DIII-D Integrated Plasma Control Solutions for ITER and Next-Generation Tokamaks*

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Plasma control design approaches and solutions developed at DIII-D to address its control-intensive advanced tokamak (AT) mission are applicable to many problems facing ITER and other next-generation devices. A systematic approach to algorithm design, termed "integrated plasma control," enables new tokamak controllers to be applied operationally with minimal machine time required for tuning. Such high confidence plasma control algorithms are designed using relatively simple ("control-level") models validated against experimental response data and are verified in simulation prior to operational use. A key element of DIII-D integrated plasma control, also required in the ITER baseline control approach, is the ability to verify both controller performance and implementation by running simulations that connect directly to the actual plasma control system (PCS) that is used to operate the tokamak itself.

The DIII-D PCS comprises a powerful and flexible C-based realtime code and programming infrastructure, as well as an arbitrarily scalable hardware and realtime network architecture [1]. This software infrastructure provides a general platform for implementation and verification of realtime algorithms with arbitrary complexity, limited only by speed of execution requirements. Pseudo-diagnostic algorithms such as realtime equilibrium reconstruction can be run on multiple CPUs, and different versions of such algorithms can be made available simultaneously, enabling any to be used at different phases within a discharge. Similarly, any control algorithm defined in the PCS can be flexibly enabled or disabled at different phases within a discharge. We present a complete suite of tools (known collectively as TokSys) supporting the integrated plasma control design process, along with recent examples of control algorithms designed and applied successfully to DIII-D. Examples of TokSys application include control-level models for axisymmetric and nonaxisymmetric MHD plasma responses, multivariable model-based MHD controller design, and verification of both algorithm implementation and control performance using TokSys simulations. Final verification is performed by connecting these simulations directly to the actual realtime PCS. TokSys simulations can make use of detailed nonlinear core plasma evolution modules derived from the Corsica [2] or DINA codes.

[1] Penaflor, B.G., et al., "Worldwide Collaborative Efforts in Plasma Control Software Development", this meeting.
[2] Casper, T.A., et al., "ITER Shape Controller and Transport Simulations", this meeting.

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