



# Can We Use Machine Learning to Control Nuclear Power Plants?

April 2023

*Changing the World's Energy Future*

Jacob A Farber



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Battelle Energy Alliance manages INL for the  
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Idaho National Laboratory

# Acknowledgements

## Idaho National Laboratory

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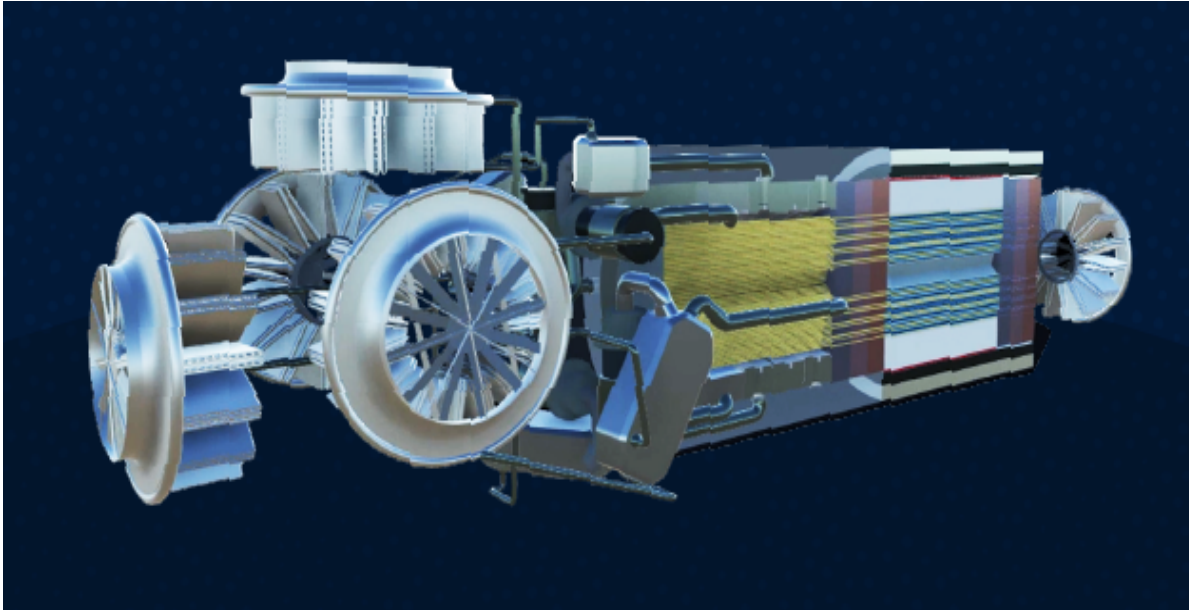
Vaibhav Yadav



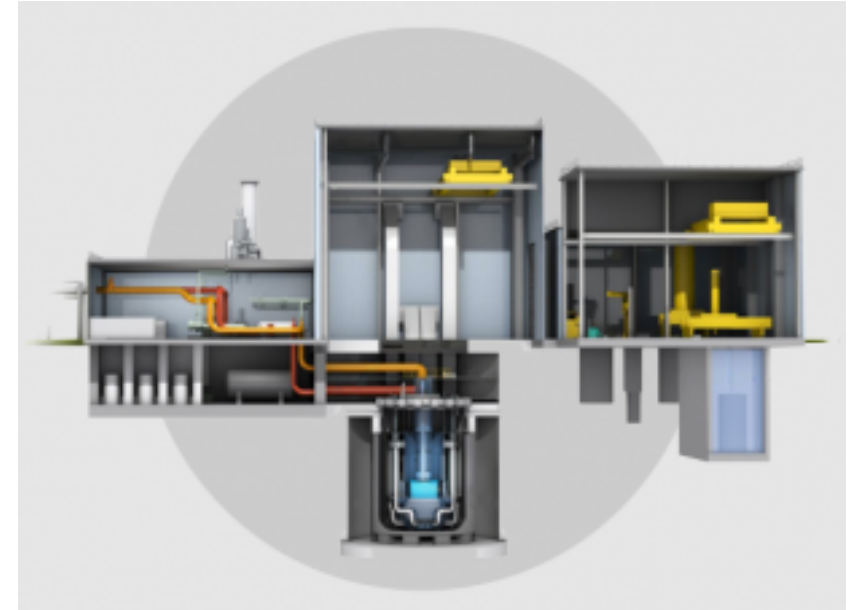
**ASI**

Advanced Sensors  
and Instrumentation

Advanced reactors will be highly autonomous and remotely controlled, and will operate at variable power ratings and in rural locations



