OAK RIDGE National Laboratory

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The Federated Computing Environment for Autonomous Smart Laboratories

Christian Engelmann

Oak Ridge National Laboratory

U.S. DEPARTMENT OF ENERGY

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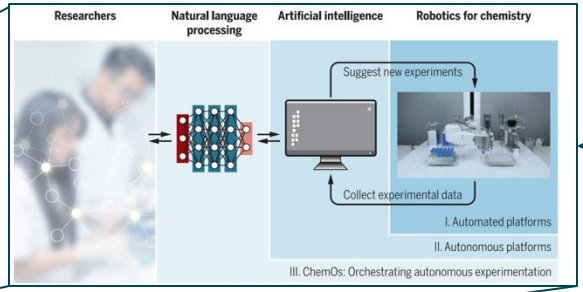
FOR THE US DEPARTMENT OF ENERGY

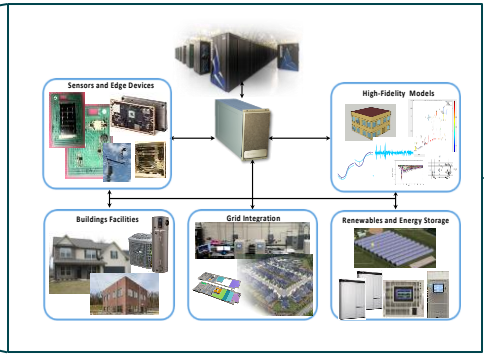
Long-Term Vision for Autonomous Smart Laboratories

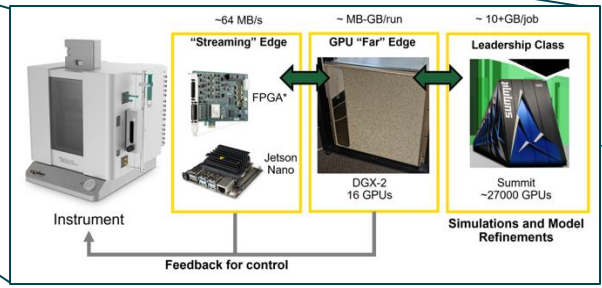
Interoperable Ecosystem Across the Instrument-to-Cloud-to-Center Computing Continuum

