GEN IV International Forum℠
Expertise | Collaboration | Excellence

Opportunities for Generation-IV Reactors Designers through Advanced Manufacturing Techniques

Summary / Objectives:

The development of critical design criteria for new advanced reactor systems, components, and materials requires an understanding of both fabrication and the irradiation environment during normal operating and accident conditions. Next-generation researchers and designers are therefore challenged **not only by demands for improved performance, they must also work to shorten the development and commercialization lifecycle** for new nuclear reactors and systems to remain competitive. This provides unique and exciting opportunities for all contributors to this field of study. This presentation will offer a strategic overview of the **impact that advanced manufacturing has on the lifecycle of new generation reactors**. By evaluating state-of-the-art practices found in other large manufacturing industries, this presentation provides an overview of major innovation areas that are considered to benefit the GEN-IV systems (SFR, GFR, LFR, FSMR...). Synergetic advanced manufacturing approaches beneficial to the collective GEN-IV systems, with some examples of differentiating approaches necessary for specific reactor designs, are discussed. Furthermore, new paradigms in licensing approaches for additively manufactured parts will be discussed.

Meet the Presenter:

Dr. Isabella J. van Rooyen holds a PhD in physics, an MSc in metallurgy, and an MBA. She is the **National Technical Director for Advanced Methods for Manufacturing Programs for the Department of Energy-Nuclear Energy Enabling Technologies**. She is also a distinguished staff scientist at the Idaho National Laboratory (INL) where she has led as principal investigator

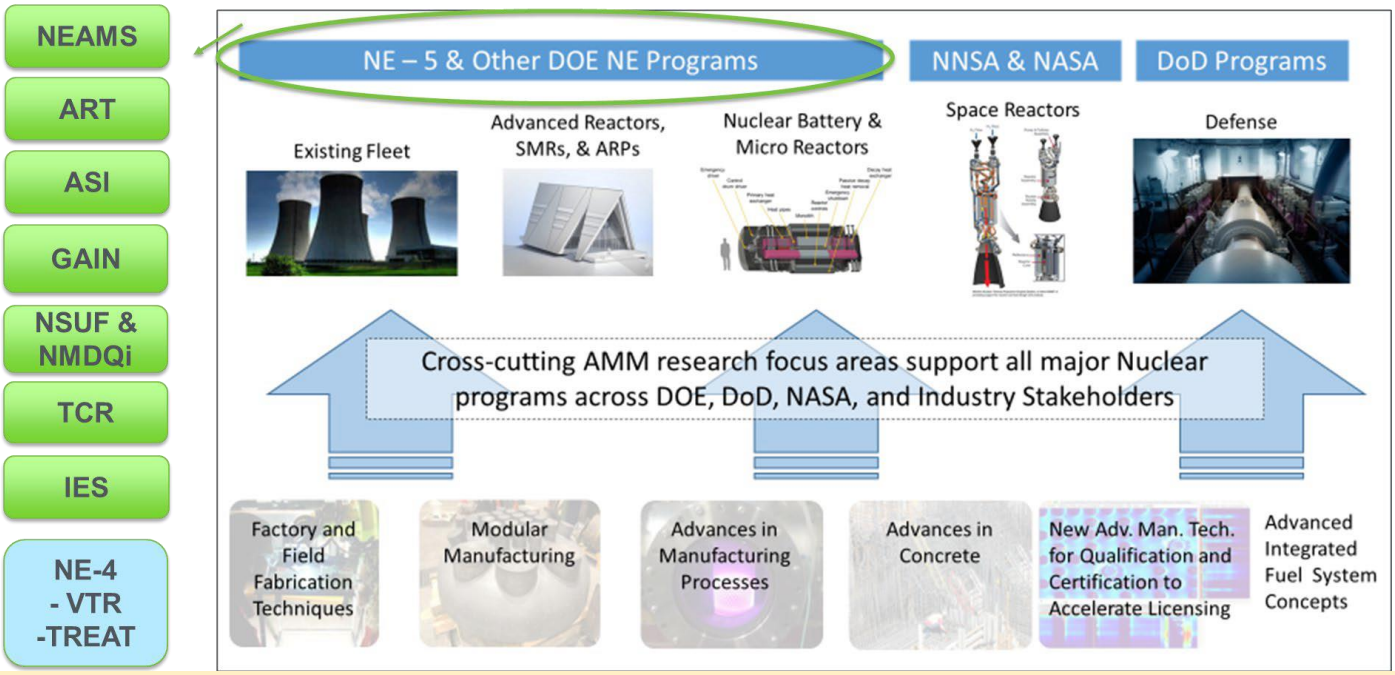
(PI) a variety of research projects for nuclear applications through competitive awards by industry strategic partners, lab-directed research funds, National Scientific User Facility (NSUF), and the Nuclear Engineering University Program (NEUP). These research projects focus on tristructural isotropic (TRISO)-coated particles, U3Si2, integrated fuel fabrication processes, high-temperature compact heat exchangers, SiC-ODS alloy gradient nano-composite cladding, fission product transport mechanisms, additive manufacturing qualification reviews, and advanced manufacturing methods.