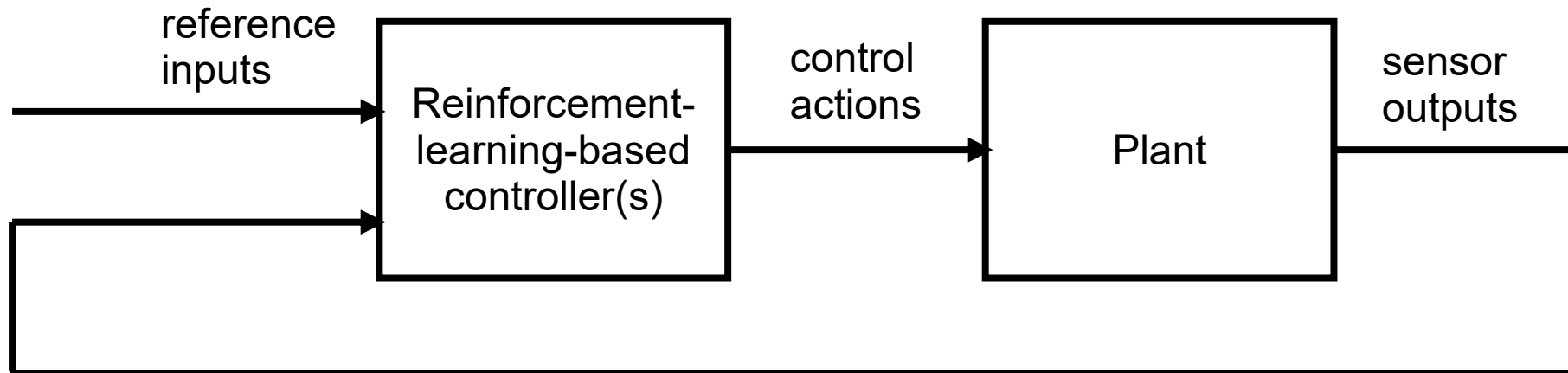
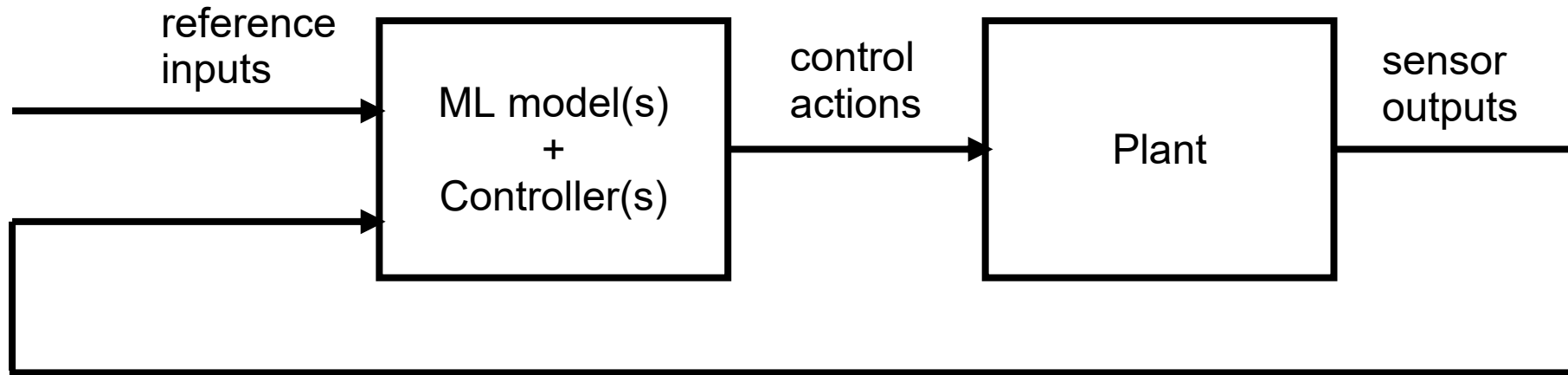
<https://www.energy.gov/ne/articles/what-nuclear-microreactor>