Materials Lab



Electric Grid Lab

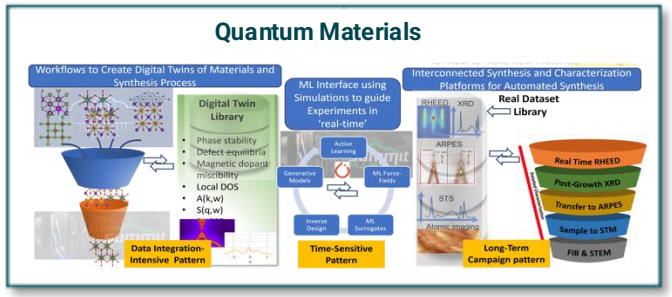


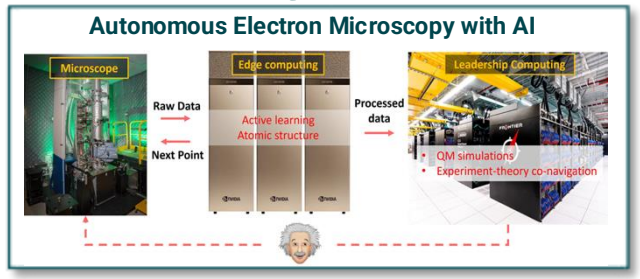


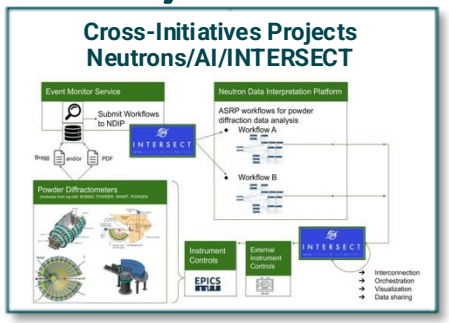
Microscopy Lab

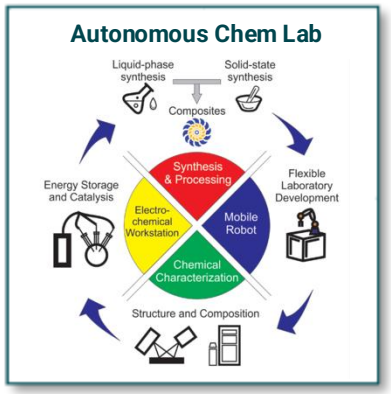
Interconnected Smart Labs

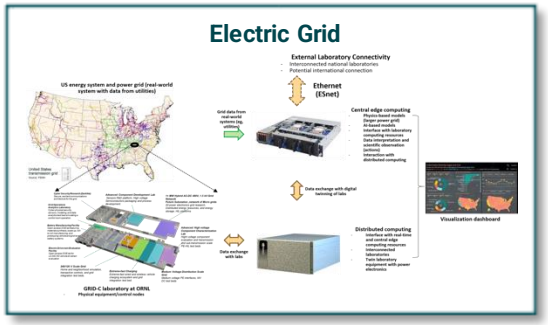
ORNL's Interconnected Science Ecosystem (INTERSECT)

