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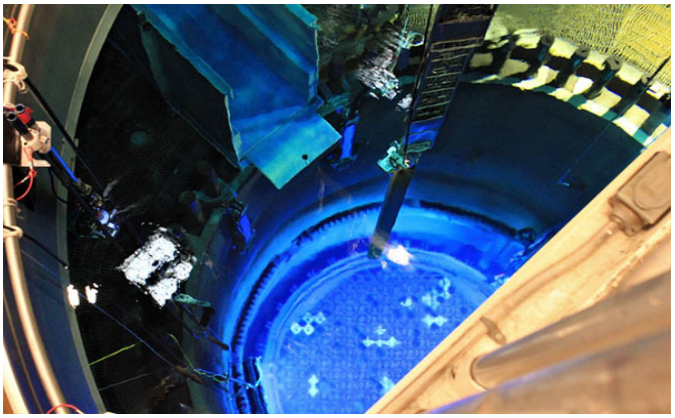
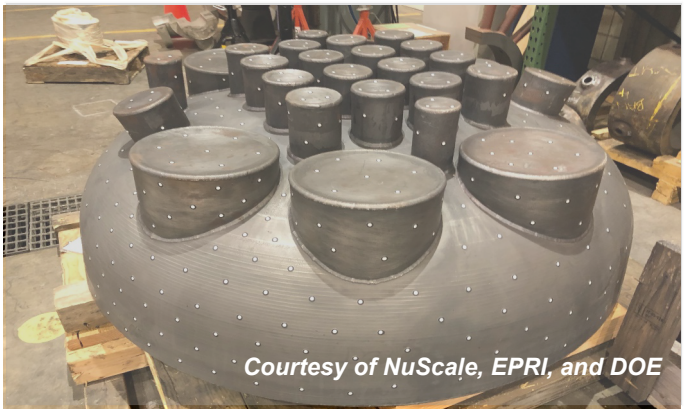
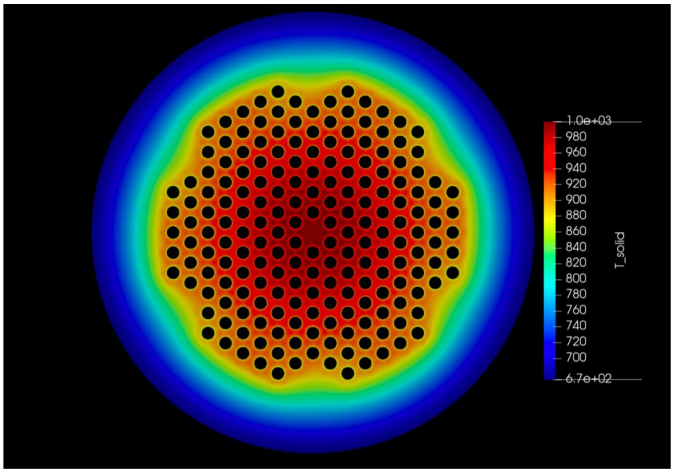
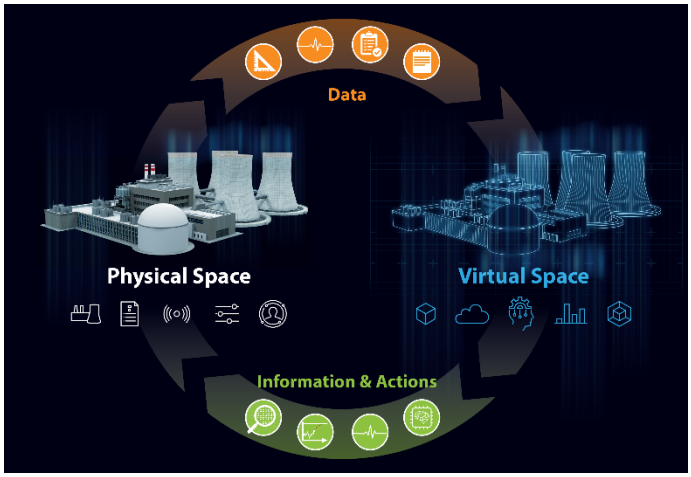
Office of Nuclear Regulatory Research
FY2021-23 Planned Research Activities









July 2021

Foreword

The Office of Nuclear Regulatory Research (RES) supports the mission of the U.S. Nuclear Regulatory Commission (NRC) by providing technical advice and tools, assessing risk, supporting resolution of safety and security issues, and coordinating the development of regulatory guidance. Research activities in general includes conducting confirmatory analyses, developing technical bases to support safety decisions, and preparing the agency for evaluation of the safety aspects for new technologies and designs for nuclear reactors, materials, waste, and security. To conduct research activities, RES relies on staff expertise and collaborates with partner offices at the NRC, commercial entities, national laboratories, other Federal agencies, universities, and international organizations.

In the effort to provide improve stakeholder visibility into NRC research activities, the program area information summaries have been developed. The information sheets describe research being conducted by RES across a wide variety of disciplines. The sheets describe the projects that are in progress and planned, impacts and benefits, deliverables, and resources and identifies the research points of contact who can be contacted for additional information.

Table of Contents

Overview of Office of Nuclear Regulatory Research (RES)

The Office of Nuclear Regulatory Research (RES) plans and conducts the research necessary for the U.S. Nuclear Regulatory Commission (NRC) to perform its safety and security mission consistent with the Energy Reorganization Act and Commission policy. This involves the following strategic objectives: (1) provide independent data and analyses to support ongoing licensing and regulatory oversight activities and prepare for new and emerging technical approaches, (2) maintain core research tools and capabilities to promptly and effectively respond to requests for research from the Commission and regulatory program offices, (3) maintain cognizance of the state-of-the-art developments in nuclear safety and security technologies by engaging with the domestic and international research community, and (4) identify the need for, and provide project management of, research that is contracted to external organizations.

For FY21, the total RES budget is $80.7 M[1], which comprises $41.5 M for contract support and travel and about $39.3 M for staffing 197 FTE (full-time equivalent).

Figure 1 shows research resources associated with the NRC Business Lines that comprise the RES budget in FY21. The figure shows how the Operating Reactors Business Line (ORBL) activities comprise the majority of RES's workload.

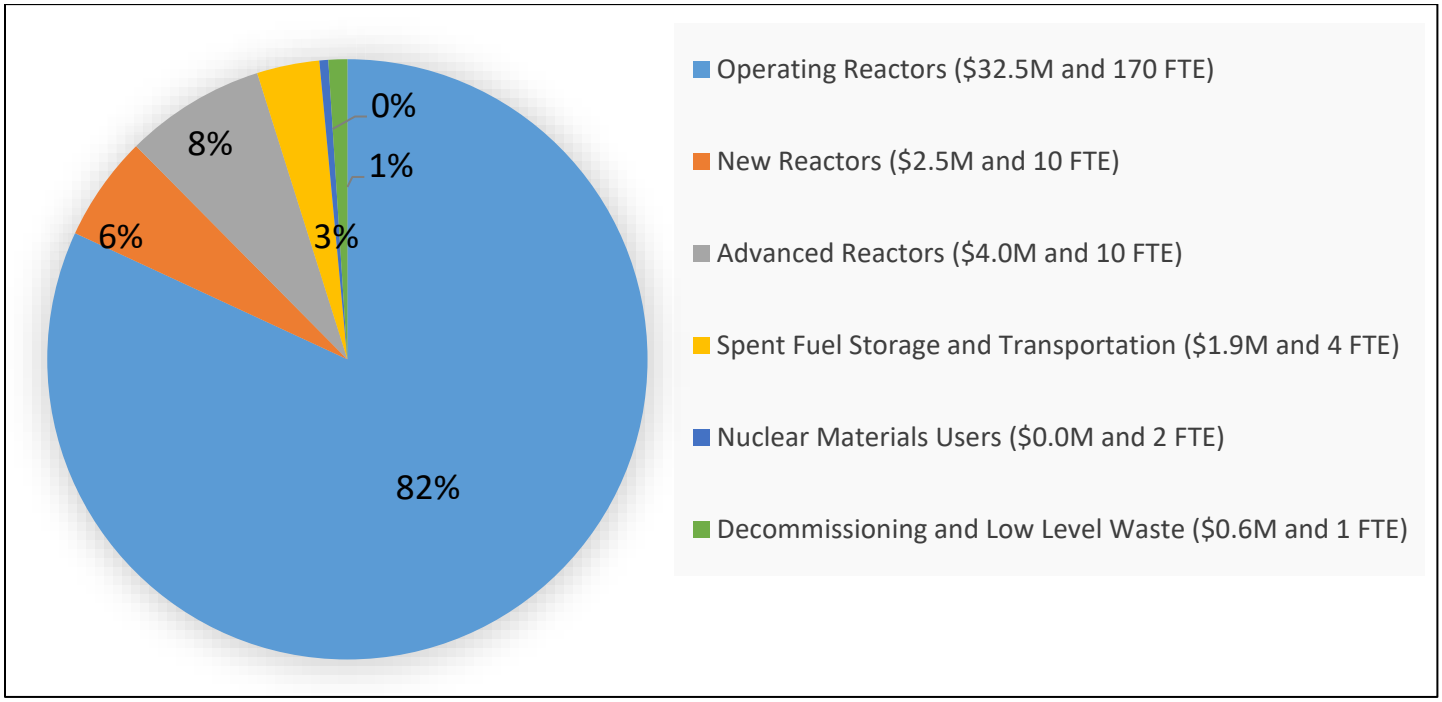


Figure 1 – RES FY2021 Resources by Business Line

[1] This total includes $10.6 M of authorized carryover to fund contract support and omits $16 M for the University Nuclear Leadership Program. This funding includes research activities led by the Office of Nuclear Regulatory Research.

Research Information Summaries

The following research information summaries for each topical area provided a further breakout of planned research activities, a summary of benefits, deliverables, technical resources supporting the activities, and planned coordination to leverage research efforts.

Summary of Research Program Accomplishments in FY2020

In FY2020 a significant number of research projects and activities were completed. The figure below provides a visual presentation of those results and our commitment to regulatory readiness and the NRC's safety and security mission.

Risk Analysis Research Activities

Accident Sequence Precursor Program
Fiscal Year 2021 Program Overview

Overview

- This program area includes activities related to nuclear facility event risk assessments performed under the Accident Sequence Precursor (ASP) Program.

Strategic Focus Areas

- Continue to provide timely reports to support the annual Abnormal Occurrence Report to Congress and the annual Agency Action Review meeting.
- Continue current efforts to improve support provided to the NRC's Operating Experience (OpE) program in accordance with NRC Management Directive 8.7.
- Maintain the ability to identify needed improvements to probabilistic risk assessment (PRA) guidance and codes.
- Continue to exercise new standardized plant analysis risk (SPAR) model features (e.g., seismic hazards, FLEX mitigation strategies) and explore use of new methods (e.g., Integrated Human Event Analysis for Event and Condition Assessment [IDHEAS-ECA]), when applicable, to provide feedback for potential improvements and to enhance existing guidance.

Impact and Benefits

- Provides the NRC's tool for long-term, risk-informed trending of industrywide operating experience of all events that occur at U.S. commercial nuclear power plants.
- Provides feedback to improve the realism of the NRC's SPAR and industry PRA models.
- Provides an independent check on the effectiveness of NRC and licensee activities to minimize risk significant events.
- Provides insights to the OpE Program on potential risk-significant events.

Drivers

- Program established in 1979 in response to the "Risk Assessment Review Group" report (NUREG/CR-0400). Commission directive (SRM SECY-98-228) transferred the ASP Program to the Office of Nuclear Regulatory Research.
- Reviews and evaluates operating experience to identify precursors to potential core damage as required by Management Directive 8.7, "Reactor Operating Experience Program."

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
ASP Program Support	Completed review and analysis of calendar year LERs and NRR OpE Program	Complete review and analysis of calendar year LERs and NRR OpE Program	Complete review and analysis of calendar year LERs and NRR OpE Program	Complete review and analysis of calendar year LERs and NRR OpE Program
	Completed ASP Program 2019 Annual Report including trend analyses to support RES input to the AARM	Complete ASP Program 2020 Annual Report including trend analyses to support RES input to the AARM	Complete ASP Program 2021 Annual Report including trend analyses to support RES input to the AARM	Complete ASP Program 2022 Annual Report including trend analyses to support RES input to the AARM

Acronyms: Fiscal year (FY), licensee event reports (LERs), the Office of Nuclear Reactor Regulation (NRR), Agency Action Review Meeting (AARM)

Office of Nuclear Regulatory Research Contact

- Mehdi Reisi Fard (Mehdi.ReisiFard@nrc.gov), Branch Chief in the Division of Risk Analysis

Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Risk Analysis Research	$0	1.2	$0	2.9	$0	2.9	→
Total		$0	1.2	$0	2.9	$0	2.9	→

CS&T ($K) includes contract support (Total ($K) includes contract support and FTE costs)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Idaho National Laboratory – Indirect and minimal contractor support for accident sequence precursor modeling (provided through the SPAR Technical Support Contract).

Collaboration and Resource Leveraging

- The ASP Program leverages the evaluation results of the Significance Determination Process (SDP).
- ASP program analysts provide support to NRR and regional senior reactor analysts on SDP evaluations.
- The ASP Program supports rotational assignments from NRR and regional analysts to develop the NRC's event and risk assessment capabilities.

Reactor Operating Experience Program
Fiscal Year 2021 Program Overview

Overview

- This program area includes activities to evaluate reactor operating experience (OpE) from a risk-perspective. The program analyzes events for long-term performance trends and serves as the basis for initiating event frequencies, component failure parameters, and common cause events employed in the NRC's standardized plant analysis risk (SPAR) models and other probabilistic risk assessment (PRA) studies.

Strategic Focus Areas

- Continue to look for efficiencies while maintaining the ability to provide timely communication of OpE to internal stakeholders for information and/or evaluation.
- Continue to identify trends, recurring events, or significant safety issues for appropriate follow-up actions.
- Periodic assessments of the OpE program to determine/confirm its effectiveness and to identify needed improvements.

Impact and Benefits

- Provides annual, up-to-date event frequencies and component reliabilities for use in NRC and licensee PRA models to support plant licensing and oversight activities.
- Produces industrywide reliability estimates, summary tables, graphs, and charts to support long-term OpE and issue-specific risk activities undertaken by the NRC (also capable of generating plant-specific information, component-specific information, and vendor-specific information as needed).
- Maintains and updates the publicly available Reactor Operational Experience Results and Databases Web pages on the NRC's public Web site with computational results based on failure rate estimates using the Institute for Nuclear Power Operations (INPO) Consolidated Events (ICES) and Mitigating Systems Performance Indicator (MSPI) databases and licensee event reports (LERs).
- Manages and updates the LER-Search public database (one of the most used NRC public Web pages) containing searchable LERs and Inspection Reports.
- Identifies potential risk significant events and distributes available information to subject matter experts.

Drivers

- Commission directive (SRM SECY-97-101) to choose the voluntary nuclear industry initiative allowing INPO to design, implement, and manage the reporting of nuclear plant licensee operating experience under long-term, renewable contractual arrangement with the NRC.
- Commission directive (SRM SECY-98-228) to transfer OpE activities related to the Accident Sequence Precursor program and long-term trending, formerly performed in the Office for Analysis and Evaluation of Operational Data (AEOD), to RES.
- NRR User Need Request (UNR) NRR-2015-009, "User Need Request for Support in the Development and Enhancement of NRC Risk Analysis Tools."

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
Evaluation of Reactor OpE	Peer review/audit of PWROG/industry FLEX data initiative. Gathered, coded, and analyzed industry-wide OpE data from LERs and INPO for use in NRC SPAR and industry PRA models covering initiating events, component and system performance, and common cause events.	Perform parameter update of all basic events in NRC SPAR/PRA models. Gather, code, and analyze industrywide OpE data for use in NRC SPAR and industry PRA models covering initiating events, component and system performance, and common cause events	Gather, code, and analyze industrywide OpE data for use in NRC and industry PRA models covering initiating events, component and system performance, and common cause events	Gather and analyze industrywide OpE data for use in NRC and industry PRA models covering initiating events, component and system performance, and common cause events

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

- Mehdi Reisi Fard (Mehdi.Reisifard@nrc.gov), Branch Chief in the Division of Risk Analysis

Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Risk Analysis Research	$1,832	2.2	$1,900	3	$1,930	3	↗
Total		$1,832	2.2	$1,900	3	$1,930	3	↗

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)
FY23 CS&T is expected to increase in accordance with the statement of work for two Idaho National Laboratory Contracts. These contracts were underfunded in FY21 and FY22

Contractor Support

- Idaho National Laboratory (INL) – Reactor Operating Experience Data for Risk Applications.
- INL – Computational Support for Risk Applications.
- INPO – Access to INPO Operational Information (ICES), which provides NRC staff with proprietary operational experience information necessary for risk-informed regulatory activities.

Collaboration and Resource Leveraging

- INPO under MOU and long-term commercial contract to provide the NRC with nuclear licensee OpE failure information.
- EPRI to collaborate with the NRC under MOU on a joint, consolidated publication consisting of a new report covering the annual tabulation and display of initiating event OpE data.

Probabilistic Flood Hazard Analysis Research and External Hazards Analysis
Fiscal Year 2021 Program Overview

Overview

- This program area includes tasks to develop an improved, more realistic framework for conducting flooding assessments at nuclear power plants as well as work on assessing other non-seismic external hazards in probabilistic risk assessments.

Strategic Focus Areas

- Complete efforts to develop a probabilistic flood hazard assessment (PFHA) framework and guidance to support future licensing and oversight actions.
- Provide support for operating reactor licensing and oversight flooding issues by providing technical assistance for review of licensee submittals and providing training for staff.
- Provide support to the Process for Ongoing Assessment of Natural Hazards Information (POANHI) by maintaining and enhancing the Natural Hazards Information Digest (NHID) and through technical engagement and coordination with other Federal Agencies.
- Maintain engagement with the National Institute of Standards (NIST) to update U.S. tornado hazard maps.

Impact and Benefits

- The PFHA research program will provide staff with improved guidance and tools for assessing flooding hazards and potential impacts to structures, systems, and components in the oversight of operating facilities as well as licensing of new facilities. Current guidance and tools are based on methods that are considered dated and, in some cases, may be overly conservative.
- PFHA research staff also provide active support to licensing and oversight offices: 1) training for hydraulic/hydrologic software used by NRC staff; 2) technical support for staff reviews of licensee submittals (e.g., post-Fukushima flooding reevaluations); and 3) knowledge transfer (e.g., project-related in-house knowledge transfer seminars, annual PFHA Research Public Workshop).
- Maintaining and enhancing the NHID and technical engagement and coordination with other Federal Agencies are key functions of POANHI.

Drivers

- The PFHA research program activities are endorsed by user need request NRO-2015-002, which is jointly supported by the New and Operating Reactors business lines.
- External hazards analysis work is supporting the development and deployment of the Commission-directed (SECY-16-0144) Process for Ongoing Assessment of Natural Hazards Information.

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
Phase I PFHA Research (Technical Basis)	Published more than 10 Technical Basis Research Reports	Continue Technical Basis Research Report publishing	Complete Technical Basis Research Report publishing	
Phase II PFHA Research (Pilot Studies)	3 PFHA Pilot Studies in progress	Finalize and publish Pilot Studies	Finalize and publish Pilot Studies	
Phase III PFHA Research (Guidance)	Completed scoping of draft guidance	Develop draft guidance	Draft guidance internal review and concurrence	1) Publish draft guidance for public comment 2) Finalize guidance
High Winds Research	Tornado hazard map updates 95% complete	Assess need for updated guidance	Develop updated guidance as needed	Develop updated guidance as needed

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Risk Analysis Research	$301	2.4	$521	1.8	$521	1.8	↘
New Reactors	New Reactors Research	$362	1.4	$300	0.9	204	0.9	↘
Total		$663	3.8	$821	2.7	725	2.7	↘

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center – Riverine Flooding PFHA Pilot Study, PFHA Frameworks.
- USACE Engineer Research and Development Center – PFHA Frameworks, Coastal Flooding PFHA Pilot Study, Uncertainty in Storm Surge Models, Structured Hazard Assessment Committee Process for Flooding (SHAC-F) for Coastal Flooding.

- U.S. Geological Survey – Flood Frequency Analysis Methods, Paleoflood Hydrology Methods, Paleoflood Studies Review Guidance.
- Pacific Northwest National Laboratory –SHAC-F for Coastal, Riverine and Site-scale Flooding, Local Intense Precipitation PFHA Pilot Study.
- Oak Ridge National Laboratory – Methods for Estimating Joint Probabilities of Coincident and Correlated Flooding Mechanisms.
- Idaho National Laboratory – Natural Hazards Information Digest, Strategies for Flood Barrier Testing
- NIST – Tornado Hazard Maps.
- National Center for Atmospheric Research – Numerical Simulation of Intense Precipitation.

Collaboration and Resource Leveraging

- Memorandum of Understanding between the NRC and the Electric Power Research Institute on Cooperative Research on External Flooding Hazards.
- International Agreement with the French Institute for Radiological Protection and Nuclear Safety on Probabilistic Flood Hazard and Risk Analysis Programs.
- Participation in a Nuclear Energy Agency Working Group on External Events.
- Participation in Federal interagency workings groups (e.g., Advisory Committee on Water Information Subcommittee on Hydrology, Office of Science and Technology Policy Subcommittee on Disaster Reduction, U.S. Coastal Research Program).

Fitness-for-Duty / Safety Culture Technical Assistance
Fiscal Year 2021 Program Overview

Overview

- This program area includes: 1) research on drugs, alcohol, fitness-for-duty to aid drug-testing, and research on fatigue management and 2) technical support on safety culture implementation.

Strategic Focus Areas:

- Maintain the ability to keep NRC regulations up to date with societal drug use trends and rapidly evolving drug and drug subversion technologies.
- Continue to support implementation of safety culture assessment in the Reactor Oversight Process.

Impact and Benefits

- Provides staff with up-to-date information on rapidly evolving drug and drug-test subversion technologies needed to provide effective oversight of licensee's fitness-for-duty programs.
- Maintains knowledge of safety culture assessment techniques needed to provide oversight of licensee's safety culture programs.

Drivers

- Requests from the Office of Nuclear Reactor Regulation (NRR) on fatigue management guidance development (NRR 2016-020).
- Requests from the Office of Nuclear Security and Incident Response (NSIR) on substance abuse technologies and guidelines (NSIR 2020-02).
- Requests from NRR and the Regions on Safety Culture technical support and inspection support (NRR-2019-012).

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
Fatigue Management and Fitness for Duty	Completed Technical Letter Report on prescription drug issues	1) Analysis of FFD performance for trends and bounding conditions. 2) Drug prevalence investigation 3) International Program review	1) Development of Urine Temperature Assessment Model 2) Research Information Letter on fitness for duty technologies	NUREG on fitness for duty technologies
Safety Culture	1) Cross-Cutting Issues Effectiveness Review Report 2) SC Refresher Training at Regional Knowledge Management Seminar	1) SC counterpart meeting 2) SC Regional and inspection support 3) SC Training Plan 4) SC assessor desk guide	1) SC counterpart meeting 2) SC Regional and Inspection Support 3) Independent SC Assessment NUREG	1) SC Counterpart meeting 2) SC Regional and Inspection Support

Acronyms: Fiscal year (FY), Nuclear Regulatory Report (NUREG), Regulatory Guide (RG)

Office of Nuclear Regulatory Research Contact

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Risk Analysis Research	$80	1.2	$75	0.6	$75	0.6	→
Total		$80	1.2	$75	0.6	$75	0.6	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Pacific Northwest National Laboratory - Fitness for Duty support.

Collaboration and Resource Leveraging

- National Institutes of Health/Substance Abuse and Mental Health Services Administration (NIH/SAMHSA) substance abuse and drug and alcohol testing research.
- Nuclear Energy Agency/Committee on the Safety of Nuclear Installations/Working Group on Human and Organizational Factors (NEA/CSNI/WGHOF) safety culture research.
- The Institute for Radiation Protection and Nuclear Safety (IRSN) safety culture research.

Agency Innovation
Fiscal Year 2021 Program Overview

Overview

- This program area includes research activities to support advancing innovation at the agency. Specific Office of Nuclear Regulatory Research (RES) activities include:
  1) Supporting the InnovateNRC 2.0 program through managing the platform, the program vision, and the day-to-day activities to maintain a state-of-the-art innovation program.
  2) Supporting the innovation community to evaluate and disposition innovative ideas submitted by staff in a timely and thorough manner.
  3) Providing support and guidance to support those who want to use crowd-sourcing to solve challenges they face in their work.
  4) Further develop the processes and engagement needed to sustain the innovation program.

Strategic Focus Areas

- Wide usage of crowd-sourcing as a method to approach challenges at all levels of the organization.
- Efficient agencywide capture of the innovation successes and measurement of those successes.
- Efficient implementation and sustainability of innovative ideas to better serve the agency and its staff.

Impact and Benefits

- This work will help provide cohesion among the separate innovation activities that the agency is undertaking and offers new approaches to problem solving, knowledge management, and knowledge sharing.

Drivers

- OEDO innovation initiative OKR to transition InnovateNRC 2.0 to RES by end of calendar year 2020.
- User Need Request from the OEDO (Office of the Executive Director for Operations), EDO-2018-001, to develop the infrastructure for innovation efforts.
- OEDO ticket for a SECY paper, OEDO-19-00096, Futures Assessment: Status and Next Steps.

Key Deliverables

Year / Project	FY 2020	FY 2021	FY 2022	FY 2023
Program Management of InnovateNRC 2.0	Completed development of program infrastructure and transitioned program to office of research	Sustain and grow innovation program	Sustain and grow innovation program	Sustain and grow innovation program
OEDO User Need on Innovation	Implement sustainable agencywide innovation	Compile lessons-learned and	Compile lessons-learned and	Compile lessons-learned and

Year / Project	FY 2020	FY 2021	FY 2022	FY 2023
	program consistent with model developed in FY 2019	capture process in RIL	capture process in RIL	capture process in RIL
Futures Core Team	Support transformation initiative teams and transformation effort			

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Risk Analysis Research	$0	2.1*	$0	0	$0	2	→
Total		$0	2.1*	$0	0	$0	2	→

*Unbudgeted work to support OEDO initiation. In FY20, resources were shifted from planned human factors activities
Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- None.

Collaboration and Resource Leveraging

- RES looks to commercial off-the-shelf collaboration solutions and for innovation programs and ideas from other government agencies (i.e., NASA).

Human Reliability Analysis Methods
Fiscal Year 2021 Program Overview

Overview

- This program area includes research on the development and improvement of human reliability analysis (HRA) methods for NRC use.

Strategic Focus Areas:

- Continue efforts to develop and advance a standardized approach for conducting HRAs to support risk-informed decision-making.
- Complete efforts to support analyzing the use of FLEX equipment.
- Continue to assess needed changes to HRA methods to support advanced reactor licensing.

Impact and Benefits

- The research will help to increase realism of the NRC's risk analyses by providing more credible HRA analyses.
- The improvement of the methods under this program will enable the staff to evaluate the use of: 1) FLEX equipment for normal operations and severe accidents, 2) digital control rooms for small modular and advanced reactors and upgrading existing control rooms, and 3) computerized procedures for modernized operations.

Drivers

- Commission direction in SRM-M061020 and M140529 to improve upon uncertainties in HRA analyses and to identify appropriate methodologies for NRC staff use.
- Requests from NRR and the NRC Regional Offices for assistance in modifying, improving, and developing HRA methodologies based upon identified programmatic issues.

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
HRA Methodology	1) Developed draft Integrated Human Event Analysis Data report (IDHEAS-DATA) - the data basis for the IDHEAS methodology 2) Developed IDHEAS for Event and Condition Assessment (IDHEAS-ECA) methodology for modeling accident and FLEX scenarios 3) Developed IDHEAS-ECA computer tool	1) IDHEAS-G NUREG 2) IDHEAS-ECA RIL Update 3) New method for dependency analysis in IDHEAS-ECA	1) IDHEAS-DATA NUREG 2) IDHEAS-ECA NUREG 3)Technical Letter Report on Minimum Joint Human Error Probability 4) NUREG on expert elicitation	HRA method improvements in uncertainty, errors of commission, and minimum joint human error probability

Acronyms: Fiscal year (FY), Nuclear Regulatory Report (NUREG), Research Information Letter (RIL)

Office of Nuclear Regulatory Research Contact

- Sean Peters (Sean.Peters@nrc.gov), Branch Chief in the Division of Risk Analysis

Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Risk Analysis Research	$630	3.4	$850	3.0	$850	3.0	↗
New Reactors	New Reactors Research	$0	0	$0	0	$600	0	↘
Total		$630	3.4	$850	3.0	$1,450	3.0	→

Funding increases in FY22 for the Halden Human Technology Organization project. These resources are expected to be moved to the Operating Reactors Business Line in future years
Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Pacific Northwest National Laboratory - HRA Method Support/IDHEAS-Data.
- Electric Power Research Institute (EPRI) - EPRI HRA Users Group.
- Halden - Halden Program Group (Human Technology Organization).

