

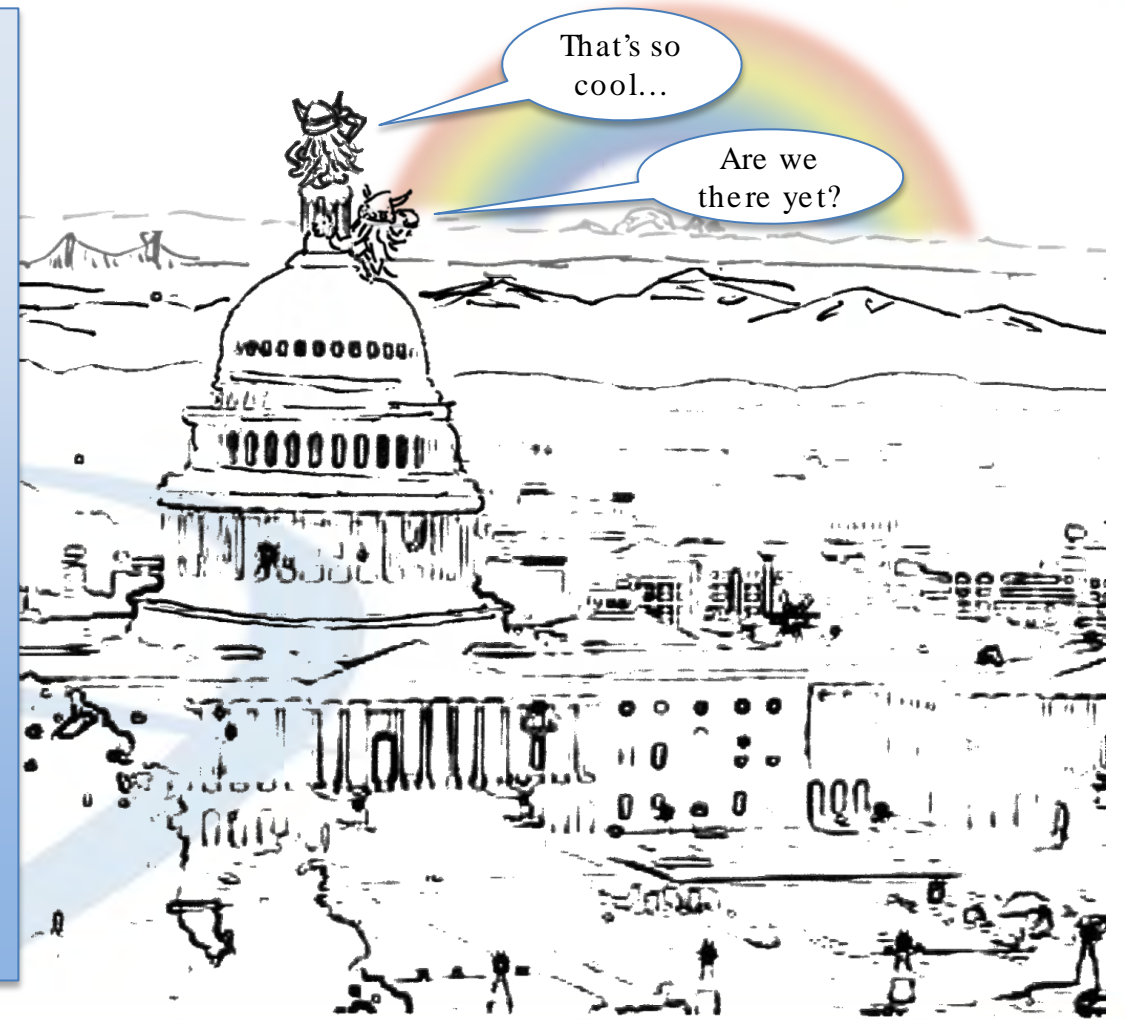
NRC's Future-Focused Research Program

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NRC Data Science and AI Workshop III –
Future Focused Initiatives

