Transformational Challenge Reactor Program

Laying the Foundation for Using Additive Manufacturing for Nuclear Energy Systems

**Reduction in Cost, Schedule & Risk in Nuclear Energy**

- **Design**: Design constraints relaxed. Rapid innovation cycle possible with rapid demonstration.
- **Manufacturing**: Flexible, scalable solutions can be deployed because the machine can be rapidly adapted with assurance of consistent quality.
- **Regulatory**: More efficient regulatory approaches because of depth of understanding gained while manufacturing and in use of embedded sensors.
- **Operation**: Operational envelopes widened with insights into real-time and predictive performance. Autonomy is achievable.
Materials Properties in Additive Manufacturing

Data to acquire:
- Uniaxial tensile tests
- Thermal creep
- Plasticity (true stress-strain)
- Fracture
- Environmental compatibility
- Thermal-physical & physical properties
- Radiation hardening
- Radiation swelling
- Radiation induced creep
- Creep fatigue
- Component testing
- Surface roughness
- Thermal aging
- High-throughput EBSD
- Large area TEM
- Residual stress
- Phase/precipitation evaluation
- Post-weld/post-processed HT
- Post-fab TMT verification
- CT scan/defect determination
- Maximum allowable defect sizes
- Sensor-component interface wetting

Materials Handbook
- Baseline mechanical properties
- Baseline thermophysical properties
- Baseline microstructure
- Batch-to-batch variability bounds
- Correlated NDE and destructive testing results

Example: 316L Stainless Steel
- Preliminary tests show additive data aligning well with wrought data
- Materials database growing on a weekly basis
Digital Platform for As-Built Quality Verification

ExOne Binder Jet equipped with in-situ sensing

In-situ imaging modalities: visible and infrared

Visible

Thermal

AI-based defect detection
Engagement to Facilitate Adoption

A Different Approach Requires Extensive Engagement

Reactors Designers
Manufacturers
Utilities
Industry Groups

NRC
ASME
ASTM
ANSI
IEEE

Cooling channels