ARPA-E GEMINA Portfolio and Digital Twins

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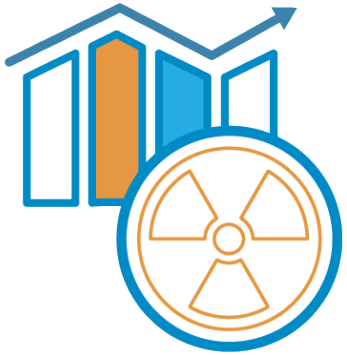
REDUCE
imports

REDUCE
emissions

IMPROVE
efficiency



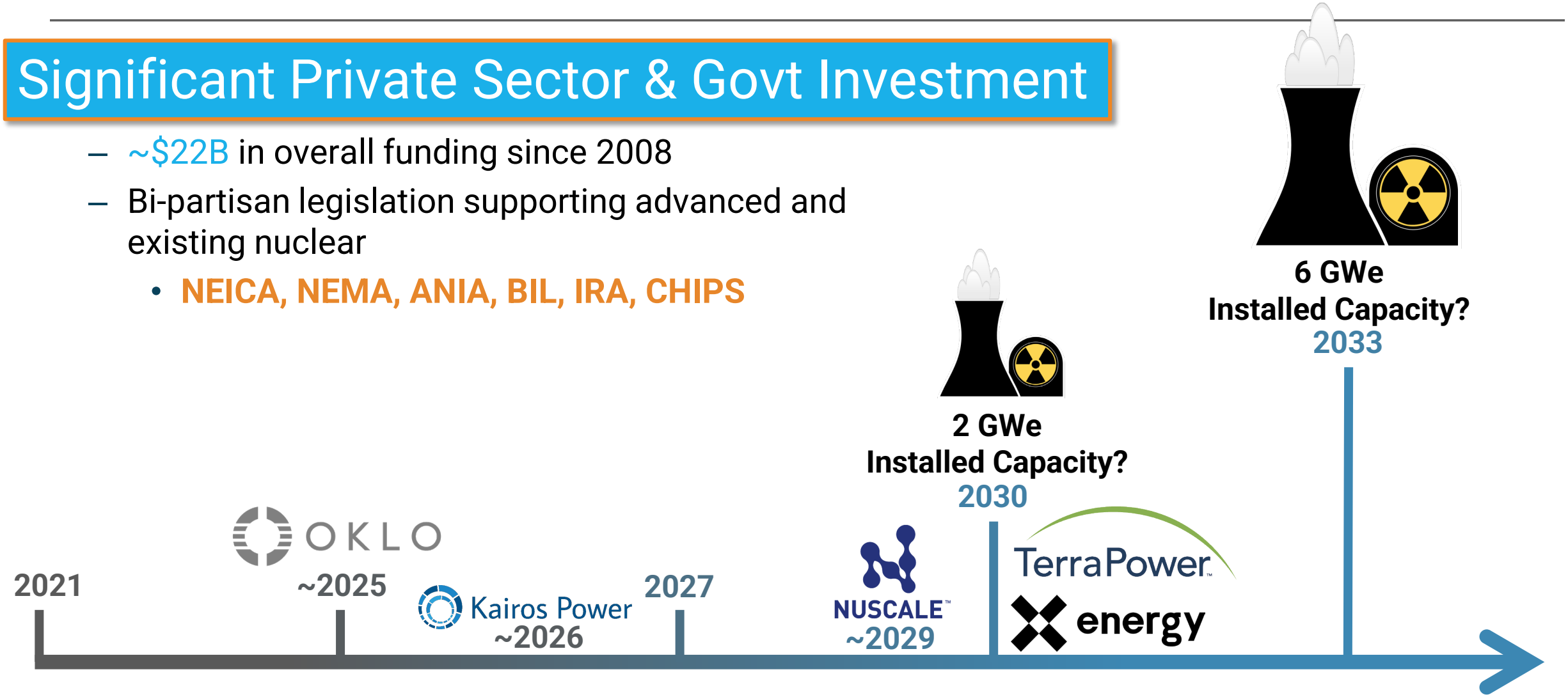
IMPROVE
radioactive waste management

IMPROVE
energy infrastructure resilience

Advanced Reactors are Coming

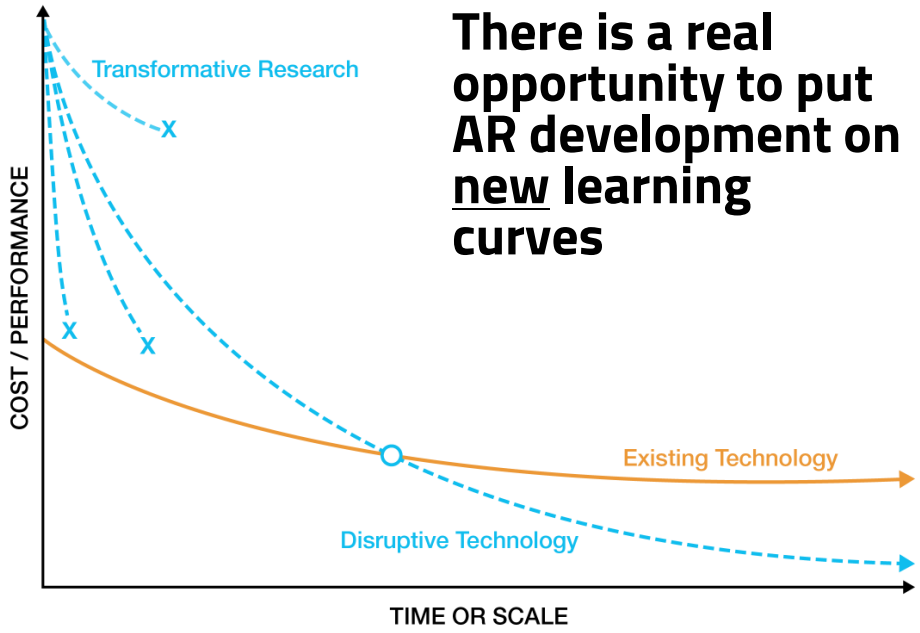
Significant Private Sector & Govt Investment

- ~$22B in overall funding since 2008
- Bi-partisan legislation supporting advanced and existing nuclear
  - **NEICA, NEMA, ANIA, BIL, IRA, CHIPS**

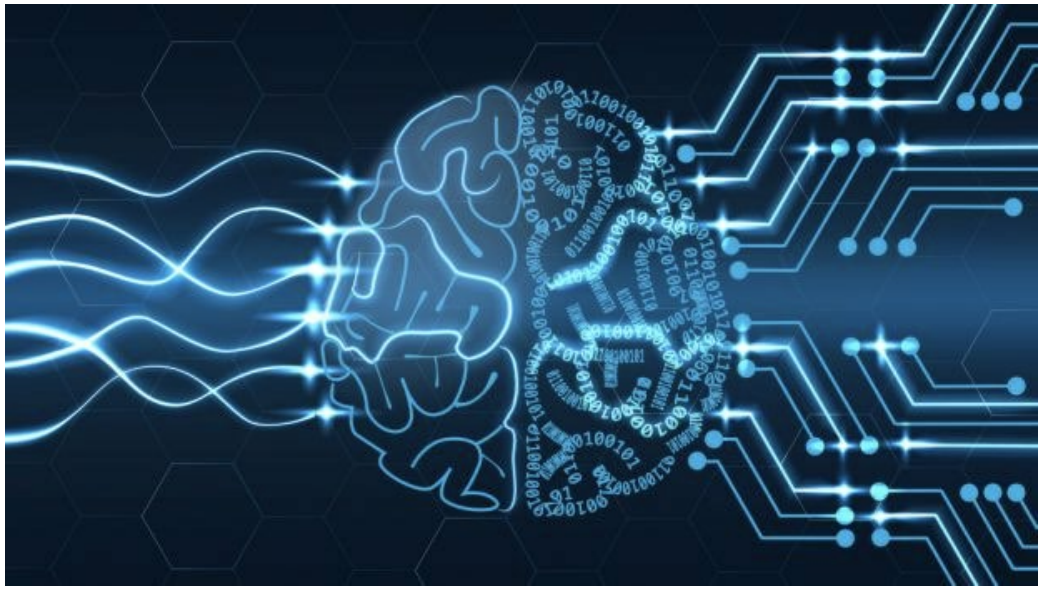


GEMINA Seed Idea

- Nuclear industry used to be leaders in asset performance management
  - Has achieved incredible capacity factors/uptime fraction
    - Happened on a slow learning curve
  - Advanced reactors need to be very economical/reliable for them to make an impact
- Lots of industries are developing better controls, better models, better data, better algorithms
  - Focus on autonomy and machine learning (ML) is getting many questions answered
  - Answer those questions specific for nuclear and prove out ideas in our systems and with our software; aid in code validation