DOE-NE activities for Advanced Manufacturing Method (AMM):

In order to **make fabrication of nuclear power plant components faster, less expensive, and more reliable**, various activities have been conducted to introduce Advanced Manufacturing Method.

Currently, Office of Nuclear Energy on United States Department of Energy (DOE-NE) have conducted their activities for AMM in the fields of “modular manufacturing” and “qualification to accelerate licensing”. They are also having **connection with all stakeholder** such as NRC and US industries to promote AMM programs.

Connections of AMM program to other R&D programs, NRC, Industry



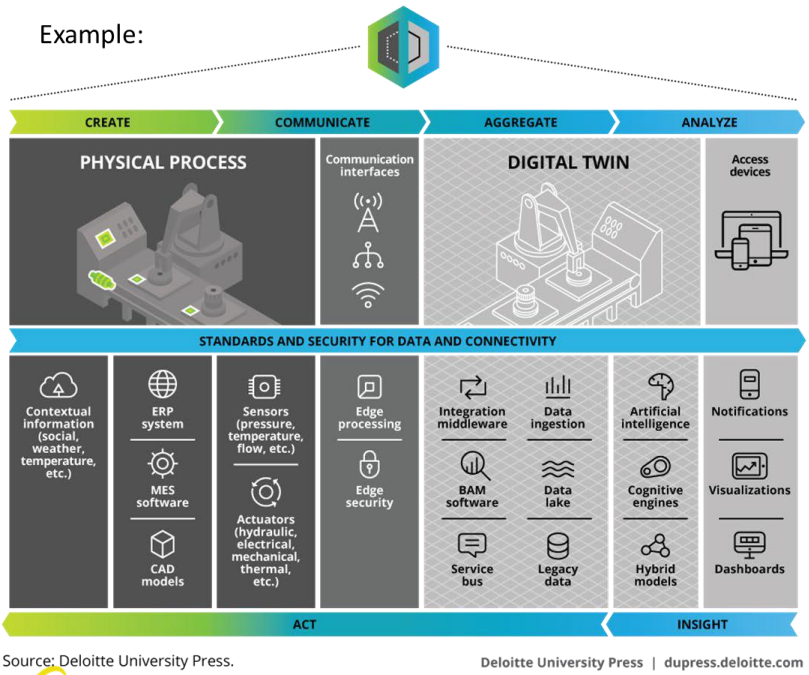
Since there is various kinds of Advanced Manufacturing technologies and materials, we need **to identify strategic path forward in technologies** rather than solve individual technology problem.

Digital-Twin:

Though there is several challenge to introduce, Digital Twin may reduce cost and time for the introduction of new products.

Manufacturing Process Digital-Twin Conceptual Architecture

Example:



Source: Deloitte University Press.

Deloitte University Press | dupress.deloitte.com

Major challenge in undertaking a digital twin process:

- Determining optimal level of detail in creating a digital twin model

Only a portion of the product life cycle:

- Manufacturing process
- Properties
- Performance

Product

Integrated system

Operation /use

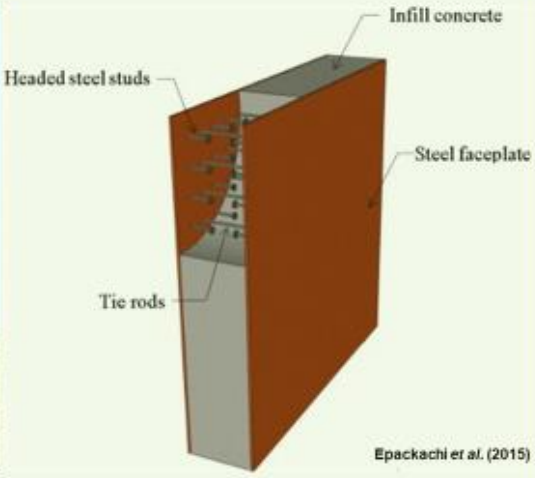
Supply chain management /risk

Collaboration with other industry:

Considering impacts on life-cycle cost, **civil works including concrete** also have opportunity to improve by introducing AMM technology. **Cross-cutting activities with other industry** may accelerate the application of AMM technology.

