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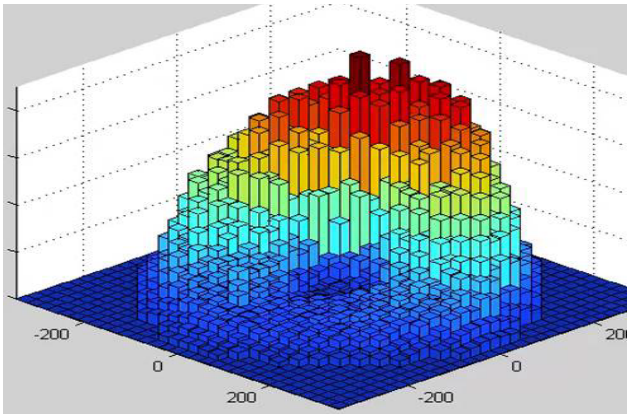
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Office of Nuclear Regulatory Research FY2020-22 Planned Research Activities



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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 include 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.

To provide improve stakeholder visibility into NRC research activities, RES has developed information summary sheets to describe research being conducted by RES across a wide variety of technical disciplines. The sheets describe the projects that are in progress and planned as well as their impacts and benefits, deliverables, and resources. In addition, they identify the research points of contact who can be contacted for additional information.

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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, as well as to 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 FY20, the total research budget is $81.1 M[1] which comprises $43.3M for contract support and travel and about $37.8 M for staffing 205 FTE (full time equivalent).

Figure 1 shows research resources associated with the NRC Business Lines that comprise the RES budget in FY20. The figure shows how the Operating Reactors Business Line (ORBL) activities comprise the majority of RES's workload.

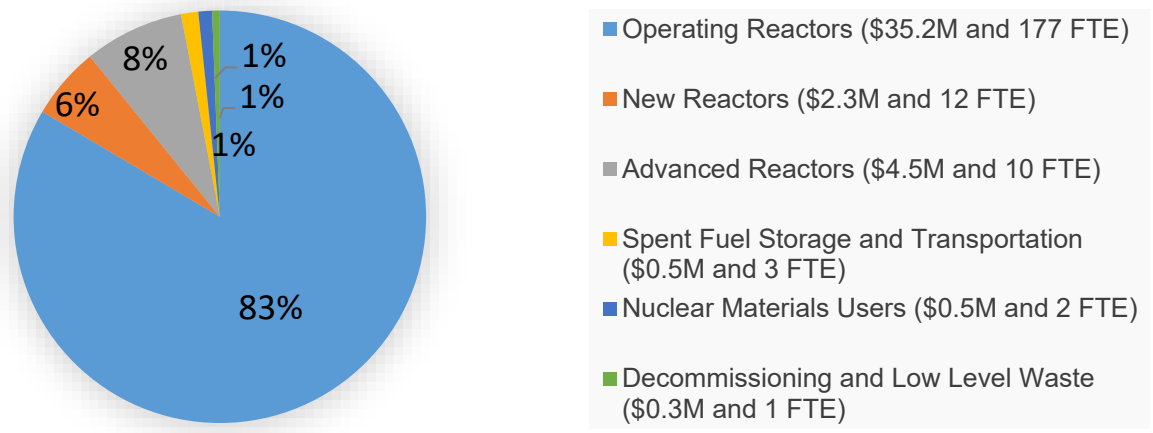

Figure 1. RES FY2020 Resources by Business Line

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, resources supporting the activities, and planned coordination to leverage research efforts.

[1] This total includes $10 M of authorized carryover to fund contract support and omits $16 M for the Integrated University Grants Program.

Risk Analysis Research Activities

Accident Sequence Precursor Program
Fiscal Year 2020 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

- Provide timely reports to support the annual Abnormal Occurrence Report to Congress and the annual Agency Action Review Meeting (an internal NRC meeting where the Agency reviews the effectiveness of the NRC's Operating Experience (OpE) program.
- Support to the NRC's OpE program in accordance with NRC Management Directive 8.7.
- Enhance realism of probabilistic risk assessment (PRA) guidance and codes.
- 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

- Provide the NRC's tool for long-term risk-informed trending of industry-wide operating experience of all events that occur at U.S. commercial nuclear power plants.
- Provide feedback to improve the realism of the NRC's SPAR and industry PRA models.
- Provide 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 trends and 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 2019 Accomplishments	FY 2020	FY 2021	FY 2022
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 2018 Annual Report including trend analyses to support RES input to the AARM	Complete 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

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

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

Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$0	1.2	$0	2.9	$0	2.9	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
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 2020 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 and component failure parameters employed in the NRC's standardized plant analysis risk (SPAR) models and other probabilistic risk assessment (PRA) studies.