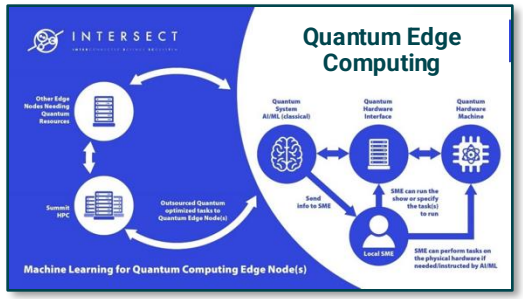


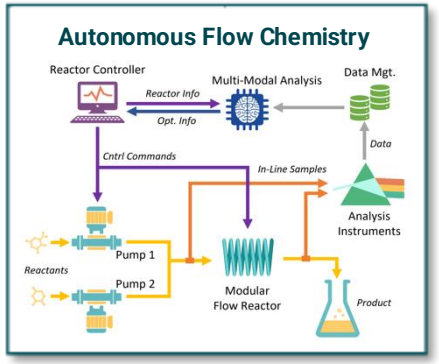


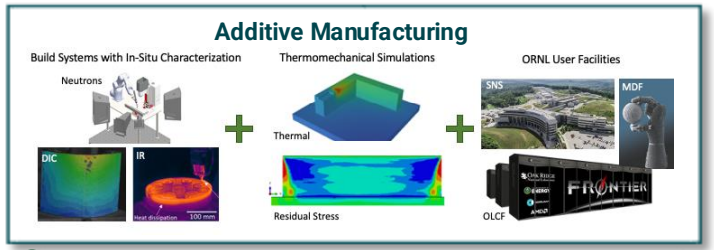


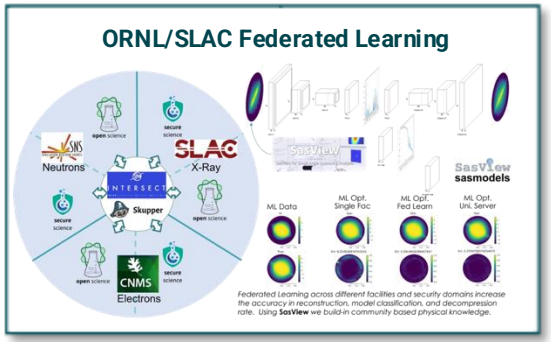


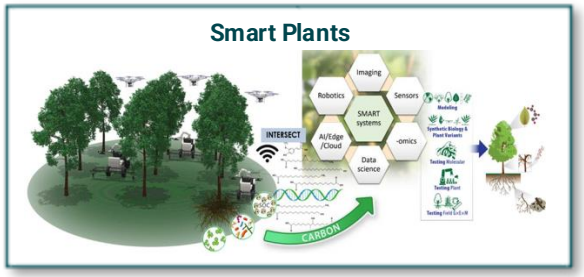


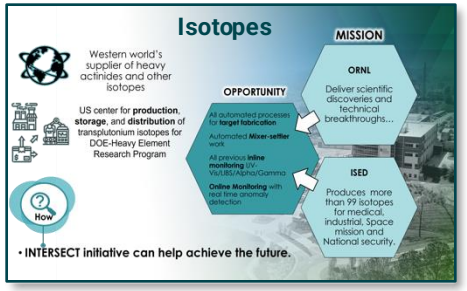












12 Use Cases

6 Directorates

Multiple Labs

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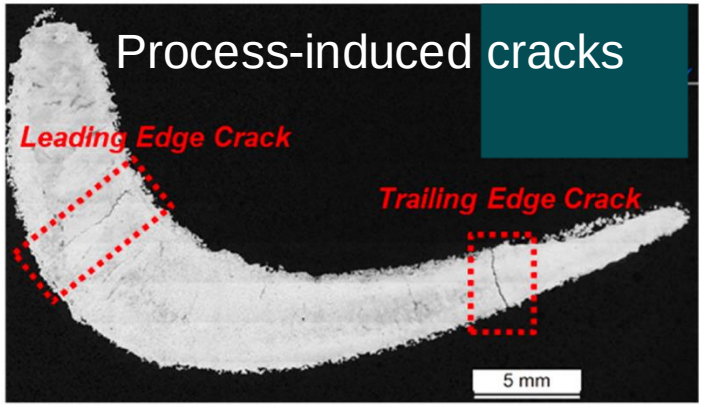
Additive Manufacturing – 3D Printing of Anything

Building a part layer-by-layer by melting small amounts of powder/wire at a time

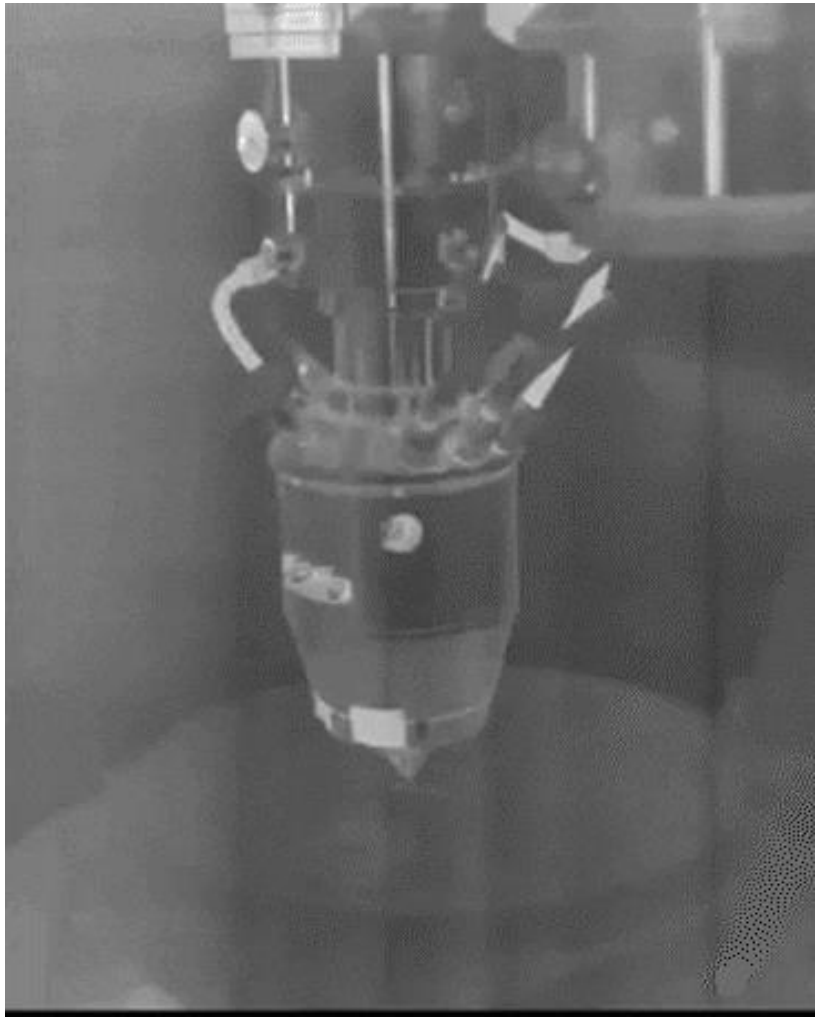
Potential for new, complex part topologies and optimized, location-specific material properties

Part quality is sensitive to process parameters

Any change can require unintuitive process changes



Lee, et al, Additive Manufacturing, 2020.