11/9/2021





FFR Program Overview

- [Program Concept and Context](#)
- [Program Objectives](#)
- [Process Considerations](#)
- [Activities](#)
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- [Future Directions](#)



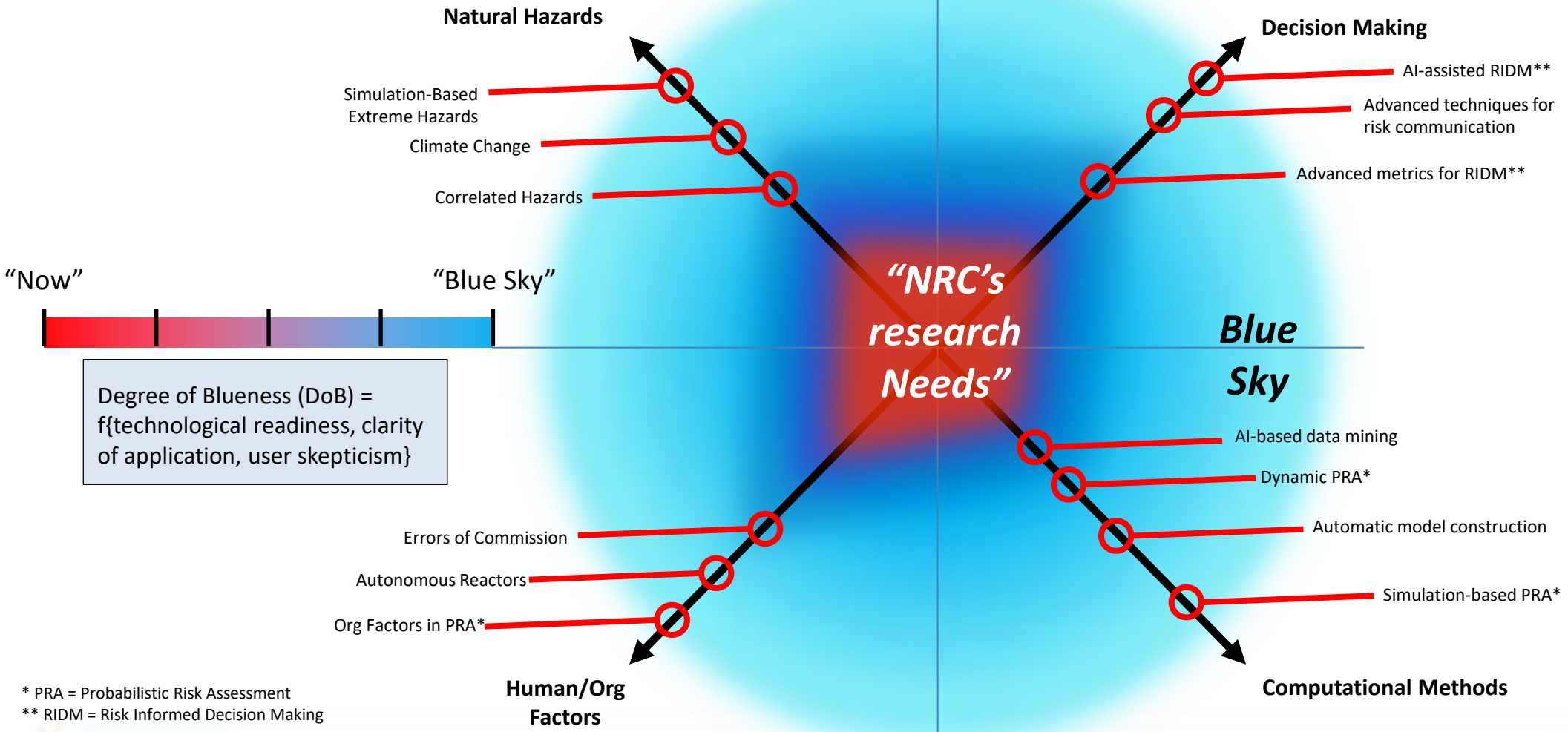
Future-Focused Research (FFR) Program Concept

