Enabling Technologies for Digital Twins
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What is a Digital Twin?
Digital Twin Characteristics

Purpose
Defines representation scope, intended use, and desired outcomes

Digital
Enables the use of advanced digital tools and virtual representation

Cognizance
Leverages state concurrence to provide useful knowledge about the system

Concurrence
Ensures adequate representation in accordance with purpose
Main Goals

Technical Letter Report*

Research Information Letter

* ML21160A074, ML21361A261, ML22192A046, ML22235A643
# Technical Challenges & Gaps

<table>
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<tr>
<th>Enabling Technology</th>
<th>Key Challenge</th>
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<tr>
<td>Advanced Sensors &amp; Instrumentation (ASI)</td>
<td>Building adequate ASI infrastructure</td>
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<tr>
<td>Data and Information Management</td>
<td>Developing user interfaces for data and information</td>
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<td>Data Analytics</td>
<td>Implementing scalable, integrable data analytics</td>
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<tr>
<td>Artificial Intelligence (AI)/Machine Learning (ML)</td>
<td>Establishing AI/ML trustworthiness and explainability</td>
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<tr>
<td>Modeling and Simulation</td>
<td>Constructing real-time, high-fidelity physics-based simulations</td>
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<td>Developing real-time, data-informed models</td>
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<td>Verifying and validating integrated models</td>
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Impact

Industry-Led Activity on Generalized Framework Presentation at Standards Forum on Sept. 28th
Opportunities for Advanced Modeling

• Enhanced Data-Informed Modeling using AI/ML or Multiphysics
  • Improved Verification and Validation
  • Realtime Data for Training AI/ML Models
  • Reduce uncertainties
  • Improved Explainability of Predictions using AI/ML

• Case Studies
  • Equipment Performance Monitoring using ML and Long Short-Term Memory (LSTM) Forecasting
  • Nuclear Materials Safeguards
Regulatory Considerations & Opportunities

Examples:

<table>
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<tr>
<th>Regulatory Consideration</th>
<th>Opportunity</th>
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<tr>
<td>Information Reporting</td>
<td>Data and report generation</td>
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<tr>
<td>Operator Licensing</td>
<td>Up-to-date and validated simulator model</td>
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<td>Component Performance</td>
<td>Real-time condition-based monitoring and</td>
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<td>preventative maintenance</td>
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<td>Event Assessment</td>
<td>Virtual environment event replay</td>
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<td>Safety Analysis</td>
<td>Integrated modeling and simulation to</td>
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<td>support decision making</td>
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The project was supported by multiple NRC offices including:

- Nuclear Regulatory Research
- Nuclear Reactor Regulation
- Nuclear Security and Incident Response
- The Chief Information Officer
- Nuclear Material Safety and Safeguards
- The Chief Human Capital Officer

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