<https://www.energy.gov/ne/articles/infographic-advanced-reactor-development>

*These characteristics necessitate more intelligent means of control*

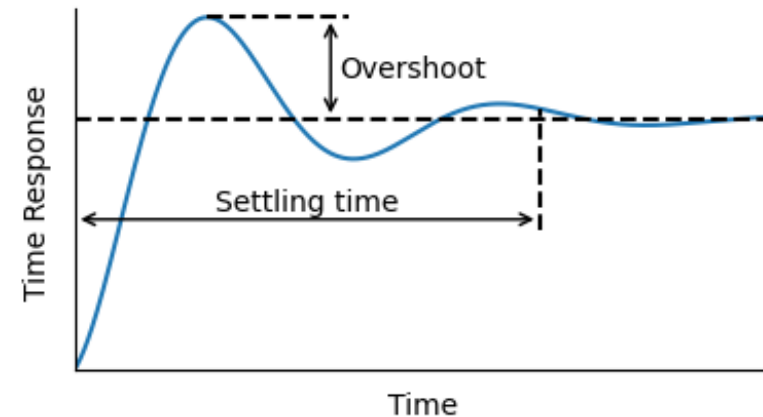
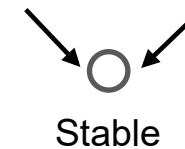
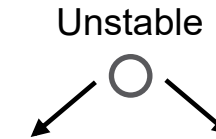
## Typical methods of ML-based intelligent control either use ML to model the plant or use reinforcement learning to directly learn control



# Regulatory requirements consider the determinism, simplicity, explainability, and verifiability of NPP control systems

- Example general considerations
  - Many ML algorithms are stochastic
  - Many ML algorithms are black box in nature
- Example control-specific consideration
  - ML-based control lacks history of verifiable stability and performance

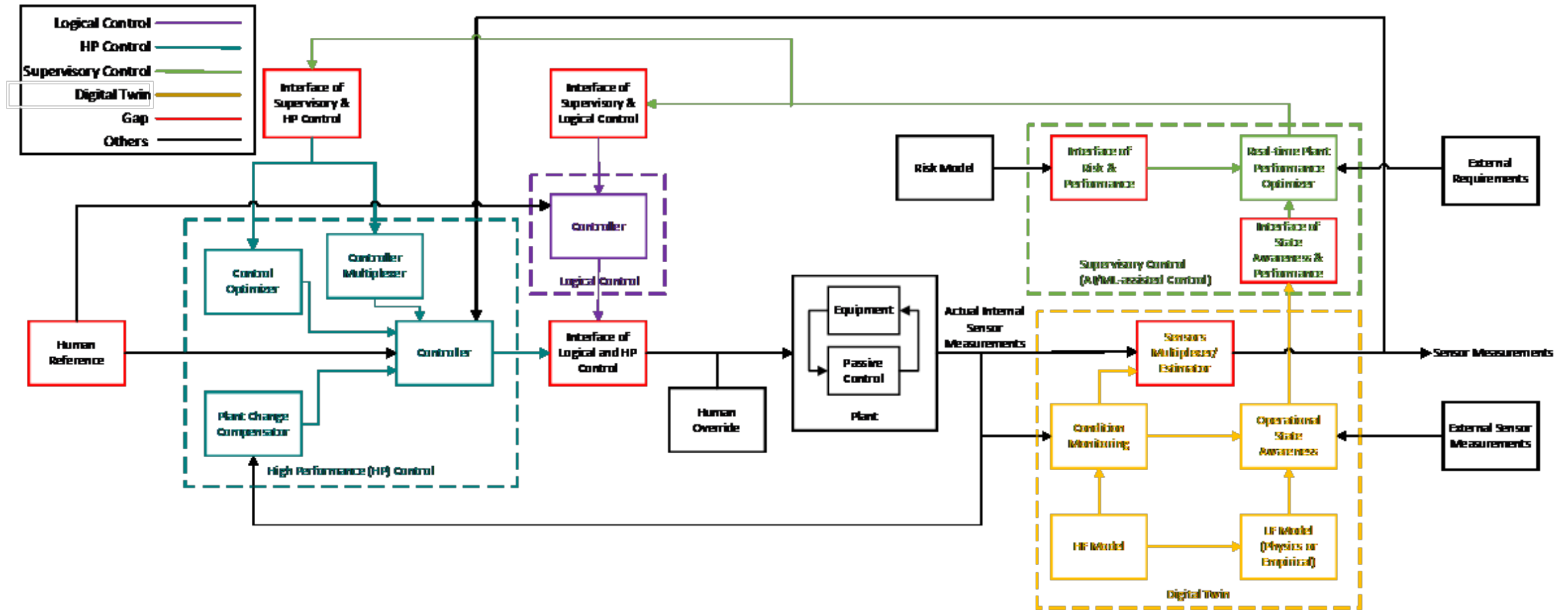
*New solutions may be necessary to overcome these barriers in using ML to directly control NPPs*







These systems can be expanded to show research gaps that need to be closed before implementing this hierarchical approach



## Conclusions

- Using ML to directly control NPPs may necessitate new solutions that consider determinism, simplicity, explainability, and verifiability
- Our hierarchical solution can be broken into two parts:
  - Perform direct control using high-performance methods that possess these important characteristics
  - Provide control support and analysis by using digital-twin-assisted supervisory control that can benefit from ML and conveys less risk
- Many open research questions remain to be answered before this hierarchical solution can be implemented

Questions?  
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