- Support NRC's need for longer-term (≥ 3 years) R&D activities
- Broad scope: all good ideas considered*
- Funding
 - Dedicated
 - Fully loaded at beginning of project
 - Exploring opportunities to leverage with University R&D Grant Program
- Program management and administration
 - Streamlined submission and review process
 - Low-burden, low-resource implementation
- Start small, grow with success
 - Initiated current program in FY-20
- Mixed project portfolio
 - Time horizons
 - Project risk: ***emphasizing riskier, less-applied ideas for FY-22 and beyond***

- Inspired by national lab “Laboratory-Directed Research and Development” (LDRD) programs
 - Concept
 - Scale
- Includes “blue sky,” “risky” projects



NRC's Blue Sky



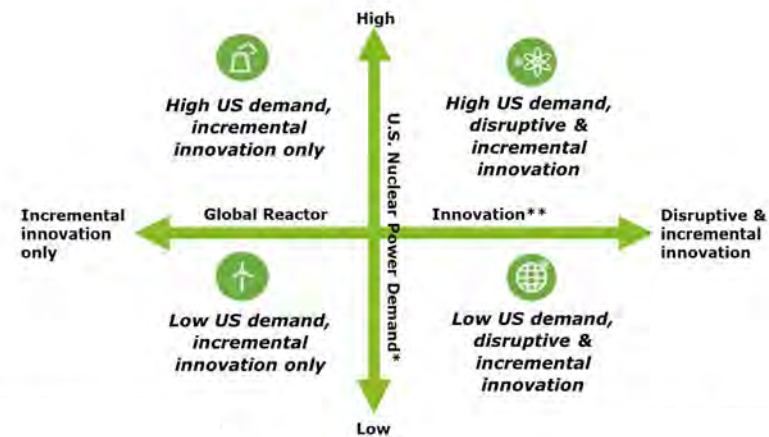
* PRA = Probabilistic Risk Assessment
 ** RIDM = Risk Informed Decision Making



NRC's Horizon: Opportunities and Challenges

“It’s tough to make predictions, especially about the future.”
- Yogi Berra

- Changing reactor technologies, concepts of operation
- Increasing knowledge base (and means to use)
- Increasing computational capabilities (hardware, software, modeling approaches, ...)
- Changing staff and other stakeholders
- Increasing and more challenging regulatory applications



U.S. Nuclear Regulatory Commission, “The Dynamic Futures for NRC Mission Areas,” 2019. (ML19022A178)

