Integrated Modeling Framework

The validated simulator behind our integrated modeling framework, for tokamak design, scenarios, disruptions, and operations.

NEXT STEP FUSION

WHAT IT IS

NSFsim is the core of our integrated modeling framework: a fast, self-consistent solver for 2D free- and fixed-boundary equilibria coupled to 1D transport. Originally based on DINA, one of the key simulation codes used at ITER, it has evolved into a substantially redesigned and extended platform, with a fully rewritten Modern Fortran core, C and Python layers, improved numerical algorithms, and expanded physics capabilities. It is IMAS-compatible and configurable from lightweight control-oriented setups to high-fidelity integrated simulations.

WHAT YOU GET

- Five core modules: forward, inverse (time-dependent and static), disruption, EdFIT reconstruction, and no-plasma
- Breakdown and burn-through to ramp-down; disruptions, VDEs, halo currents, and electromagnetic loads
- Coupled with TRAVIS, ASCOT5, TGLF, MISHKA, TORIC, Aurora/STRAHL, SOL Box Model, a 3D structures solver, etc.
- Bit-exact checkpoint and restart: branch any run from a saved step and replay it exactly
- Upcoming: scenario limits (with Columbia Engineering), 2D–3D coupling for halo currents and EM loads, and more

HOW IT WORKS

Start from physical profiles or diagnostic data (TS/ECE, CXRS, MSE), not mathematical surrogates. Run free- or fixed-boundary, switch modes mid-calculation, and branch any discharge from a checkpoint. Configure the same core for fast control studies or full integrated runs. We can do the work for you, or provide NSFsim as a local installation or a web API.

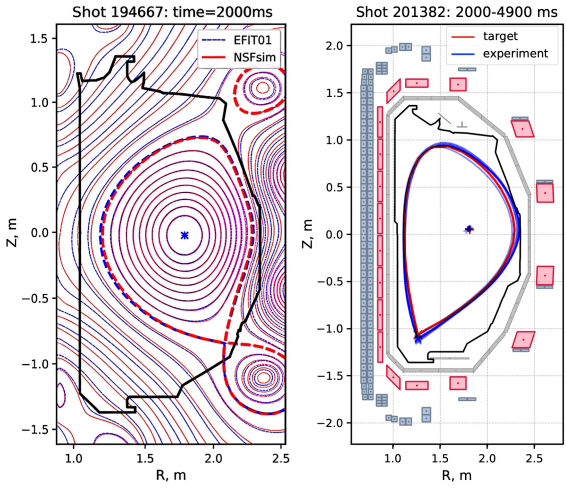


Fig. 1. DIII-D validation of NSFsim enabled RL control of plasma shape and position. Left: flux surfaces from NSFsim and EFIT01 for shot 194667 at 2.0 s. Right: shot 201382, 2.0–4.9 s, the boundary tracked as 32 points by an agent trained in an NSFsim environment and transferred to the DIII-D PCS (target red, experiment blue), one of over 30 successful shots, matching conventional control. Clark et al., Fusion Eng. Des. (2025); Subbotin et al., Nucl. Fusion (2026).

PROOF

At DIII-D, NSFsim is validated in five plasma shapes, including negative triangularity, against measured signals, EFIT, and GSevolve. It trained the deep reinforcement learning controllers that ran on the live tokamak, reaching target parameters from the first discharge without tuning. Its shape agent, trained on 120 DIII-D shapes, reaches a mean shape error of 2.01 cm with 30% of sensors masked. It was demonstrated in DTT disruption studies and is applied in feasibility studies and tokamak design projects: at DANTE Fusion we lead all design activities on the neutron-source tokamak for medical isotope production; other customers are under non-disclosure agreements.

Our mission is to accelerate fusion companies by bridging world-class science with deployable, industry-ready solutions.

Next Step Fusion is a specialized fusion supply chain company, founded in 2023, with its HQ in Luxembourg, a UK office, and a distributed team across Europe.

MADE IN LUXEMBOURG

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