Additive Manufacturing – 3D Printing of Anything

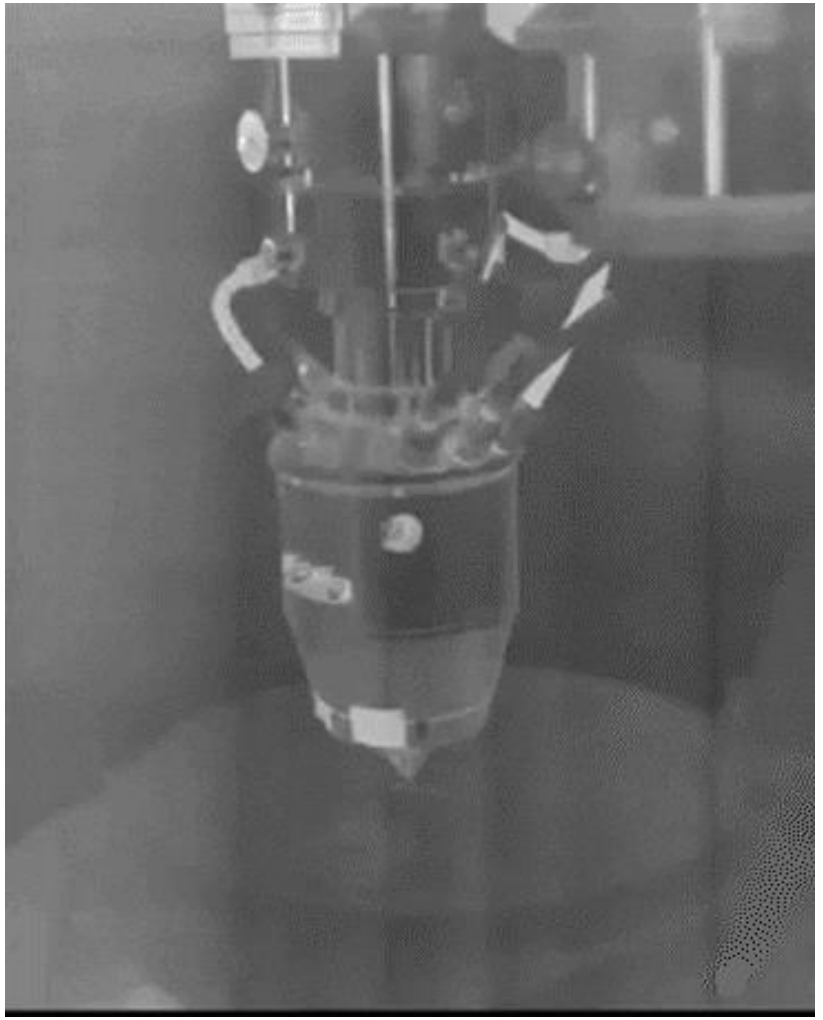
Building a part layer-by-layer by melting small amounts of powder/wire at a time

Potential for new, complex part topologies and optimized, location-specific material properties

Part quality is sensitive to process parameters → Any change can require unintuitive process changes

Grand challenge:
Produce parts that are safe and ready to use immediately “Born Qualified”

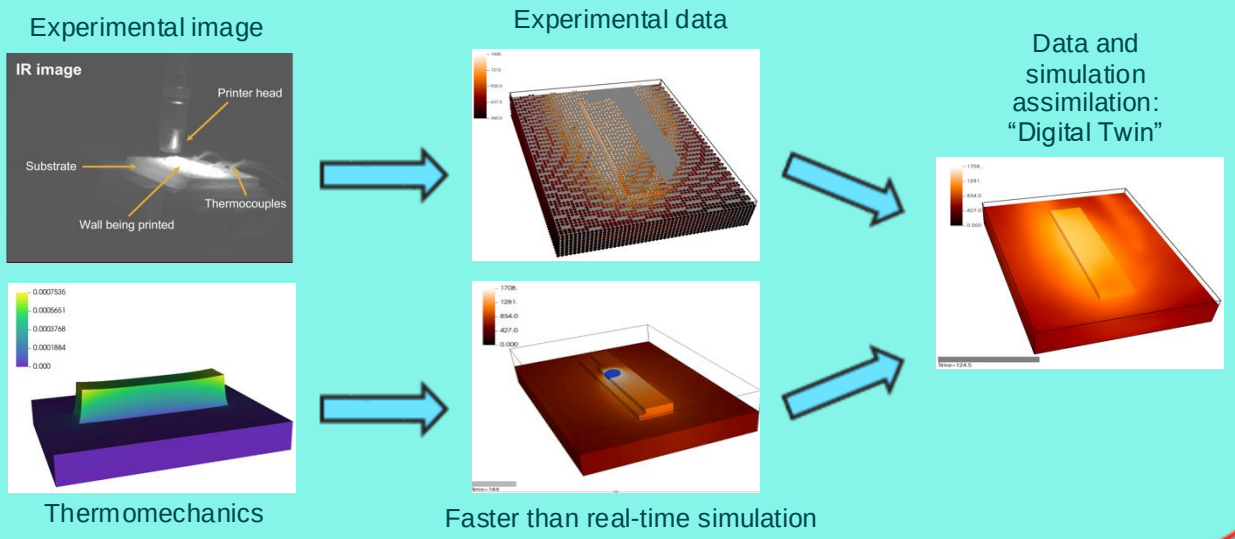
Approach:
Autonomous planning and control