RES goal: help ensure that NRC is prepared

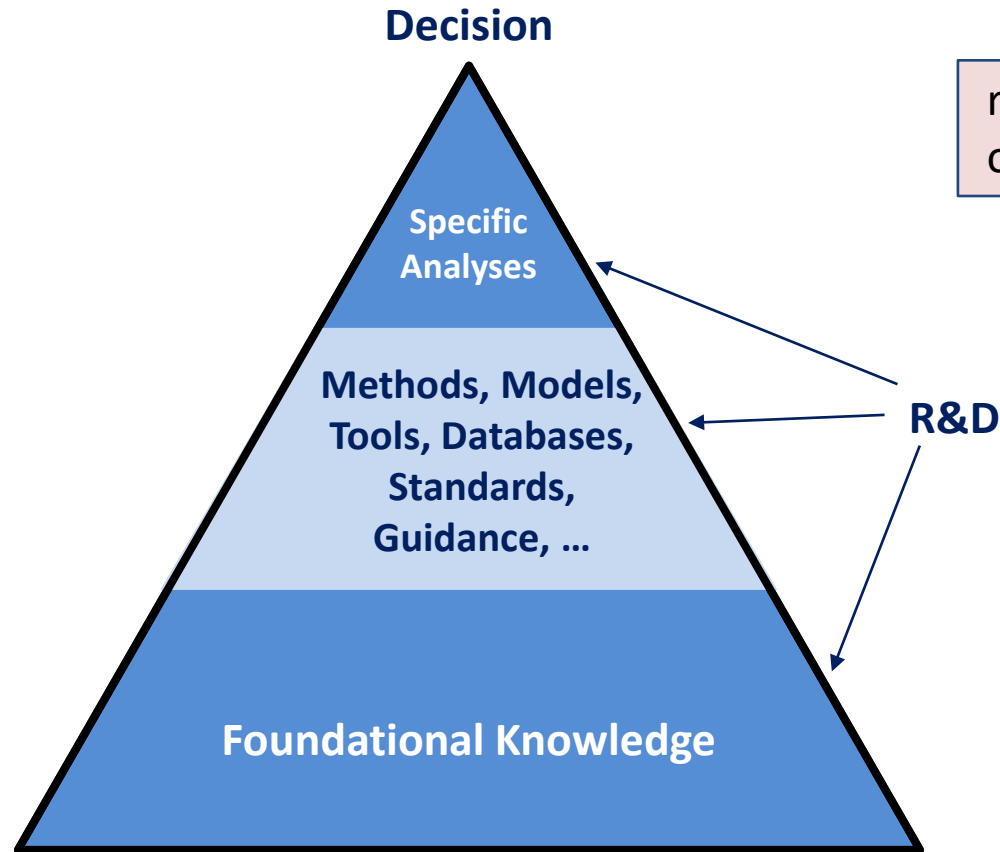


FFR Objectives

- Provide kickstart (basis, direction, and support) for extended projects (outside the FFR program) on likely important topics
- Promote more robust R&D program to sustain agency
- Energize staff
- Improve (and perhaps even radically change) foundational knowledge on key topics
- Develop useful products and appropriate staff cognizance of same
 - Actionable insights (including dismissal of potential issues)
 - Tools and data for analyses
 - Current status, directions, and likely schedules for potentially important technologies, programs, etc.
- Create synergy with related programs (e.g., University R&D Grants)



Research: providing a basis for decisions



re•search, *n.* diligent and systematic inquiry or investigation in order to discover or revise facts, theories, applications, etc.

Typical products (regulatory research)

- Ways to look at and/or approach problems (e.g., frameworks, methodologies)
- Points of comparison (e.g., reference calculations, experimental results)
- Job aids (e.g., computational tools, databases, standards, guidance: best practices, procedures)
- Problem-specific information (e.g., results, insights, uncertainties)

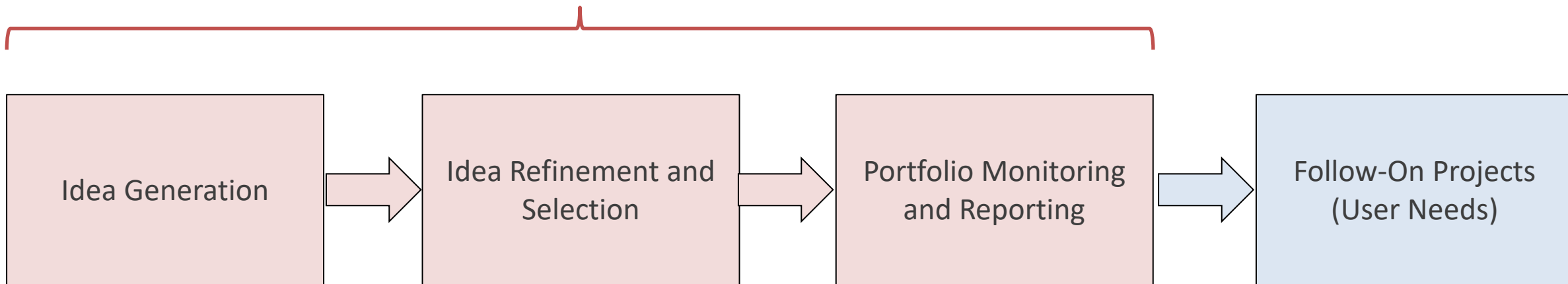
Side benefits

- Education/training of workforce
- Networking with technical community



FFR Process

FFR Program



- Gather ideas – could be individual or crowdsourced
- Open to ideas from across agency