There is a real opportunity to put AR development on <u>new</u> learning curves

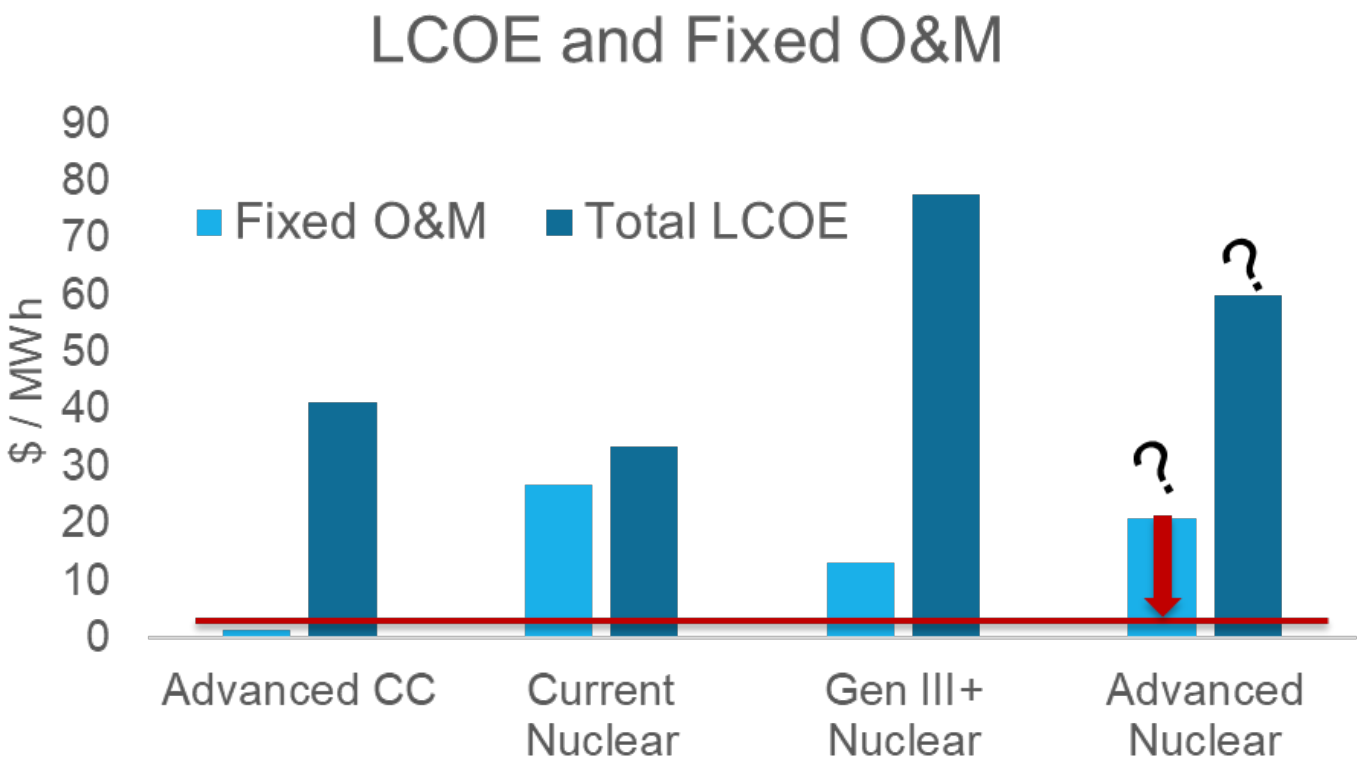


GEMINA (Generating Electricity Managed by Intelligent Nuclear Assets)

- **Goal:** Develop the tools and cost basis for ARs to **achieve fixed O&M costs of $2/MWh** without shifting costs to other parts of LCOE

Awardee teams are developing the following for one or more of the most promising AR designs:

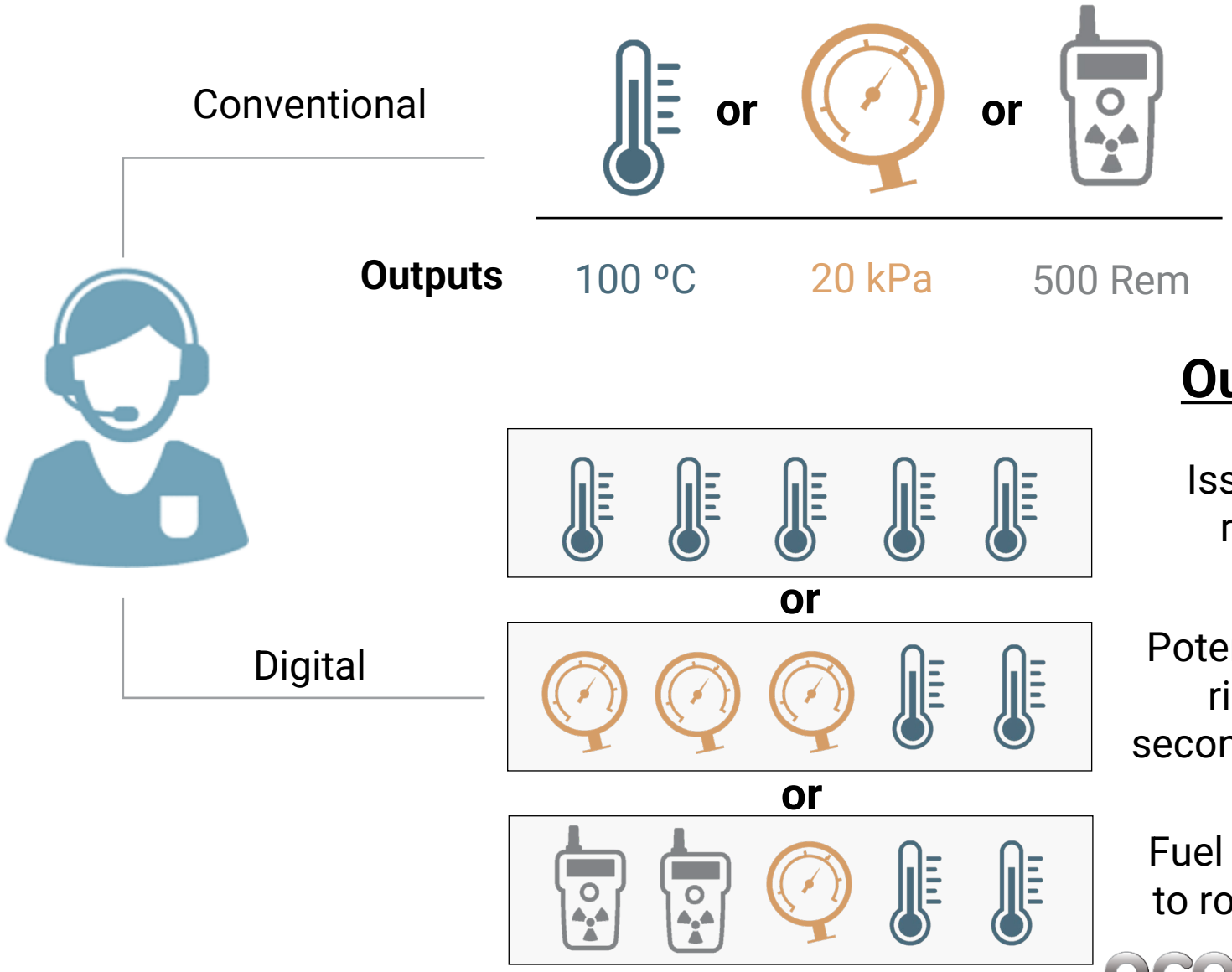
- **Digital twins for advanced reactor systems**
- **Relevant cyber physical systems**
- **O&M approaches for advanced reactors**
- **Cost models and design updates**