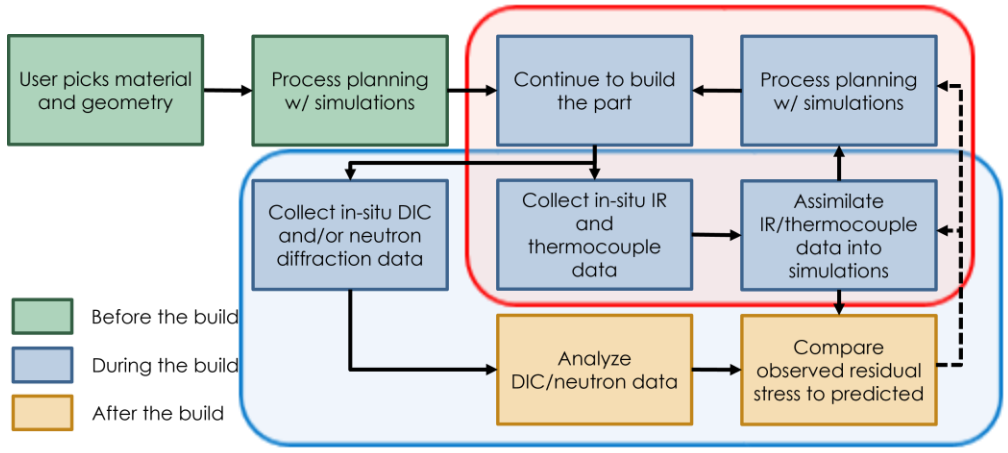
Lee, et al, Additive Manufacturing, 2020.