Collaboration and Resource Leveraging

- MOU between NRC and EPRI on Human Reliability Analysis.

Human Reliability Analysis Data
Fiscal Year 2021 Program Overview

Overview

- This program area includes the collection, development, and analysis of data for the improvement of the NRC's human reliability analysis (HRA) methods for NRC and licensee use.

Strategic Focus Areas:

- Continue effective and cost-effective ways of maintaining and updating data needed to support HRA analyses.

Impact and Benefits

- The research will improve realism in Probabilistic Risk Assessments through development of better HRA methods as well as providing less variability in HRA results.
- The collection and analysis of data under this program will enable the staff to evaluate the use of: 1) FLEX equipment for normal operations and severe accidents; 2) digital control rooms for small modular, advanced, and upgrading existing control rooms; and 3) computerized procedures for modernized operations.

Drivers

- Commission direction in SRM-M061020 and M140529 to improve upon uncertainties in HRA analyses and identify appropriate methodologies for NRC staff use. SRM-M090204b directed the staff to keep the Commission informed of the NRC's HRA data program.
- Requests from NRR and the regions for assistance in modifying and improving HRA methodologies based upon identified programmatic issues.

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
HRA Database and HRA Methodology Improvement	1) SACADA modification to collect ex-control room data 2) Draft RIL – IDHEAS-DATA using SACADA data to inform HRA methods	1) Development of International Cooperative to exchange Human Reliability Data through the Halden – Human Technology Organization 2) Analysis report on the use of SACADA data for HRA method improvement	1) NUREG on data for incorporation into NRC HRA methods 2) Targeted improvements to selected NRC methods	Targeted improvements to selected NRC methods

Acronyms: Fiscal year (FY), Scenario Authoring Characterization and Debriefing Application (SACADA), Nuclear Regulatory Report (NUREG), Research Information Letter (RIL), Integrated Human Event Analysis System (IDHEAS)

Office of Nuclear Regulatory Research Contact

- Sean Peters (Sean.Peters@nrc.gov), Branch Chief in the Division of Risk Analysis

Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Risk Analysis Research	$73	0.9	$285	1.6	$285	1.6	→
Total		$73	0.9	$285	1.6	$285	1.6	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Idaho National Laboratory (INL) – SACADA.
- University of Central Florida – Human Performance Test Facility Data Collection.
- GSE Systems Inc. – PWR Simulator Maintenance.

Collaboration and Resource Leveraging

- MOU between the NRC and EPRI on Human Reliability Analysis.
- MOU between the NRC and South Texas Project Nuclear Operating Company (STPNOC) on the SACADA project – STPNOC is contributing cost-free human performance data for the NRC to analyze.
- MOU with the Korean Atomic Energy Research Institute (KAERI) on HRA Data Exchange – KAERI has a similarly sized data program and shares the information with the NRC.
- The Halden Reactor Project and INL's Advanced Test Reactor also supply data to the NRC's SACADA database.

Fire Protection Activities and Fire Risk Training
Fiscal Year 2021 Program Overview

Overview

- This program area includes the development and implementation of tools, methods, and data to improve realism in fire probabilistic risk assessment (PRA) to support risk-informed decision-making and support fire risk training activities.

Strategic Focus Areas:

- Continue ongoing collaborative efforts with the Electric Power Research Institute (EPRI) to improve realism in fire PRAs.
- Assess if new research efforts are needed in this area to support advanced reactor licensing.
- Support Program Offices with development of specialized tools and training.

Impact and Benefits

- Reduce conservatism and uncertainties in fire PRAs leading to a better understanding of plant risk.
- Shorten timeline for licensing decisions and minimize requests for additional information.
- Consistent understanding and application of fire PRA tools by NRC licensing and inspection staff and by licensees through training.

Drivers

- Resolve Pre-Generic Issue 018 Aluminum High Energy Arcing Faults (HEAF).
- Improve and maintain the knowledge and tools needed to support regulatory oversight activities.
- Collaborate with EPRI on research identified as high priority to improve realism in fire PRA.
- Confirmatory analysis and assessment of new industry proposed methods for fire PRA.
- Provide fire risk training to support the NRC's policy to increase the use of PRA technology.

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
Fire PRA Realism	Published final version NUREG-2230			
	Published final version NUREG-2178 volume 2	Resolution of Pre-GI 018 Aluminum HEAFs		
	Conducted testing and analysis to expand transient fuel package models	Document additional transient fuel package testing and development of spread model		
	Published draft and final versions of NUREG-2233	Testing, analysis, and documentation for additional topics as appropriate	Testing, analysis, and documentation for additional topics as appropriate	Testing, analysis, and documentation for additional topics as appropriate
Fire Risk Training	Supported delivery of fire risk training	Support delivery of fire risk training	Support delivery of fire risk training	Support delivery of fire risk training

Acronyms: Fiscal year (FY), Nuclear Regulatory Report (NUREG)

Office of Nuclear Regulatory Research Contact

- MarkHenry Salley (MarkHenry.Salley@nrc.gov), Branch Chief in the Division of Risk Analysis

Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		Fy23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Risk Analysis Research	$306	2.2	$401	3.7	$401	3.7	↘
Total		$306	2.2	$401	3.7	$401	3.7	↘

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contract Support

- Sandia National Laboratories – Support for fire PRA methods development.
- National Institute of Standards & Technology – Support for fire testing for fire PRA.
- Organization for Economic Co-operation and Development – Support for HEAF (NRC Led) PRISME 3 and Incident Exchange Project.

Collaboration and Resource Leveraging

- MOU between the NRC and EPRI on Cooperative Fire Research.
- Committee on the Safety of Nuclear Installations Fire Propagation in Elementary Multi-Room Scenarios (PRISME 3), HEAF and Incident Exchange Project.

High Energy Arcing Fault Hazard
Fiscal Year 2021 Program Overview

Overview

- This program area includes research related to high energy arcing fault (HEAF) hazard on nuclear power plant reactor safety.

Strategic Focus Areas

- Continue current work to support closeout of pre-generic issue (GI) 018, "Proposed Generic Issue on High Energy Arc Faults Involving Aluminum."
- NRC/Electric Power Research Institute (EPRI) working group PRA methodology development.
- Continue work with the Nuclear Energy Agency (NEA) to complete Phase 2 Project.

Impact and Benefits

- Adequate characterization and understanding of HEAF hazard.
- Reduced uncertainties in fire probabilistic risk assessment (PRA) in the area of HEAF modeling.
- Resolution of pre-GI 018.

Drivers

- Pre-GI 018.
- International agreement on the Organization for Economic Co-operation and Development (OECD) NEA HEAF Phase 2 Project.
- Enhance realism in PRAs used in risk-informed decision-making.

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
Pre-GI 0018	NRC/EPRI working group PRA draft methodology development	Assessment of plant risk (GI Assessment Report) Conduct Decrement HEAF testing (if deemed necessary by NRC/EPRI WG)	Finalize and publish	
HEAF Initiating Event Frequency			Finalize and publish	
Phase II – International HEAF	FY 2020 tests postponed due to COVID-19 impacts	Testing of OECD sponsored HEAF	Testing of OECD sponsored HEAF	Finalize and publish
Fire PRA Model Refinement	NIST FDS model development SNL HEAF source term model development	Model refinement	Model refinement	Finalize and publish

Acronyms: Fiscal year (FY), Operating Experience (OpE)

Office of Nuclear Regulatory Research Contact

- MarkHenry Salley (MarkHenry.Salley@nrc.gov), Branch Chief in the Division of Risk Analysis

Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Risk Analysis Research	$621	2.5	$443	1.0	$443	1.0	→
Total		$621	2.5	$443	1.0	$443	1.0	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- National Institute of Standards & Technology – Support for HEAF test thermal measurements.
- Sandia National Laboratories – Support for photometrics, spectroscopy, and model development.
- KEMA Laboratories – Support for use of power test laboratory.
- Brendan Stanton Inc. – Support for electrical contractor.

Collaboration and Resource Leveraging

- MOU between the NRC and EPRI on Cooperative Fire Safety Research related to HEAF methods refinement for fire PRA.
- International Agreement on the OECD NEA HEAF Phase 2 Project.
- MOU Between the NRC and Japan's Nuclear Regulatory Authority (JNRA) on joint publication of relevant JNRA work.

Risk Analysis Research
Fiscal Year 2021 Program Overview

Overview

- This program area includes research to maintain state-of-the-art risk assessment methods, tools, data, and technical information to support the NRC's safety mission and increasing use of risk--informed regulatory decision-making. In support of this research, cooperative partnerships have been established with other government agencies, universities, industry organizations, international regulators, and technical support organizations.

Strategic Focus Areas

- Continue to support efforts to increase the use of risk insights in regulatory decision-making.
- Continue efforts to support licensing reviews through resolution of industry-identified probabilistic risk assessment (PRA) issues.
- Investigate PRA research needs for advanced reactors.

Impact and Benefits

- Directly supports program office oversight and licensing activities by providing guidance, methods, and data for use in risk-informed decision-making (i.e., updates to the Risk Analysis Standardization Project (RASP) Handbook, support in resolving issues such as common cause failure, support in the staff's review of new methods and approaches proposed by industry).
- Supports advancements in the state-of-art in PRA by working with universities through periodic grants.

Drivers

- NRR User Need Request (UNR) NRR-2015-009, "User Need Request for Support in the Development and Enhancement of NRC Risk Analysis Tools."

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
Risk Analysis of Operational Events	Provided technical support to NRR and Regions in the risk analysis of operational events	Provide technical support to NRR and Regions in the risk analysis of operational events by increasing the number of SPAR models updated using staff resources to supplement contractor resources	Continue to provide technical support to NRR and Regions in the risk analysis of operational events	Continue to provide technical support to NRR and Regions in the risk analysis of operational events
RASP Handbook		Provide input for the RASP Handbook (as requested)	Provide input for the RASP Handbook (as requested)	Provide input for the RASP Handbook (as requested)

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

- John Nakoski (John.Nakoski@nrc.gov), Branch Chief in the Division of Risk Analysis

Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		Fy23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Risk Analysis Research	$113	5.3	$295	2.7	$295	2.7	→
Total		$113	5.3	$295	2.7	$295	2.7	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE).

Contractor Support

- OECD Nuclear Energy Agency (NEA) – The NRC is a member of the International Common Cause Failure Data Exchange under the NEA. This project provides information used in understanding common cause failure and provides data used in determine dependencies in failures of like components.
- Energy Research, Inc. (ERI) – ERI provides technical support on general topics on the application and development of risk tools in support of NRC oversight and licensing.
- Sandia National Laboratories - Support for implementing and developing non-LWR PRA tools and regulatory guidance for risk-informed activities associated with internal events, internal flood, internal fire, seismic, high wind, and external flood PRA for at-power Level 1/LERF, Level 2, Level 3, LPSD, and treatment of parameter uncertainties. Also serves as independent body to support development of national consensus PRA standards.

Collaboration and Resource Leveraging

- Memoranda of Understanding (MOU) with the Electric Power Research Institute (EPRI) to avoid unnecessary duplication of effort by sharing of information related to research programs of mutual interest.
- MOU with the National Aeronautics and Space Administration (NASA) to support the development of advanced risk analysis techniques and tools to support risk-informed decision-making.
- Participate in the Nuclear Energy Agency (NEA) Committee for the Safety of Nuclear Installations Working Group on Risk Assessment (WGRISK) to foster continual improvement in the application of risk assessment methods by NEA member countries to improve the safety of nuclear installations.
- Participate in the NEA Working Group on External Events (WGEV) to enhance the understanding of the phenomenological aspects of external hazards to better inform regulatory decisions within a risk-informed framework.

Development and Enhancement of NRC Risk Analysis Tools
Fiscal Year 2021 Program Overview

Overview

- This EPID includes research to maintain and update the capabilities of the Systems Analysis Programs for Hands-on Integrated Reliability Evaluation (SAPHIRE) computer code and the NRC--developed Standardized Plant Analysis Risk (SPAR) plant-specific probabilistic risk assessments (PRAs) models. Research under this EPID also includes risk-related topical activities such as updating and confirming PRA success criteria; developing approaches to assess the risk for new issues (i.e., NUREG-2195 on consequential steam generator tube ruptures issued in May 2018); and adopting new approaches (i.e., mitigating strategies - FLEX equipment) and technology (i.e., improved reactor coolant pump seals) within a risk-informed decision-making framework.

Strategic Focus Areas:

- Continue to update SPAR models and the SAPHIRE code.
- Continue efforts to perform more SAPHIRE code updates in-house.
- Assess modeling needs to support advanced reactors.

Impact and Benefits

- Directly support the Significance Determination Process, implementation of Management Directive 8.3, “NRC Incident Investigation Program,” the Accident Sequence Precursor Program, Generic Safety Issues screening and prioritization, and risk impact studies on system and components by making tools available for staff to perform accurate and efficient risk calculations.
- Provide tools for the program office to develop industry-wide risk insights using state-of-practice methods.
- Support development of methods for assessing risk from potential safety issues; and for understanding the risk impact of advances in state-of-practice, operational approaches and new technologies.

Drivers

- The Office of Nuclear Reactor Regulation (NRR) User Need Request (UNR) NRR-2015-009, “User Need Request for Support in the Development and Enhancement of NRC Risk Analysis Tools.”
- New Reactor business line Research Assistance Request dated May 22, 2018, for new and advanced reactor SPAR model development.

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
Risk Analysis Tools	• Updated SPAR models incorporating external hazards • Performed routine updates to six SPAR models with plant specific information • Incorporated FLEX into all SPAR models	• Continue updates to SPAR models incorporating external hazards • Continue routine SPAR updates (target six models a year)	• Continue updates to SPAR models incorporating external hazards • Continue routine SPAR updates (target six models a year)	• Continue updates to SPAR models incorporating external hazards • Continue routine SPAR updates (target six models a year)

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
	• Published Success Criteria NUREG • Provided direct support to Regional staffs and user office staff on use and implementation of models • Piloted risk-app to support broader access to risk insights from the SPAR models for non-risk analyst use	• Apply lessons learned to all SPAR models from incorporating FLEX • Secure portal (cloud) based SAPHIRE operational • Direct support to Regional staffs and user office staff on use and implementation of models • Expand pilot to all plants using the risk-app to support broader access to risk insights from the SPAR models for non-risk analyst use • Pilot the approach to incorporate IDHEAS-ECA into SPAR models.	• Direct support to Regional staff and user office staff on use and implementation of models • Continue development and maintenance of risk applications for broader risk-informed decision-making • Expand pilot for IDHEAS-ECA use in SPAR models	• Direct support to Regional staff and user office staff on use and implementation of models • Continue development and maintenance of risk applications for broader risk-informed decision-making. • Apply IDHEAS-ECA to routine risk-informed decisions
New and Advanced Reactor SPAR Models	• Began the development of the Vogtle 3/4 plant-specific SPAR models • Maintained awareness of status of NUSCALE PRA development by applicant • Maintained awareness of advanced reactor PRA development activities	• Finish the update to the Vogtle 3/4 SPAR models • Assess current state of practice in the use of advance PRA methods (such as dynamic PRA) – this work supports current operating reactors as well	• Maintain the Vogtle 3/4 SPAR model. • Identify gaps and tools to address gaps in the regulatory framework to support use of advanced PRA methods (such as dynamic PRA)	• Develop new risk tools to address gaps in regulatory framework to support new and advanced reactors that rely on advanced PRA methods (such as dynamic PRA)
Incorporation of External Hazards into NRC Risk Tools	• Added internal flooding scenarios to three SPAR models • Updated seismic binning and the use of plant specific NTTF 2.1 hazard curves for seven SPAR models.	• Develop and implement approaches to incorporate advances in the understanding of external hazards into NRC risk tools	• Continue to incorporate new insights on external hazards into NRC risk tools	• Continue to incorporate new insights on external hazards into NRC risk tools
Develop Advanced PRA Methods	• Participated in internal and external stakeholder meetings for awareness of ongoing activities related to advanced PRA methods in support of new and	• Continue research on advanced risk tools in areas such as security, digital Instrumentation and Controls (I&C), emerging technologies and	• Continue research on advanced risk tools in areas such as security, digital Instrumentation and Controls (I&C), emerging technologies and	• Continue development of advanced risk tools in areas such as security, digital Instrumentation and Controls (I&C), emerging

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
	advanced reactor designs. • Started research on advanced risk tools in areas such as security, digital Instrumentation and Controls (I&C), emerging technologies and operating challenges, new methods to account for dynamic processes within existing PRA models, and improved understanding of success criteria used to determine results of representative sequences in PRAs.	operating challenges, new methods to account for dynamic processes within existing PRA models, and improved understanding of success criteria used to determine results of representative sequences in PRAs • Begin development of PRA model for advanced reactor concept using advanced PRA methods	operating challenges, new methods to account for dynamic processes within existing PRA models, and improved understanding of success criteria used to determine results of representative sequences in PRAs • Finalize PRA model for advanced reactor concept	technologies and operating challenges, new methods to account for dynamic processes within existing PRA models, and improved understanding of success criteria used to determine results of representative sequences in PRAs

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

- John Nakoski (John.Nakoski@nrc.gov), Branch Chief in the Division of Risk Analysis

Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Risk Analysis Research	$2,113	3.2	$2,095	5.6	$2,095	5.6	→
New Reactors	New Reactors Research	$0	0.1	$100	0.2	$100	0.2	→
Advanced Reactors	Advanced Non-LWR Regulatory Readiness	$0	0	$300	1	$600*	1*	→
Total		$2,113	3.3	$2,495	6.8	$2,795	6.8	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)
*FY22 Advanced Reactor resources are still being finalized.

Contractor Support

- Idaho National Laboratory (INL) – provides support in the development and maintenance of SAPHIRE, SPAR All Hazards, interactions with EPRI under the MOU, New Reactor SPAR model development, and technical support for risk-informed decision-making. INL will support the development of new applications to meet the needs of NRR in the areas of

reactor oversight and licensing, support the integration of IDHEAS HRA methods into the suite of risk tools, prepare for the use of advanced PRA methods (such as dynamic PRA), and provide support to NRC Headquarters' and Regional risk analysts in the use of NRC's risk tools.

- Electric Power Research Institute (EPRI) – provides support through the licenses for CAFTA and FTREX risk tools that support the development of NRC risk tools and in understanding the use of risk tools by the nuclear industry.

Collaboration and Resource Leveraging

- EPRI under MOU to support identification and resolution of SPAR model issues.
- Sharing of SPAR models with licensees (currently all licensees have SAPHIRE and SPAR models for their plants).
- Sharing of SAPHIRE with other U.S. Federal Agencies (NASA, NAVSEA, U.S. Air Force, Bureau of Reclamation, etc.) as well as Non-Government Organizations (universities, technical support organizations, individual researchers) and foreign regulatory authorities (Spain, Japan, Ghana, etc.) subject to acceptable non-disclosure agreements.

Level 3 Probabilistic Risk Assessment Project
Fiscal Year 2021 Program Overview

Overview

- This EPID includes research on the state-of-practice methods, tools, and data reflecting advances in the application of probabilistic risk assessments (PRAs) to gain new insights on PRA for enhancing the agency's capabilities for regulatory decision-making.

Strategic Focus Areas

- Continue efforts to complete and document the Level 3 PRA work.
- Look for ways to incorporate insights to support current licensing work and advanced reactors work.

Impact and Benefits

- Inform and update the staff's understanding of reactor risk in relationship to the Commission Safety Goals to support the use of risk insights in decision-making.
- Advance PRA state-of-practice for integrated site-wide assessment of risk to public health and safety from all major radiological sources.
- Advance PRA state-of-practice by developing a human reliability analysis approach for post core damage response.
- Advance PRA modeling concepts for new and advanced reactor designs (e.g., non-reactor source terms, multi-unit risk, use of risk metric other than core damage frequency).
- Demonstrate and increase NRC staff capability in PRA and related technical areas.
- Pilot and identify improvements to PRA standards (Level 1, Level 2, Level 3, risk aggregation, etc.).
- Demonstrate the NRC's expert elicitation guidance.

Drivers

- Response to Staff Requirements Memorandum (SRM) for SECY-11-0089, "Options for Proceeding with Future Level 3 Probabilistic Risk Assessment (PRA) Activities," dated September 21, 2011.
- Response to SRM-SECY-11-0172, "Response to Staff Requirements Memorandum COMGEA-11-0001, 'Utilization of Expert Judgment in Regulatory Decision Making'," dated February 7, 2012.

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
Level 3 PRA Activities	1) Finalized internal technical reports on reactor, at-power, Level 3 PRA for internal events and internal floods and reactor, at-power, Level 1 PRAs for internal fires and seismic events 2) Completed technical work on reactor, at-power, Level 2 PRA models for internal fires,	1) Finalize internal technical report on reactor, at-power, Level 2 PRA for internal fires, seismic events, and high winds 2) Finalize internal technical reports on reactor, low power and shutdown, Level 1	1) Finalize internal technical reports on reactor, at-power, Level 3 PRA for internal fires, seismic events, and high winds; reactor, low power and shutdown, Level 3 PRA for internal events; and spent fuel pool Level 3 PRA for all hazards	Publish Final NUREG on Level 3 PRA Project

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
	seismic events, and high winds 3) Completed technical work on reactor, low power and shutdown, Level 1, and Level 2 PRA models for internal events 4) Completed initial spent fuel pool Level 1 and Level 2 PRA models for all hazards	and 2 PRAs for internal events 3) Finalize internal technical report on spent fuel pool Level 1 and Level 2 PRAs for all hazards 4) Prepare public reports on the finalized results of the Level 3 PRA project	2) Finalize internal technical report on dry cask storage Level 1, 2, and 3 PRAs for all hazards 3) Finalize internal technical report on integrated site risk 4) Issue draft NUREG for public comment	

Acronyms: Fiscal year (FY), Nuclear Regulatory Report (NUREG)

Office of Nuclear Regulatory Research Contact

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Resources

		FY20 Actuals		FY21 President's Budget		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Risk Analysis Research	$0	3.9	$100	1	$100	1	↘
Total		$0	3.9	$100	1	$100	1	↘

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Sandia National Laboratories (SNL) – Human reliability analysis support, spent fuel pool PRA support.
- Energy Research Inc. (ERI) – Reactor Level 2 PRA modeling and analysis support (all hazards and plant operating states) and integrated site risk assessment support.
- Pacific Northwest National Laboratory (PNNL) – Low power and shutdown phenomena identification and ranking table (PIRT) development support.
- Idaho National Laboratory (INL) – PRA model development using SAPHIRE, internal fire, and high wind PRA modeling and analysis support.

Collaboration and Resource Leveraging

- Pressurized Water Reactor Owners' Group (PWROG) support for PRA Standards-based peer reviews.
- EPRI and Westinghouse Subject Matter Expert support to the Level 3 PRA Project Technical Advisory Group.

PRA Standards and Regulatory Guidance Development
FY 2021 Program Overview

Overview

- This work develops approaches determining the acceptability of probabilistic risk assessments (PRAs) used to support regulatory applications to provide confidence in the results of the PRA for risk-informed decision-making. Further, it addresses the development of guidance for licensing and oversight of risk-significant technical areas.

Strategic Focus Areas:

- Maintain the ability to support the use of risk insights in licensing through updating guidance and standards.
- Continue support for licensing reviews through development of technical review guidance and participation in activities to review industry PRA initiatives.

Impact and Benefits

- Supports the development of national consensus standards for the development and application of probabilistic risk assessment tools in decision-making by participating in standards development organizations such as the American Society of Mechanical Engineers and American Nuclear Society.
- Provides broadly accepted approaches for conducting PRA analyses, which allows for greater alignment between staff and licensee's assessments.
- Clarifies NRC staff position and expectations regarding an acceptable PRA in support of risk-informed regulatory activities.
- Reduces timeline and staff resources for risk-informed licensing decisions and generates fewer requests for additional information.
- Reduces uncertainties in determining structural safety margins.
- Endorses consensus PRA standards in support of risk-informed decision-making.
- Provides technical review guidance for rapidly advancing state-of-the-art control technologies and concepts of operation.
- Identifies the most risk-significant issues associated with non-destructive examination (NDE) and NDE training programs.

Drivers

- Response to Commission Direction Setting Initiative 13 requesting the staff to work with standards development organizations to develop PRA standards.
- User Need Requests NRR/NRO-2011-009 for assistance in enhancing regulatory guidance in support of risk-informed regulatory activities.
- User Need Requests NRR-2019-008 on Human Factors Engineering Technical Support and NRR-2015-001.

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
ASME/ANS Standard for Level 1/LERF LWR PRA – at-power conditions	Finalizing revision to standard	Publication as ANSI Standard	Staff review for endorsement	NRC endorses in Rev. 4 to RG 1.200
ASME/ANS Standard for Level 2 LWR PRA	Finalizing revision to standard	Finalizing revision to Standard	Publication as ANSI Standard	NRC endorses in Rev. 4 to RG 1.200

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
ASME/ANS Standard for Level 3 LWR PRA	Finalizing revision to standard	Finalizing revision to standard	Publication as ANSI Standard	Potential staff endorsement review
ASME/ANS Standard for Level 1/LERF LWR PRA – low power shutdown	Finalizing revision to standard	Finalizing revision to standard	Publication as ANSI Standard	Potential staff endorsement review
ASME/ANS Standard for Advanced Non-LWRs PRA	Finalizing revision to standard	Publication as ANSI Standard	Staff review for endorsement; NRC endorses in new document; support development of next revision	Support development of next revision
ASME/ANS Standard for Level 1/LERF Advanced LWR PRA – design certification stage	Finalizing revision to standard	Finalizing revision to standard	Publication as ANSI Standard	NRC endorses in Rev. 4 to RG 1.200
ASME/ANS Standard for Multi-Unit PRA	Continued development of draft trial use PRA standard	Continued development of draft trial use PRA standard	Publication as ASME/ANS standard for trial use	Trial use period continued
NEI 17-07, LWR PRA Peer Review Guidance	NEI revised based on pilots and NRC-issued approval letter	NRC endorses in Rev. 3 to RG 1.200	Industry guidance available for use as endorsed by the NRC; observation of guidance implementation	Industry guidance available for use as endorsed by the NRC; observation of guidance implementation
NEI 20-09, ANLWR PRA Peer Review Guidance	NEI developed draft for staff consideration	Revised based on NRC draft staff position	Staff review for endorsement; the NRC endorses in new document	Industry guidance available for use as endorsed by the NRC; observation of guidance implementation
Regulatory Guide 1.200	Received stakeholder input on Rev. 3	Publish Rev. 3	Development of draft guide	Publish draft Rev 4 for public review and comment
Staff Endorsement of the ASME/ANS Standard for Advanced Non-LWR PRA and NEI 20-09	Staff reviewed draft documents and developed draft staff positions	Continued development of draft staff positions and endorsement	The NRC endorses documents in new endorsement vehicle	Staff endorsement available for use; observation of guidance implementation
Catalog of state-of-practice and approved PRA methods	N/A	Initiate the development of the catalog	Complete the draft product for review and comment	Finalize the work product
NUREG-2122, Glossary of PRA Terms	Planning phase	Initiate next revision	Continue development of draft revision	Publish draft revision for public review and comment
Enhanced guidance on the treatment of uncertainty (e.g., NUREG-1855)	Planning phase	Initiate next revision	Continue development of draft revision	Publish draft revision for public review and comment
Human Factors (HF) of Non-Destructive Examination (NDE)	Completed Technical Letter Report on challenges of HF in manual Ultrasonic Testing (UT)	1) Technical letter reports on training and practice in NDE 2) NUREG on HF in Manual UT	Technical Letter Report on HF in encoded UT	NUREG on HF in encoded UT

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
		3) Complete field research on HF in encoded UT		
Human Factors Review Guidance	Completed NUREG-0700, Rev. 3, "Human System Interface Design Review Guidelines"	Develop recommendations for innovation of human performance operational experience trending	1) Develop HFE technical training program 2) HFE Review Guidance for Small / Non-LWR Nuclear Power Plant Designs	Targeted updates to the NRC's HF technical review guidance

Deliverables are driven by ASME and ANS Joint Committee on Nuclear Risk Management (JCNRM)
Acronyms: Fiscal year (FY)

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Risk Analysis Research	$329	3.9	$345	3.4	$345	3.4	→
New Reactors	New Reactors Research	$0	0.9	$385	1.0	$385	1.0	→
Advanced Reactors	Adv. Non-LWR Regulatory Readiness	$145	0	$0	0	$0	0	→
Total		$474	4.8	$730	4.4	$730	4.4	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE), light water reactor (LWR)

Contractor Support

- Sandia National Laboratories - Support for implementing and developing PRA tools and regulatory guidance for risk-informed activities associated with internal events, internal flood, internal fire, seismic, high wind, and external flood PRA for at-power Level 1/LERF, Level 2, Level 3, LPSD, and treatment of parameter uncertainties. Also serves as independent body to support development of national consensus PRA standards.
- Pacific Northwest National Laboratory - Support for human factors engineering of NDE.
- Brookhaven National Laboratory - Support for human factors engineering technical review guidance development.