State of practice

Reinforced Concrete (RC) Wikipedia



Steel-plate Composite (SC)

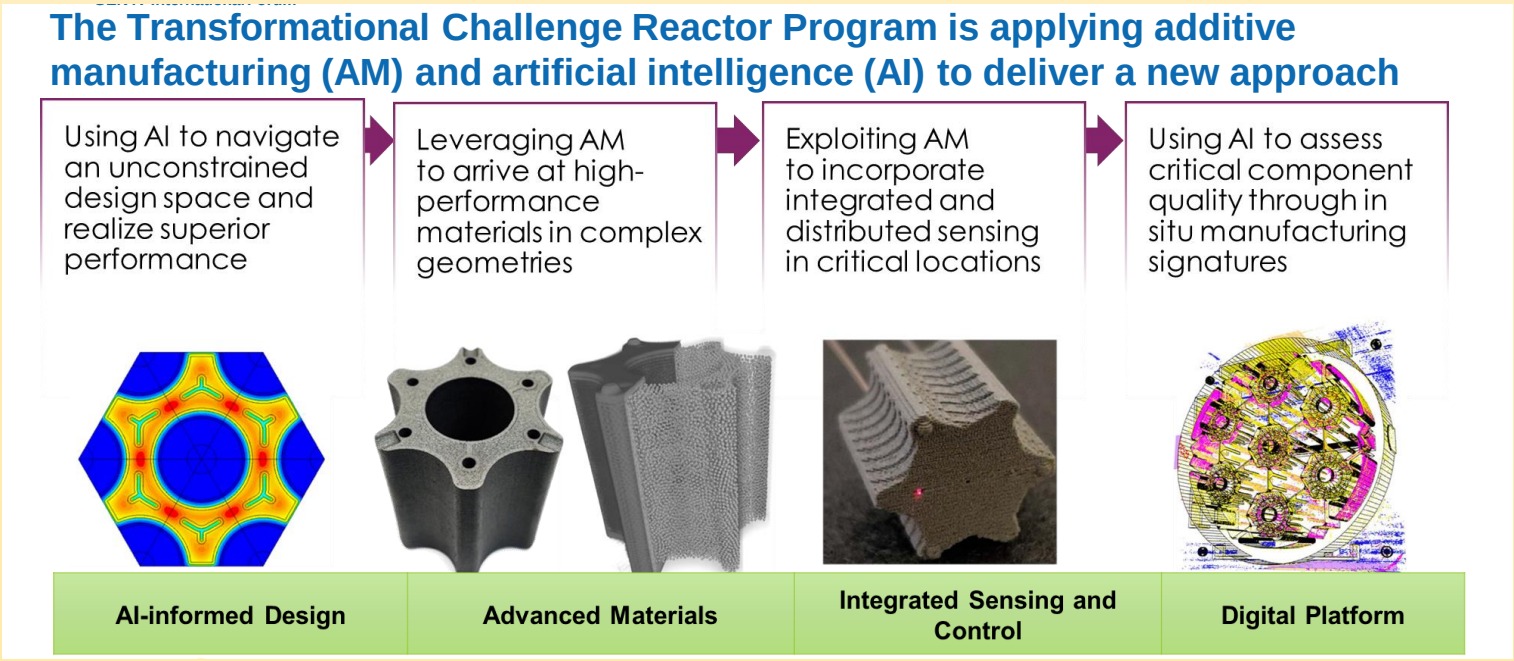
Nuclear construction

Precast Concrete http://www.windfarmbop.com

Not nuclear construction (yet)

Artificial Intelligence:

Oak Ridge National Laboratory have been conducted Transformational Challenge Reactor (TCR) program to accelerate deployment new approach. This program is applying Additive Manufacturing and Artificial Intelligence.



To address challenges of AMM technology:

There are various challenges on introducing AMM technologies. Bring together diverse set of manufacturing methods and materials with harsh environmental working capabilities, and then identify common barriers and technical pathways to addressing these challenges.

High Impact Materials & Manufacturing Technology Challenges

- Design approaches for manufacturing
  - More qualified materials are needed by reactor developers to allow for design flexibility and to meet performance targets.
  - Optimized process modeling and AI
  - Interface design
  - Residual stresses relationships to design features
  - Topology optimization
- Develop and qualify high strength, corrosion and radiation resistant materials for molten salt reactors
- Accelerate qualification (new paradigm?)
  - Verification of quality & validation of modeling tools: specific manufacturing process modeling
  - "New" material discovery (or is it adoption of lessons learned from other disciplines)
  - High-throughput testing and characterization
  - Verification of quality & validation of modeling tools: specific manufacturing process modeling
  - Acceptance protocols for high temperature reactor components fabricated by advanced manufacturing methods
  - Integrated shared databases
- Compact Heat Exchangers
- Large component fabrication and welding, Size limitations (Scalability – size, volume)
- Sensors:
  - Radiation tolerant sensors
  - Wireless sensors
  - Embedded
  - Miniaturization
  - Multi-properties
  - Real time
  - Integrated manufacturing processes
- Thermal barrier coatings: Interface designs to prevent scaling, functional materials, isolation