Additive Manufacturing – Reuse, the Power of INTERSECT

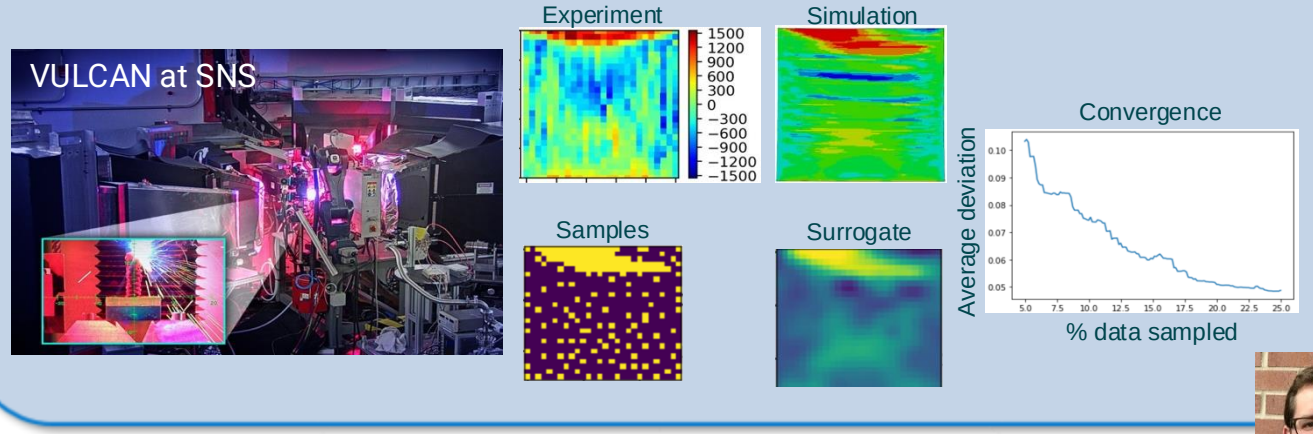
Additive Manufacturing Digital Twin



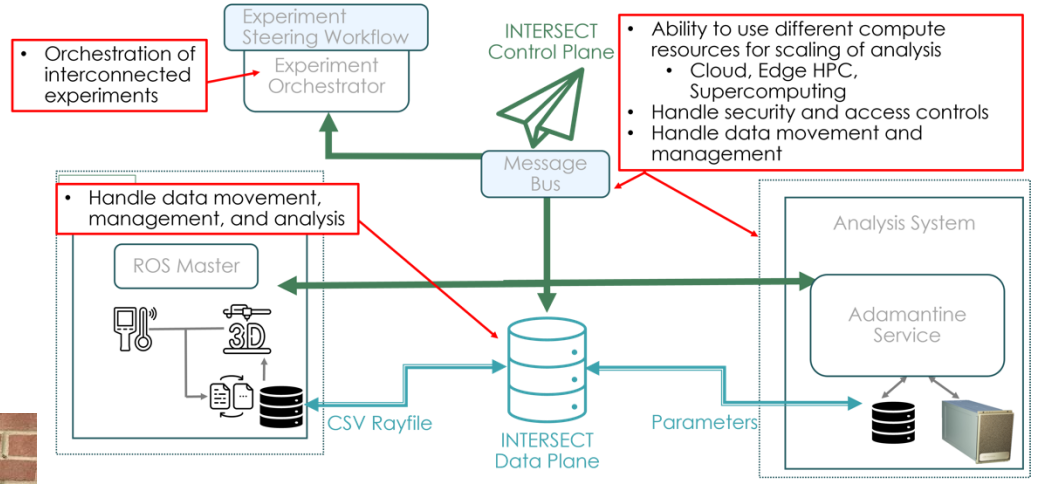
Additive Manufacturing Autonomous Workflow



Additive Manufacturing / SNS Integration



INTERSECT Software Services



Stephen DeWitt (ORNL PI)

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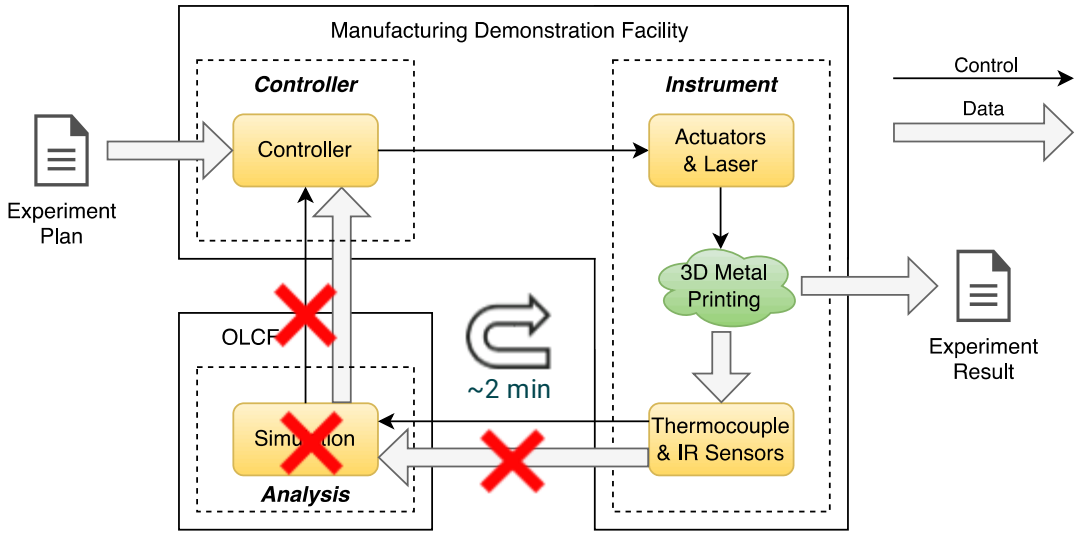
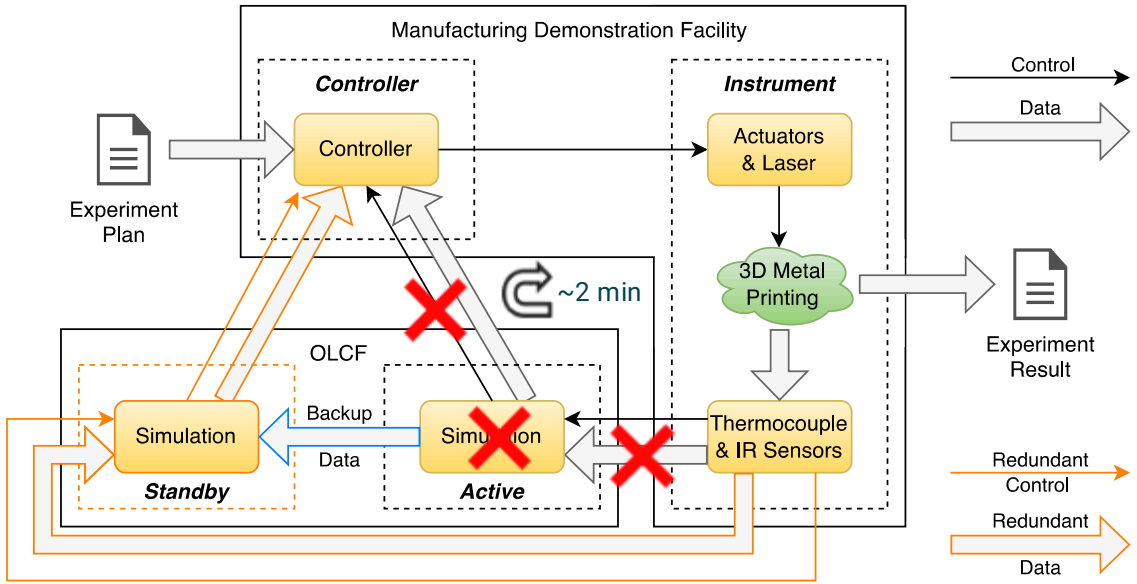
SNS SPALLATION NEUTRON SOURCE