- As needed, work with submitters to refine initial concept
- Advisors recommend and senior RES managers choose projects

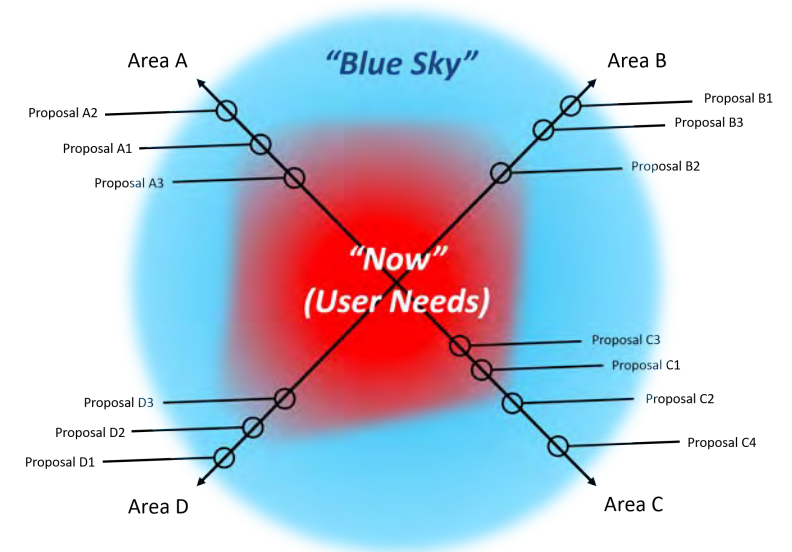
- Communicate and monitor progress through program reviews and seminars

- May identify research for potential future development through user needs



Project Rating Considerations*

- Agency impact
 - Improves NRC’s future capabilities
 - Improves foundational knowledge important to future decision making
 - Addresses recognized gaps
- Resource leveraging
 - Enables NRC’s influencing of important external activities
 - Potentially benefits multiple NRC programs
 - Leverages available resources for research
- Staff enrichment
 - Is attractive to individual researchers
 - Is attractive to university research programs



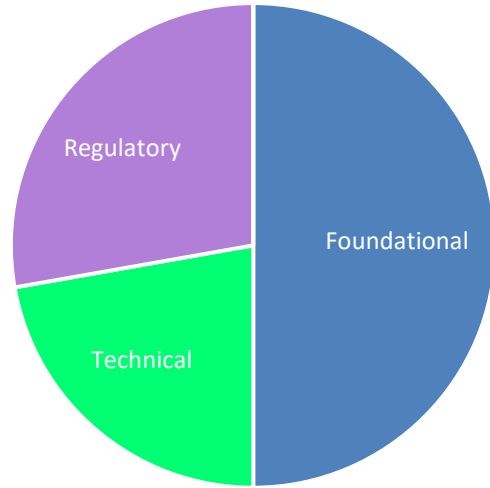
*Notes:

- 1) Considerations used as guidance.
- 2) Selection committee also considers the overall portfolio of FFR activities
 - a) Risk
 - b) Resources