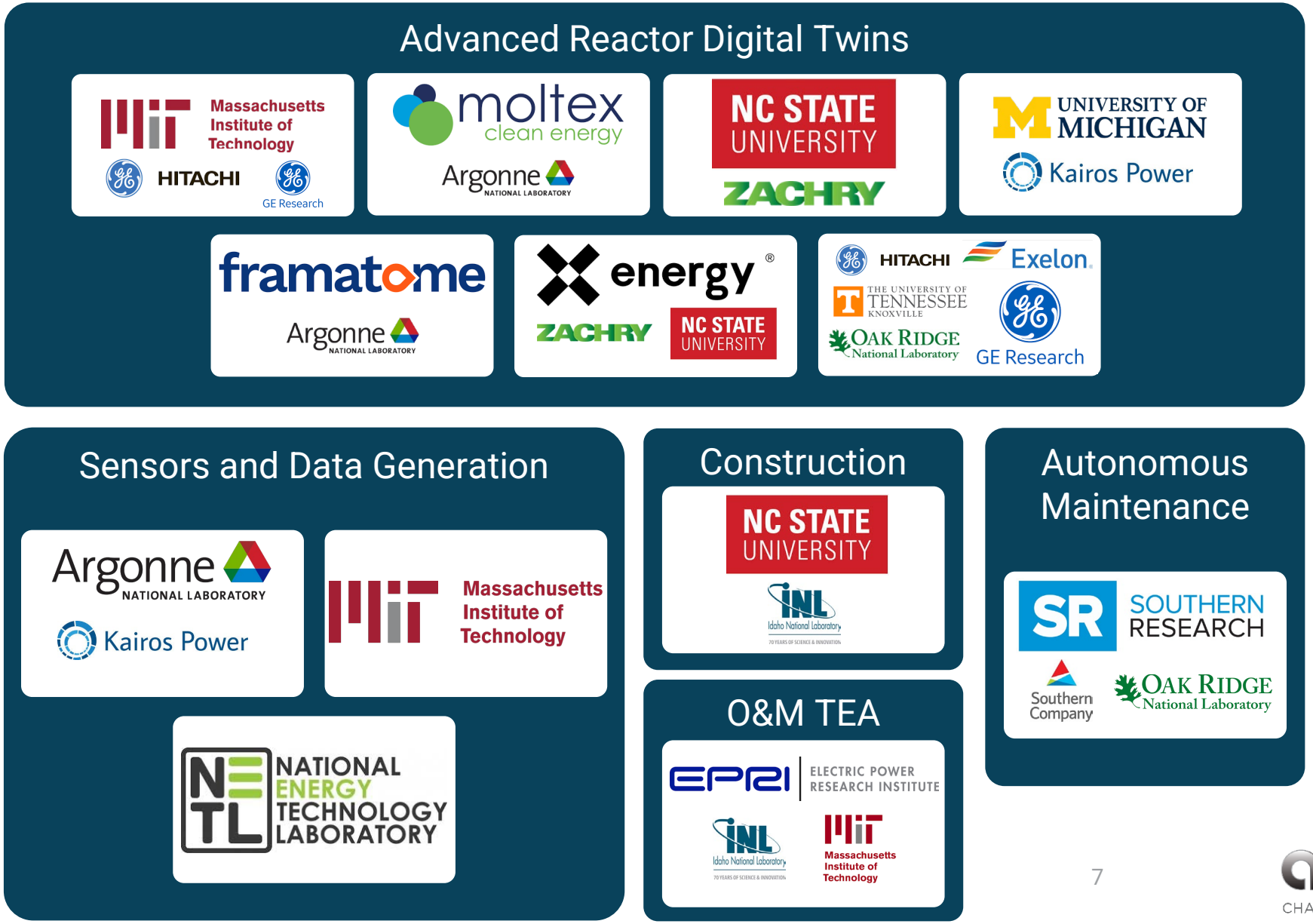
https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf, https://www.innovationreform.org/wp-content/uploads/2018/01/Advanced-Nuclear-Reactors-Cost-Study.pdf

Digital activities within GEMINA Portfolio

- Modeling (or twinning) an aspect of the reactor system.
- Are purely at the advisory stage
- Envisioned deployment is in parallel with conventional advisory and indicator tools



ARPA-E teams are building digital tools for ARs and building blocks for DTs



LISA: NC State University & PowerN, Inc.

Project Title:

A Data-driven Approaches to High Precision Construction and Reduced Overnight Cost and Schedule

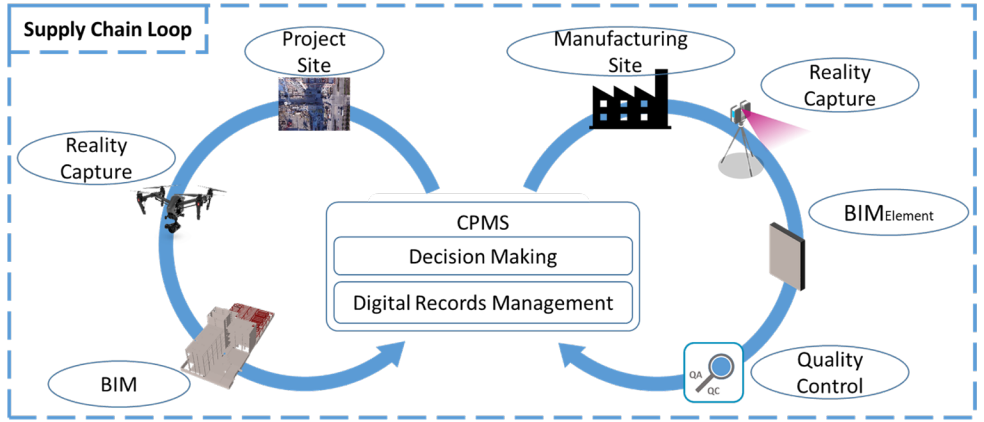
PI:

Kevin Han
kevin.han@powern.ai

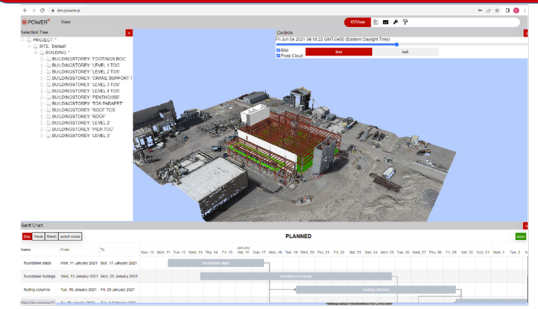
Project Outcomes:

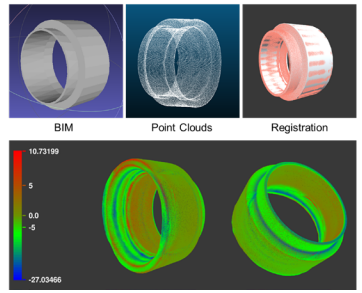
Economic competitiveness through reduced construction costs and schedule. Reduction in uncertainties associated with construction of nuclear power plants

CPMS in the Supply Chain Loop



4D As-built vs. BIM & Virtual Inspection





Key takeaway: Reduce uncertainties, construction costs, and schedule delays

GEMINA: Framatome Inc.

framatome Argonne NATIONAL LABORATORY metroscope Constellation

Project Title:

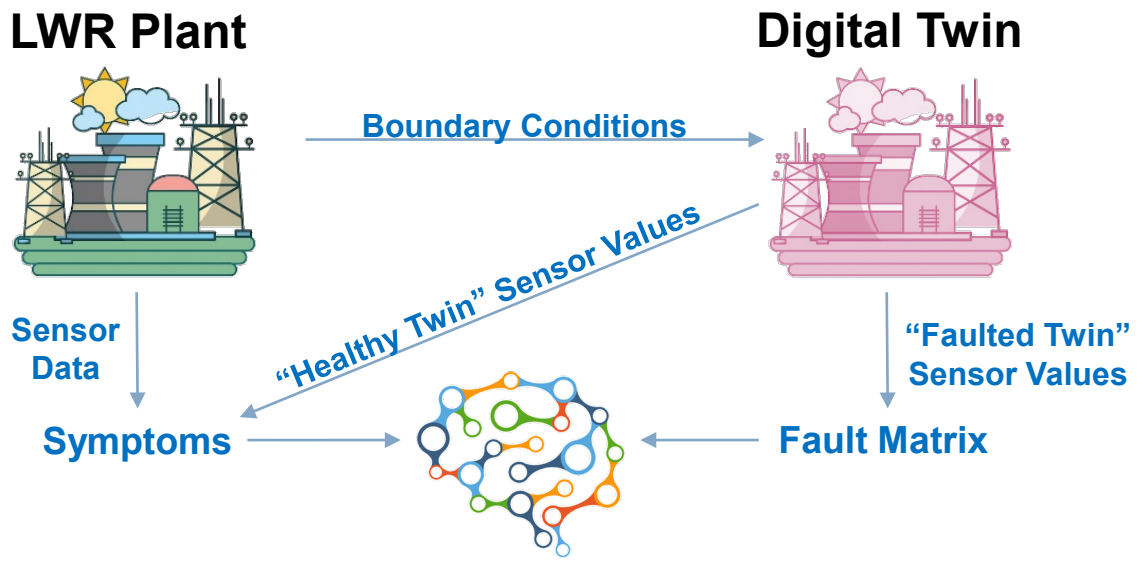
Digital Twin Diagnostics for
Nuclear Plant Auxiliary Systems