MDF Manufacturing Demonstration Facility

INTERSECT Autonomous Additive Manufacturing with Failure Resilience for the Simulation in the Feedback Loop



Schematic of the autonomous additive manufacturing experiment's control-, data- and workflow with a simulation in the real-time feedback loop performed at the OLCF.



Schematic of an active/standby resilience example for the simulation in the feedback loop. Here, the standby is deployed at the OLCF and fail-over is potentially transparent.

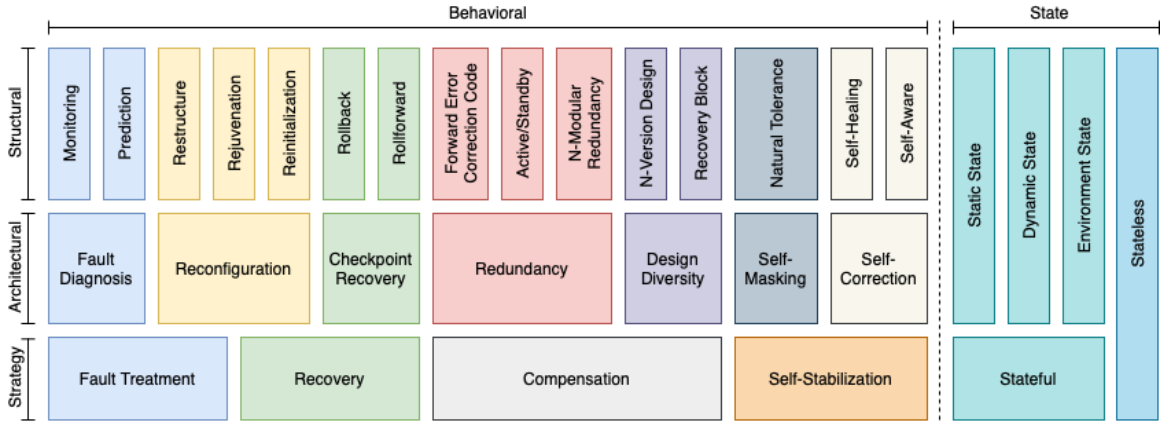
The analysis and/or its backup can be at the edge (instrument), the Cloud, some cluster computing system, or a supercomputer, depending on actual needs and availability.

Ongoing Work in INTERSECT's Resilient Federated Ecosystem

Architecture: Resilience Design Patterns

Resilience design patterns for INTERSECT systems, services, and microservices

Resilience design patterns for workflows



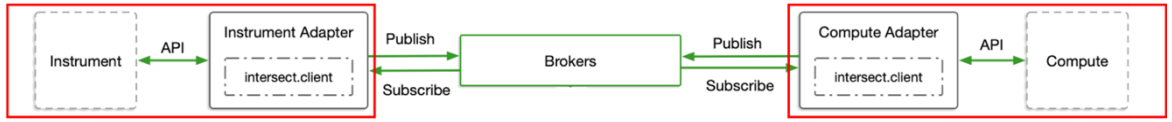
HPC Resilience Design Patterns (DOE Early Career Award 2015-20)

SDK: Resilient Communication and Services

Resilient communication and microservices

Detection, notification and mitigation APIs and microservices

Design templates for resilient architecture features



INTERSECT SDK example: SDK clients and message brokers connect an instrument with a computing resource (control path).

