Implications for ITER CODAC From DIII-D Experience*

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The DIII-D digital plasma control system (PCS) has been in use since 1993 controlling DIII-D plasmas. The control research and PCS development process at DIII-D have revealed many aspects of advanced tokamak control which can help inform the ITER design. In the past few years, the PCS has also been adapted for use at several other devices worldwide, which has allowed the DIII-D team to obtain a significant amount of understanding of the common requirements for plasma control on multiple fusion devices, along with substantial experience in the alternative computing, data acquisition, and networking technologies that are presently available.

In this work, we describe some of what has been learned through the experience gained on these devices and highlight the relevance of these lessons learned for the ITER Control, Data Acquisition, and Communication (CODAC) system. Several capabilities of the DIII-D PCS are described that are consistent with the requirements of ITER, including a reliance on off-the-shelf hardware, validation of plasma control programming via simulation, and a capability to detect and respond to off-normal events. This description touches on multiple subsystems described in the ITER CODAC Conceptual Design. We also discuss some features of the DIII-D PCS architecture, such as support for modification of discharge programming immediately prior to the plasma pulse, that are appropriate for today's experimental devices but may not be appropriate for ITER, which requires a much more comprehensive system for ensuring device safety because of the much larger energy content of the plasma and coil systems. Even for these applications, however, the knowledge gained in implementing control systems to aid in ensuring device safety on present fusion devices provides useful guidance for an eventual ITER solution.

Topics discussed include the general architecture and philosophy of the PCS, use of multiple cpus for real-time computing, fast real-time networks for data acquisition and inter-process communication, use of true Grad-Shafranov equilibrium reconstruction in real-time control, multivariable model-based design and verification, validation through simulation, and architectural approaches for off-normal response.

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