Collaboration and Resource Leveraging

- Collaboration with ASME and ANS JCNRM to develop PRA standards.
- Collaboration with Nuclear Energy Institute to develop peer review guidance.

- Collaboration with BWR and PWR Owners Groups to conduct workshops to resolve technical issues.
- Collaboration with the Electric Power Research Institute on human factors of NDE.
- Collaboration with the Nuclear Energy Agency's Working Group on Human and Organizational Factors with respect to human factors guidance development.

MACCS Code Development, Maintenance, and V&V
Fiscal Year 2021 Program Overview

Overview

- This EPID covers development, maintenance, verification, validation, documentation, and distribution of the MACCS computer code (MELCOR Accident Consequence Code System), a tool used to perform consequence analysis from potential accidents of nuclear reactors and spent fuel. MACCS supports a wide variety of regulatory applications listed below.

Strategic Focus Areas

- Complete MACCS near-field modeling updates and guidance to support emergency planning applications for non-LWR.
- Complete state-of-practice updates consistent with the cost-benefit improvement project.
- Use information exchanges to maximize external and international resource leverage.
- Maintenance, development, and MACCS documentation activities will continue to build staff expertise and ensure that a modern, state-of-practice code can be used to address current and future regulatory applications (e.g., emergency planning, consequence analyses for safety studies and cost--benefit analyses, environmental reviews, changes to rules and regulatory guides, backfit reviews, etc.).
- Address obsolescence issues related to computing architecture to improve flexibility.
- Continued focus on customer support to improve ease of use and to address bugs identified by staff or Cooperative Severe Accident Research Program (CSARP) members.

Impact and Benefits

- MACCS is the only U.S. code for probabilistic consequence analysis that is used by nuclear power plant licensees and applicants, academia, DOE, and international regulators.
- MACCS use in SAMDA and SAMA environmental reviews minimizes litigative risk in large-scale applications such as design certifications, license renewals, and subsequent license renewals.
- MACCS provided technical basis for risk-informed rulemaking such as decommissioning and emergency preparedness (EP) small modular reactor (SMR) rule.
- MACCS studies (e.g., SOARCA, spent fuel pool studies, containment protection and release reduction) enable risk-informed decision-making by providing unique insights on margins to the quantitative health objectives (QHOs).

Drivers

- Non-LWR Implementation Action Plan Strategy 2, “Acquire/develop sufficient computer codes and tools to perform non-LWR regulatory reviews.” This is an advanced reactor driver that is also applicable to emergency planning calculations under the operating reactor business line.
- User Need Request NMSS-2020-002, “Consolidated Cost-Benefit Guidance Improvement Activities.”
- MACCS Code Suite Maintenance, Development, Documentation, Verification, Distribution, User Support, Workshops, and International Collaboration.

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
NMSS-2020-002: Cost-Benefit Guidance Improvement Activities Non-LWR Implementation Action Plan Strategy 2	• Released major upgrade to MACCS (v4.0) with alternative atmospheric model with significant code distribution improvements	• Release minor version update to MACCS (v4.1) with near-field atmospheric transport and dispersion (ATD) model and associated documentation • Complete radionuclide screening analysis for non-LWRs	• Release minor version update to MACCS (v4.2) with health effects valuation model • Incorporate new radionuclide options identified from the radionuclide screening analysis, if needed	• Release minor version update MACCS (v4.3) with state-of-practice long-term protective action and cost modeling updates • Address obsolescence issues
MACCS Code Development and Maintenance	• Draft MACCS User Guide • Draft MACCS theory manual • MACCS architecture modernization • Held virtual IMUG 2020 meeting	• Develop MACCS Modernization Plan • Complete MACCS Verification Report, MACCS User Guide, MACCS theory manual • IMUG 2021 virtual meeting • User support for MACCS (v4.0) release	• Address MACCS obsolescence issues • IMUG 2022 meeting • User support for new release	• Address MACCS obsolescence issues • IMUG 2023 meting • User support for new release

Acronym: Fiscal year (FY)

*** NOTE:** Currently budgeted contract funds are not sufficient to support all the planned accomplishments.

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Resources

		FY20 Actuals		FY21 President's Budget		FY22 President's Budget		FY23 Trend
Business Line	Product	$K	FTE	$K	FTE	$K	FTE	Research Planning
Operating Reactors	Risk Analysis	$624	3.3	$300	2.0	$400	2.0	→
New Reactors	New Reactors Research	$45	0.2					→
Advanced Reactors	Advanced Non-LWR Regulatory Readiness	$200		$200	0.4	$100*	0.3*	↘
Total		$869	3.5	$500	2.4	$500	2.3	↘

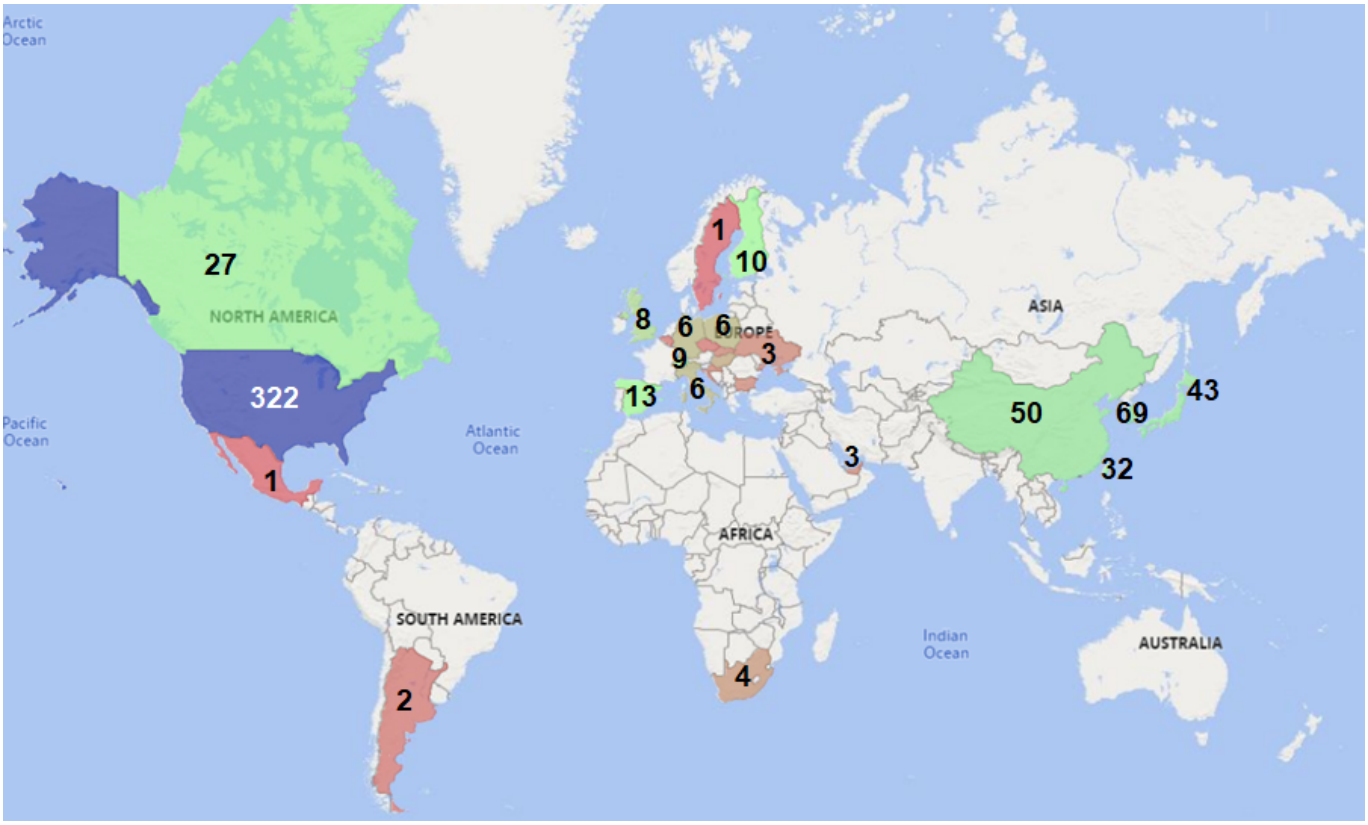
Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)
*FY22 Advanced Reactor resources are still being finalized.

Contractor Support

- Sandia National Laboratories – MACCS Code Suite Maintenance, Development, Applications and Technical Support.
- Southwest Research Institute – MACCS Code Suite Development**.**

Collaboration and Resource Leveraging

- Interactions with EPA to incorporate its BPIP source code into the MACCS code to support our effort to improve MACCS's capability to more accurately model near-field atmospheric transport.
- MOU with the National Oceanic and Atmospheric Administration (NOAA) to support the development of modern atmospheric dispersion tools for nuclear power risk and consequence analysis techniques.
- MACCS development is leveraged domestically (e.g., DOE, NOAA) and internationally via the NRC's CSARP. CSARP contains over 25 member countries, and their membership dues are used to support MELCOR and MACCS code development, maintenance, and international meetings and cooperative projects. The number of MACCS users by country is shown in the map below.



WinMACCS, MelMACCS, and SecPop Code Development and Maintenance
Fiscal Year 2021 Program Overview

Overview

- This EPID covers development, maintenance, verification, validation, documentation, and distribution for the user interface, utility, pre-processor, and post-processor codes that support MACCS (MELCOR Accident Consequence Code System) consequence analysis calculations and enable its use in a variety of regulatory applications.

Strategic Focus Areas

- Address obsolescence issue related to computing architecture to improve flexibility.
- Complete COMIDA2 updates and documentation.
- Complete MelMACCS updates including user interface and documentation.
- Continued focus on customer support improving ease of use and address bugs identified by staff or Cooperative Severe Accident Research Program (CSARP) members.

Impact and Benefits

- Use of the following MACCS utility codes enhances the efficiency and effectiveness of regulatory analyses and assessments:
  - WinMACCS is the graphical user interface for MACCS.
  - MelMACCS is the pre-processor code that converts MELCOR source term results into MACCS input format.
  - SecPop is the pre-processor code that prepares site-specific data including population, land use and land fraction, and economic data.
  - COMIDA2 is the pre-processor code that prepares food chain/ingestion model input data.
  - AniMACCS is the post-processor code that enables visualization of plume dispersion and air and ground concentrations of modeled accident releases.
  - LHS is the pre-processor code that supports uncertainty analysis by generating values of uncertain parameters based on user-defined probability distributions.
- These codes plus MACCS support regulatory applications including (1) regulatory cost-benefit analyses, (2) environmental analyses of Severe Accident Mitigation Alternatives (SAMA) and Design Alternatives (SAMDA), (3) Level 3 PRA, (4) research studies of accident consequences, (5) support for emergency preparedness, and (6) dose-distance evaluations for emergency planning.

Drivers

- MACCS Code Suite Maintenance, Development, Documentation, Verification, Modernization, Distribution, User Support, Workshops, and International Collaboration.
- Improving robustness and runtime performance of MACCS calculations for NRC and other external domestic and international code users.

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
MACCS Code Suite Development and Maintenance	• Release AniMACCS publicly	• Complete COMIDA2 input parameter technical basis report • Complete FogBugz implementation	• Publish MelMACCS User Guide, Theory Manual, and Verification Report • Update SecPop code to include 2020 US Census • Address WinMACCS Graphical User Interface obsolescence	Transition to new interface

Acronym: Fiscal year (FY)

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Resources

		FY20 Actuals		FY21 President's Budget		FY22 President's Budget		Research Planning
Business Line	Product	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	Risk Analysis	$187	0.1	$50	1.0	$50	1.0	→
New Reactors	Risk Analysis	$14						→
Total		$201	0.1	$50	1.0	$50	1.0	→

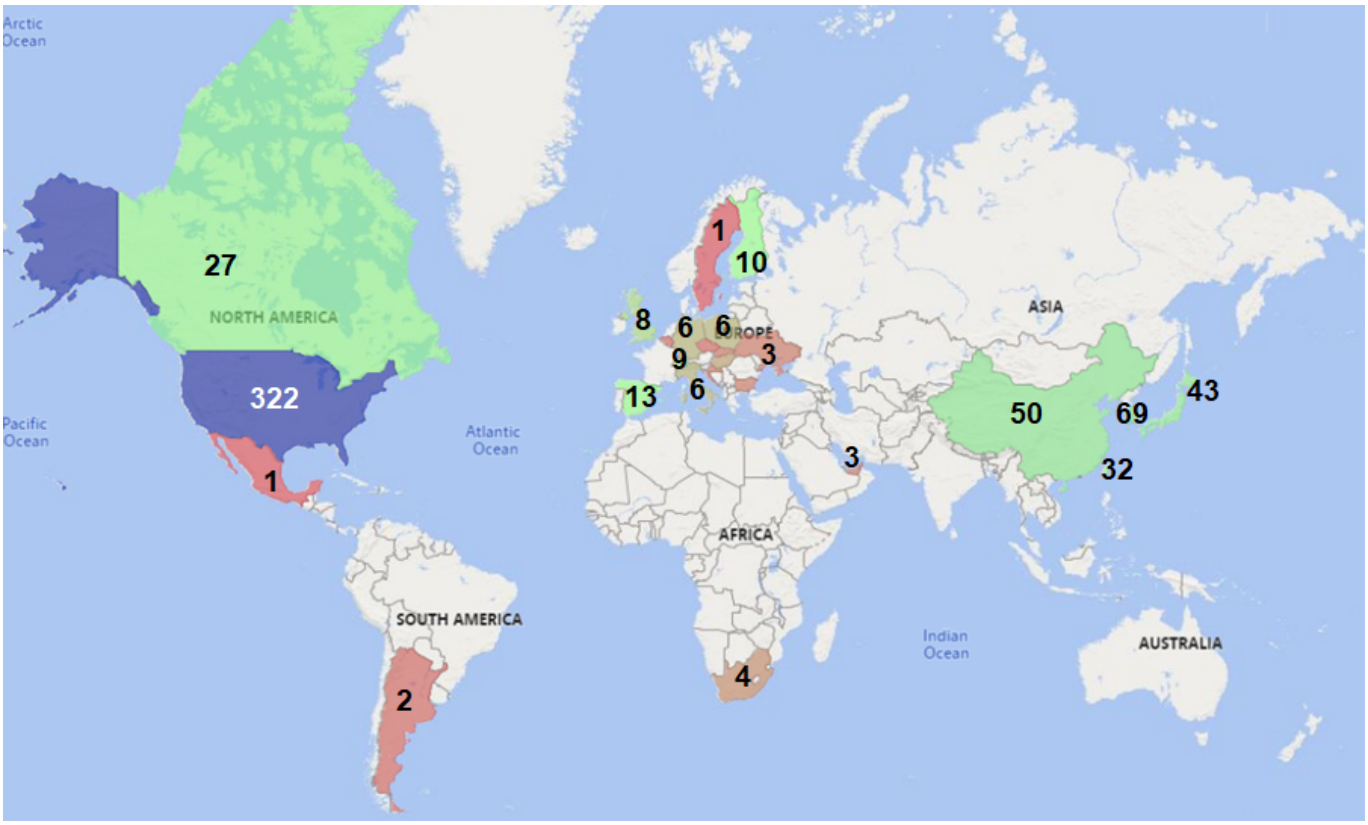
Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Sandia National Laboratories – MACCS code suite maintenance, development, and verification and validation.
- Southwest Research Institute – Verify Sample Problem Input Parameters.

Collaboration and Resource Leveraging

- MACCS and its supporting utility codes are shared internationally via NRC's Cooperative Severe Accident Research Program (CSARP). CSARP contains over 25 member countries, and their membership dues are used to support MELCOR and MACCS code development, maintenance, and international meetings and cooperative projects. The number of MACCS users by country is shown in the map below.


Arctic Ocean
27
NORTH AMERICA
322
1
Pacific Ocean
Atlantic Ocean
SOUTH AMERICA
2
1
10
8
6
6
9
3
13
6
EUROPE
ASIA
50
69
43
32
3
AFRICA
4
Indian Ocean
AUSTRALIA

Consequence Analysis
Fiscal Year 2021 Program Overview

Overview

- This EPID covers the planning, performance, documentation, and review of consequence analysis calculations for a variety of regulatory purposes. Consequence calculations generally use the MACCS code suite, but this EPID also covers analyses and projects that do not involve MACCS.

Strategic Focus Areas

- Enhance readiness to support licensing actions by
  - Using recently completed consequence analyses to risk-inform regulatory processes.
  - Using consequence analysis to support the cost-benefit guidance improvement program.
  - Using consequence analysis to support risk-informing emergency planning.
- Develop and maintain staff core capabilities in consequence analyses for light- water and non-light-water reactors.

Impact and Benefits

- Safety studies like the Commission-directed State-of-the-Art Reactor Consequence Analyses (SOARCA) studies provide technical basis for possible reactor program changes based on margins to the quantitative health objectives.
- Evacuation time estimate (ETE) studies facilitate 10 CFR 50, Appendix E reviews.
- Level 3 PRA activities enable licensing modernization for innovative non-LWR designs.
- Consequence analysis projects underpin methodology for scalable emergency planning zone (EPZ).
- Incident response E-library and ETE studies improve NRC incident response readiness.

Drivers

- SRM-SECY-11-0089 (Level 3 PRA Project).
- User Need Request NMSS-2020-002, “Complete Consolidated Cost-Benefit Guidance Improvement Activities,”
- Draft NRR User Need Request (Consequence Analysis Applications).
- User Need Request NSIR-2016-001, “Incident Response Electronic Library.”
- User Need Request NSIR-2017-002, “Support Emergency Preparedness Rulemaking and Related Activities.”
- Strategy 2 of the Implementation Action Plan (IAP) for advanced non-light water reactors.

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
SRM-SECY-11-0089: Level 3 PRA Project	• Completed Level 3 PRA project offsite consequence analysis calculations and documentation for low power and shutdown sequences	• Complete Level 3 PRA project offsite consequence analysis calculations and documentation for spent fuel pool releases	• Complete Level 3 PRA project NUREG documentation of all offsite consequence analyses	
NMSS-2020-002: Cost-Benefit Guidance	• Completed Replacement Energy Costs NUREG Study	• Complete Cost-Benefit Guidance Update Appendix K on Morbidity Valuation	• Develop screening analysis to inform	• Develop an electronic repository of MACCS

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
Improvement Activities		• Complete consequence analysis to inform cost uncertainty for use in regulatory cost-benefit applications	level of detail needed for SAMDA/SAMA	analyses for use in future activities
NRR Consequence Analysis Applications	• Completed Research Information Letter (RIL-2020-003) on the many benefits and uses of the SOARCA project • Completed final revision of the SOARCA brochure (NUREG/BR-0359, Rev. 3)	• Complete analysis to identify which accident mitigation equipment are most important in severe accidents for SDP and reactor oversight (leverage SOARCA UA and L3PRA) • Complete SOARCA Uncertainty Analysis Summary NUREG report • Complete NUREG study to inform when site-specific SAMDA are needed in new reactor applications or whether generic SAMDA could be used	• Additional offsite consequence analyses, as needed • Provide technical advice and guidance on the use of the MACCS code suite for regulatory applications, as needed • Begin evaluation of consequences from non-LWRs source term demo calculations using MACCS	• Additional Offsite Consequence Analyses, as needed • Provide technical advice and guidance on the use of the MACCS code suite for regulatory applications, as needed • Continue the evaluation of consequences from non-LWRs source term demo calculations using MACCS, if needed
NSIR-2014-002: Evacuation Time Estimate Studies	• Completed NUREG/CR-7269, "Enhancing Guidance for ETE Studies" to support NSIR development of updated ETE guidance in NUREG/CR-7002, Rev. 1. • Closed UNR.			
NSIR-2016-001: Offsite Response Organization Emergency Response Plans and Procedures		• Complete electronic library of emergency plans and other information useful for the Operations Center during emergency response	• Complete report capturing electronic library information useful for MACCS consequence analyses • Update Op Center electronic library	
NSIR-2017-002: Emergency Preparedness		• Completed evaluation of non-radiological consequences of evacuation and relocation • Evaluation of MACCS code updates and their impact on protective action recommendations (PAR)	• Conduct updated PAR study to better risk-inform EP (future user need)	• Infiltration of Radionuclides and Impact on Shelter Dose Reduction Factors
Ad Hoc support to NRR staff reviews of NPP licensing amendment	Provide assistance as requested			

Acronym: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

		FY20 Actuals		FY21 President's Budget		FY22 President's Budget		FY23 Trend
Business Line	Product	$K	FTE	$K	FTE	($K	FTE	Research Planning
Operating Reactors	Risk Analysis	$559	1.8	$300	3.0	$300	3.0	↘
New Reactors	Risk Analysis	$32	0.1	$80	0.5	$80	0.5	→
Total		$591	1.9	$380	3.5	$380	3.5	↘

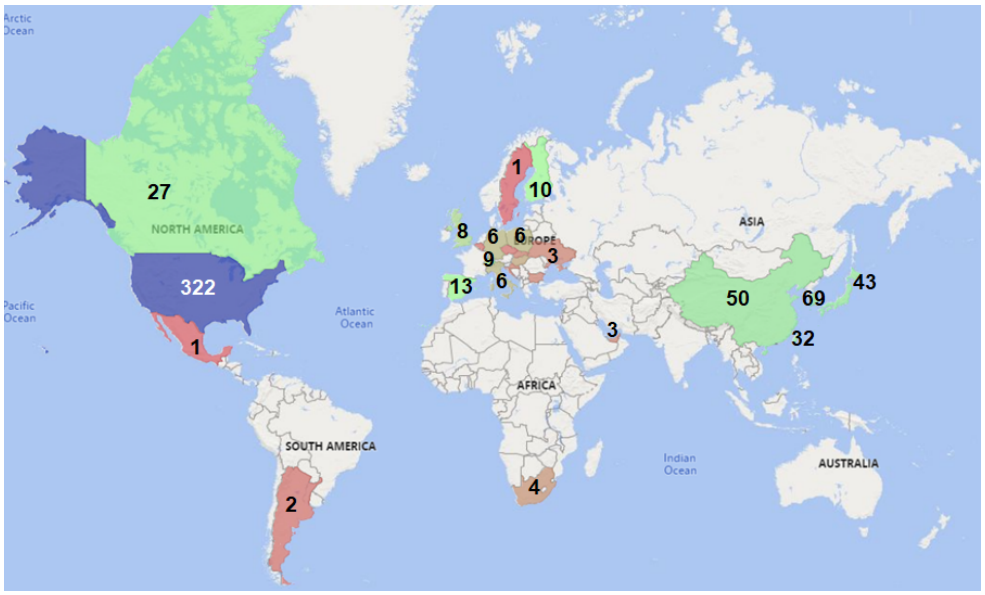
Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Sandia National Laboratories – Providing technical support as needed.
- ICF – Replacement Energy Costs Study.
- Gryphon Scientific – Literature Survey and Analysis on Non-Radiological Consequences of Evacuation and Relocation.

Collaboration and Resource Leveraging

- MACCS is shared internationally via the NRC's Cooperative Severe Accident Research Program (CSARP). CSARP contains over 25 member countries, and their membership dues are used to support MELCOR and MACCS code development, maintenance, and international meetings and cooperative projects. The number of MACCS users by country is shown in the map below.



Data Science and Artificial Intelligence
Fiscal Year 2021 Program Overview

Overview

- Research under this EPID supports identifying and evaluating technical issues and gaps for using data science and artificial intelligence (AI) as part of the regulatory programs.

Strategic Focus Areas

- Evaluate the regulatory readiness levels and gaps of data science and AI technologies.
- Build staff core capabilities in data science and AI to better position the agency to benefit from these technologies.
- Keep abreast of advances in state-of-practice and state-of-art in data science and AI technologies.
- Increase awareness and develop a common understanding of data science and AI capabilities across NRC and the nuclear industry.

Impact and Benefits

- Develop Data Science and AI Strategic Plan to improve coordination of AI development and usage across the agency, prepare staff for regulatory applications, and accelerate internal NRC business improvements.
- Develop a regulatory infrastructure for using data science and AI technologies.
- Enhance staff knowledge in applications and use of data science and AI.

Drivers

- Research Assistance Request NRR-2020-018, “Resource Prediction Based on Historical Licensing Actions”
- Research Assistance Request NRR-2021-010, “Data Science and Artificial Intelligence Regulatory Applications Workshops”
- NRC initiative to use data analytics for regulatory enhancements to become a modern, risk-informed regulator, “The Dynamic Futures for NRC Mission Areas”

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
NRR-2020-018: Resource Predictor Tool		• Develop resource prediction tool based on historical licensing actions		
NRR-2021-010: Data Science and AI Workshop		• Complete workshops for application of advanced data science techniques in regulatory decision-making	• Complete memorandum documenting workshop proceedings	
Data Science and AI Strategic Plan		• Prepare internal draft Data Science and AI Strategic Plan	• Publish final Data Science and AI Strategic Plan	• Execute Data Science and AI Strategic Plan
Capstone Use Cases in Data Science and AI			• Develop and implement capstone use cases in data science and AI	• Continue execution of capstone use cases in data science and AI

Acronyms: Fiscal year (FY), Artificial Intelligence (AI)

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Resources

		FY20 Actuals		FY21 President's Budget		FY22 President's Budget		FY23 Trend
Business Line	Product	$K	FTE	$K	FTE	$K	FTE	Research Planning
Operating Reactors	Research Reactor Support	$0	0.0	$0	0.0	$0	0.0	↗

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- None.

Collaboration and Resource Leveraging

- Finalized Memorandum of Understanding Addendum with the U.S. Department of Energy on Data Analytics for operating experience.
- Finalizing Memorandum of Understanding with the Electric Power Research Institute that includes, among other topics, collaboration on Data Analytics
- Collaborate with the U.S. Department of Energy and the Electric Power Research Institute to better understand industry's use cases for Data Analytics and identify areas for future cooperation.
- Participation in Federal interagency workings groups (e.g., National Institute of Standards Artificial Intelligence Standards Coordination Working Group) and leverage research activities with federal agencies.
- Hosted three Data Science and AI workshops in Summer 2021.

MELCOR Code Development and Maintenance
Fiscal Year 2021 Program Overview

Overview

- This EPID includes the research to enable the NRC to develop, validate, and maintain the state-of-the-art MELCOR computer code used to perform severe accident and source term analysis in support of safety issue resolution and risk-informed decision-making.

Strategic Focus Areas

- Efficiently maintain code at state-of-the-practice especially for a variety of regulatory applications, Fukushima forensics, and other long-running analysis.
- Modernize MELCOR to enhance its technical and regulatory readiness.
- Develop and maintain staff core capabilities in source term and severe accident analyses for light- water and non-light-water reactors.
- Continued focus on customer support improving ease of use and address bugs identified by staff or Cooperative Severe Accident Research Program (CSARP) members.
- Use commercial entities to increase CSARP participation and leverage advanced reactor capabilities.

Impact and Benefits

- MELCOR code development activities have supported many regulatory analyses, inspection support, emergency response support, and formal studies activities that are described in the Source Term and Accident Consequences EPID one-pager, such as
  - Technical Specifications Amendments.
  - Formal studies (e.g., Spent Fuel Pool Study [NUREG-2161], containment protection and release reduction rulemaking [NUREG-2206]) that led to hundreds of millions of averted costs.
  - Updates to Standardized Plant Analysis Risk (SPAR) models and development of Severe Accident Management Guidelines (SAMG) insights.
  - Rulemaking technical basis (e.g., decommissioning rule, spent fuel pool petition for rulemakings).
  - Upgrades the Reactor Technical Tool designed for responses to emergencies at the NRC's Operation Center.
- Note that drivers and resources for Accident Tolerant Fuel (ATF), High Burnup and High Enrichment MELCOR Code Development and Maintenance are covered by the Accident Tolerant Fuel EPID.
- MELCOR supports non-LWR source term demo calculations and regulatory reviews.

Drivers

- NRR-2020-010 - MELCOR State-of-Practice Modernization Project.
- Code development and maintenance supports other user needs (i.e., NRR-2019-009, NRR-2019-010) and NRC projects and regulatory applications.
- Strategy 2 of the Implementation Action Plan (IAP) for advanced non-light water reactors.

