ICALEPCS 2025 - The 20th International Conference on Accelerator and Large Experimental Physics Control Systems

Contribution ID: **164** Contribution code: **TUCR002** Type: **Contributed Oral Presentation**

Control system upgrades at the National Ignition Facility for higher laser energy and higher fusion yields

Tuesday 23 September 2025 13:45 (15 minutes)

Following the landmark achievement of fusion ignition in December 2022, the National Ignition Facility (NIF) has now repeated ignition multiple times, reaching record yields and fusion gains. To further advance fusion research into new experimental regimes, NIF is currently planning the Enhanced Yield Capability (EYC) upgrade, raising laser energy to 2.6 MJ by fully utilizing the laser amplification potential of its design. Simulations predict EYC yields exceeding 30 MJ, enabling transformative opportunities for Inertial Confinement Fusion (ICF) and High-Energy-Density (HED) sciences. This paper focuses on the dual challenge of implementing EYC while sustaining aging control systems nearly two decades old. While the data-driven NIF control system architecture requires only modest modifications for higher laser energy, these still demand coordination with the sustainment of the pulse shaping, amplification, and optical damage mitigation subsystems. Upgrades must remain compatible with legacy interfaces and hybrid legacy-modern components while delivering enhanced performance for higher energies. We detail the technical approaches and operational strategies for integrating capability enhancement and component renewal in a facility with ongoing experiments, highlighting how well-planned design synergies minimize conflicts between major upgrades and sustainment efforts.

Footnotes

Keywords: Control System Upgrade, Legacy Equipment Maintenance, Hybrid Control System, Control System Obsolescence

Funding Agency

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344

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Session Classification: TUCR MC02 Control System Upgrades

Track Classification: MC02: Control System Upgrades in Existing Facilities