PI:

Eric Helm, Framatome
eric.helm@framatome.com

Project Outcomes:

Expanded the reach of Metroscope automatic diagnostics technology to advanced reactor auxiliary systems; working toward testing at an operating reactor to reach TRL 9 and accelerate commercialization



Key takeaway: Revolutionizing nuclear reactor diagnostics and cutting costs with field-proven digital twin technology

GEMINA: Massachusetts Institute of Technology

GE VERNOVA HITACHI

Project Title:

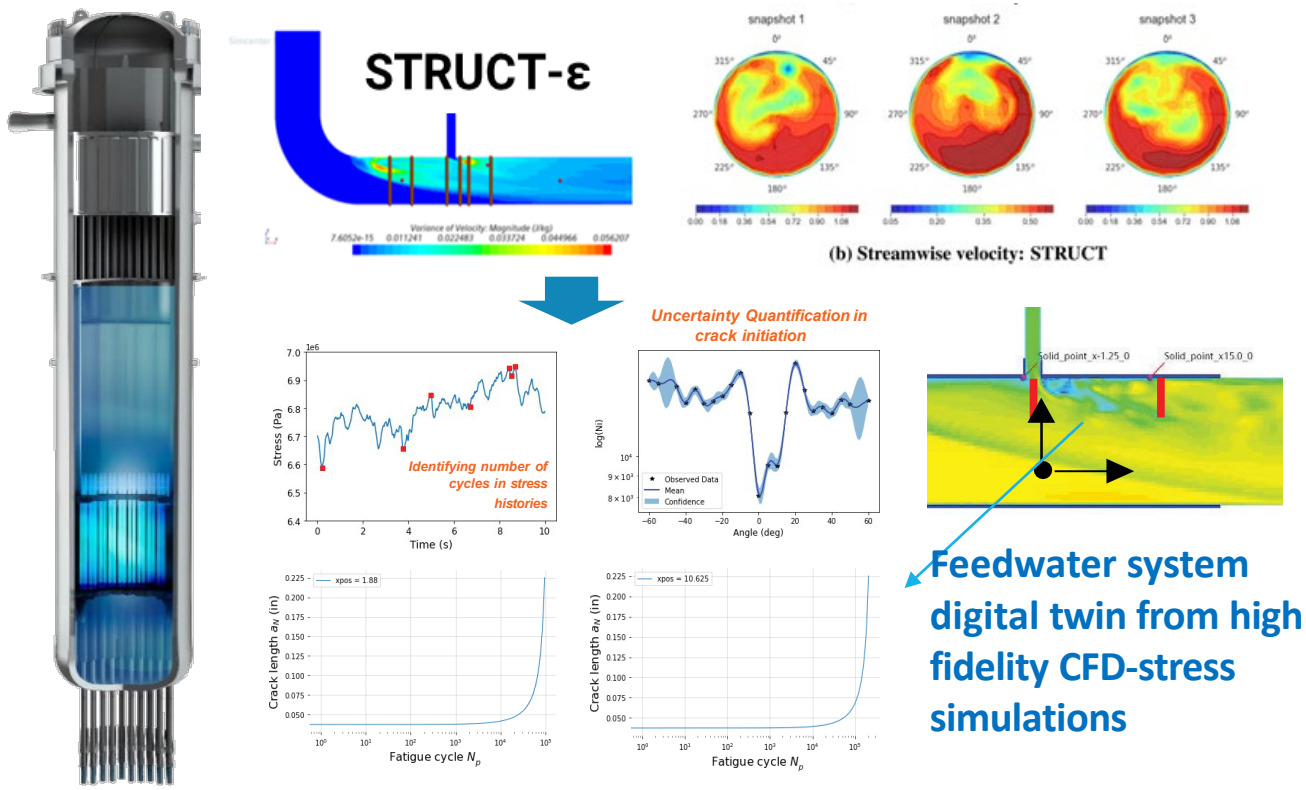
HIGH FIDELITY DIGITAL TWINS FOR BWRX-300 CRITICAL SYSTEMS

PI:

Emilio Baglietto
emiliob@mit.edu

Project Outcomes:

High-fidelity simulations based maintenance approaches and model based fault system detection techniques



Feedwater system digital twin from high fidelity CFD-stress simulations

Key takeaway: High-fidelity simulations are a key enabler for condition based maintenance in advanced reactors

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CHANGING WHAT'S POSSIBLE