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
MELCOR Development & Modernization	Release of MELCOR 2.2 build 15254 with improvements to fission product models and code stability	Release of MELCOR 2.2 with code stability & robustness improvements for source term prediction	Release of MELCOR 2.2 with improvements and bug fixes & interim release of modernized code (hydrodynamic package)	Release of MELCOR 2.2 with improvements and bug fixes & implementation of core damage models in the modernized code
MELCOR for non-LWR applications	Models implemented for various technologies & support for source term demo calculations	Code release with model improvements to support source term demo calculations and regulatory reviews Complete source term demonstration project for representative heat pipe, gas-cooled, and salt-cooled reactors.	Code release with model improvements to support source term demo calculations and regulatory reviews	Code release with model improvements to support regulatory reviews
MELCOR user group workshops and training	Delayed due to COVID-19	Preparation of workshop materials and hands-on problems	Preparation of workshop materials and hands-on problems	Preparation of workshop materials and hands-on problems
MELCOR technical review meetings (MCAP/EMUG/AMUG)	Conducted virtual annual technical exchange meetings	Develop presentations and exchange technical information to improve MELCOR modeling	Develop presentations and exchange technical information to improve MELCOR modeling	Develop presentations and exchange technical information to improve MELCOR modeling

Acronym: Fiscal year (FY)

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	$K	FTE	$K	FTE	$K	FTE	Research Planning
Operating Reactors	Risk Analysis	$1,293	1.0	$1223	1.0	$1350	1.0	→
Advanced Reactors	Advanced Non-LWR Regulatory Readiness	$1,376	0.4	$800	0.4	$600*	0.3*	→
Total		$2,669	1.4	$1050	1.4	$1950	1.4	→

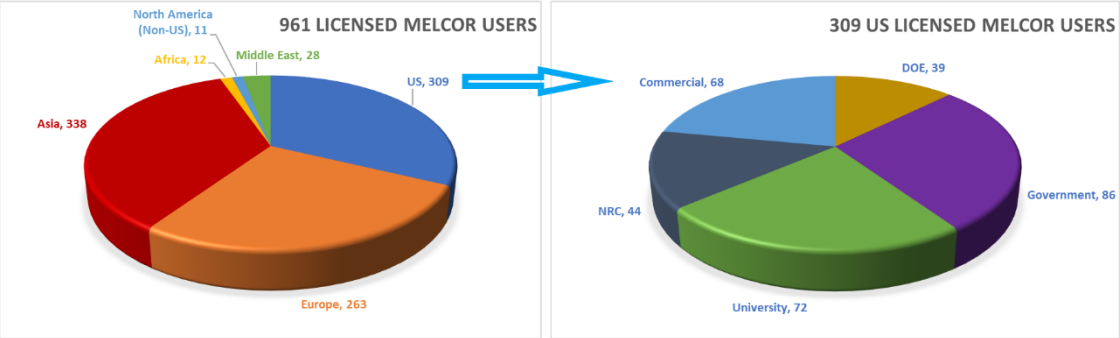
Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)
*FY22 Advanced Reactor resources are still being finalized.

Contractor Support

- Sandia National Laboratories - Development and Maintenance of MELCOR computer code.

Collaboration and Resource Leveraging

- Through the CSARP, RES provides MELCOR to international code users (about 1,000 users in 30 countries). The NRC receives about $1M annually from fees collected from international organizations (not reflected in above amount).



Severe Accident Verification and Validation
Fiscal Year 2021 Program Overview

Overview

- This EPID includes cooperative research to enable the NRC to obtain experimental data and analyses for verification and validation of its severe accident codes, mainly MELCOR, which are used to formulate a technical basis for regulatory decision-making.

Strategic Focus Areas

- Remain almost exclusively leveraged and focused on supporting industry driven projects.
- Reduced source term engagements unless useful for accident-tolerant fuel (ATF) or advanced reactors.
- Support the Japanese, DOE, and industry cooperation on Fukushima forensics.
- Rebuild severe accident phenomenology expertise due to losses in expertise associated with staff retirements.

Impact and Benefits

- Provides technical leadership and support to highly leveraged (often 10:1 benefit to cost ratio) international projects that reduce key uncertainties in severe accident code and knowledge (e.g., spent fuel pools, severe accidents, source terms).
- Provides access to the largest repository of severe accident verification and validation information since Three Mile Island for pennies on the dollar.
- Cost for participation in cooperative experimental programs is offset by funding from the Cooperative Severe Accident Research Program (CSARP).

Drivers

- Need to continue improvements in the predictive capability of MELCOR as a state-of-the-practice reactor safety analysis code to provide independent confirmatory reactor analysis capability.

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
Committee on the Safety of Nuclear Installations (CSNI)/Nuclear Energy Agency (NEA) PreADES & ARC-F	Published annual report	Publish annual report	Publish NEA summary reports	
CSNI/NEA ESTER	Initiate ESTER program	Continue with testing and synthesis of results. Start of semi-integral and EPICUR test	Continue with testing and synthesis of results. Focus on tests with VERDON samples	Continue with additional semi-integral and EPICUR testing and synthesis of results
Institut de Radioprotection et de	MEDEA steam/water spray penetration into bundle test; MIDI and	Synthesize cladding oxidation test results;	Prepare final reports	

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
Surete Nucleaire (IRSN) DENOPI experiment	ASPEC – spray cooling test matrix development	conduct ASPEC spray cooling		
CSNI/NEA HYMERES-2 (2017-2021)	Development of database related to HYMERES-2 for Knowledge Management and future benchmarking and validation.	Benchmarking advanced simulation tools using HYMERES-2 results.		
CSNI/NEA Reduction of Severe Accident Uncertainties (ROSAU)	Agreed on the first test to be carried out; completed necessary facility modification	DCAM-1 first test results and MST-1 test specifications	Conduct additional tests in DCAM/MST test matrix, analysis, and reporting	Conduct additional tests in DCAM/MST test matrix, analysis, and reporting

Acronym: Fiscal year (FY)

- OECD/NEA/CSNI Senior Expert Group on Safety Research Opportunity Post-Fukushima (SAREF) near term projects - Preparatory Study on Analysis of Fuel Debris (PreADES) and Analysis of Information from Reactor Buildings and Containment Vessels of Fukushima Daiichi Nuclear Power Station (ARC-F).
- OECD/NEA/CSNI Experiments on Source Term for Delayed Releases (ESTER) project – experiments and analysis on long-term radionuclide release mechanisms focusing on revaporization of surface deposits in the reactor coolant system and containment and on iodine chemistry, specifically organic iodide formation performed at the Cadarache Nuclear Center in France.
- IRSN DENOPI experiments at Cadarache Nuclear Center – spent fuel pool related (e.g., spray droplets penetration into PWR bundle and air/steam oxidation of zirconium cladding).
- OECD/NEA/CSNI HYMERES project – Computational Fluid Dynamics (CFD) quality experiment data on hydrogen behavior in containment and pool scrubbing (of aerosols).
- OECD/NEA/CSNI Reduction of Severe Accident Uncertainties (ROSAU) project - Ex-vessel molten core concrete interaction (MCCI) experiments conducted at the Argonne National Laboratory.

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Resources

		FY20 Actuals		FY21 President's Budget		FY22 President's Budget		FY23 Trend
Business Line	Product	$K	FTE	$K	FTE	$K	FTE	Research Planning
Operating Reactors	Risk Analysis	$1,558	1.0	$100	1.0	$100	1.0	→
New Reactors	New Reactors Research	$55						→
Total		$1613	1.0	$100	1.0	$100	1.0	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support & Payment for International Projects

- Sandia National Laboratories - CSNI/Pre-ADES and ARC-F projects providing information on Reactor Building, Containment Vessel, and Water Sampling at Fukushima
- NEA/CSNI ESTER - long-term radionuclide release and Iodine chemistry experiments.
- IRSN DENOPI - Cladding oxidation in air/steam and spray penetration into PWR bundle testing.
- NEA/CSNI HYMERES - CFD quality experiment data on hydrogen behavior in containment and pool scrubbing.
- NEA/CSNI ROSAU - MCCI experiments.

Collaboration and Resource Leveraging

- Nuclear Energy Agency/Committee on the Safety of Nuclear Installations (NEA/CSNI).
- Institut de Radioprotection et de Surete Nucleaire, or Institute for Radiological Protection and Nuclear Safety.
- Canadian Regulatory body (CNSC) and national laboratory (CNL) on code assessment and validation against Canadian experiments.
- Japanese Regulatory body (NRA-J) and other organizations (TEPCO, JAEA).

Accident Progression and Source Term Analysis
Fiscal Year 2021 Program Overview

Overview

- This EPID includes research for the NRC to perform independent plant safety and risk analyses using the MELCOR code to formulate a technical basis for risk-informed regulatory decision-making.

Strategic Focus Areas

- Maintain state-of-the-practice severe accident and source term staff expertise and analytic capability for licensing and inspection applications

Impact and Benefits

- Licensees continue use of RG 1.183 to request Technical Specifications (TS) changes to reduce operational cost and regulatory burden in maintaining equipment used to control and or mitigate radionuclides releases, such as
  - Relaxation of TS operability requirements allowing for a more efficient execution of reactor outage work with a resulting reduction in operator radiation exposure.
  - Relaxation of TS allowable main steam isolation valve leak rate which reduces the need for refurbishing main steam isolation valves and commensurate operator radiation exposure.
- Analyses support updating Standardized Plant Analysis Risk (SPAR) models, providing best-estimate thermal-hydraulic calculations to confirm or enhance specific success criteria for system performance and operator timing used in the Significance Determination Process.
- Analysis of the NEA-led Fukushima forensic analysis efforts will improve severe accident realism and more risk-informed decisions.

Drivers

- User Need Request NRR-2013-011, which provides support for the SHINE Operating License licensing review.
- Informal Assistance Request IAR 2020-11-30, re-evaluation of settling velocity distribution and the multi-group method in support of revision to RG 1.183.
- Regulations in 10 CFR Part 50 (Design Criteria), Part 51 (NEPA), and Part 100 (Siting) require source term analysis to support TS and License Amendment Requests.
- Other drivers include on-call support to modify the Reactor Technical Tool for the Operation Center, for petitions for rulemakings and rulemaking support, and for SPAR model development.
- Note that drivers and resources for Accident Tolerant Fuel (ATF), High Burnup, and High Enrichment analyses are covered by the Accident Tolerant Fuel EPID.

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
SPAR model development (RES/DRA led)	Published final NUREG-2236 for the Duane Arnold model	Develop model for Grand Gulf	Perform Grand Gulf analysis and documentation	Decide on the next SPAR model
Site Level 3 analysis (reactor and spent fuel pools	Documented final spent fuel pool analysis	Finalize internal technical report for spent fuel pool (SFP)	Publish draft NUREGs for public comments	Publish final NUREGs
Research and Technical Assistance on Severe	Maintain state-of-practice for fuel coolant interactions (FCI) phenomenology and the TEXAS code§			

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
Accidents – University of Wisconsin				
Re-evaluation of the Fission Product Release and Transport for a Fuel Handling Accident [FHA]	Documented fission product assessment and FHA reports.			
Re-evaluation of aerosol characteristics in support of RG 1.183		Complete the re-evaluation analysis and propose updated particle characteristics		
Ad Hoc support to NRR staff reviews of NPP licensing amendment	Provided assistance as requested			
CSNI Analysis of Information from Reactor Building and Containment Vessel and Water Sampling in Fukushima Daiichi NPS (ARC-F) – MELCOR analysis of Fukushima accidents	TEPCO provided latest Fukushima forensic investigation and data to continue forensics analysis and code improvements			

§ TEXAS is a stand-alone code for fuel coolant interaction (FCI), a severe accident phenomenon that takes place in a very short timescale that it is not feasible to incorporate into MELCOR.
Acronym: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

		FY20 Actuals		FY21 President's Budget		FY22 President's Budget		FY23 Trend
Business Line	Product	$K	FTE	$K	FTE	$K	FTE	Research Planning
Operating Reactors	Risk Analysis	$74	0.2	$50	1.7	$50	1.7	→
New Reactors	New Reactors Research	$150	0.1					→
Total		$224	0.3	$50	1.7	$50	1.7	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Sandia National Laboratories – MELCOR Analysis Support.
- University of Wisconsin – Fuel coolant interaction and the TEXAS code.

Collaboration and Resource Leveraging

- Through the CSARP, the NRC receives about $1M annually from fees collected from international organizations (not reflected in above amount).

Dose Assessment Code Development and Maintenance
Fiscal Year 2021 Program Overview

Overview

- This EPID includes computer code development and maintenance for design-basis accidents (DBAs) using the Symbolic Nuclear Analysis Package/Radionuclide Transport, Removal And Dose Estimation (SNAP/RADTRAD) computer code and incident response using the Radiological Assessment System for Consequence Analysis (RASCAL) dose assessment computer codes.
- Also includes computer code development and maintenance of Radiation Protection Computer Code Analysis and Maintenance Program (RAMP) codes that support licensing of nuclear power plants (NPPs). Examples include atmospheric codes (ARCON & PAVAN), siting and effluent codes (NRCDose & the Gaseous and Liquid Effluent (GALE) code), and the control room habitability (HABIT) code.

Strategic Focus Areas

- Maintain a high level of technical and regulatory readiness for all RAMP NPP codes.
- Develop and maintain staff core capabilities in dose assessment.
- Identify resource savings and consolidation opportunities across dose projection and atmospheric codes. Examples include merging former NRO-supported atmospheric codes (ARCON, PAVAN & XOQDOQ); siting and effluent codes (NRCDose software suite & GALE); and control room habitability (HABIT) into this EPID.
- Determine a baseline computer code development and maintenance budget for all RAMP NPP codes.

Impact and Benefits

- The RASCAL computer code is a key Protective Measures Team tool supporting the NRC incident response function. RASCAL is used to assess and confirm protective action recommendations of NRC-licensees (NPPs) to make informed protective action decisions.
- The SNAP/RADTRAD code allows users to efficiently and effectively perform confirmatory design basis accident radiological dose calculations to confirm compliance with the applicable criteria of 10 CFR 100.11 and 50.67 by applying either the TID-14844 source term or Alternative Source Term (AST). Analysis with the AST has resulted in more efficient execution of reactor operations and relaxation or deletion of various structures, systems, and component operability and surveillance requirements in the Technical Specifications.
- The RAMP atmospheric computers codes of ARCON and PAVAN are used to calculate the relative ground-level air concentrations (X/Q) for the assessment of potential accidental releases of radioactive material from NPPs. The ARCON code is used in support of control room habitability assessments required by 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 19 and RG 1.194. The PAVAN code is used in support of the exclusion area boundary and the outer boundary of the low population zone assessments required by 10 CFR Part 50, 10 CFR Part 100, and RG 1.145.,
- The NRCDose (GASPAR, LADTAP, and XOQDOQ) and GALE codes implement the NRC's current requirements for As Low As Reasonably Achievable (ALARA) for radioactive effluents from nuclear power plants required by 10 CFR Part 20 and RGs 1.109, 1.111 and 1.113.
- The HABIT code is used in support of control room habitability in the event of chemical release as required by 10 CFR Part 50, Appendix A, GDC 19, and RG 1.78.

Drivers

- User Need Request NRR-2017-012, "User Need Request to Support and Enhance the SNAP/RADTRAD Computer Code for Use in Nuclear Regulatory Commission Licensing Activities," (ML17184A139) requests RES assistance in addressing specific enhancements specific enhancements and continued code support for the SNAP/RADTRAD computer code.
- Research Assistance Request NRR-2021-002, "GALE-NRCDose3 Computer Code Development," (ML20346A056) requests RES assistance in addressing specific enhancements specific enhancements and continued code support for the GALE and NRCDose3 computer code.
- User Need Request NSIR-2021-002, "RASCAL Computer Code Maintenance and Development," (ML21041A150) requests the Office of Nuclear Regulatory Research (RES) assistance in addressing specific enhancements to the RASCAL computer code and the evaluation of other technical assessment tools used for assessing possible effects of a radiological incident.
- Strategy 2 of the Implementation Action Plan (IAP), "NRC Non-Light Water Reactor (Non-LWR) Vision and Strategy, Volume 4 – Licensing and Siting Dose Assessment Codes," (ML21085A484).

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
RASCAL 5.0 NSIR-2015-002	Released beta version of RASCAL 5.0 (Java) for testing	Update RASCAL 5.0 with all NPP Models and further testing	Code maintenance and add user requested features into RASCAL 5.0	Code maintenance
SNAP/RADTRAD 5.0 NRR-2017-012	Released RADTRAD-AC versions 5.0.0 and 5.0.1	RADTRAD-AC v5.0.1 validation testing and code maintenance	Code maintenance	Code maintenance
NPP Licensing Support Computer Codes (NRCDose3, HABIT, GALE, ARCON & PAVAN)	Released NRCDose3 v1.1.2, HABIT v2.1 and ARCON v2.0	Update NRCDose3 release v1.1.3 and HABIT v2.2 & provide code maintenance	Code maintenance and consolidation ATD codes - ARCON, PAVAN & XOQDOQ - Release consolidated ATD code.	Code maintenance and consolidation ALARA Siting codes - GALE with NRCDose3 and development of normal effluent source term module for non-LWRs. Update of Regulatory Guides (RGs) 1.109, 1.111, 1.145, and 1.194

Acronym: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	$K	FTE	$K	FTE	$K	FTE	Research Planning
Operating Reactors	Risk Analysis	$863	1.1	$372	2.0	$472	2.0	↗
New Reactors	New Reactors Research	$446	0.4	$300	0.6	$300	0.6	→
Spent Fuel Storage and Transportation	Waste Research			$40	0.2	$200	0.2	→
Advanced Reactors	Advanced Non-LWR Regulatory Readiness	$200	0.2	$200	0.4	$100	0.3	→
Total		$1,509	1.7	$912	3.2	$1,072	3.1	↗

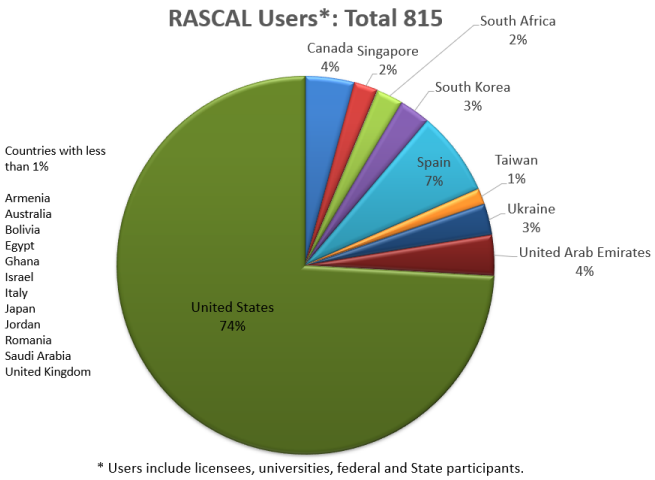
Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Athey Consulting – RASCAL computer code and emergency response assessment tools and training for the NRC Operations Center.
- Sandia National Laboratories – Code development, updates, and maintenance for the source term models in the RASCAL computer code.
- Pacific Northwest National Laboratory – Code development, updates, and maintenance for the atmospheric transportation and dispersion models in the RASCAL computer code & the licensing and siting ATD codes (ARCON & PAVAN).
- ISL – Code development, updates, and maintenance for the SNAP/RADTRAD computer code.
- Leidos, Inc. – RAMP Web site development and maintenances and the HABIT computer code development, updates, and maintenance.

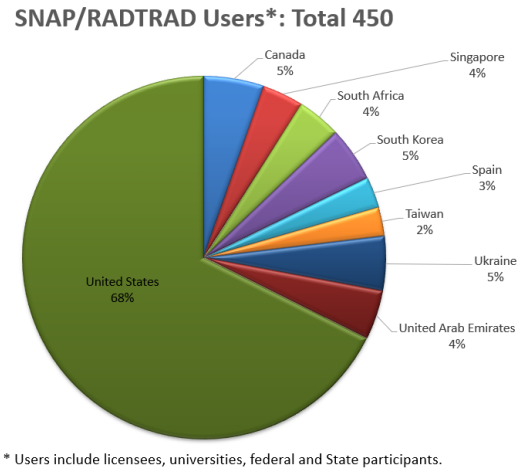
Collaboration and Resource Leveraging

- Through RAMP, RES provides RASCAL to about 212 international users (20 countries) and 603 domestic users (as shown below).



* Users include licensees, universities, federal and State participants.

- Through RAMP, RES provides SNAP/RADTRAD to about 144 international users (8 countries) and 306 domestic code users (as shown below).



- Leverage assets of the DOE developed for the Federal Radiological Monitoring and Assessment Center (FRMAC) computer code (Turbo FRMAC) into RAMP. The Turbo FRMAC code is a tool used in conjunction with the Nuclear/Radiological Incident Annex (NRIA) to the National Response Framework (NRF) during the intermediate and late phase of a radiological event at an NPP facility.
- Leverage (add) New Reactor Business Line funding related to code development and maintenance for atmospheric codes (ARCON and PAVAN), siting and effluent codes (GALE and NRCDose (XOQDOQ, LADTAP & GASPAR)), and the control room habitability (HABIT) code into this Operating Reactor Business Line EPID.

Radiation Protection Code Development and Maintenance
Fiscal Year 2021 Program Overview

Overview

- This EPID includes computer code development and maintenance for the radiation protection assessment computer codes (i.e., VARSKIN, Phantom with Moving Arms and Legs [PIMAL], and Radiological Toolbox [RadToolbox]). These codes are used to evaluate radiation safety and protection of workers and members of the public from releases during normal and accident conditions and are within the NRC's Radiological Protection Code Analysis and Maintenance Program (RAMP).

Strategic Focus Areas

- Support regulatory decision making with respect to dose assessment, emergency response, decommissioning, and environmental assessments.
- Develop and maintain staff core capabilities in health physics and radiation protection topics of regulatory importance.
- Rebuild advanced dosimetry technical expertise.
- Continued focus on customer support improving ease of use and address bugs identified by staff or RAMP members.

Impact and Benefits

- RAMP, initiated by SECY-14-0117, is a growing program intended to leverage resources for the development and maintenance of a set of radiation protection related codes (e.g., radiological, dose assessment, emergency response, decommissioning, and environmental codes) such that they don't become technically and functionally obsolete.
- The VARSKIN computer code is used by inspection staff and NRC licensees to calculate skin dose and to perform confirmatory calculations of licensees' submittals regarding skin dose estimates at any skin depth or skin volume with point, disk, cylindrical, spherical, or slab sources and even enables users to compute doses from multiple sources.
- The PIMAL computer program is a graphical user interface (GUI) with pre-processor and post-processor capabilities to aid NRC staff and licensees in developing realistic worker doses for Monte Carlo N-Particle (MCNP) input decks and code execution. Users can generate realistic dose limits based upon actual scenario-based geometries (worker positioning) to calculate dose more accurately as compared to a box standing straight in a direct path to a source.
- The RadToolbox computer code provides ready access to data of interest in radiation safety and protection of workers and members of the public. The data include radioactive decay data, dose coefficients, bio kinetic data, and other tabular date of interest to radiation protection personnel.

Drivers

- The purpose, functions, and responsibilities of the RAMP cooperative research and code-sharing program are delineated in SECY-14-0117, "The Radiation Protection Computer Code Analysis and Maintenance Program."
- The VARSKIN computer code is used to calculate dose to the skin resulting from exposure to radiation emitted from hot particles as required by 10 CFR Part 20.1201(c).
- Research Assistance Request (RAR) NMSS-2021-001, "Dosimetry Analysis, Computations, and Support for RAMP Tools for Material Licensing and Inspection," (ML21039A665) provides dosimetry analysis support including but not limited to providing MCNP, VARSKIN,

and PIMAL calculations. Provide maintenance, support, and development for the PIMAL, VARSKIN and the Integrated Modules for Bioassay Analysis (IMBA) computer codes.

- RAR NRR-2021-011, "VARSKIN Computer Code Development," (ML21082A303) provides the maintenance, development, distribution, and technical support for the VARSKIN through RAMP. Additionally, this RAR supports the development and integration the NCRP Report No. 156 and the ISO 20031:2020 biokinetic wound dosimetry calculation model for beta and gamma radiation into the VARSKIN computer code.

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
RAMP Web site development and technical Support	Started the update to latest version of website software (Drupal-9)	Complete the update to Drupal-9, add IMBA and DCFPAK codes to RAMP, and update RAMP website pages.	Maintain and update RAMP Web site pages	Maintain and update RAMP Web site pages
VARSKIN Code	Developed new dosimetry models (i.e., wound, eye alpha and neutron) for VARSKIN	Release VARSKIN Plus (v7.0 +) which contains new dosimetry models (including NCRP wound model)	Code maintenance and support (as needed)	Code maintenance and support (as needed)
PiMAL Code	Update code to fix Java errors and compatibility with the Windows 10 OS	Explore updates to include animal phantoms for veterinary support (BL-34)	Code maintenance and support (as needed)	Code maintenance and support (as needed)
RadToolbox	Code maintenance and support (as needed)	Possible code consolidation with VARSKIN and DCFPAK	Code maintenance and support (as needed)	Code maintenance and support (as needed)

Acronym: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	$K	FTE	$K	FTE	$K	FTE	Research Planning
Operating Reactors	Risk Analysis	$174	1.1	$85	2.0	$85	2.0	→

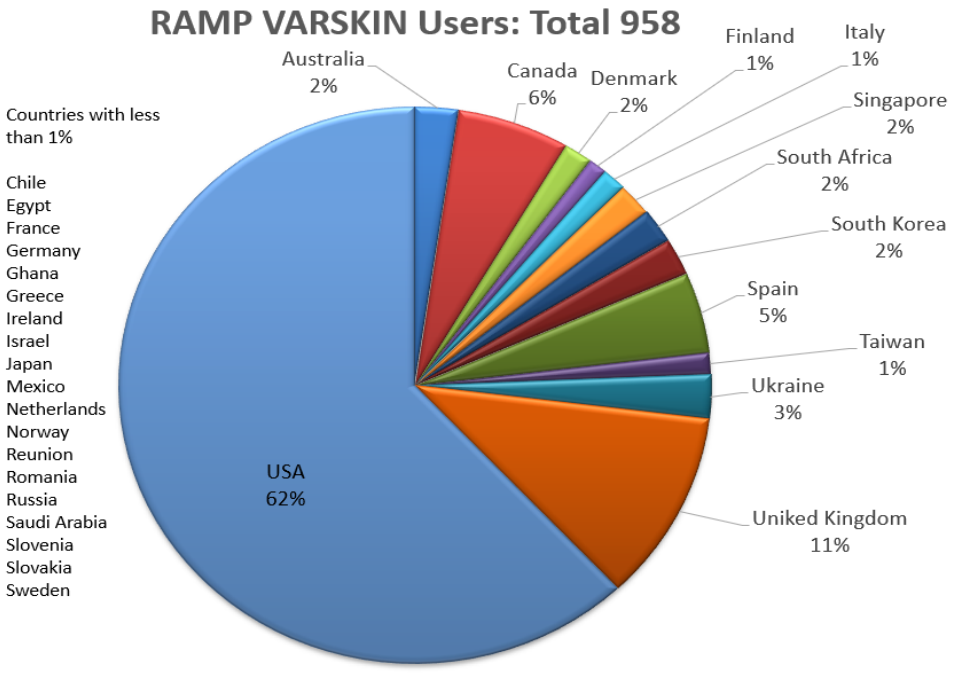
$K includes contract support (total resource amount includes contract support and FTE costs)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Pacific Northwest National Laboratory – RAMP Support.
- Renaissance Code Development - VARSKIN Technical Support and Code Development.
- Oak Ridge National Laboratory (ORNL) – PiMAL.
- ORNL – Radiological Toolbox.
- ORNL – Advanced Radiation Dosimetry Technical Support.

Collaboration and Resource Leveraging

- Through RAMP, RES provides VARSKIN to about 364 international users (31 countries) and 594 domestic users (as shown below).
- Leverage resources to incorporate the DCFPAK into RAMP.



* Users include licensees, universities, federal and State participants.

Decommissioning Code Development and Maintenance
Fiscal Year 2021 Program Overview

Overview

- This EPID includes resources to maintain the following computer codes: 1) the Decommissioning and Decontamination (DandD) code, 2) the Visual Sampling Plan (VSP) code, 3) the MILDOS code, and 4) the Residual Radioactivity (RESRAD) code. These codes are commonly used in support of regulatory reviews and to improve staff effectiveness when performing confirmatory analyses in support of regulatory decision-making.

Strategic Focus Areas

- Support regulatory decision-making with respect to decommissioning and environmental assessments.
- Develop and maintain staff core capabilities in health physics and radiation protection topics of regulatory importance.
- Continued focus on customer support improving ease of use and address bugs identified by staff or Radiological Protection Code Analysis and Maintenance Program (RAMP) members.

Impact and Benefits

- RAMP, initiated by SECY-14-0117, is a growing program intended to leverage resources for the development and maintenance of a set of radiation protection related codes (e.g., radiological, dose assessment, emergency response, decommissioning, and environmental codes) such that they don't become technically and functionally obsolete.
- The DandD computer code is analytical tool used by the staff and NRC licensees to model soil containment to calculate radionuclide concentrations in soil for plants.
- The VSP computer code is an analytical tool used by the staff and NRC licensees to calculate coupled site, building, and sample location visualization capabilities with optimal sampling design and statistical analysis strategies.
- The MILDOS computer code is an analytical tool used by the staff and NRC licensees to estimate the radiological impact from airborne emission from uranium milling and mining facility.
- The RESRAD computer code is a suite of tools used by the staff and NRC licensees for environmental radiological dose assessment.