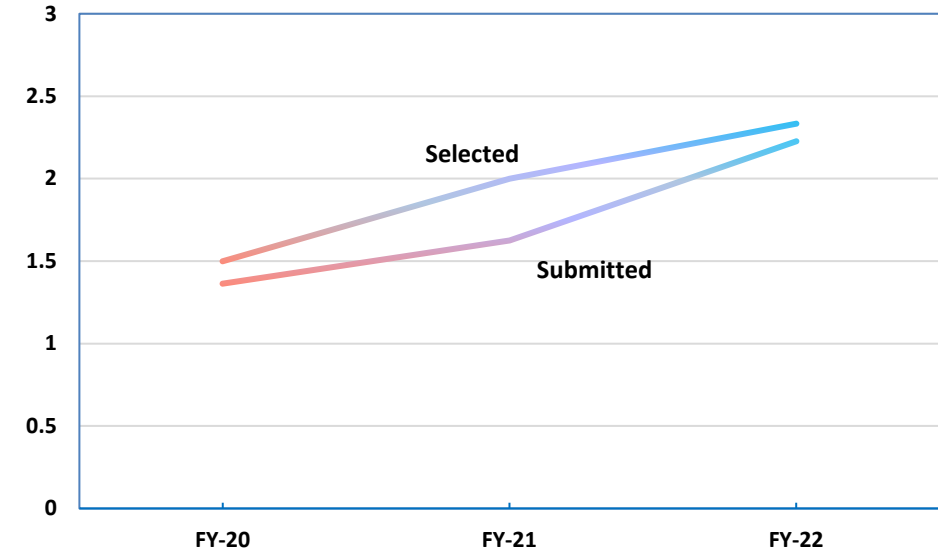
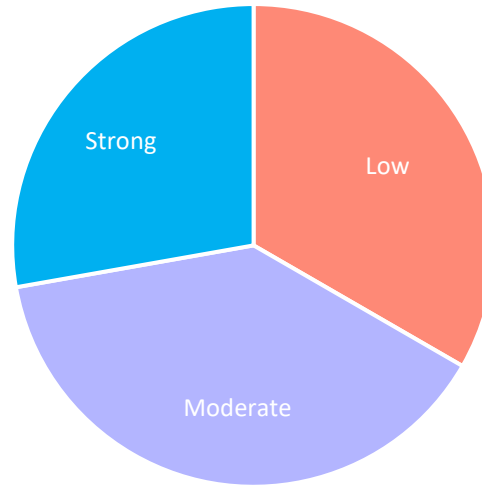


FFR Portfolio

Gap Objectives



Degree of Blueness



- Appropriate balance among efforts
 - 50% developing foundational knowledge
 - 50% developing more specific technical tools or addressing regulatory framework gaps

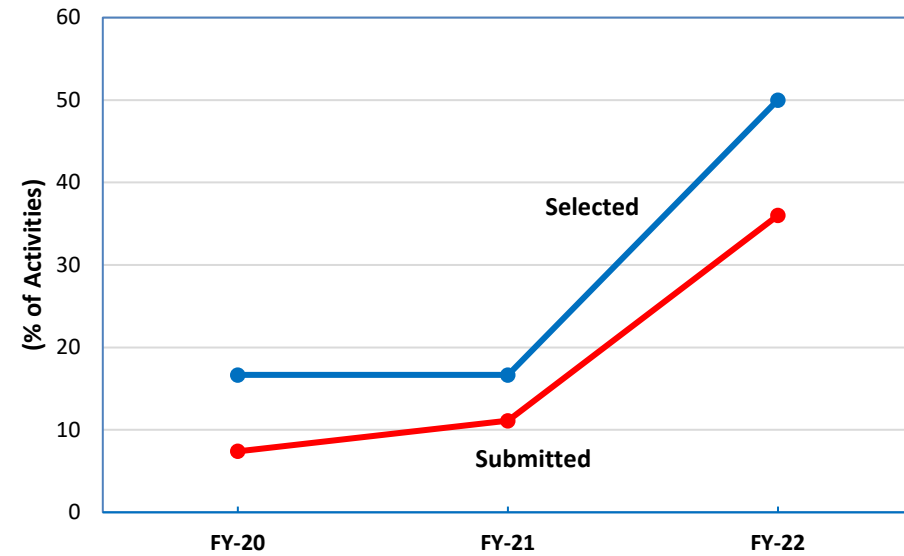
- Current portfolio is balanced across risk horizon spectrum.
- Trending toward “bluer sky” activities as FFR program has matured.



