Matthew Vernacchia, Ph.D.

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Selected skills: Python, Rust, physics simulation, numerical optimization, applied physics.

Work Experience

Commonwealth Fusion Systems

MIT spinout commercializing fusion energy via high-magnetic-field tokamaks, $2.9B raised.

Senior Manager, Scientific Software — 2023-present

Our team makes software to design and build superconducting magnets, the key tech behind CFS's fusion device. Better superconductor (HTS) -> 2x stronger magnets -> more fusion power (power ~ (magnetic field)^4). Our software helped scale HTS magnets from bespoke articles that fit on a dinner plate to a factory building multiple truck-sized magnets/month.

Helped increase magnet production rate >10x. Our software lets CFS utilize a large fraction of the world's HTS production, ~$100M/year, by yielding consistent magnet performance while accepting a wide range of superconductor quality. Optimizer allocates superconductor to magnets (Python); web app automates superconductor acceptance tests & serves build-plans to factory machines (TypeScript, Rust). Magnet production would halt without this software.

Simulations accurately predict magnet performance for design and acceptance tests; critical b/c magnets operate with tight margin in difficult-to-test conditions (20 kelvin, 20 tesla). Python API with Rust backend; high-fidelity sims in minutes on a laptop. Modular stack: open-source electromagnetics library + proprietary materials library and filament-based cable model.

Protect multi-$M magnets with signal processing algorithms and optics simulations for a novel quench detection system.

Lead a 10-person team owning delivery and maintenance of these projects; cross-train physics and software experts.

Scientific Software Manager — 2022-2023

Built a team of senior-to-principal engineers with expertise outside my own (e.g. web, perf. eng., finite-element methods) and high autonomy. Hired for mission alignment and unique needs, not "the trendiest" resumes. Onboarded into complex, unique technical challenges and multi-team interfaces. Regretted attrition below company and industry average.

Established software quality practices to ship reliable tools fast: CI, code review, tests, dev tools (pyright, ruff, uv).

Scientific Software Engineer — 2020-2022

Developed optimization software for design and manufacture of 20-tesla magnets; optimally allocated >$10M of superconducting tape for CFS's first large-scale magnet demo.

Evaluated ARC tokamak power-plant power cycles, fluid systems, and maintenance for $1.8B Series B technical diligence.

SpaceX

Engineering Intern — 2013-2017

Four internships (Dragon Propulsion; Guidance, Navigation & Control). Integrated flight simulator and ran UI/handling-qualities tests with astronauts. Performed full-motion Dragon docking LiDAR tests on robot gantry. Automated flight-critical valve tests.

Selected Patents & Publications

Techniques for removing a vacuum vessel from a tokamak and related systems and methods — 2023

Patent US12488904B2

Developed robotic tokamak vacuum-vessel replacement concept; simpler and faster than prior art; reduces power-plant downtime. Owned concept-of-operations for separating tokamak halves and rotating out the vessel; drew key figures.

Design, Fabrication, and Assembly of the SPARC Toroidal Field Model Coil — Experiment in 2021, published 2024

doi.org/10.1109/tasc.2024.3356571 (open access)

Built superconducting-tape-selection optimizer for van-sized 20-tesla magnet, the first large-scale demo of CFS's magnets.

Low-Thrust Solid Rocket Motors for Small, Fast Aircraft Propulsion: Design and Development — 2021

doi.org/10.2514/1.b38104 (paid), (open access link)

Designed and tested ultra-slow-burn solid motors for kg-scale transonic UAVs; modeled motor + aircraft sizing; first author.

Education

Massachusetts Institute of Technology

Visiting Scientist, Plasma Science and Fusion Center — 2020-present

Ph.D. in Aeronautics and Astronautics, Space Propulsion — 2020

Developed solid rocket propulsion for a kg-scale transonic UAV; produced and tested ultra-slow-burn motors; built lab + procedures; mentored undergrads; developed autodiff-compatible propulsion models.

M.S. in Aeronautics and Astronautics (Aerospace Engineering) — 2017

B.S. in Aeronautics and Astronautics (Aerospace Engineering) — 2015