Drivers

- The purpose, functions, and responsibilities of the RAMP cooperative research and code-sharing program are delineated in SECY-14-0117, (ML14204A795) "The Radiation Protection Computer Code Analysis and Maintenance Program."
- User Need Request (UNR) NMSS-2021-003, "Decommissioning and Uranium Recovery Computer Code (RESRAD, VSP, DandD & MILDOS) Maintenance," (ML21083A118) provides for the support, maintenance and distribution of the decommissioning (i.e., RESRAD, VSP & DandD) and uranium recovery (MILDOS) dose assessment computer codes.
- Research Assistance Request (RAR) NMSS-2021-002, "VSP Code Improvements (GPS/GIS and Scoping Subsurface)," (ML21076A237) provides for modifications to the VSP code to facilitate radiological survey design, data importation, data analysis, and data visualization for complex reactor and materials decommissioning sites involving scan (e.g., scan surveys using autonomous vehicles and subsurface surveys).

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
Decommissioning and Uranium Recovery Computer Code (NMSS-2021-003)	Released new code versions and provided training and technical support	Ongoing code support, maintenance, and distribution of the decommissioning (i.e., RESRAD, VSP & DandD) and uranium recovery (MILDOS) dose assessment computer codes.		
VSP Code Improvements (NMSS-2021-002)	Released new code versions and provided training and technical support	Ongoing code support and modifications to the VSP code to facilitate radiological survey design, data importation, data analysis, and data visualization for complex reactor and materials decommissioning sites involving scan (e.g., scan surveys using autonomous vehicles and subsurface surveys).		

Acronym: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	$K	FTE	$K	FTE	$K	FTE	Research Planning
Decommissioning and LLW	Waste Research	$189	0.5	$300	0.5	$300	0.5	→

$K includes contract support (total resource amount includes contract support and FTE costs)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Pacific Northwest National Laboratory – DandD, VSP & RAMP Support.
- Argonne National Laboratory – RESRAD & MILDOS.

Collaboration and Resource Leveraging

- Through RAMP, RES provides a majority of these codes to about 364 international users (31 countries) and 594 domestic users.

Radiation Protection Analysis
Fiscal Year 2021 Program Overview

Overview

- This EPID includes the evaluation of radiation protection and event data, development of dosimetry tools, and the monitoring of ongoing radiation health effects research to ensure the NRC's system of radiation protection is adequately protecting public health and safety.

Strategic Focus Areas

- Develop, use, and maintain the epidemiological, radiation shielding, and radiation dosimetry skillsets to support regulatory activities.
- Monitor and support national and international radiation health effects research, especially low-dose research, to ensure the NRC's current system of radiation protection is still adequate and not overly burdensome.
- Increase Radiation Exposure Information and Records System (REIRS) database access efficiency through concept modernization (e.g., posting verified summary dose data online for public access before the NUREG is published, eventually moving the entire NUREG to an electronic format with supporting text).

Impact and Benefits

- Inform external stakeholders including Congress and the public of events that results in public health and safety and security concerns (i.e., Abnormal Occurrence [AO] Report) and radiation exposures to the workforce at certain NRC-licensed facilities [e.g., REIRS]).
- Analyses performed support safety studies, updates to regulatory guidance, petitions for rulemaking, and new health physics or radiation protection questions that arise (e.g., low dose radiation, external and internal dosimetry coefficients).

Drivers

- Section 208 of the Energy Reorganization Act of 1974, as amended (Public Law 93 438), requires that the NRC report abnormal occurrences to Congress.
- REIRS is based upon the statutory and regulatory reporting requirement of annual personnel exposure to ionizing radiation in 10 CFR Part 20.2206(b) by NRC-licensees.
- Petitions for rulemaking per 10 CFR 2.802 that require expertise and technical support for various subjects related to radiation dosimetry and health effects.

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
NUREG-0713, "Annual Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities"	Published Volume 40 "2018: Fiftieth-First Annual Report"	Publish Volume 41: "2019: Fifty-Second Annual Report" to include the Evidence Act Evaluation of the Radiation Protection Program (SRM-SECY-20-0067)	Publish Volume 42: "2020: Fifty-Third Annual Report	Publish Volume 43: "2021: Fifty-Fourth Annual Report

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
NUREG-0090, "Annual Report to Congress on Abnormal Occurrences" (FY20 – FY23)"	Published Volume 42: "Fiscal Year 2019"	Publish Volume 43:"Fiscal Year 2020"	Publish Volume 44: "Fiscal Year 2021"	Publish Volume 45:"Fiscal Year 2022"
Regulatory Guide Support	Reviewed and commented on RGs 8.24 and 1.21; issued RGs 8.39, Revision 1	Complete draft guides (DGs) for RGs 8.28, 8.29 and 8.36	Support NRR efforts to update RGs 1.109, 1.111, 1.145, and 1.194	Complete DG for RGs 1.109, 1.111, 1.145, and 1.194
Ad Hoc support to NRR staff reviews of NPP licensing amendment	Provide assistance as requested			

Acronym: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

- John Tomon (John.Tomon@nrc.gov), Branch Chief in the Division of Systems Analysis

Resources

		FY20 Actuals		FY21 President's Budget		FY22 President's Budget		Research Planning
Business Line	Product	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	Risk Analysis	$119	1.7	$240	1.5	$240	1.5	→
Nuclear Materials Users	Materials Research	$500	1.1	$0	2.0	$0	2.0	→
Decommissioning and LLW	Waste Research		0.2					→
Total		$619	3.0	$240	3.5	$240	3.5	→

$K includes contract support (total resource amount includes contract support and FTE costs)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Oak Ridge Associated University (ORAU) – Radiation Exposure Information and Records System (REIRS) and the NRC Employee Database System (EEDS).
- Information System on Occupational Exposure (ISOE) - North American Technical Center (NATC) – Membership. ISOE/NATC is sponsored by the Organization for Economic Co-operation and Development/Nuclear Energy Agency (OECD/NEA) and International Atomic Energy Agency (IAEA).

Collaboration and Resource Leveraging

- Monitor, review, and provide feedback/comments on the low dose research being performed by the Department of Energy (DOE) - Nuclear Energy Advisory Committee, IAEA, National

Council on Radiation Protection and Measurements (NCRP), American National Standards Institute (ANSI) and ISOE.

- OECD/NEA – ISOE.
- Explore options to provide contractual support for the ICRP for FY21 – FY 23, to create an opportunity for the staff to discuss technical details with the originators of the latest radiation protection recommendations and demonstrate to the international community that the United States is their partner in radiation protection.

Consequence Analysis (Subsurface Characterization and Waste Covers)
Fiscal Year 2021 Program Overview

Overview

- The primary focus of RES/DRA's work for NMSS under the Consequence Analysis area is to develop the technical bases, guidance, and models for subsurface characterization and Final Status Surveys for decommissioning sites, and the long-term performance of earthen covers of Uranium Mill Tailings Radiation Control Act (UMTRCA) and Waste Incidental to Reprocessing (WIR sites), including evapotranspiration covers (ET) and geomembranes.

Strategic Focus Areas

This program area includes tasks to develop:

- Guidance and tools for characterization and Final Status Surveys for sub-surface radioactive residual material.
- Technical basis for design and draft guidance for ET Covers.
- Guidance for evaluation of geomembranes.
- Models to estimate UMTRCA cover end-state performance for risk assessment.
- A method for characterizing (lead (Pb)-210 method) the long-term radon transport in covers in collaboration with the Department of Energy's Office of Legacy Management (DOE/LM).

Impact and Benefits

- This research will expand guidance and computational tools for characterization and Final Status Surveys of subsurface residual radioactive material deeper within the subsurface than covered by existing guidance and methods.
- It will provide guidance and the associated technical bases for evaluating and identifying risks for ET covers and the long-term performance of covers including synthetic geomembranes, intruder protection, and methods to monitor the long-term performance of radon barriers.
- It will provide a probabilistic performance assessment model of UMTRCA cover end-states to evaluate the ability of age-degraded covers to meet the regulatory criteria for potential releases to air or ground water. This will provide staff with a tool to evaluate licensee's plans for new and rebuilt earthen covers over uranium mill wastes.

Drivers

- These projects are coordinated with NMSS through User Need NMSS- 2020-003 (ML20100F251). The regulatory driver for the subsurface characterization task is decommissioning as regulated by 10 CFR 20 Subpart E, Radiological Criteria for License Termination, also Parts 50.75, 50.82, 51.53, and 51.95.
- Regulatory drivers for covers are to ensure appropriate long-term performance of radioactive waste covers for uranium mill tailings as required under the Uranium Mill Tailings Radiation Control Act (UMTRCA) and the regulations under 10 CFR Part 40 Appendix A. Regulatory drivers also include covers' performance under 10 CFR Part 61 Subpart C for Low-Level Radioactive Waste (LLW) and WIR**.**

Key Deliverables

Year / Project Driver (Start - Stop)	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
Technical basis for sub-surface residual radioactivity characterization	Established contract with SC&A	Continue work on technical basis report, Stakeholder Workshop	Complete technical basis report/ start to develop guidance	Draft Guidance End FY 23
Technical basis for guidance for ET covers	Established contract with USGS	Continue work on technical basis report	NUREG/CR	
Pb-210 methodology collaboration with DOE/LM	Established contract with Eberline, samples from Grand Junction analyzed	Continue sample evaluation and method refinement	RIL on Pb-210 method for Rn transport	

Office of Nuclear Regulatory Research Contact

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Resources

		FY20 Actuals		FY21 President's Budget		FY22 President's Budget		Research Planning
Business Line	Product	$K	FTE	$K	FTE	$K	FTE	Trend
Decommissioning and LLW	Waste Research	$260	0.95	$310	0.5	$310	0.5	↗
Total		$260	0.95	$310	0.5	$310	0.5	↗

Resources increase in FY23 to support user need (NMSS 2020-003)
$K includes contract support (total resource amount includes contract support and FTE costs)
Acronyms: Fiscal year (FY), full-time equivalent (FTE), Low-Level Waste (LLW)

Contractor Support

- SC&A – Develop guidance for remediation of subsurface contamination.
- USGS – Assist documentation of guidance on long-term behavior of ET covers for UMTCA, Part 61 and WIR Covers.
- Eberline Laboratory – Pb-210 analysis.

Collaboration and Resource Leveraging

- Interagency agreement with the Environmental Protection Agency to Support Federal Remediation Technologies Roundtable.
- Interagency agreement with U.S. Geological Survey on Technology Transfer Seminars.
- Collaboration with DOE/LM on use of Pb-210 Method to characterize long-term Rn transport.
- NRC Crowd-source Challenge to gather ideas for Sub-Surface Guidance from staff in NMSS and Regions.

Engineering Research Activities

Cable and Equipment Aging
Fiscal Year 2021 Program Overview

Overview

- This program area includes research on the aging-related degradation of electrical and power cables, including determinations of anticipated service life and methods to monitor the condition of cables.

Strategic Focus Areas

- Collaborate with industry efforts and the U.S. Department of Energy (DOE) Light Water Reactor Sustainability (LWRS) Program for assessing cable performance, including joint efforts on loss-of-coolant accident (LOCA) tests.
- Assess the power cable performance for long-term operations in light of the failure data from operating experience and collected industry data.
- Enhance information exchanges and foster additional collaborative research activities with industry and DOE.
- Keep abreast of advances in state-of-the art capabilities for cables condition-monitoring techniques and equipment qualification.

Impact and Benefits

- Enhance NRC acceptance criteria for assessment and aging management of cables to support long--term operations.
- Facilitate the review of industry guidance for managing the aging of cables in submerged environments.
- Confirm the adequacy of the most commonly used condition-monitoring techniques to track the aging of cables.
- Shorten the timeline for licensing decisions, including for subsequent license renewal application reviews.
- Endorse consensus codes and standards related to electrical cable qualification and condition monitoring.

Drivers

- Response to Commission direction to evaluate the aging of cables and cable systems during long--term operations.
- Requests from the Office of Nuclear Reactor Regulation (NRR) for assistance in enhancing regulatory guidance for electrical cable condition monitoring.
- Requests from NRR to update Regulatory Guides on cable condition monitoring, environmental qualification of electrical equipment, and qualification of safety-related cables.

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
UNR NRR 2011-014 (60 years) Assessment of Electrical Cable's Condition-Monitoring Methods (FY13 – FY22) and UNR NRR 2016-012 (Extends NRR 2011-014 to 80 years) - Assessment of Condition-Monitoring Techniques for Electrical Cables	Cables completed thermal and radiation aging at Sandia National Laboratories (SNL) followed by testing at the National Institute of Standards & Technology (NIST)	Cables complete testing at NIST followed by LOCA Testing by a to be awarded	Continue with LOCA Testing of Cables and evaluation of results	Complete LOCA Testing of Cables, evaluation of results and complete

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
		commercial contractor		overall project report
UNR NRR 2011-014 (60 years) Assessment of Electrical Cables Condition-Monitoring Methods (FY13 – FY22) - Assessment of the Electric Power Research Institute (EPRI's) Tan Delta Approach to Manage Cables in Submerged Environments	Pacific Northwest National Laboratory (PNNL) issued final statistical analysis report on the data collected by EPRI from nuclear power plants	Complete overall project report		
Assessment and guidance development associated with Cable and Equipment Aging Project's results in collaboration with internal and external stakeholders,		Ongoing staff support		

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Engineering Research	$266	2.1	$1295	2.0	$735	2.0	↘
Total		$266	2.1	$1295	2.0	$735	2.0	↘

Total Resources = CS&T (includes contract support) + FTE (staffing at approxiately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- NIST – Assessment of Condition-Monitoring Methods for Electrical Cables.
- PNNL – Assessment of EPRI's Tan Delta Approach to Manage Cables in Submerged Environments.
- Commercial Contractor – Conduct LOCA Test on Aged Cables and complete overall project report.

Collaboration and Resource Leveraging

- Memorandum of Understanding (MOU) between the NRC and EPRI on Aging, Qualification, and Condition Monitoring of Electrical Cables.
- LWRS Program where EPRI, DOE, and NRC meet face-to-face twice a year to share and discuss ongoing research activities at each institution.
- Information Exchange Meetings with the Japanese Nuclear Regulation Authority (JNRA) where the NRC and the JNRA discuss and exchange information on ongoing research projects related to cable aging.

Electrical System Evaluation
Fiscal Year 2021 Program Overview

Overview

- This program area includes research on the evaluation of design and operation of electrical power distribution systems at nuclear power plants including offsite and onsite power systems, protection, switchgear and DC systems.

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Strategic Focus Areas

- Develop additional collaborative research activities with industry and the U.S. Department of Energy (DOE) for critical components other than cables.
- Ensure effective representation of the NRC in harmonizing industry standards and development activities for the Institute of Electrical and Electronics Engineers, Inc. (IEEE) and the International Electrotechnical Commission (IEC).

Impact and Benefits

- Support the safety evaluation and updating of regulatory guidance concerning the use of IEEE and IEC consensus codes and standards.
- Address technical knowledge gaps related to the performance of electrical power system equipment.
- Contribute electrical engineering expertise to the assessment of emergent technical issues such as high-energy arc faults (HEAF).
- Support knowledge management in the areas of power systems operations, motor-operated valve controls, and generator islanding.

Drivers

- Requests from the Office of Nuclear Reactor Regulation (NRR) to update Regulatory Guides (RGs) addressing electrical power systems.
- Requests from NRR to represent the NRC on standards development activities for IEEE and IEC.

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
User Need Request (UNR) NRR-2018-002: UNR for developing new RG related to degraded (DV) voltage and loss of voltage protection	Draft RG prepared	Update draft RG on newly revised IEEE Standard 741	Issue RG and final report	
Anticipated UNR to develop a RG addressing IEEE Standard 946 and NUREG/CR 7229 (Battery/Charger Fault Calculations).		Develop draft RG	Issue final RG	
Support revision of RG 1.89 to new IEC/IEEE Standard	Draft RG developed	Issue final RG		
Revision of RG 1.9 addressing new revision to IEEE 387 - emergency diesel generators (EDGs) and IEEE 2420 – combustion turbine generators (CTGs)		Develop draft and issue final RG	On-going staff support	
HEAF testing electrical engineering input and review	Staff support completed	On-going staff support		

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
Environmental Qualification (EQ) Inspection, Training, and Issue technical consulting and instruction	Staff support completed	On-going staff support		
IEEE Standards support	Staff support completed	On-going staff support		

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

		FY20 Actuals		FY21 President's Budget		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Engineering Research	$0	1.0	$0	4.0	$0	3.0	→
Total		$0	1.0	$0	4.0	$0	3.0	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- None.

Collaboration and Resource Leveraging:

- Institute of Electrical and Electronics Engineers (IEEE)
- International Electrotechnical Commission (IEC)
- Memorandum of Understanding (MOU) between the NRC and the Electric Power Research Institute for cooperative research concerning electrical system evaluation.

Safety of I&C
Fiscal Year 2021 Program Overview

Overview

- This program area includes research concerning the safety of instrumentation and controls (I&C) in NRC-licensed facilities. It includes both efforts related to I&C (in general) and efforts related to applications of digital technology in I&C.

Strategic Focus Areas

- Increase the use of risk insights to inform the assessment of I&C technologies.
- Establish lessons learned from use of digital I&C in other technical sectors.
- Enhance information exchanges and foster additional collaborative research activities with the Electric Power Research Institute (EPRI), the U.S. Department of Energy (DOE), and international partners via Memoranda of Understanding (MOUs) and international agreements.
- Keep abreast of advances in state-of-the art capabilities for I&C technologies.
- Continue participatory and leadership roles in standards development activities.

Impact and Benefits

- Enable upgrades in operating plants, confirm the safety of industry proposals for the broader adoption of digital I&C in operating plants.
- Streamline licensing guidance and clarify acceptance criteria (ISG [Interim Staff Guidance]-06).
- Develop and resolve issues for licensing, common-cause failure (CCF), Reactor Oversight Process (ROP), online monitoring, etc.
- Participate in standards development activities to facilitate the broader endorsement of consensus codes and standards in regulations and regulatory guidance.
- Support domestic and international collaborative agreements to leverage resources and enhance staff knowledge.

Drivers

- Response to Commission direction in SRM-SECY-15-0106 and SECY-16-0070 to develop a plan to Modernize Digital Instrumentation and Controls Regulatory Infrastructure.
- Requests from the Office of Nuclear Reactor Regulation (NRR) for research on specific topics to support the implementation of the IAP.
- Requests from NRR to regularly review and update Regulatory Guides pertaining to I&C in consideration of development of associated industry standards and of accumulated experience.

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
User Need Request (UNR) NRR-2018-001: Investigate the implications of the use of embedded digital devices and evolving technologies	Completion of Contractor Report	Publication of NUREG/CR-7273	Technical Letter Report (TLR)	

Project \ Year	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
UNR NRR-2018-003: Investigate the implications of, and ways to mitigate, common -cause failures (CCF) in applications of digital technology		Deliver Task 1 and 2 contractor reports. Task 3 – Recommendation Memorandum	Task 3: TLR Ongoing staff support for CCF	Ongoing staff support for CCF
UNR NRR-2018-004: Investigate opportunities for the use of risk insights in the licensing of applications of digital technology	Completion of Task 1, TLR; NRR requested closure of UNR	Closed UNR based on current program office needs		
Research Assistance Requests (RAR): RAR-2020-006: Assessing Op Ex for DI&C RAR-2020-008: Hazard Analysis for DI&C RAR-2020-016: Update RG 1.168 RAR-2020-017: Training on EPRI DEG RAR-2021-012: Guidance for DI&C Hazard Analyses RAR-2021-014: Safety of Wireless at NPPs	Complete several TLRs, support updates to Regulatory Guide 1.168, develop training, and provide support for DI&C-related document reviews.			
Review of industry standards and participation in standards development. Also support EPRI MOU and international research activities.	Staff support completed	Ongoing staff support	Ongoing staff support	Ongoing staff support

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

		FY20 Actuals		FY21 President's Budget		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Engineering Research	$513	6.9	$750	8.8	$755	7.5	→
Total		$513	6.9	$750	8.8	$755	7.5	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Oak Ridge National Laboratories (ORNL) – Investigate Embedded Digital Devices, Safety of Wireless.
- Idaho National Laboratory (INL) – Investigate CCF.
- Electric Power Research Institute (EPRI) – Digital Engineering Guide (DEG)

Collaboration and Resource Leveraging

- MOU between the NRC and EPRI for cooperative research concerning applications of digital technology in I&C.
- Collaboration with Halden (IFE) on applications of digital technology in I&C.

Security of I&C
Fiscal Year 2021 Program Overview

Overview

- This program area primarily encompasses research on the cybersecurity of instrumentation and control (I&C) systems in NRC-licensed facilities [i.e., Nuclear Power Plants (NPPs)].

Strategic Focus Areas

- Establish core capabilities and technical expertise in cybersecurity to support emerging needs.
- Increase the use of risk insights to inform cybersecurity assessments.
- Enhance information exchanges and foster additional collaborative research activities with the Electric Power Research Institute (EPRI), the U.S. Department of Energy (DOE), and international partners via Memoranda of Understanding and international agreements.
- Keep abreast of advances in state-of-the art for cybersecurity evaluations.
- Continue participatory and leadership roles in standards development activities.

Impact and Benefits

- Enhance awareness of the threat environment for cybersecurity of I&C systems.
- Enhance staff guidance for addressing cybersecurity issues for licensing or inspection activities.
- Confirm nuclear power plant resilience against geomagnetic or EMP disturbances.
- Expand the use of risk information to inform cybersecurity evaluations.

Drivers

- Requests from the Office of Nuclear Security and Incident Response (NSIR) for research concerning specific topics related to the support of the cybersecurity program and the evaluation of I&C measures to improve security, including cybersecurity approaches.

Key Deliverables

Project \ Year	FY2020 Accomplishments	FY 2021	FY 2022	FY 2023
Research Assistance Request (RAR)-2020-001: Cyber Security Expert Seminars .	Expert seminars to provide NRC staff with a broad technical overview on a number of topics to support regulatory oversight for security of digital systems.			
RAR-2021-001: Research on Security Implementation of Wireless Communication Technologies at NPPs			Draft report on research findings	Produce final composite report
RAR-2021-003: Attack Surface Measurement: a quantitative measurement of the vulnerability of a cybersecurity attack surface.			Draft report on research findings	Product final composite report
RAR-2021-005: Feasibility of Licensee Network Replica for Cyber Security Training			Draft report on research findings	Product final composite report
New RAR(s): Research on cybersecurity posture quantification methods and Field Programmable Gate Array (FPGA)-based applications related to industrial control and safety systems in use at NPPs				Draft report on research findings

Project \ Year	FY2020 Accomplishments	FY 2021	FY 2022	FY 2023
Review of industry standards, participation in standards development, and assist with guidance to support cybersecurity inspections and licensing reviews	Staff support completed.	Ongoing staff support		

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Engineering Research	$0	0.1	$210	0.5	$630	2.0	↘
Total		$0	0.1	$210	0.5	$630	2.0	↘

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Sandia National Laboratory
- Idaho National Laboratory

Collaboration and Resource Leveraging

- MOU between the NRC and EPRI for cooperative research concerning applications of digital technology in I&C, which covers cybersecurity.

Seismic Analysis and Evaluation
Fiscal Year 2021 Program Overview

Overview

- This program area includes research to support seismic hazard analyses for operating and new reactor applications.

Strategic Focus Areas

- Keep abreast of advances in technical knowledge and new methodologies developed by the technical community to modernize and risk-inform the NRC's seismic regulatory activities.
- Enhance information exchanges and foster collaborative activities with other government agencies to achieve efficiency in the NRC's regulatory research activities.
- Enhance fidelity and capability of tools used for seismic assessments.
- Continue participatory and leadership roles in international activities through the International Atomic Energy Agency and the Nuclear Energy Agency.

Impact and Benefits

- Clarify and simplify the NRC's acceptance criteria for seismic hazard analyses of operational and new reactors, increase the efficiency of NRC licensing reviews and decisions.
- Reduce uncertainties and enhance the use of risk information in determining seismic hazard estimates.
- Support situational awareness and incident response for seismic events that affect licensed facilities.
- Support the Process of Ongoing Assessment of Natural Hazard Information (POAHNI) activities.

Drivers

- Closeout of key research items identified in the Seismic, Geotechnical, and Structural Engineering Research Plan 2017-2021 (SGSERP).
- User Need Requests (UNRs) to maintain capability for seismic event analysis to support safe operation of existing reactors and new reactor licensing applications.
- The POANHI process research engagements with external groups.

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
UNR NRO-2015-006 - Research to develop the technical bases to support revision to Regulatory Guide (RG) 1.208	Completed technical reports on updated data and models to support Probabilistic Seismic Hazards Assessments	Complete Technical Letter Report on seismic hazard and ground motion models	Develop draft of RG 1.208	Issue Final RG 1.208 Revision
UNR NRO-2015-008 - Research to develop the technical bases to support revisions to RG 1.198 and the Standard Review Plan (SRP)	Completed Phase I and initiated Phase II research activities in probabilistic liquefaction model development	Complete research activities and collaboration with external experts on probabilistic liquefaction model development	Develop draft RG 1.198	Issue Final RG 1.198 revision, and if needed, updates to SRP

SGSERP - Seismic source characterization, ground motion models, and seismic hazard calculations	Continue joint research efforts with the USGS on seismic hazards and seismic source characterization in the central and eastern United States	Continuation of joint research efforts with the USGS on seismic hazards and seismic source characterization in the central and eastern United States	Develop Technical Letter Reports on updated seismic and ground motion models	Update RGs and SRP, as appropriate

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

		FY20 Actuals		FY21 President's Budget		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Engineering Research	$1302	1.9	$200	1.9	$600	1.9	→
New Reactors	New Reactors Research	$576	3.1	$595	3.1	$595	3.1	→
Total		$1878	5.0	$795	5.0	$1195	5.0	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- U.S. Geological Survey (USGS) – Research to support NRC's seismic hazard analyses.
- Southwest Research Institute (SwRI) – Technical assistance for geologic and seismic evaluations and guidance.
- SwRI – Liquefaction model development.

Collaboration and Resource Leveraging

- Leveraging resources of the USGS to jointly conduct research on seismic hazard issues of mutual interest.
- U.S. Bureau of Reclamation (USBR) resources are to be leveraged in the SwRI liquefaction model development contract as liquefaction model development is also a priority item for USBR.

Structural and Geotechnical Evaluations
Fiscal Year 2021 Program Overview

Overview

- This program area includes research to support nuclear power plant structural integrity, potential degradation mechanisms, and design and construction issues.

Strategic Focus Areas

- Maintain awareness of operating experiences to identify emergent degradation issues and/or performance trends that could affect plant safety.
- Increase the use of risk-informed decision-making in seismic and structural safety assessments.
- Enhance information exchanges and foster collaborative research activities with industry and the U.S. Department of Energy (DOE) via the respective Memoranda of Understanding (MOUs).
- Keep abreast of advances in state-of-the art capabilities for structural modeling and simulation using modern and efficient computational tools.
- Continue participatory and leadership roles in international cooperative activities through the International Atomic Energy Agency and the Nuclear Energy Agency.

Impact and Benefits

- Clarify and simplify the NRC's acceptance criteria for assessment and aging management of safety--related structures to support long-term operations.
- Shorten timeline for licensing decisions including subsequent license renewal application reviews.
- Improved understanding of risk significance of structural issues to focus attention on those most important to safety.
- Reduce uncertainties in determining structural safety margins.
- Endorse consensus codes and standards for structural design, analysis, and inspection.

Drivers

- Evaluate and assess the structural integrity of existing nuclear power plants to support long-term operations.
- User Need Requests (UNRs) for assistance in enhancing regulatory guidance for performing structural integrity calculations, analyzing structural degradation, and conducting periodic inspections or surveillances.
- Closeout of activities identified in the Seismic, Geotechnical, and Structural Engineering Research Plan 2017-2021 (SGSERP).

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
UNR NRR-2012-004 – Alkali-Silica Reaction (ASR) Research	Completed the ASR concrete degradation project. Obtained extensive data on ASR expansion.	Complete knowledge management documents, Technical Letter Reports	Complete Regulatory Guidance updates on how to deal with ASR affected concrete structures for future activities	
UNR NRR-2015-007 –	Issued draft NUREG/CR.	Complete interim technical documents on	Conduct accelerated testing and	Issue Technical

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
Research on the Effects of Irradiation on Concrete Structures		irradiation- induced concrete degradation; start concrete degradation research based on harvested material from a decommissioned nuclear power plant.	modeling/simulation of concrete degradation and safety implications. Analyze harvested materials and conduct research to confirm models and simulations.	Letter Reports and, as needed, updates to NUREG-1801
SGSERP – Aging and Degradation of Post-tensioned Concrete Containments	Reviewed creep and shrinkage of post-tensioned containment	Conduct VERCORS 1/3 scale containment testing and modeling.	Issue technical reports to document the research findings and make recommendations for enhancing the effectiveness of staff regulatory guidance on aging management of concrete structures	Develop updates to Regulatory Guide 1.35.1, NUREGs 1801/2191/2192.
SGSERP - Risk-Informed, Performance-Based (RIPB)	Completed Phase I of seismic RIPB research activities	Identify alternative regulatory pathways for RIPB seismic safety	Support establishing regulatory pathways for RIPB seismic safety	RG on RIPB approaches in seismic safety

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

		FY20 Actuals		FY21 President's Budget		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Engineering Research	$727	6.6	$1000	5.3	$1200	5.8	↘
New Reactors	New Reactors Research	$0	1.3	$0	0	$0	0	→
Advanced Reactors (FY23 funding proposed)	Advanced Non-LWR Regulatory Readiness	$0	0	$0	0	$200*	1*	→
Total		$727	7.9	$1000	5.3	$1400	6.8	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)
*FY22 Advanced Reactor resources are still being finalized.

