National Nuclear Security Administration (NNSA):

Nuclear Weapons Stockpile Stewardship

1. **Application Domain:** Complex coupled, multi-scale, weapons physics.
2. **Problem:** Full range of complex scenarios for component and full-system simulations for weapons in the nuclear stockpile (normal, extreme temperatures, accidental drop…).
3. **Benefit:** Prediction of system behavior for the weapons in the nuclear weapons complex, for purpose of enhanced surety that weapons in our stockpile will operate when needed and will not operate in any other situation.
4. **Algorithmic technique(s):** Weapons codes integrate initial value partial differential equations for the conservation of particles, momentum, and energy for important elements and constituents of the system. The PDEs are solved with a combination of explicit, implicit, and Monte Carlo techniques. Linear and non-linear solvers are also employed. In general, time-dependent, multi-physics elements are handled by operator splitting with some time centering**.**
5. **Is there a "tipping point" (i.e., is the application area not feasible now but that will take off once some measure of computer performance reaches x)?** N/A
6. **HEC driver/requirement:**
    a. **Why is _high end_ computing needed for progress?** Requirements for very fine spatial, energy and temporal resolution, 100s of DOF, non-linear systems, data storage, memory, low latency, as well as rapid communication and overall speed (FLOP/s) drive us to Teraflop and higher machines.
    b. **What are the high performance computational capabilities or capacities required to enable this application?** Application requirements obviously vary with the system, model, or code employed, resolution desired and so forth, but typical calculations use 10,000 to 1×10^9 mesh cells, and run on thousands of processors.

        What is needed –

        i. At least a ten-fold increase in resolution
        ii. 10-100 fold increase in computational capability (→ 2000 TF),
        iii. A time-to-solution of on the order of a week (as opposed to the current 20 weeks)
        iv. GBs of memory for each processor (→ 200 TB)
        v. TBs of secondary storage with very broad I/O pathways. (→ 14,000 TB of secondary storage).