Scientific and Computational Challenges of the Fusion Simulation Program (FSP)

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This presentation will highlight the scientific and computational challenges facing the proposed U.S. national Fusion Simulation Program (FSP) – a new U.S. Department of Energy initiative supported by its Offices of FES and ASCR (Advanced Scientific Computing Research) -- that is currently concluding a 2-year program definition/planning phase. The primary objective of the FSP is to develop a predictive integrated simulation capability for magnetically-confined fusion plasmas that are properly validated against experiments in regimes relevant for producing practical fusion energy. This will demand computing resources in the multi-petascale (*10^{15} floating point operations per second*) range and beyond together with the associated multi-core algorithmic formulation needed to address burning plasma issues relevant to ITER. Even more powerful supercomputers at the "exascale" (*10^{18} floating point operations per second*) range and beyond will be needed to meet the future challenges of designing a demonstration fusion reactor (DEMO). Analogous to other major applied physics modelling projects, plasma physicists will need to closely collaborate with computer scientists and applied mathematicians to develop advanced software that is validated against experimental data from tokamaks around the world. Examples of expected advances which are needed to enable such a comprehensive integrated modelling capability and possible "co-design" approaches will be discussed.