Contractor Support

- National Institute of Standards and Technology (NIST) – ASR degradation in concrete.
- Argonne National Laboratory (ANL) – Radiation effects on concrete.
- Oak Ridge National Laboratory (ORNL) – Bond strength in irradiated concrete.

- Brookhaven National Laboratory (BNL) and Southwest Research Institute (SwRI) – Risk-informed seismic safety.
- ORNL – Fluence calculations in concrete.
- Sandia National Laboratories (SNL) – Aging and Degradation of post-tensioned concrete.

Collaboration and Resource Leveraging

- MOU Between the NRC and DOE on Cooperative Nuclear Safety Research Related to Long-Term Operations.
- MOU Between NRC and Electric Power Research Institute (EPRI) on Long Term Operations Beyond 60 Years.
- Committee on Safety of Nuclear Installations (CSNI) Assessment of Structures Subjected to Concrete Pathologies (ASCET).
- CSNI Observatoire de la durabilité des ouvrages en béton armé (ODOBA).
- MOU between the NRC and the Japanese Nuclear Regulation Authority (JNRA).

Methodology and Evaluation Tools for Digital Twin Applications
Fiscal Year 2021 Program Overview

Overview

- This program area includes research to support the identification and evaluation of technical issues and gaps that would impact regulatory outcome and the development of a regulatory infrastructure for use of digital twins as part of the regulatory programs.

Strategic Focus Areas

- Keep abreast of advances in technical knowledge and new methodologies for applications of reactor digital twins.
- Facilitate information exchanges and foster collaborative activities with other entities to obtain the latest information regarding the technique.
- Build capabilities in applications of artificial intelligence/machine-learning, data analytics, and advanced sensors and instrumentation.
- Evaluate the regulatory readiness levels and gaps of digital twin technologies.

Impact and Benefits

- Identify the technical challenges and assess gaps for the digital twins technique in cornerstones like data quality and analytics, machine learning/artificial intelligence algorithms, and multi-physics modeling.
- Enhance staff knowledge in applications and use of artificial intelligence/machine learning and multi--physics tools used in digital twins.
- Enhance staff knowledge and technical capabilities leading to better decision-making regarding confirmatory research.
- Develop a regulatory infrastructure for use of digital twins.

Drivers

- Future Focused Research.

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
001728 NB-OR-Future Focus Research	Interagency project team established working group and awarded the contract with Idaho National Laboratory	Complete TLR on the state of technology of applications of DTs Complete TLR documenting the state of art, technical challenges, and gaps for DT in using data analytics, ML/AI, and multi-physics models Complete TLR on documentation of regulatory readiness levels and gaps pertaining to DT Complete summary of technical and regulatory gaps pertaining to DT	Prepare and issue RIS (or other appropriate communication) to gauge industry interest Conduct workshops and complete report documenting workshop proceedings focus on technology advances, industry plans, and regulatory topics Complete TLR documenting the state-of-technology in communication	

		Conduct workshop and complete report documenting workshop proceedings focus on technology advances, industry plans, and regulatory topics	between physical system and digital twin.	
TBD			Complete TLR documenting the state-of-technology and technical challenges for online monitoring for enhanced diagnostics and prognostics Complete TLR documenting challenges and current state-of-practice in the representation of physical systems in digital platforms and associated standards	Complete TLR documenting the potential methodologies that address the technical and regulatory challenges for DT application Complete TLR describing the different elements and functions of a potential regulatory infrastructure required for use of DT as part of regulatory program Complete regulatory guidance framework document for use of DT as part of regulatory oversight program Conduct training programs on technology and regulatory use of digital twins

Acronyms: Fiscal year (FY), Digital Twin (DT), Artificial Intelligence AI), Machine Learning (ML)

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Resources

		FY20 Actuals		FY21 President's Budget		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors (FFR)	Engineering Research	$334.2	0	$797	0	$474	0	↘
Operating Reactors	Engineering Research	$0	0	$0	0	$0	0	↗
New Reactors	Engineering Research	$0	0	$0	0	$0	0	↗
Advanced Reactors	Advanced Non-LWR Regulatory Readiness	$0	0	$0	0	$0*	1*	→
Total		$334.2	0	$797	0	$474	1	→

CS&T ($K) includes contract support
Acronyms: Fiscal year (FY), full-time equivalent (FTE)
*FY22 Advanced Reactor resources are still being finalized.

Contractor Support

- Idaho National Laboratory (INL) – Technical Support for Assessment of Regulatory Viability of Digital Twins.

Collaboration and Resource Leveraging

N/A

Aging and Materials Research Activities

Advanced Manufacturing Technology (AMT) Action Plan – RES Support
Fiscal Year 2021 Program Overview

Overview

- This program area includes regulatory research tasks on the use of Advanced Manufacturing Technologies (AMTs) for safety-related applications in operating nuclear power plants and advanced reactors.

Strategic Focus Areas

- Support the Agency Action Plan for AMTs.
- Maintain awareness of developments in pertinent AMTs and of applications for the use of AMT -fabricated structures, systems, and components (SSCs).
- Ensure AMT knowledge base is adequately captured for regulatory use.
- Participate in codes and standards development in the area of AMTs.
- Perform gap analysis in the areas of modeling and simulation and non-destructive examination (NDE).
- Develop an interagency agreement (IAA) with the National Institute of Standards and Technology (NIST) to support development of data package requirements.

Impact and Benefits

- Assess the safety significant differences between AMTs and traditional manufacturing processes from a performance-based perspective.
- Identify and address AMT characteristics pertinent to safety that are not managed or addressed by codes, standards, regulations, etc.
- Inform regulatory decisions associated with installation of AMT components in NRC-licensed facilities.
- Establish guidance and tools for review consistency, communication, and knowledge management for AMT activities.
- Provide transparency to stakeholders on AMT activities.

Driver

- Revision 1 of the Agency Action Plan for Advanced Manufacturing Technologies (ML19333B980).

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
AMT Action Plan	External interaction plan developed; Knowledge Management Plan developed; RES seminars from ORNL and INL on AMT-related activities	Technical letter reports (TLR) on: • Additive Manufacturing (AM) – Laser Powder Bed Fusion • AM – Directed Energy Deposition • Cold Spray • Inspection and NDE for AMTs • Modeling and Simulation for AMTs Activities: • Internal seminars on AM and cold spray • Public workshop on AMTs	TLRs on: • Powder metallurgy – hot isostatic pressing • Electron beam welding • AMT components for advanced fuel assemblies Additional and follow-on tasks defined in future AMT Research Plans	Additional and follow-on tasks defined in future AMT Research Plans.

Acronyms: Fiscal year (FY)

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Resources

		FY20 Actuals		FY21 President's Budget		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Aging and Materials Research	$282	2.3	$250	1.5	$700	3.0	→
Total		$282	2.3	$250	1.5	$700	3.0	→

CS&T ($K) includes contract support
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Argonne National Laboratory (ANL) – Modeling and Simulation for AMTs.
- Pacific Northwest National Laboratory (PNNL) – NDE for AMTs and Cold Spray Assessment and Gap Analysis.
- Oak Ridge National Laboratories (ORNL) – AMT Assessments and Gap Analyses.
- NIST – AMT Technical Support and Training.
- Idaho National Lab – AMT components for advanced fuel assemblies.

Collaboration and Resource Leveraging

- Finalized Memorandum of Understanding Addendum with the Electric Power Research Institute (EPRI) for AMT Research in July 2019.

- Ongoing quarterly meetings with the EPRI and DOE, Office of Nuclear Energy on Advanced Methods for Manufacturing.
- Workshop on Advanced Manufacturing for Nuclear Applications in December 2020.
- Seminar series by NIST to address AMT issues in November/December 2020 and in March/April 2021.
- Two NRC staff rotations at ORNL.

Evaluation Techniques (NDE)
Fiscal Year 2021 Program Overview

Overview

- This program area supports research on nondestructive examination (NDE) of nuclear plant systems and components as well as the effects of human performance issues on NDE reliability.

Strategic Focus Areas

- Increase in-house capability for NDE modeling and simulation.
- Continue to identify areas for improvement in NDE performance via the research on human performance for NDE.
- Enhance information exchanges and foster additional collaborative research activities with the Electric Power Research Institute (EPRI) and international partners via Memoranda of Understanding (MOU) and international agreements.
- Keep abreast of advances in state-of-the art capabilities for NDE.
- Continue participatory and leadership roles in the American Society of Mechanical Engineers (ASME) Code activities.

Impact and Benefits

- Confirm the performance of new NDE technologies and methodologies proposed by industry for more effective in-service inspections (ISI).
- Provide support to the Office of Nuclear Reactor Regulation (NRR) and Regional Offices to efficiently disposition in-service inspection findings.
- Identify and develop a resolution path for key knowledge gaps related to NDE performance such as human factors.
- Participate in ASME Boiler and Pressure Vessel Code (ASME Code) activities to facilitate the endorsement of standards in regulations and regulatory guidance.
- Support domestic and international collaborative agreements to leverage resources and enhance staff knowledge.

Drivers

- Requests from NRR for assistance in evaluating the accuracy and reliability of NDE methods used by industry for the inspection of plant components including the efficacy of modeling, the implications of incomplete examination coverage, and human performance issues
- Emergent requests from NRR and Regional Offices to assist with the analysis of findings from ISI of plant components.
- Requests from NRR to represent the NRC on Committees of the ASME Code related to NDE and ISI.

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
User Need Request (UNR) NRR-2013-009, Evaluating the Reliability of NDE for Vessels and Piping, Task 5 – Cast Austenitic	Issued NUREG/CR-7263, NDE Reliability Issues for the Examination of CASS Components	Complete TLR on CASS round robin analysis with specimen data revealed (pending	Completion of Task 5	

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
Stainless Steel (CASS) Examination Wrap-Up		release of flaw true state by EPRI)		
UNR NRR-2020-002, Task 1 – Ultrasonic Modeling & Simulation	Issued PNNL-28362, Ultrasound Modeling and Simulation: Status Update	Complete TLR summarizing the results of NDE modeling round robin exercise Issue NUREG/CR documenting standard method to evaluate modeling results from commercially available software packages	Issue draft Regulatory Guide for public comment; DG will describe standard method for licensees to perform and present modeling data	Finalize RG
UNR NRR-2020-002, Task 2 – Effects of Missed Volumetric Coverage	Issued PNNL-30238, Evaluating Flaw Detectability under Limited-Coverage Conditions	Continue work on limited coverage	Issue NUREG/CR documenting the effects of limited coverage	Completion of Task 2
UNR NRR-2020-002 Task 9 – International Collaboration	Complete Analysis of Empirical Probability of Detection Data for Dissimilar Metal Welds Initiated PIONIC Program	Issue TLR summarizing results of POD analysis and PIONIC virtual round robin study	Issue a summary report documenting PIONIC activities.	
User Need Request to Explore the Effects of Human Performance Issues on NDE Reliability– Training and Practice	Issued PNNL-29761, NDE Training and Qualifications: Implications of Research on Human Learning and Memory, Instruction, and Expertise	Close UNR		
UNR NRR-2020-002 (FY20-FY24) Task 3 - Human Factors in Analysis of Encoded Data	Initiated work on human factors in analysis of encoded data	Issued PNNL-31245, Human Factors of Encoded Ultrasonic Examinations in Nuclear Power Plants	Issue NUREG summarizing findings, conclusions, and recommendations from Human Factors and Training and Practice studies	Completion of Task 3
NRR-2020-002 Task 8 - Eddy current inspections for partial penetration weld examinations	Complete PNNL-29113. Baseline Evaluation of Eddy Current Testing for PWSCC Susceptible Materials Continue work on eddy current inspections of partial penetration welds	Continue work on eddy current inspections of partial penetration welds	Issue TLR describing worldwide literature survey to ID existing COTS technology for volumetrically examining partial penetration welds	Completion of Task 8

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
UNR NRR-2020-002Task 7 – Advanced PAUT	Initiated work on assessing capabilities and limitations of Advanced PAUT	Continue work on assessing capabilities and limitations of Advanced PAUT	Issue TLR describing capabilities and limitations of Advanced PAUT	Completion of Task 7
UNR NRR-2020-002Task 7 - Automated Data Analysis (deliverable due in FY23 not shown)	Initiated assessment of capabilities of machine learning systems and automated data analysis	Continue assessment of capabilities of machine learning systems and automated data analysis	Continue assessment of capabilities of machine learning systems and automated data analysis	Issue TLR describing the current capabilities of machine learning systems and automated data analysis

Acronyms: Fiscal year (FY)

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Resources

		FY20 Actuals		FY21 President's Budget		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Aging and Materials Research	$2260	2.7	$1750	3.0	$1525	2.5	→
Total		$2260	2.7	$1750	3.0	$1525	2.5	→

CS&T ($K) includes contract support
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Pacific Northwest National Laboratory (PNNL) – Evaluating the Reliability of NDE of Vessels and Piping.
- PNNL – Evaluation of Advanced NDE Techniques.

Collaboration and Resource Leveraging

- NDE Addenda for NRC/EPRI MOU addressing several topics including ultrasonic modeling and simulation. Recently completed topics include human factors for NDE, visual testing, and CASS round robin. PIONIC being added.
- Program for Investigation of NDE by International Collaboration (PIONIC) - International collaborative research program with six countries and EPRI participating. Research topics include NDE modeling and simulation, flaw relevance evaluation, material degradation monitoring, probability of detection analysis, and machine learning in NDE.
- NRC/French Institut de Radioprotection et de Surete Nucleaire (IRSN) Specific Topic of Cooperation Sheet No. 01, Modeling and Simulation. Topics 3 and 4 added to address Advanced PAUT and Machine Learning for Automated Data Analysis, respectively.

Integrity Analysis Tool (IAT) Development and Guidance
Fiscal Year 2021 Program Overview

Overview

- This program area includes research to develop probabilistic fracture mechanics (PFM) analytical tools to evaluate the structural integrity of reactor piping systems and pressure boundary components.

Strategic Focus Areas

- Probabilistic component integrity analysis tools and methodologies.
- Develop Regulatory Guide to enhance quality in PFM applications.
- Enhance staff capabilities in reviewing probabilistic submittals.
- Complete probabilistic evaluations of leak-before-break of nickel-based alloys exposed to primary water environments and assessment of current leak-before-break regulations and guidance.
- Maintain and develop the state-of-practice for the Extremely Low Probability of Rupture (xLPR) and Fracture Analysis of Vessels-Oak Ridge (FAVOR) PFM codes.

Impact and Benefits

- Update NRC acceptance criteria for the use of PFM analyses on piping systems with active degradation mechanisms.
- Develop and maintain PFM analysis in-house capabilities of xLPR.
- Reduce conservatisms associated with deterministic submittals by enhancing staff capabilities in the area of probabilistic integrity assessment.
- Use risk-insights to make further enhancements and to expand the use of PFM tools.

Drivers

- Request from the Office of Nuclear Reactor Regulation (NRR) to develop and implement probabilistic methods to evaluate leak-before-break of nickel-based alloys exposed to primary water environments.
- Request from NRR to develop supporting regulatory guidance to enhance the efficiency and effectiveness of PFM analyses used for licensing actions and in consensus codes and standards.
- Request from NRR to maintain and develop state-of-practice of probabilistic tools for nuclear power plant component integrity risk assessments.

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
User Need Request (UNR) NRR-2014-004, Implementation of Probabilistic Methods for Evaluating Leak-Before-Break	Completed domestic and international public release of the xLPR code and public outreach meetings to build base for user group; drafted NUREG on xLPR Version 2.0 code development; completed xLPR Version 2.1	Issue Technical Letter Report (TLR) on select probabilistic evaluations of leak-before-break; issue TLR on generalization study to bound probabilistic evaluations of leak-before-break requirements and guidance		

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
UNR NRR-2016-004, Development of Regulatory Guidance on PFM Best-Practices	Completed final draft of PFM regulatory guide and technical basis; completed Interactions with public for PFM regulatory guide	Complete PFM regulatory guide comment resolution	Publish final RG for PFM	
New UNR to Maintain and Develop State-of-Practice of Probabilistic Tools for Nuclear Power Plant Component Integrity Risk Assessments			Commence incremental xLPR code release(s); commence assessment of results of benchmarking studies	Continue incremental xLPR and FAVOR code releases; continue assessment of results of benchmarking studies
UNR NRR-2014-004, Implementation of Probabilistic Methods for Evaluating Leak-Before-Break	Completed domestic and international public release of the xLPR code and public outreach meetings to build base for user group; completed draft NUREG on xLPR Version 2.0 code development; completed xLPR Version 2.1	Complete draft TLR on select probabilistic evaluations of leak-before-break; complete draft TLR on generalization study to bound probabilistic evaluations of leak-before-break requirements and guidance		

Acronyms: Fiscal year (FY)

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Resources

		FY20 Actuals		FY21 President's Budget		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Aging and Materials Research	$679	4.1	$1350	3.5	$500	3.0	↗
Total		$679	4.1	$1350	3.5	$500	3.0	↗

CS&T ($K) includes contract support
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- EMC^2 – probabilistic leak-before-break evaluations; xLPR code maintenance, support, and distribution.
- NUMARK – FAVOR maintenance and development.
- Sourcery, Inc. – FAVOR maintenance and development.

Collaboration and Resource Leveraging

- Memoranda of Understanding (MOU) between the NRC and the Electric Power Research Institute (EPRI) on xLPR code documentation and leak-before-break applications.
- MOU between the NRC and EPRI on xLPR code maintenance, support, and distribution.
- Engagement with domestic and international stakeholders to receive feedback on development of the PFM regulatory guidance.

Materials Degradation, Analysis, and Mitigation Techniques
Fiscal Year 2021 Program Overview

Overview

- This program area covers research on the degradation of primarily metallic reactor materials by corrosion, irradiation, cracking, and other forms of physically and chemically induced damage.

Strategic Focus Areas

- Maintain awareness of operating experience to identify emergent degradation issues or materials performance trends that could affect plant safety.
- Pursue information sharing and cooperative research with the U.S. Department of Energy (DOE) and industry counterparts.
- Identify opportunities to harvest ex-plant materials for analysis and testing.
- Remain cognizant of new materials and manufacturing technologies that may be used for plant components.
- Engage with DOE, the Electric Power Research Institute (EPRI), and international counterparts to identify alternatives to the Halden Reactor Project (Halden/HRP) for ex-plant materials irradiation and irradiated materials testing.
- Develop long-term plans for use of NRC-funded materials testing infrastructure at DOE laboratories.

Impact and Benefits

- Enhance NRC acceptance criteria for assessment and aging management of safety-related structures, systems, and components (SSCs) for continued and long-term operations.
- Shorten timeline for licensing decisions including for subsequent license renewal (SLR) application reviews.
- Improve understanding of risk significance of materials degradation issues to focus attention on those most important to safety.
- Identify and develop a resolution path for key knowledge gaps related to the adoption of new materials and manufacturing technologies.

Drivers

- Response to Commission direction to evaluate the aging-related degradation of SSCs including irradiation-assisted degradation of reactor internals for long-term operations.
- Requests from the Office of Nuclear Reactor Regulation (NRR) for assistance in independently confirming industry tests and analyses that support licensing actions related to materials degradation including primary water stress corrosion cracking (PWSCC), irradiation-assisted degradation (IAD), and neutron absorbing materials degradation

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
UNR NRR-2017-006: Research Assistance on Potential Significant Technical Issues During the SPEO	Conducted Cables Aging Workshop; participated in Joint Harvesting Workshop at NEA Developed Joint Roadmap for Metals and RG 1.188 Rev.2 on "Standard Format and Content for Applications to Renew Nuclear Power Plant Operating Licenses"	Complete meeting summaries, Research Information Letters, and other summary reports; Ageing Management Training		
New UNR to replace NRR-2017-006: Research Assistance on Potential Significant Technical Issues During LTO			Conduct Concrete Aging Workshop; complete documentation of NRC and counterpart technical meetings	Continue related support with new User Need Request
UNR NRR-2020-005: Irradiation-Assisted Degradation of Reactor Pressure Vessel Internals for LTO	Obtained results from Cooperative Zorita Plate Materials Testing at Studsvik; obtained initial results from confirmatory testing of Zorita baffle plate samples at ANL; obtained results from cooperative Zorita welds testing	Obtain final results from Zorita materials testing at ANL; complete NRC assessment of Zorita testing results Kickoff of FIDES and SMILE projects		
New UNR to replace NRR-2020-005: Irradiation-Assisted Degradation of Reactor Pressure Vessel Internals for LTO			Continue related support with new User Need request	Continue related support with new User Need request
UNR NRR-2013-005: To Develop the Technical Bases for the Evaluation of Neutron Absorbing Materials in Spent Fuel Pools (SFPs)	Completed TLR on the evaluation of Boral surveillance programs; completed TLR on the measurement uncertainty associated with in-pool neutron absorber areal density measurements using the BADGER system Research contracts closed out; UNR closed out			
UNR NRR-2020-004, Task C: Environmental Materials Degradation for Reactor Coolant Pressure Boundary Components	Completed NUREG/CRs of PWSCC Crack Growth Rate Testing (ANL/PNNL)	Complete TLR on Alloy 182 Testing of Stress Effects	Complete TLR on PWSCC Initiation of Alloy 690/52/152	
New UNR to continue NRR-2020-004, Task C: Environmental Materials Degradation for Reactor Coolant Pressure Boundary Components				Complete TLR on PWSCC Initiation of Alloy 690/52/152 dilution zones and defects

Acronyms: Fiscal year (FY)

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Resources

		FY20 Actuals		FY21 President's Budget		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Aging and Materials Research	$1095	4.7	$1830	4.5	$1460	3.0	→
Operating Reactors	International Technical Cooperation	$0	0.1	$0	0	$0	0	→
New Reactors	New Reactors Research	$0	0.1	$0	0	$0	0	→
Total		$1095	4.9	$1830	4.5	$1460	3.0	→

CS&T ($K) includes contract support
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Halden – HRP International Agreement.
- EPRI/Studsvik – Zorita Internals Research Project.
- EPRI/Studsvik – Irradiation-Assisted Degradation of Vessel Internals Materials.
- ANL – Ex-Plant Materials Testing.
- ANL – PWSCC Crack Growth Testing.
- PNNL – PWSCC Crack Growth Testing.
- PNNL– Ex-plant Harvesting.
- PNNL – PWSCC Initiation Testing.
- Savannah River National Laboratory (SRNL) – Zion Boral Evaluation.
- Oak Ridge National Laboratory – BADGER Measurement Uncertainty.

Collaboration and Resource Leveraging

- NEA Studsvik Materials Integrity for Life Extension (SMILE) project: performs research on materials harvested from the reactor internals, reactor pressure vessel, piping, and steam generators from shutdown Swedish plants.
- NEA Framework for Irradiation Experiments (FIDES): supports irradiation-assisted degradation research on irradiated stainless-steel welds and creep/relaxation of baffle bolt materials.
- Memorandum of Understanding Addenda with EPRI for PWSCC Expert Panel Activities, PWSCC Crack Initiation Testing, Neutron Absorber Materials from Zion, Long Term Operations (LTO) research.
- International Forum for Reactor Aging Management (IFRAM).
- MOU Addendum with DOE on cooperative nuclear safety research related to LTO including information sharing with DOE and EPRI on DOE's Light Water Reactor Sustainability (LWRS) program.

- Component Operational Experience Degradation and Ageing Program (CODAP) – Organization for Economic Co-operation and Development. Thirteen participating countries renewed for Phase 3 (2018-2020).

Analyses and Evaluation Tools for Advanced non-LWR Materials, Chemistry, and Component Integrity
FY21 Program Overview

Overview

- This program area includes research activities on the performance of materials and components used in advanced non-light-water reactors (ANLWRs) aimed at developing technical bases for materials applications, confirmatory predictive tools for assessing component integrity, and evaluation methods for assessing corrosion and chemistry effects on structures and components.

Strategic Focus Areas

- Assess performance needs and issues for materials, chemistry, and component integrity in ANLWRs.
- Facilitate use of existing regulatory guidance, industry codes and standards, applicable to ANLWRs.
- Acquire or develop computer codes and tools to perform ANLWR regulatory reviews.

Impact and Benefits

- Improve staff knowledge of industry-proposed timelines and focus areas for ANLWRs.
- Address the need for staff engagement on the use of consensus codes and standards related to materials that may be used in the construction and operation of advanced reactors.
- Enhance staff knowledge and technical capabilities leading to better decision-making regarding confirmatory research.
- Acquire/develop knowledge, technical skills, and capacity to perform ANLWR regulatory activities.

Driver

- Request from NRR to support the NRC Implementation Action Plan (IAP) for advanced non-LWRs (ADAMS Accession No. ML17165A069). Specifically, activities associated with acquiring or developing sufficient computer codes and tools to perform non-LWR regulatory reviews (IAP Strategy 2), and activities associated with the facilitation of industry codes & standards for Non -LWRs (e.g., ASME B&PV Code, Section III, Division 5) (IAP Strategy 4). Such activities include participation in code meetings, guidance development, and stakeholder outreach

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
NRC Non-Light Water Reactor Near-Term Implementation Action Plans (Strategy 2)	Issued Technical Letter Report (TLR) on environmental creep-fatigue and weld creep cracking; developed post-processing tool to aid in executing the ASME, Section III Division 5 design rules; issued RIL 2020-09, International Workshop on Advanced Non-Light Water Reactor – Materials and Component Integrity; issued TLR addressing adequacy of ASME, Section III Division 5 design rules related to high temperature	TLR addressing graphite properties and degradation including source dependency; complete report documenting materials, chemistry and component integrity accomplishments, and plans regarding IAP 2.	TLR/Whitepaper on molten salt compatibility of structural materials and graphite high temperature; corrosion/erosion/oxidation of structural materials in gas-cooled and Na fast reactors	Incorporate graphite degradation POF model into a simple software tool for use by staff; TLR documenting systematic comparison of static corrosion methodologies; TLR on the effect of containment material on corrosion test results; TLRs on the

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
	metallic materials and graphite; provided recommended guidance based on literature review and gap analysis of High Temperature Corrosion/Oxidation of Structural Material; developed technical basis for the thermal embrittlement effects of anticipated structural materials used in ANLWRs; issued TLR on gap identification and recommendations on consensus codes and computational codes			use of FLiNaK as a FLiBe surrogate; corrosivity of fission products; evaluation of the effects of sample surface to salt volume ratio; and effects of oxide and hydroxide contents of salts
NRC Non-Light Water Reactor Near-Term Implementation Action Plans (Strategy 4)	Provided Input to a NUREG documenting the NRC's review/endorsement of the ASME Code, Section III, Division 5. .	Continued support for development and issuance of a RG and NUREG documenting NRC's review/endorsement of the ASME Code, Section III, Division 5. Draft NUREG and RG to be issued for public comment FY2021 Q3		

Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Advanced Reactors	Advanced Non-LWR Regulatory Readiness	$733	0.2	$700	2.0	$768*	2.6*	→
Total		$733	0.2	$700	2.0	$768	2.6	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)
*FY22 Advanced Reactor resources are still being finalized.

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Contractor Support

- Oak Ridge National Laboratory – Technical assistance pertaining to advanced reactors.
- NUMARK – Graphite.
- Argonne National Laboratory – Creep-fatigue and creep cracking.
- Idaho National Laboratory – Graphite for ANLWRs.

Collaboration and Resource Leveraging

- International Workshop on Advanced Non-Light Water Reactors - Materials and Component Integrity, December 9-11, 2019.
- Collaboration with the Department of Energy and the Electric Power Research Institute, which have research programs on materials integrity in advanced reactors.
- NRAN Apprentice working on molten salt chemistry issues (10/20-3/21).

Piping and Other Components Integrity and Analysis Tools and Methods for Mechanical Systems and Inservice Testing
Fiscal Year 2021 Program Overview

Overview

- This program area includes research and codes and standards activities related to in-service inspection (particularly, flaw evaluation), repair/replacement of safety-related components in operating reactors, and evaluation of component integrity criteria and methods.

Strategic Focus Areas

- Maintain core capabilities for conducting component integrity assessments using in-house analytical tools.
- Ensure consistency, efficiency, and transparency for participatory roles in the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code.
- Enhance interactions with international counterparts to support information exchanges on best practices for the use of probabilistic fracture mechanics.

Impact and Benefits

- Provide technical support for the evaluation of proposed changes to Section XI of the ASME Boiler and Pressure Vessel Code, which is incorporated by reference into Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50.55a.
- Develop modeling guidelines aimed at increasing the efficiency of staff reviews of licensing actions related to leaking and cracked piping welds.
- Develop and maintain in-house software tools and analytical methods used by the Office of Nuclear Reactor Regulation (NRR) staff to review industry submittals (e.g., ABAQUS capabilities and flaw evaluation software).
- Conduct research to support the NRR staff in establishing regulatory positions related to new repair techniques and materials proposed by industry (e.g., carbon fiber and high-density polyethylene).