AI and Data Science in FFR

Related FFR Activities

- **FY-20**
 - Digital Twins - Regulatory Viability
- **FY-21**
 - RESbot - A web-based bot to aid RES Researchers
- **FY-22**
 - Use Machine Learning to Prioritize Inspections
 - Characterizing Cyber Security Using AI/ML
 - Application of Natural Language Processing to NRC Regulatory Documents



- Explosion of AI-DS topics both submitted and selected in latest data call
- General bias in selecting AI-DS topics as FFR activities



Existing AI-DS FFR Activities

- Digital Twins - Regulatory Viability
 - **Objective:** Understand the potential industry applications of reactor digital twins and the regulatory viability of use of digital twins
 - **Approach:** Assess existing technical information, knowledge, tools, and codes and standards to determine state-of-the-art and current gaps; identify regulatory gaps and fundamental infrastructure elements
 - **Status:**
 - Held December 2020 and September 2021 workshops: published December proceedings (ML21083A132)
 - Completed report: *The State of Technology of Application of Digital Twins* (ML21160A074)
 - Transitioned out of FFR and is continuing as a follow-on research project
- RESbot - A web-based bot to aid RES Researchers
 - **Objective:** Develop one or more web-based bots, to aid NRC researchers in mining, for example, experimental data, analyses, compilation of field experience, and risk assessments to support decision-making
 - **Approach:** Create NRC use cases and develop RESbot implementation plan to address use cases; executing implementation plan would be a follow-on effort
 - **Status:** Defined use cases on technical document querying, modeling and simulation, and report preparation; currently evaluating use cases using IBM Watson Discovery and Microsoft Azure platforms



FY-22 AI-DS FFR Activities

- Use Machine Learning (ML) to Prioritize Inspections
 - **Objective:** Explore use of commercially available ML applications to prioritize inspections and their associated periodicity during abnormal situations (i.e., pandemics)
 - **Approach:** Define licensees as “customers”; define and build “safety behavior” using data similar to “customer preferences; perform test case using several off-the-shelf ML tools
- Characterizing Cyber Security Using AI/ML
 - **Objective:** Evaluate issues associated with future AI/ML applications used to characterize cyber security system performance and configurations, and detect abnormal system states associated with a cyber attack
 - **Approach:** Identify viable AI/ML technologies; evaluate technologies relative to defined nuclear cyber use case; apply most promising approach to benchmark test case
- Application of Natural Language Processing (NLP) to NRC Regulatory Documents
 - **Objective:** Assess use of existing NLP tools for NRC use to assist review of licensing actions
 - **Approach:** Create licensing benchmark case and collect associated data; apply named entity recognition to data set and subsequently create term-frequency inverse document frequency model; evaluate Google’s BERT model to retain semantic meaning for neural network training and implementation



Thoughts for Future: AI/DS

- Nuclear is typically a later adopter of technological innovations
 - Slower pace of innovation
 - Opportunities to build off advancements and investments in other industries
 - **Which AI/DS advancements hold biggest promise and challenges for nuclear application?**
- Nuclear energy landscape is continually changing
 - Future reactors will likely be smaller; may be more widely distributed
 - Bulk of aging LWR fleet may require operation beyond 60 to 80 years to meet nation's energy goals
 - **How can AI/DS be used to both optimize the new design, certification, and approval process?**
 - **How can AI/DS optimize efficiencies of existing plants to retain safety and economic viability?**
 - **How can NRC use AI/DS to evaluate this landscape to better position itself for future regulatory challenges?**
- Continuous pressure to decrease human operations to maximize efficiencies
 - **What are the actions/operations where decreasing human involvement is most beneficial?**
 - **Are there actions/operations that should always retain human involvement/oversight and, if so, how can these be best identified?**



Questions?

