity error by 99.1% versus the forward EKF; post-fit residual analysis identified an unmodeled cross-track signature.

Technical Skills

Programming: Python (advanced), MATLAB (advanced), C, C++, Bash, Wolfram Mathematica; familiarity with Fortran

Machine Learning / RL: PyTorch, Stable Baselines3, Gymnasium, CUDA; PPO, SAC, TD3, Q-learning, SARSA, value iteration; YOLO (Ultralytics), ResNet, OpenCV; FP32 inference on the STM32 FPU; INT8 via STM32Cube.AI as a memory contingency

Estimation, Controls & Simulation: Kalman filtering (EKF, IEKF), RTS smoother, batch least squares, SNC; LQR, sliding-mode, quaternion-feedback PD, B-dot detumble; root locus and z-plane pole placement, ZOH discretization; Basilisk, NASA GMAT, Ansys STK (Master Integration L2), FreeFlyer 7; MRP/DCM/quaternion attitude representations, Sentman/FMF panel methods, magnetic-dipole torque models; AstroChymera (in development, flexible-body membrane sats)

Flight Software & Process: FreeRTOS on STM32U575; shared RACE 0/RACE 1 design; architecture patterns from NASA cFS and JPL FPrime; DO-178C-informed partitioning; NASA NPR 7150.2D software practices; interface-control / code-segment documentation; modular golden-backup failover on internal error detection; STM32 ECC memory modes

Embedded & Hardware: STM32U575 (Cortex-M33, bare-metal + FreeRTOS, ECC memory modes), STM32H723, Arduino, NVIDIA Jetson Nano, ModalAI VOXL; OpenOCD, STM32CubeMX, PlatformIO, KiCad, SolidWorks, AutoCAD, Blender

Infrastructure & Tooling: Linux CLI (Fedora, RHEL, Ubuntu, Debian, Arch/CachyOS, AlmaLinux, TrueNAS), macOS, Windows; ROS; Linux virtualization (Proxmox, VMware, VirtualBox, Hyper-V), Docker; Git, GitLab, LaTeX, JetBrains IDEs; AI-assisted development and automation (Cursor, Claude Code, Grok Build); conda/Miniforge, Jupyter, LabVIEW, Tailscale, WireGuard, n8n

Credentials & Languages: Ansys STK Master Integration (L2), Solidworks CAD Design Associate, FCC HAM Technician (KK7WNQ) | English (full professional), Czech (native), German (B1)