Drivers

- Requests from NRR to represent the NRC and communicate staff positions on Subcommittees and Working Groups of the ASME Boiler and Pressure Vessel Code.
- Requests from NRR to develop regulatory guidance for the use of probabilistic fracture mechanics in licensing actions.
- Requests from NRR for emergent support on component integrity evaluations for operating plants.
- Requests from NRR to review and update the criteria and associated technical basis for postulating pipe ruptures in fluid system piping at nuclear power plants.

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
NRR 2019-001, User Need Request (UNR) for Confirmatory Testing of Carbon Fiber Reinforced Polymer	Developed and implemented contracts with Numark and EMC2 to support required mechanical and durability testing; completed white paper on	Complete Technical Letter Report (TLR) summarizing results of Carbon Fiber Reinforced Polymer (CFRP) confirmatory	Complete TLR on environmental durability testing	

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
IAR-NRR Risk Assessment of Repair of Degraded Piping	nondestructive examination of carbon fiber reinforced polymer	testing; complete TLR on assessment of the risk (and safety significance) and consequences of the failure of repaired piping.	UNR closed	
UNR NRR-2020-10, Flaw Evaluation	Completed final publication of NUREG-2228 on weld residual stress validation; completed Two TLRs on xFEM applications and limitations	Complete FES V 5 release; complete two TLRs on xFEM for regulatory use		
UNR NRR-2020-10, ASME Section XI Code Technical Basis Review and Development	Continued support for quarterly ASME Code meetings and activities in various Section XI task groups, working groups, subgroups, and standards committee activities	Continue support	Continue support	Continue support
NRO-2015-007, UNR on Acceptance Criteria for Pipe Ruptures in Fluid System Piping	Completed TLR documenting currently available background on break location criteria and licensing submittals involving departure from the current Standard Review Plan 3.6.2 criteria	UNR closed		
New UNR on Acceptance Criteria for Pipe Ruptures in High-Energy Fluid Systems Piping		New UNR developed.	Complete TLR on alternative acceptance criteria for failure of high-energy fluid systems piping	Issue draft NUREG and Regulatory Guide for public comment on alternative acceptance criteria

Acronyms: Fiscal year (FY)

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Aging and Materials Research	$216	2.3	$350	2.0	$45	2.0	→
Operating Reactors	Engineering Research	$332	0.3	$200	1.5	$200	1.8	↘
New Reactors	New Reactors Research	$0	0.1	$85	0.7	$85	0.7	→
Total		$548	2.7	$635	4.2	$330	4.5	↘

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Pacific Northwest National Laboratory – Orderly close-out of previous research project on peening effectiveness; Crack initiation testing (completed).
- Numark/Emc2 – Carbon Fiber Repair: Confirmatory testing.
- Emc2 – Carbon Fiber Repair: Durability testing.
- Numark/Emc2 – xFEM Technical support: PWSCC Crack Growth (completed).
- Enterprise Wide Commercial – High-energy fluid systems piping.

Collaboration and Resource Leveraging

- Close communications with industry stakeholders for carbon fiber repair testing campaign to avoid duplication of efforts.

Steam Generator Integrity
Fiscal Year 2021 Program Overview

Overview

- This program area includes regulatory research on the inspection and structural integrity of existing and new steam generators (SGs), particularly SG tubes.

Strategic Focus Areas

- Maintain awareness of SG operating experience to identify emergent degradation issues or materials performance trends that could affect safety.
- Keep abreast of advancing technologies in SG inspections.
- Continue leadership roles in international cooperative activities.

Impact and Benefits

- Confirm the effectiveness of new SG tube examination methodologies proposed by industry to improve inspection times.
- Provide support to the Office of Nuclear Reactor Regulation (NRR) and Regional Offices for the independent evaluation of licensee SG tube inspection data.
- Enhance the efficiency of licensing actions by assessing the risk significance and structural safety margins for SG tubes.
- Support domestic and international collaborative agreements to leverage resources and enhance staff knowledge.

Driver

- User Need Request from NRR for assistance to enhance regulatory guidance for performing SG tube structural integrity calculations, analyzing structural degradation, and conducting periodic inspections or surveillances.

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
NRR-2018-007 Steam Generator Tube Integrity and Inspection Issues	Completed Technical Letter Report – Evaluations on the Effect of Eddy Current Probe Wear on Flaw Sizing NUREG/CR covering Development and Validation of Models for Predicting Leakage from Degraded Tube-to-Tubesheet Joints During Severe Accidents	Complete development of software to predict structural/ leakage integrity of SG tubes; Technical Letter Report – Inspection and structural integrity of U-bend tubes with PWSCC flaws; NUREG/CR covering detection of cracking near volumetric defects	Issue update to NUREG/CR that covers probability of detection in in-service inspections	Issue update to NUREG/CR that covers new developments in automated analysis of eddy current inspections

Acronyms: Fiscal year (FY)

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Aging and Materials Research	$540	0.9	$600	1.5	$600	1.5	→
Total		$540	0.9	$600	1.5	$600	1.5	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Argonne National Laboratory (ANL) – Steam Generator Tube Integrity Program including inspection and pressure testing.

Collaboration and Resource Leveraging

- International agreement for the International Tube Integrity Program (TIP-6) – Canada, South
  Korea, France, Germany, and possibly United Arab Emirates.
- Memorandum of Understanding (MOU) Addendum with the Electric Power Research Institute for SG Tube Base Research Program.

Vessel Integrity
Fiscal Year 2021 Program Overview

Overview

- This program area includes research on the structural integrity of reactor pressure vessels (RPVs) including the effects of irradiation-induced embrittlement and flaw analyses.

Strategic Focus Areas

- Develop and maintain staff core capabilities in RPV integrity assessments and performance of fluence analyses.
- Increase use of risk-information for RPV regulatory issues via enhancements to FAVOR [Oak Ridge National Laboratory Software] and increase use of FAVOR by staff and stakeholders.
- Develop, maintain, and use powerful and efficient state-of-the-art computational tools for RPV integrity assessments (FAVOR, GRIZZLY [software]).
- Enhance information exchanges and foster additional collaborative research activities with industry, the U.S. Department of Energy (DOE), and foreign counterparts on the topics of RPV analysis computational tools and of neutron fluence and embrittlement assessments.

Impact and Benefits

- Update NRC acceptance criteria for assessment and aging management of the RPV to support long--term plant operations including high-fluence material properties and RPV nozzle support embrittlement.
- Enhance the technical bases for regulatory guidance and rulemaking related to RPV surveillance requirements and pressurized thermal shock including potential revision of Regulatory Guide 1.99, Revision 2.
- Reduce uncertainties in determining structural safety margins including for the evaluation of shallow surface-breaking flaws.
- Increase the use of risk insights to inform deterministic and probabilistic RPV integrity analyses.
- Maintain in-house expertise in the use, maintenance, and development of analytical software tools critical to independent safety reviews (e.g., Flaw Analysis of Vessels – FAVOR).
- Engage the technical community in the development of consensus codes and standards related to RPV inspection and structural analyses.

Drivers

- Response to Commission direction to evaluate the aging-related degradation of the RPV during long--term operations.
- Requests from the Office of Nuclear Reactor Regulation (NRR) for assistance in enhancing regulatory guidance for performing structural integrity calculations of the RPV such as fluence calculation methodologies.
- Requests from NRR to maintain independent analytical capabilities.
- Requests from NRR to support the updating of regulations and regulatory guidance for RPV analyses and to represent the NRC in the development of associated consensus codes and standards.

Key Deliverables

Year / Project	FY 2020 Accomplishments	FY 2021	FY 2022	FY 2023
User Need Request (UNR) NRR 2015-002: RPV Fluence Evaluation Methodology Guidance		Issued TLR, Calculational Methods for Reactor Pressure Vessel Fluence in Extended Beltline Locations Issued TLR, Reactor Pressure Vessel Fluence, DPA, and Uncertainty Quantification in Extended Beltline Locations		
UNR NRR 2017-007: RPV Integrity and FAVOR Support	Completed FAVOR Software Quality Assurance and Verification and Validation (V&V) assessment; completed FAVOR Training for code users and code developers; completed Regulatory Guide (RG) 1.99 Revision 2 Update Scoping Analyses UNR closed in FY20			
UNR NRR 2020-003: RPV and Internals Materials, Fluence, and FAVOR Support	Completed shallow flaw issue disposition; completed REAP modernization	Ongoing FAVOR Software Quality Assurance (SQA) and V&V; create FAVOR Users' Group REAP integration with NRC Information Technology infrastructure	UNR Closed in FY21	
New UNR for RPV integrity technical assistance		New UNR in development	Conduct REAP maintenance Collaboration with DOE and EPRI on RPV data analysis Engagement with Codes and Standards on RPV embrittlement issues	Conduct REAP maintenance Collaboration with DOE and EPRI on RPV data analysis Engagement with Codes and Standards on RPV embrittlement issues

Acronyms: Fiscal year (FY)

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	Aging and Materials Research	$1003	1.3	$750	2.0	$750	2.0	↘
Total		$1003	1.3	$750	2.0	$750	2.0	↘

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Numark – RPV integrity analysis, REAP, and FAVOR support.
- Sourcery Inc. – FAVOR software development.

Collaboration and Resource Leveraging

- International agreement with the Japan Atomic Energy Agency for exchange of information on materials and component integrity research.
- International agreement with the French Institut de Radioprotection et de Surete Nucleaire exchange of information on integrity assessment and mechanical modeling computational tools.
- Memoranda of Understanding (MOU) between the NRC and DOE on cooperative nuclear safety research related to long-term operations.

Systems Analysis Research Activities

Accident Tolerant Fuels (ATF)
Fiscal Year 2021 Program Overview

Overview

- The ATF Project Plan was developed jointly between NRR, RES, and NMSS staff to ensure efficient and timely licensing of near-term ATF concepts.
- This EPID includes computer code development, literature reviews/information gathering, conducting of phenomena identification and ranking table activities (PIRTs), technical assistance, and stakeholder engagement needed to support the NRC's Accident Tolerant Fuels Project Plan (ML18236A507).

Strategic Focus Areas

- Develop staff core capabilities in ATF, high burnup, and high enrichment fuel performance phenomena.
- Keep abreast of advances in state-of-the art in modeling due to the industry focus of tying ATF to benefits, reduced margins.
- Continue participatory and leadership roles in international (Committee on the Safety of Nuclear Installations [CSNI]/Nuclear Energy Agency [NEA], Studsvik Cladding Integrity Project [SCIP]) projects to remain aware of and influence international activities related to ATF, burnup, and enrichment.

Impact and Benefits

- Confirmatory tools are expected to play a critical role in topical reviews as limited data have the potential to increase uncertainties in the phenomena of ATF concepts.
- Literature reviews and information gathering will help develop staff core capabilities and provide a basis for developing interim staff guidance (ISG) to supplement NUREG-0800.
- The PIRT exercise(s) will serve as an additional independent resource of expertise that will aid in the development of ISGs.
- Staff and contractors will support licensing reviews and confirmatory analysis on an as-needed basis.
- Stakeholder engagement will ensure that staff and industry are properly aligned with expectations of timelines, data, and testing generation as well as the licensing approach to take benefits from ATF.

Drivers

- This EPID supports the ATF NRR-2019-010 & NMSS-2020-004 user-needs as well as the high burnup and enrichment (near-term) user needs, NRR-2019-009 & NMSS-2020-005.
- ATF-related activities support the Agency's Accident Tolerant Fuel Project Plan.
- Industry is on an aggressive schedule to license and reload ATF concepts with the request of a shortened review period.
- In conjunction with ATF, the industry is now pursuing higher burnups and enrichments that have their own unique set of new phenomena that need to be understood.

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
Code Development	• FAST with updates for doped fuel, coated claddings, FeCrAl • Assessment of nuclear data library for SCALE	• FAST with ATF updates as data becomes available • Nuclear data review and assessment for SCALE	• FAST with ATF updates as data becomes available • Assessment of SCALE/PARCS for ATF, high burnup and enrichment	• FAST with ATF updates as data becomes available • Updates with vendor information to support topical reports

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
	• Source term updates for coated claddings in MELCOR • Couple TRACE with FAST	• Improve TRACE/FAST coupling to include transfer of 3D kinetics and mechanistic fuel relocation data	• Source term updates for high burnup in MELCOR • Add new ATF fuel properties to TRACE • Implement new models for high burnup and high enrichment fuel in TRACE	
Code Analysis	Supported Calvert Cliffs LAR for Coated Cladding and Doped Fuel	• Define methodology to calculate rod burst population and estimate fuel dispersal • Perform source term calculations for PWR and BWR with high burnup fuel • Perform confirmation calculations to support LAR and LTR reviews, as requested by NRR	• Demonstrate methodology for rod burst population and fuel dispersal • Perform source term calculations for PWR and BWR with coated cladding • Perform confirmatory calculations to support LAR and LTR reviews, as requested by NRR	• Perform source term calculations for PWR and BWR with FeCrAl cladding • Perform confirmatory calculations to support LAR and LTR reviews, as requested by NRR
PIRTs	Severe accident literature review	• High enrichment reports related to in-reactor, transportation, and storage behavior • Complete severe accident PIRT		
Ad Hoc support to NRR staff reviews of NPP licensing amendment	Provide assistance as requested			

Acronym: Fiscal year (FY)

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	System Analysis	$3,538	2.8	$4,650	4.5	$3,100	4.4	↘
Operating Reactors	Risk Analysis	$279		$250	0.5	$250	0.5	→
Spent Fuel Storage and Transportation	Waste Research	$600	0.3	$1,500	0.7	$2,213	0.9	↘
Total		$4,417	3.1	$6,400	5.7	$5,563	5.8	↘

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support & International Projects

- Pacific Northwest National Laboratory (PNNL) – FAST Code Development.
- Oak Ridge National Laboratory – SCALE Code Development.
- Sandia National Laboratories – MELCOR Code Development.
- Information Systems Laboratories – TRACE Code Development.
- University of Michigan – PARCS Code Development.
- Studsvik Cladding Integrity Project Phase IV (SCIP-IV) – Focus on high burnup effects on FFRD.
- QUENCH-ATF – focus on Cr-coated bundle behavior under DBA and BDBA conditions.

Collaboration and Resource Leveraging

- NRC-DOE Memorandum of Understanding (MOU) on ATF – DOE is to provide NRC access to data and information gathered through the ATF test program.
- NRC involvement in OECD/NEA TOPATF – Working with international regulators and utilities to identify the applicability of existing fuel safety criteria to ATF concepts.
- NRC involvement in OECD/NEA research proposal on High Enrichment – working with international regulators and utilities to capture operating experience relevant to high enriched fuel utilization.
- SCIP-IV Total cost – 180.9mSEK (~$18.9 million); NRC cost of $850K.
- QUENCH-ATF Total cost - ~$1.67 million euros (~$2 million); NRC cost of $184K

Thermal-Hydraulic Analysis
Fiscal Year 2021 Program Overview

Overview

- This EPID includes research for the NRC to perform independent safety analyses related to thermal hydraulics and computational fluid dynamics in addition to maintenance of thermal-hydraulic technical expertise that supports technical bases for risk-informed regulatory decision-making.

Strategic Focus Areas

- Leverage cooperative international research programs to gain reactor safety insights.
- Develop and use internal expertise in reactor safety research topics.
- Modernize and maintain TRACE plant decks so that they are ready, on-demand, for licensing decision-making.

Impact and Benefits

- Shortens timeline for licensing decisions and generates fewer requests for additional information.
- Offers insights into the relative importance of reactor safety phenomena to aid in the informed allocation of NRC resources.
- Provides foresight into new reactor system behaviors and phenomena.

Drivers

- Request from NRR for assistance in reactor accident and stability analyses for operating, small modular, and advanced reactors, support for research and test reactors (RTR) license renewal (e.g., SHINE).
- Ensure TRACE/PARCS has the capability to perform thermal-hydraulic analyses on an on-call basis.
- Maintain thermal-hydraulics and computational fluid dynamics (CFD) experts.

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
Plant Decks Development and Maintenance	Completed plant model Oconee	Complete LOCA and PARCS models for Palo Verde and Point Beach	Complete LOCA and point-kinetics transient models for AP1000, North Anna, and Monticello Complete PARCS model for AP1000	Complete LOCA and point-kinetics models for Vogtle, Brunswick, and Sequoyah Complete PARCS model for North Anna
				NuScale, BWRX-300, and HOLTEC Licensing Support
	Maintain Plant Models			
	Ensure compatibility between Plant Models and Latest TRACE Version			
MELLLA+	ATWS-I confirmatory analysis of Brunswick MELLLA+ with ATRIUM 11 fuel Closed UNR			

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
Test Reactors	1) Support for License Renewal and HEU to LEU Core Conversion; 2) Support for SHINE operating license permit 3) Pre-application support for Eden Isotopes and ACU molten salt reactor			
Full Spectrum LOCA	Final report complete, RAR closed			
GSI-191	Input provided to NRR for closeout. RES work is done. This is closed.			
CFD Reactor Analysis	Participation in OECD/NEA HYMERES-2 project	Development of Nuclepedia Page related to HYMERES-2 for Knowledge Management	Benchmarking advanced Nek5000 code using HYMERES-2 Containment test.	
CFD Spent Fuel Storage and Transportation Analysis	Supported several dry cask storage application reviews Completed validation of vertical dry cask simulator (NUREG-2238) Completed several knowledge management presentations	Complete uncertainty quantification of horizontal dry cask simulator (NUREG/CR-7274) Complete several knowledge management presentations and provide application review support	Complete several knowledge management presentations and provide application review support	Complete several knowledge management presentations and provide application review support Complete Supplemental NUREG to NUREG-2152 (CFD best practice guidelines for dry cask applications)
Ad Hoc support to NRR and NMSS staff reviews of NPP and spent fuel licensing amendments	Provide assistance as requested			

Acronym: Fiscal year (FY)

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	System Analysis Research	$180	5.0	$500	6.1	$625	6.1	↘
New Reactors	New Reactors Research	$89	1.4					↗
Spent Fuel Storage and Transportation	Waste Research		0.8		1.0		0.8	→
Total		$269	7.2	$500	5.1	$625	5.1	↗

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Energy Research, Inc. – TRACE Analysis and Plant Deck Modernization support.

Collaboration and Resource Leveraging

- Through the CAMP, the NRC receives about $1M annually from fees collected from international organizations (not reflected in above amount).
- RES is participating in the HYMERES-2 project and containment mixing benchmark in cooperation with DOE to develop skills and best practice guidelines for the advanced DOE code Nek5000.

Fuels and Neutronics Analysis
Fiscal Year 2021 Program Overview

Overview

- This EPID includes research for the NRC to perform independent safety analyses for fuels and neutronics, supported by the SCALE, PARCS, and FAST codes, to support technical bases for risk-informed regulatory decision-making.

Strategic Focus Areas

- Enhancing readiness for next generation fuel licensing actions through analytical tool development and support for audits.
- Develop and use internal expertise in fuels and neutronics research topics including
  - Fuel performance phenomena and modeling, uncertainty quantification.
  - Criticality and shielding modeling and uncertainty quantification.

Impact and Benefits

- Potential for shortening licensing review times by having expertise available to perform confirmatory analyses and on-call expertise, such as through audit support.
- Neutronics and fuels codes (e.g., SCALE, PARCS, and FAST) are ready to support amendments and topical report reviews for
  - Loss-of-coolant accident (LOCA) analyses.
  - New fuel designs and evaluation methods.
  - Plant life extension fluence calculations.
  - Source term evaluations for siting and NEPA analyses.
  - Support for SMR reviews (e.g., NuScale, BWRX-300).
- Analyses performed support safety studies, updates to regulatory guidance, rulemaking regulatory bases, and generic issue resolution.

Drivers

- Neutronics and fuels codes analyses (SCALE/Polaris, PARCS, FAST) are inputs to the thermal- hydraulics (e.g., LOCA, design basis transient) analyses and the TRACE Plant Deck development work.
- This EPID supports NRR-2019-011 (TRACE Plant Deck Model Development work).

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
Site Level 3 analysis (reactor and spent fuel pools (2018-2022)	Completed associated Level 3 analysis			
TRACE Plant Deck development (neutronics input)	Completed plant model Oconee	Complete PARCS models for Palo Verde and Point Beach	Complete PARCS model for AP1000	Complete PARCS model for North Anna
NuScale	Completed NuScale design certification in August 2020.			
VERA-TRACE/PARCS RAR		Demonstration and comparison of VERA to TRACE/PARCS		

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
Ad Hoc support to NRR staff reviews of NPP licensing amendment	Provide assistance as requested			

Acronym: Fiscal year (FY)

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	System Analysis Research	$100	0.4	$500	0.5	$500	0.5	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Oak Ridge National Laboratory (ORNL) – Support for plant model update activities.
- ORNL – Support on providing technical bases for vessel and concrete fluence calculations.

Collaboration and Resource Leveraging

- SCALE leverages ~8,000 users including 33 foreign regulators who exercise all areas of the code and provide additional assessment beyond the assessment performed by the code development team at ORNL.
- The VERA User Group and VERA code suite are CASL tools leveraged to provide high-fidelity reference solutions for specialized applications.

Advanced Non-LWR Support Using the Comprehensive Reactor Analysis Bundle (CRAB)
Fiscal Year 2021 Program Overview

Overview

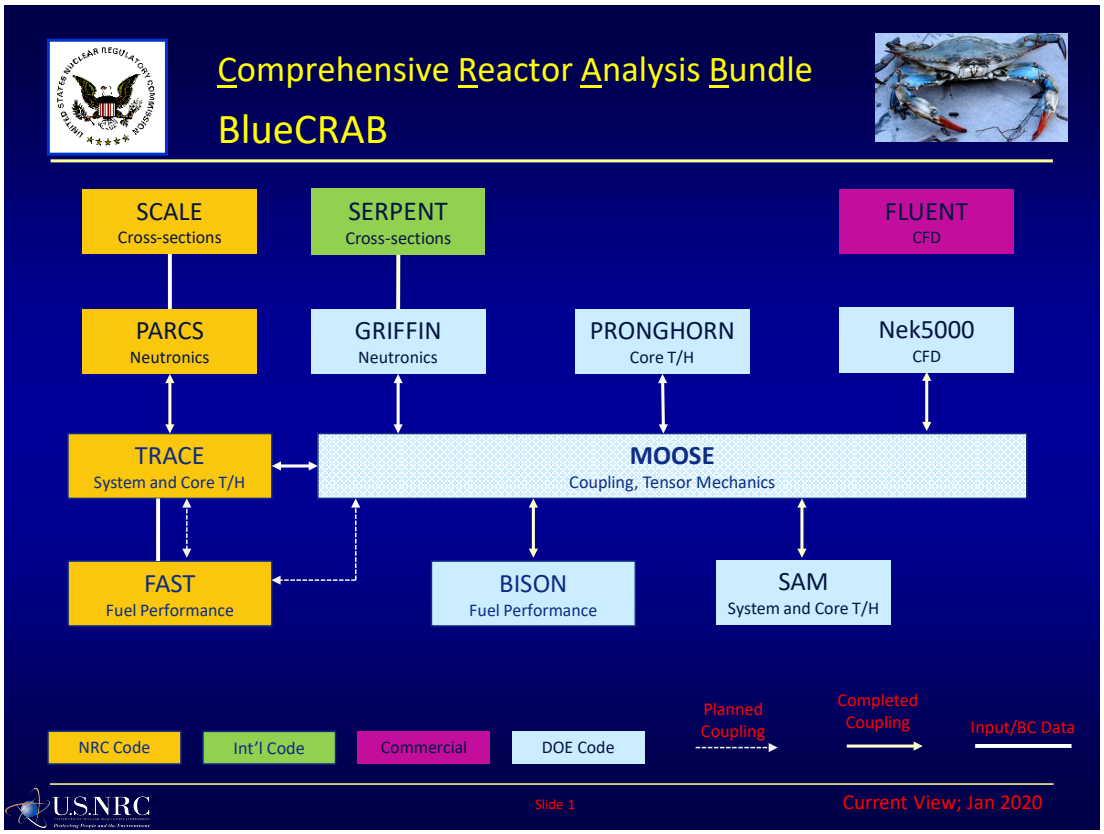
- This EPID includes development of tools to address Strategy 2 of the Implementation Action Plan (IAP) for advanced non-light water reactors (non-LWR).
- Specifically, this involves the development of codes suitable for confirmatory systems analysis of heat pipe cooled micro-reactors, molten salt cooled reactors (FHRs), gas-cooled reactors (GCRs), sodium fast reactors (SFRs), and molten salt fueled reactors (MSRs).

Strategic Focus Areas

- Initial efforts have been directed at understanding requirements for modeling and simulation of these new designs and identifying codes that could be used to support confirmatory analyses or to perform safety studies.
- Leverage cooperative domestic and international research programs to gain reactor safety insights.
- Develop and use internal expertise in advanced non-LWR safety research topics.

Impact and Benefits

- Codes used by the NRC for confirmatory analyses have been largely designed and assessed for light water reactors (LWRs) and are not immediately extendable to future advanced reactor designs.
- Although development and modification of NRC codes is one means to extend the applicability of NRC codes to non-LWRs, codes developed by DOE under the Nuclear Energy Advanced Modeling and Simulation (NEAMS) program will be used and are being modified for NRC regulatory purposes at a substantial cost savings to the NRC (as compared to NRC developing its own new codes).
- NEAMS codes possess unique and advanced modeling capabilities that are directly applicable for non-LWR analyses.
- Analyses with these tools offer the potential to shorten timelines for licensing especially if safety studies can be performed in advance of developer's submittals. These studies can be used to help focus the technical reviews on the most safety significant aspects.



Drivers

- The primary objective of Strategy 2 of the Implementation Action Plan (IAP) for advanced non-LWRs is the development of codes suitable for confirmatory analysis of these advanced designs (see figure above).

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
Code Development Report on Systems Analysis for non-LWRs	Released of Volume 1 Report			
Complete reference plant models	• Heat Pipe-Cooled Micro Reactor • Sodium-Cooled Fast Reactor	• Fluoride-Salt-Cooled High-Temperature Reactor	• Gas-Cooled Pebble Bed Reactor • Molten Salt Fueled Reactor	TBD based on industry development
Vendor-specific model		Heat pipe cooled micro-reactor[2]		

Acronym: Fiscal year (FY)

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[2] Vendor specific micro-reactor model generation in response to licensing office is on hold awaiting more information from the applicant.

Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Advanced Reactors	Advanced Non-LWR Regulatory Readiness	$580	2.8	$600	3.0	$600*	2.0*	↘

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)
*FY22 Advanced Reactor resources are still being finalized.

Contractor Support

- Argonne National Laboratory – Advanced Reactor Support for the SAM (Systems Analysis Module) code and analyses using SAM to support NRC needs.
- Idaho National Laboratory – Advanced Reactor Support for NRC's Blue Crab Suite and analyses using Blue Crab to support NRC needs.

Collaboration and Resource Leveraging

- Use of DOE-funded NEAMS program codes (MOOSE, BISON, SAM, GRIFFIN, PRONGHORN, Nek5000) were developed to support non-LWR analyses. Adoption, modification, and use of these codes for NRC regulatory purposes represents a substantial (many millions of dollars) NRC savings since the NRC did not possess the analytic capability for non-LWR accident analyses.

Thermal-Hydraulic Verification and Validation
Fiscal Year 2021 Program Overview

Overview

- This EPID represents the maintenance of and participation in domestic and international experimental research programs that directly support the technical basis for reactor safety code development and license application reviews.

Strategic Focus Areas

- Maintain an independent confirmatory analysis capability at the NRC.
- Expand the robust assessment and validation framework for ensuring the applicability of TRACE to reactor safety analysis.
- Continue to refine the analysis capabilities of TRACE when applied to small modular reactors (SMRs) and non-light water reactors (LWRs).
- Leverage experimental research programs as necessary for confirmatory analysis and expansion of the capabilities and applicability range for the TRACE code.

Impact and Benefits

- Ensures that the NRC will continue to have available audit tools that are sufficiently sophisticated to confirm industry plant modification applications and updates.
- Expands the range of phenomena and designs that are within the capability of the TRACE code.
- Ensures a robust assessment base and validation framework for demonstrating TRACE applicability.

Drivers

- Continue developing TRACE as a state-of-the-practice reactor safety analysis code.
- Maintain independent confirmatory reactor analysis capability at the NRC.
- Continuous improvement of the predictive capability of the TRACE reactor safety code.