The Federated Ecosystem for the Smart Laboratory of the Future

Computing, Data and Network Resource Needs

A diverse set of computing resources

- Capability computing for large-scale modeling, simulation, and training
- Capacity computing for small-to-medium scale modeling, simulation, training, and inference
- Edge computing for dedicated tasks
- Co-scheduling, on-demand and real-time features

A diverse set of data resources

- Data transfer (files and stream), store, curation, and archive across the computing continuum spectrum

A network that connects all these resources with minimal barriers and dedicated capabilities and capacities

Software Ecosystem Needs

A standardized cross-facility communication layer for control and coordination

Services that expose capabilities

- Infrastructure management
- User management
- Orchestration
- Data management
- Campaign management

Error and failure notification and handling with ignore, abort and user-defined response options

A scientific data management strategy that includes meta data and provenance information for reproducibility

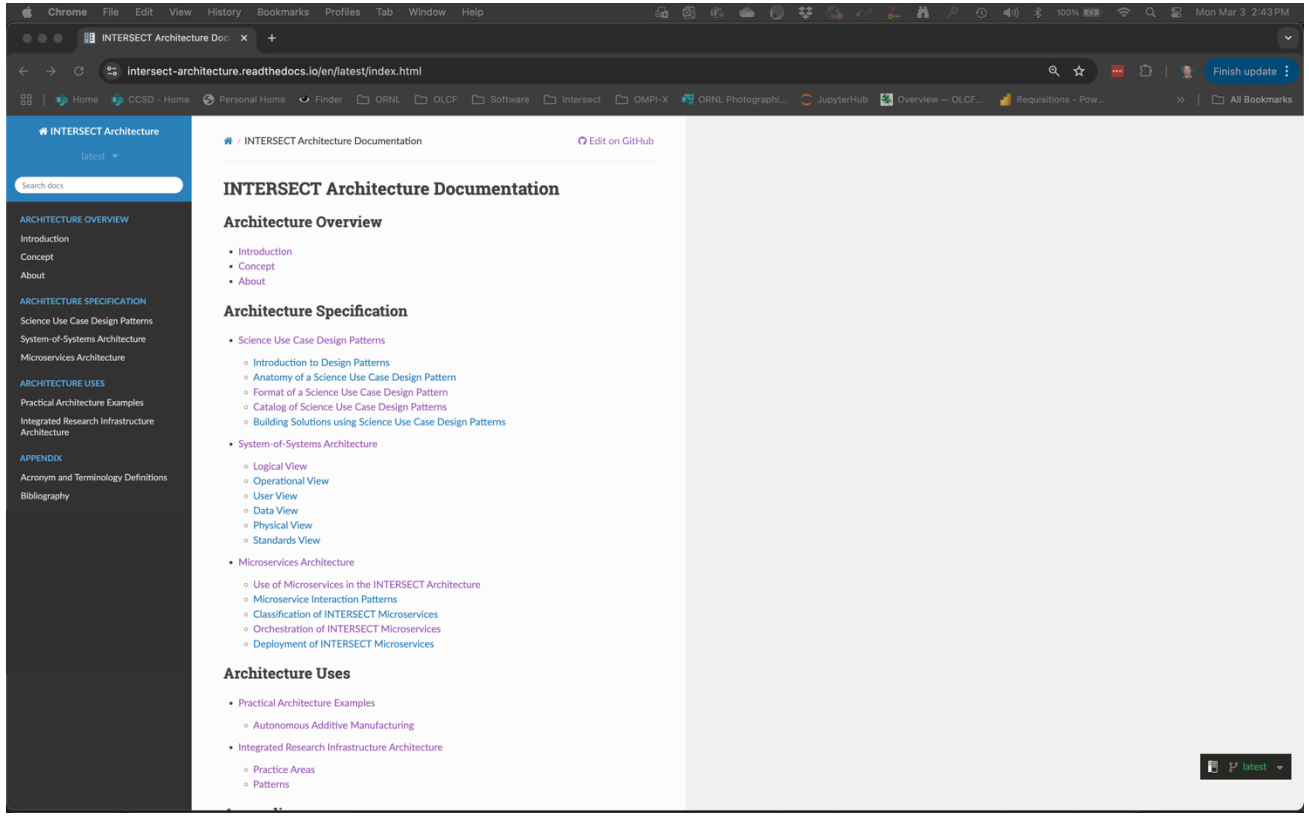
INTERSECT Resources

INTERSECT: www.ornl.gov/intersect

Architecture: intersect-architecture.readthedocs.io

SDK: github.com/INTERSECT-SDK

Autonomous Additive Manufacturing: www.ornl.gov/project/enabling-adaptively-controlled-additive-manufacturing-through-automation



Acknowledgements

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