Key Deliverables

Year / Project	FY 20 Accomplishments	FY21	FY22	FY23
RBHT	Kick-off of OECD/NEA activity, completed 11 open tests, and hosted first workshop	Lead OECD/NEA International Activity that evaluates reflood rate and core heat transfer rate. Prepare five blind tests and second workshop.		
PKL	The fourth phase of the 4-year PKL program concluded. Eight experiments were conducted, covering subject areas such as loss-of-coolant accidents (LOCAs), cool-down procedures, and multiple steam-generator tube ruptures	The fifth installment of PKL, PKL-ETHARINUS, will begin. This four-year program will investigate passive heat-removal systems, core-blockages, and LOCAs under design-extension conditions RES participation in this program is still undecided	PKL-ETHARINUS experiments conducted	PKL-ETHARINUS experiments conducted
ATLAS	Performed five tests: 1) Open test chosen by NRC, SBLOCA with total failure of high-pressure injection and actuation of the passive auxiliary feedwater system, 2) direct vessel injection line break, 3) steam line break with steam generator tube rupture, 4) shutdown coolability	Last test of ATLAS-2 will be performed (SBLOCA with passive emergency core cooling system). Joint workshop with PKL. ATLAS-2 wrap-up ATLAS-3 kickoff	ATLAS-3 tests will be performed according to the schedule agreed upon by the participants	ATLAS-3 tests will be performed according to the schedule agreed upon by the participants

Year / Project	FY 20 Accomplishments	FY21	FY22	FY23
	without the residual heat removal system, 5) counterpart test small vessel head break			
KATHY	Completed KATHY experimental program Continued assessment of TRACE	Complete final experimental program report and finalize a NUREG/CR	Complete TRACE assessment	
PERFROI	Continued development and testing for the COAL experimental program (cladding deformation in a 7x7 rod bundle) and COCAGNE experimental program (single rod cladding deformation)	Complete COAL Preliminary Report 1, COAL Preliminary Report 2, COCAGNE Final Report	COAL Preliminary Report 3, and COAL Final Report	
PERSEO	1) Finished TRACE PERSEO project analyses and documentation 2) Merged TRACE PERSEO results into the state-of-the-art report of the OECD/WGAMA passive system reliability workgroup for workgroup peer review	Complete PERSEO benchmark and final documentation.		

Acronym: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	System Analysis Research	$585	1.7	$300	2.9	$300	2.9	→
New Reactors	New Reactors Research		2.2					→
Total		$585	3.9	$300	2.9	$300	2.9	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Pennsylvania State University - Rod Bundle Heat Transfer program (RBHT).
- IRSN – PERFROI.
- Information Systems Laboratories (ISL) - Large System Code Performance Evaluation and Uncertainty Quantification.
- Orano (previously Areva) – KATHY experiments.
- University of Illinois – TRACE assessment against KATHY data.

Collaboration and Resource Leveraging

- The RBHT program has been transformed into an international cooperation effort with the OECD.
- Participate in international research programs such as PERFROI, ATLAS, and PKL that provide valuable assessment and validation data for confirmatory codes and analysis.

FAST Code Development and Maintenance
Fiscal Year 2021 Program Overview

Overview

- This EPID includes computer code development, maintenance, and research related to obtaining experimental data and analyses used to support the NRC's thermal-mechanical fuel performance code FAST, which is used in support of formulating a technical basis for regulatory decision-making.

Strategic Focus Areas

- Maintain staff core capabilities in steady-state, anticipated operational occurrences (AOO), and Design-Basis Accident (DBA) fuel performance as well as non-light water reactor technologies.
- Develop staff core capabilities in Accident Tolerant Fuel (ATF), high burnup (HBU), and high-assay low-enriched uranium (HALEU) fuel performance.
- Keep abreast of advances in state-of-the-art fuel performance modeling and phenomena.
- Continue participatory and leadership roles in [NEA] and Studsvik Cladding Integrity Project [SCIP]) projects to obtain experimental data and analyses to further fuel performance code modeling and to maintain state-of-the-art modeling capabilities.

Impact and Benefits

- FAST is used to support confirmatory studies for new fuel designs, methods, and fuel vendor code update including ATF and HBU activities for NRR.
- FAST is used to support technical bases such as DG-1327 and 10 CFR 50.46(c).
- FAST provides the input conditions used to support plant licensing decisions such as loss-of-coolant accidents (LOCAs).
- FAST maintains the material library (MatLib) used by other NRC tools such as TRACE.
- Experimental programs provide independent data used to validate FAST as well as serve as an independent data source used to compare to fuel vendor topical reports (TRs).
- FAST is used to support non-LWR regulatory reviews.

Drivers

- The RES FAST Code Development and Maintenance program supports a variety of user needs from the Office of Nuclear Reactor Regulation (NRR) and the Office of Nuclear Material Safety and Safeguards (NMSS) such as NRR-2019-009 & NRR-2019-010 for ATF, HBU / HALEU, NMSS-2020-004, and NMSS-2020-005 for ATF and HBU activities respectively, and NMSS-2020-006 Research Assistance Request (RAR) on the assessment of gross ruptures in HBU Fuel.
- FAST is used to perform confirmatory calculations to support the review of new fuel designs and updates to codes/methods for vendor thermal-mechanical codes.
- FAST provides inputs to TRACE for full-core NRR reviews, such as LOCA analysis
- RES provides FAST to both domestic and international users, including regulators and technical support organizations (TSOs).
- Strategy 2 of the Implementation Action Plan (IAP) for advanced non-light water reactors.

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
FAST Development, Maintenance, and Assessment	Released FAST-1.0 Completed assessments of cladding and steady-stat g creep e and transient FGR modeling Completed literature reviews for advanced fuel and cladding materials	Release of FAST-1.1 with incorporation of all FRAPTRAN features and improvements to ATF, code stability, and assessment Implement axial fuel relocation model Perform LOCA assessments	Perform targeted assessments of fission gas release (FGR), chromium-coated cladding, and reactivity-initiated accidents (RIA) models	Perform targeted assessments of advanced cladding and fuel material and high burnup fuel
FAST User Group Meeting	Presentations of Code updates	Presentations of Code updates	Presentations of Code updates	Presentations of Code updates
FAST Training	Hands-on training to NRC staff; updated training materials	Hands-on training to NRC staff; updated training materials	Hands-on training to NRC staff; updated training materials	Hands-on training to NRC staff; updated training materials
FAST for non-LWRs	Completed gap analysis of FAST for U(Pu)-10Zr metallic fuel	Assess FAST for metallic fuel against EBR-II data and TRISO fuel against IAEA benchmarks (TECDOC-CD-1674)	Improve metallic and TRISO fuel models and quantify uncertainties in the models	Model improvement and assessment for TRISO and metallic fuel needed for emerging issues
FAST for ATF	Used to support audit of Calvert Cliffs lead test assembly of chromia-doped fuel in chromium-coated M5 cladding	Assessment/updates for near-term ATF concepts as information is made available	Assessment/updates for near-term ATF concepts as information is made available	Assessment/updates for near-term ATF concepts as information is made available

Acronym: Fiscal year (FY)

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	System Analysis Research		0.5	$300	1.5	$300	1.5	→
New Reactors	New Reactors Research		0.2					→
Advanced Reactors	Advanced Non-LWR Regulatory Readiness		0.3	$200	0.3	$200*	0.2*	→
Total			1.0	$500	1.8	$500	1.7	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)
*FY22 Advanced Reactor resources are still being finalized.

Contractor Support & International Projects

- Pacific Northwest National Lab – FAST Code Development, Assessment and Maintenance.
- Commercial contractor (Information Systems Laboratories) – FAST Code Improvement and Feature Extension.
- CABRI - In-pile Reactivity Initiated Accident (RIA) testing.
- FIDES Framework, including P2M in-pile power ramp testing and High-burnup Experiments in Reactivity Initiated Accidents (HERA) testing, under development.

Collaboration and Resource Leveraging

- SCIP-IV Total cost – 180.9mSEK (~$18.9 million); NRC cost of $850K (on shortfall list).
- Along with items listed above, Institut de Radioprotection et de Surete Nucleaire (IRSN) receives FAST and provides DRACCAR to NRC at no cost; provides the NRC with code updates and data to support code assessment.
- DOE provides ATF and non-LWR fuel performance data through MOU agreements.
- FIDES Total cost – 12.9 million euros (~$15.4 million); NRC cost of $2.15 million

SCALE Code Development and Maintenance
Fiscal Year 2021 Program Overview

Overview

- This EPID includes research to enable the NRC to develop, validate, and maintain the state-of-practice with the SCALE computer code, which is used to develop capability and understanding in neutronics-related phenomena (e.g., nuclear data libraries, depletion and activation, criticality and shielding, and sensitivity uncertainty analysis methods), and initialize other NRC codes (i.e., TRACE/PARCS, MELCOR, and MACCS) in support of safety issue resolution and risk-informed decision-making.

Strategic Focus Areas

- Support regulatory decision-making with respect to reactor physics phenomena, criticality, and shielding.
- Understand the safety impact of changes to nuclear cross section data including ENDF/B-VIII.
- Expand review capabilities to support accident tolerant fuel (ATF), high-assay low-enriched uranium (HALEU), high burnup (HBU) fuel, and non-light water reactors (non-LWRs).
- Improve methods and modeling enhancements to help the NRC better understand advanced applications that involve more sophisticated operation of the existing LWR fleet (e.g., ATF)
- Understand impact of design changes in the front-end and back-end of the fuel cycle including the spent fuel pool.

Impact and Benefits

- SCALE analyses capabilities to enable ATF concepts including support of HALEU and HBU efforts.
- Provides staff and contractors with a core physics tool to support independent regulatory decision-making.
- SCALE is coupled with PARCS, TRACE, MELCOR, MACCS, and FAST to solve integrated and complex simulations.
- SCALE supported a number of formal studies (e.g., Spent Fuel Pool study, Level 3 PRA, MELLLA+, generic plant decks, non-LWR code strategy) that provide the technical basis for agency risk informed decision-making that have resulted in hundreds of millions of averted costs to industry.

Drivers

- Licensed SCALE userbase of ~70 NRC staff and ~8,000 users globally, including 33 foreign regulators.
- Used extensively to provide Part 50 safety analysis calculations, core physics, source term, criticality, and shielding calculations.
    - SCALE capabilities underpin 10 CFR Part 50 Appendix A GDC Criteria 26-28, 50.68 spent fuel pool analyses, Appendix G and 50.61, Part 100 requirements with Regulatory Guide 1.183 and Technical Specifications Amendments that reduce operational cost and regulatory burden.
- SCALE capabilities are used to inform staff review of core designs and operating regimes, shutdown margin, reactivity control, etc. (10 CFR Part 50 Appendix A, GDC Criteria 10, and 26 through 28).
    - Provide MELCOR and MACCS with inventory, reactor kinetics data, decay heat, etc.
    - Support FAST by providing radial power distribution data.

- Support criticality and shielding applications.
- SCALE supports the MELCOR Code Development and Maintenance program, which supports a variety of research projects and user needs and requests from NRR - International research potential impact on Regulatory Guide (RG) 1.183, Independent Review/Update of RG 1.183, “Alternative Radiological Source Term for Evaluating Design Basis Accidents at Nuclear Power Reactors.”
- Supports MELCOR confirmatory source term analysis capabilities for 10 CFR Part 50 (Design Criteria), Part 51 (NEPA), and Part 100 (Siting) reviews.
- ATF/HBU/HALEU User Needs NRR-2019-009 & NRR-2019-010.
- TRACE Plant Deck development User Need NRR-2019-011.
- Strategy 2 of the Implementation Action Plan (IAP) for advanced non-light water reactors.

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
SCALE Development	Released SCALE 6.2 with updated nuclear data libraries, MC- based nodal data capabilities, code stability & robustness improvements	Release of SCALE 6.3	Release of SCALE 7	Release of SCALE 7.1
SCALE user group workshops and training	Preparation of workshop materials and hands-on problems	Preparation of workshop materials and hands-on problems	Preparation of workshop materials and hands-on problems	Preparation of workshop materials and hands-on problems
SCALE code modeling for Accident Tolerant Fuel, HALEU & HBU	Reviewed available benchmark data & code updates	Assessments and model validation including data gaps (focus on reactor)	Assessments and model validation including data gaps (focus on spent fuel)	Assessments and model validation including data gaps (focus on design specific activities)
SCALE code modeling for non-LWRs	Code updates to support MELCOR for source term demo calculations	Code updates to support MELCOR for source term demo calculations & regulatory reviews	Code updates to support MELCOR for source term demo calculations & regulatory reviews	Code updates to support MELCOR for regulatory reviews

Acronym: Fiscal year (FY)

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	System Analysis Research	$375	0.5	$450	0.5	$450	0.6	→
Spent Fuel Storage and Transportation	Waste Research	$338	0.1	$105	0.9	$300	0.4	↘
Advanced Reactors	Advanced Non-LWR Regulatory Readiness	$1,032	0.4	$800	0.3	$900*	0.2*	→
Total		$1,745	1.0	$1,355	1.7	$1650	1.2	↘

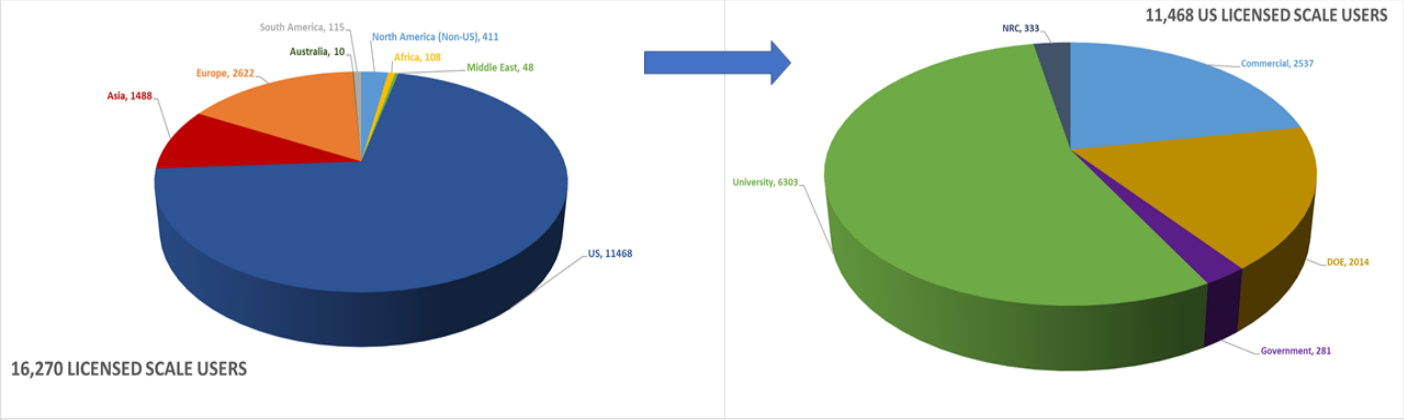
Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)
*FY22 Advanced Reactor resources are still being finalized.

Contractor Support

- Oak Ridge National Laboratory – Maintenance and Development of SCALE computer code.

Collaboration and Resource Leveraging

- RES/DSA actively collaborates with the Organization for Economic Co-Operation and Development/Nuclear Energy Agency (OECD/NEA) to have the code assessed by international regulators.



PARCS Code Development and Maintenance
Fiscal Year 2021 Program Overview

Overview

- The aim of this EPID is to support regulatory decisionmaking through the development of the Purdue Advanced Reactor Core Simulator (PARCS) code as software to be used in safety reviews of power plant operator actions, power uprates, license amendments, and the design certification of advanced reactors.

Strategic Focus Areas

- Support regulatory decisionmaking with respect to core reactor physics phenomena.
- Improve methods and modeling enhancements to help the NRC better understand more advanced applications that involve more sophisticated operation of the existing LWR fleet (Accident Tolerant Fuel [ATF] and power uprates), and advanced non-LWRs.
- Core reactor physics directly supports thermal-hydraulic analysis by providing three-dimensional power feedback during transients as well as by providing cycle specific edits (burnup and history) from which to execute the transient calculations.
- Making PARCS easier to use for NRC staff, contractors, and international collaborators (Code Applications and Maintenance Program [CAMP]).

Impact and Benefits

- Robust core physics tool for staff and contractors to perform independent analysis.
- Simulation and visualization with TRACE/PARCS that inform BWR operating behavior during anticipated transient without scram (ATWS) scenarios.
- These types of calculations will become more important as fuel vendors, licensees, and reactor designers move towards more complex, optimized, and heterogeneous fuel designs with the expectation that they will operate with reduced thermal-hydraulic margins to fuel damage.
- Capabilities to perform complex coupled simulations including control rod ejection, multicycle core depletion, and reload calculations.

Drivers

- NRC/RES develops and assesses independent simulation tools to confirm the safety of nuclear power plant designs.
- PARCS models are used to inform staff review of core designs and operating regimes with respect to shutdown margin and reactivity control at all points in the cycle (10 CFR Part 50 Appendix A, GDC Criteria 26 through 28) and with respect to nuclear power plant (NPP) transients (Chapter 4 and Chapter 15 of the Standard Review Plan for LWRs [NUREG-0800]).
- PARCS analysis was central to fulfilling RES support to the MELLLA+ License Amendment Requests for Brunswick and Browns Ferry, in informing the NuScale safety evaluation under NuScale Reactor Systems Analysis Research Plan (ML19039A152), and in supporting the development of confirmatory models for the TRACE plant deck work request (ML19143A320).

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
Improve robustness and	PARCS v3.3.2 released	PARCS v3.3.3, v3.3.4, v3.3.5, v3.3.6	PARCS v3.4	PARCS v3.4.1

Year Project	FY20 Accomplishments	FY21	FY22	FY23
run time performance of PARCS	Supported staff review of the NuScale application (ML20104C082)			
Training	Provided annual training	Provide annual training	Provide annual training Update training materials and instruction	Provide annual training
PARCS Watts Bar Unit 1 Assessment for hot zero power startup tests and HFP Cycles 1-3	PARCS/PATHS core models completed with compared to measured detector responses and VERA (CASL) and KENO-VI predictions in terms of the boron letdown curve, multiplication factor, power shapes, and rod worth of several banks	Final Models and Completion Report		
PARCS micro-depletion model	Beta micro-depletion PARCS/GenPMAXS versions were developed New cross section format developed to accommodate large amount of isotopic data Integrated new solvers which can accommodate 20 actinides and several burnable absorbers	Final PARCS distribution (SDID/Completion Report, manuals, code version, and test problems)		
Accident Tolerant Fuel (ATF) and High Burnup/High Assay fuel concepts[1]		PARCS v3.3.3 contains upgrades that expand the staff ability to analyze more advanced ATF forms through additional cards for fuel/gap/clad. These cards further parameterization of fuels conductivity in terms of burnup, temperature, LHGR, and MATLIB libraries	Core level code assessment/scoping report(s) with comparisons to higher fidelity models (code-to-code) and PARCS/PATHS demonstrations of feasibility of operating limits with ATF/EE/HB fuel ATF assessment report – due 8/22 Enrichment/High Burnup/ATF assessment report – due 6/22	Update PARCS/PATHS with appropriate algorithms and methods (if necessary) ATF Updates – due 6/23 Enrichment/High Burnup/ATF Updates – due 4/23
Large Sodium Fast Reactor (SFR) Code Upgrades, Documentation, and Assessment	New SFR triangular nodal kernel (code beta) being used to generate point kinetics parameters for EBR-II SHRT45 tests (IAEA-TECDOC-1819)	Pull existing SFR code beta modifications into PARCS trunk in tested stages (core expansion, new Doppler averaging, triangular nodal solver for steady-state, spatial reactivity weighting with adjoint, and transient) Translate core-level and lattice Serpent models into SCALE/Shift models	Develop and document TRACE SHRT4-45R decks for the station blackout test experiment (run 138B) Perform TRACE/PARCS SHRT-45R simulations Develop and test anticipated code fixes to support assessment Document assessment through a completion report	

Year Project	FY20 Accomplishments	FY21	FY22	FY23
Unanticipated PARCS upgrades and documentation due to modeling standard, advanced, and nuclear power plant operation in expanded domains[2,3]	Numerous enhancements and code fixes to support staff in the development of confirmatory PARCS models for the Oconee and Palo Verde PARCS and TRACE/PARCS standalone and coupled steady-states and coupled transients Development, implementation, documentation, and testing of new nodal flux solvers	Code support of staff in the development of PARCS decks for Point Beach; AP1000, North Anna, and Monticello Finalize micro-depletion Hexagonal node pin power reconstruction Advanced point kinetics Mounting of PARCS assessment suite onto Cdash/Cmake	Code support of staff in the development of PARCS decks for Vogtle, Brunswick, and Sequoyah Fortran 2018 upgrade Radial/axial meshing refinement for flux/material meshes for all solvers Low-power physics improvement TRACE/PARCS Assessments: Ringhals Stability, Peach Bottom Turbine Trip, and Peach Bottom Stability Nuclear Power Plant tests	Code support of staff in the development of PARCS decks for Nine Mile Point2, Calvert Cliffs, and River Bend Code parallelization Sensitivity/Uncertainty methodology Develop PATHS lateral cross-flow PATHS Assessments against the following facilities: FRIGG (Full-Scale Single-Bundle BWR Test Loop); BFBT (BWR Full-size Fine-mesh Bundle Test Facility); and FIST (Full Integral Simulation Test)

Acronym: Fiscal year (FY), 1 -- input to "ATF Research Plan", 2 – input to "Improve Robustness of TRACE/PARCS", 3 – input to "Uncertainty Quantification", 4 – SHRT = Shutdown Heat Removal Test

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	$K	FTE	$K	FTE	$K	FTE	Research Planning
Operating Reactors	System Analysis Research	$128	1.1	$200	1.0	$150	0.8	→
Advanced Reactors	Advanced Non-LWR Regulatory Readiness			$100	0.2	$50	0.1	↘
Total		$128	1.1	$300	1.2	$200	0.9	↘

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210 k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- University of Michigan – Maintenance and Development of PARCS computer code.

Collaboration and Resource Leveraging

- Several PARCS code assessment activities and methodology improvements are conducted through the NRC bi-lateral (Institut de Radioprotection et de Surete Nucleaire - IRSN) and the multiparty (CAMP) code safety programs. PARCS assessments have been completed against operational plants in Europe, Asia, and Canada, and these are documented in NUREG/IAs.

SNAP Code Development and Maintenance
Fiscal Year 2021 Program Overview

Overview

- This EPID includes the planning, development, and management of the Symbolic Nuclear Analysis Package (SNAP) computer code. SNAP provides user interface for input and output for the following NRC codes: TRACE, PARCS, FRAPCON, FRAPTRAN, FAST, RADTRAD, MELCOR, MACCS, and SCALE.

Strategic Focus Areas

- Maintain current the SNAP User Interface with NRC code suite.
- Expand SNAP capabilities for modeling fuel performance and uncertainty analysis.
- Add capability to run jobs on the cloud and couple simulations across codes.

Impact and Benefits

- Provides a common user interface for many NRC codes.
- Provides capability for uncertainty and sensitivity studies with an uncertainty plug-in that supports an interface to the DAKOTA code.
- Supports the organization and simplification of complex, multicode analysis with an engineering-template plug-in that allows for codes to be coupled via input and output files in one SNAP model.
- Provides post-processing capabilities to allow for manipulating and analyzing code results, plotting outputs, and animating/visualizing data and code results.

Drivers

- Supports User Need requests that require the use of computer code for confirmatory analysis and uncertainty quantification.
- Supports most of the TRACE, FAST, MELCOR, PARCS, and SCALE analyses performed by RES staff in support of the agency mission.

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
SNAP Development	• Python directed Job-Stream released • MAACS support • MELCOR 2.2 fully supported • SNAP version 3.1.3 released • SAM plugin developed	• Graphics integration and improvements • UQ toolbox development • DAKOTA Support Improvements • Plugin updates • MACCS support • Jupyter integration • MELLLA+ wizard • Direct cloud support	• MELCOR 2.3 support • Plugin updates	• MELCOR 2.4 Support • Plugin updates
SNAP training & videos	Total of 12 training videos, 5 created this FY	• Preparation of workshop materials and hands-on problems • Preparation of training videos • NRC staff and contractor support		

Acronym: Fiscal year (FY)

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Resources

		FY20 Actuals		FY21 Enacted		FY22 President's Budget		FY23 Trend
Business Line	Product	$K	FTE	$K	FTE	$K	FTE	Research Planning
Operating Reactors	System Analysis Research	$130	1.0	$300	0.8	$200	0.8	→
Total		$130	1.0	$300	0.8	$200	0.8	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210 k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Applied Programming Technologies (APT) – Maintenance and Development of SNAP computer code.

Collaboration and Resource Leveraging

- The CAMP program provides some funding in support of features that benefit CAMP members ($50K-$100K/yr.
- Naval Reactors provides considerable code development on SNAP core and the MELCOR plug-in independently, but both organizations mutually benefit.
- SNAP supports the RADTRAD/RAMP program as well as the fuels code development program in RES.
- Some funding for SNAP is provided by the fuels code development program ($50K/yr).
- Some funding for SNAP is provided by the MACCS/MELCOR development program ($100K/yr).

RSICC Distribution of NRC Codes
Fiscal Year 2021 Program Overview

Overview

- This EPID includes the planning, development, and management of the NRC legacy code distribution services provided by the Radiation Safety Info Computational Center (RSICC).

Strategic Focus Areas

- Continue migration of NRC codes not actively used for regulatory applications to RSICC to ensure the code is properly archived and maintained.

Impact and Benefits

- Ensure that NRC legacy codes used for regulatory purposes in the past are readily available, if needed.
- Ensure that NRC employees and contractors are able to request software from RSICC easily.
- Ensure that software distributed to the public is in compliance with export control regulations.

Drivers

- The NRC uses RSICC to help with code distribution, minimally maintain legacy codes, and support university activities.

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
Process Annual Participation Contracting Package with ONRL	FY20 Procurement Completed	FY21 Procurement Completed	FY22 Procurement	FY23 Procurement

Acronym: Fiscal year (FY)

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Resources

		FY21 Actuals		FY22 Enacted		FY23 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	System Analysis Research	$120	0.1	$200	0.2	$200	0.2	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210 k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Oak Ridge National Laboratory (ORNL) – RSICC Participation.

Collaboration and Resource Leveraging

- Program is heavily leveraged with ORNL and other participants.

TRACE Code Development and Maintenance
Fiscal Year 2021 Program Overview

Overview

- This EPID includes the planning, development, and management of the TRACE computer code for evaluating coupled neutronic and thermal-hydraulic transient behavior of nuclear reactor and plant systems under normal, abnormal, and accident conditions for current and advanced reactors.

Strategic Focus Areas

- Implementing features for specialized applications (e.g. accident tolerant fuel (ATF) designs, advanced reactors, test reactors, code uncertainty).
- Improving robustness of advanced modeling features to aid solution stability/convergence, improve code run time, and ensure physics are being modeled correctly (e.g., implicit numerics, droplet field, fuel rod models, etc.).
- Continued focus on customer support to improve ease of use and to address bugs identified by staff or Code Application and Maintenance Program (CAMP) members.

Impact and Benefits

- Ensure that NRC simulation tools are state of the practice and match vendor code capabilities.
- Enable effective licensing reviews and analysis.
- Shorten timeline for licensing decisions and generate fewer requests for additional information.

Drivers

- Supporting User Needs (e.g., ATF, uncertainty, plant models for operating reactors, small modular reactors, high burnup/high enrichment uranium fuel, test reactors).
- Improving staff effectiveness when performing confirmatory analyses.
- Improving robustness and runtime performance of TRACE and TRACE/PARCS calculations.

Key Deliverables

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
Improve robustness and run time performance of TRACE/PARCS calculations (driven by Thermal Hydraulics Analysis EPID)	Released TRACE versions which improved TRACE/PARCS robustness	TRACE V5.0 Patch 6 will improve robustness of droplet field and implicit numerics Developmental code versions that improve robustness of level tracking Upgrade PARCS to v3.3.3	TRACE V5.0 Patch 7 will improve PARCS timestep control and implement detector signals Implements axially offset fuel rods	TRACE V5.0 Patch 8 will provide further TRACE enhancements RES will implement to support current (in FY23) NRR Licensing Topical Reports, License Amendment Requests, and New Reactor Design Certifications

Year / Project	FY20 Accomplishments	FY21	FY22	FY23
Uncertainty quantification using TRACE	Release TRACE version with improved modeling of uncertainty parameters			
Improving staff effectiveness when performing confirmatory analysis in support of test reactors	Release TRACE version with improved modeling for flat plate heat transfer and rectangular ducts			

Acronym: Fiscal year (FY)

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Resources

		FY21 Actuals		FY22 Enacted		FY23 President's Budget		FY23 Trend
Business Line	Product	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Research Planning
Operating Reactors	System Analysis Research	$900	1.4	$400	3.0	$425	3.2	→
New Reactors	New Reactors Research		1.3					→
Total		$900	2.7	$400	3.0	$425	3.2	→

Total Resources = CS&T (includes contract support) + FTE (staffing at approximately $210 k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Information Systems Laboratories Inc. – Maintenance and Development of TRACE Thermal-Hydraulic Computer Code.

Collaboration and Resource Leveraging

- Through the CAMP, the NRC receives about $1M annually from fees collected from international organizations (not reflected in above amount).
- DOE sponsored code development activities to couple TRACE to BISON and TRACE to FAST using the MOOSE framework to support future ATF license reviews.