Strategic Focus Areas:

- Provide timely communication of OpE to internal stakeholders for information and/or evaluation.
- Identify trends, recurring events, or significant safety issues for appropriate follow-up actions.
- Conduct periodic assessments of the OpE program to determine/confirm its effectiveness and to identify needed improvements.

Impact and Benefits

- Provide up-to-date event frequencies and component reliabilities for use in NRC and licensee PRA models to support plant licensing and oversight activities.
- Produce industry-wide 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).
- Maintain and update the publicly-available Reactor Operational Experience Results and Databases webpages on the NRC's public website 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).
- Manage and update the LER-Search public database (one of the most used NRC public webpages) containing searchable LERs and Inspection Reports.
- Identify 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 NRC.
- Commission directive (SRM SECY-98-228) to transfer OpE activities, ASP 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 2019 Accomplishments	FY 2020	FY 2021	FY 2022
Evaluation of Reactor OpE	Gathered and analyzed industry-wide OpE data from LERs and INPO for use in the PRA models covering initiating events, component and system performance	Gather and analyze industry-wide OpE data for use in the PRA models covering initiating events, component and system performance	FY annual activities plus perform parameter update of all basic events in PRA models	Gather and analyze industry-wide OpE data for use in the PRA models covering initiating events, component and system performance

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Resarch Contact

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

Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$1,997	2.3	$2,193	3.3	$1,900	3.0	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

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 NRC with nuclear licensee OpE failure information.
- Collaborate with EPRI and Owners Groups on more efficient collection, publication, and dissemination of plant operating data.

Probabilistic Flood Hazard Analysis Research and External Hazards Analysis
Fiscal Year 2020 Program Overview

Overview

- This program area includes tasks to develop a 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 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 National Institute of Standards (NIST) to update U.S. tornado hazard maps.

Impact and Benefits

- Provides 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.
- Provides 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).
- Maintain and enhance the NHID and technical engagement and coordination with other Federal agencies.

Drivers

- NRO User Need Request for Probabilistic Flood Hazard Assessment Research (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 (SRM-SECY-16-0144, ML17123A453) Process for Ongoing Assessment of Natural Hazards Information.

Key Deliverables

Year / Project Driver (Start - Stop)	FY 2019 Accomplishments	FY 2020	FY 2021	FY 2022
Phase I PFHA Research (Technical Basis)	Completed Technical Basis Research Projects	Publish Technical Basis Research Reports		
Phase II PFHA Research (Pilot Studies)	Developed Pilot Studies	Implement Pilot Studies	Finalize and publish Pilot Studies	Finalize and publish Pilot Studies
Phase III PFHA Research (Guidance)	Initiated discussion with User Office on Scope of Draft Guidance	1) Complete Scoping of Draft Guidance 2) Develop Initial Draft Guidance	1) Revise Draft Guidance 2) Internal Review and Concurrence	1) Publish Draft Guidance for Public Comment 2) Finalize Guidance
High Winds Research	Coordinated tornado hazard map research with existing NIST effort	Complete tornado hazard map updates and 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

- Joseph Kanney (Joseph.Kanney@nrc.gov), Hydrologist in the Division of Risk Analysis

Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$1,108	2.4	$521	1.9	$521	1.8	→
New Reactors	$ 447	1.6	$455	1.9	$300	0.9	↘
Total	$1,555	4.0	$976	3.8	$821	2.7	↘

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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 – Potential Climate Change Impacts on NPPs, SHAC-F for 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, Application of Point Precipitation Frequency Estimates to Watersheds, State of Practice for Dam Risk Assessment.

- 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 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).

Drug-and-Alcohol-Related Fitness-for-Duty and Fatigue Management Research
Safety Culture Inspections and Technical Assistance
Fiscal Year 2020 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.
- Support implementation of safety culture assessment in the Reactor Oversight Process.

Impact and Benefits

- Provide 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.
- Maintain 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 2011-002).
- Requests from the Office of Enforcement (OE), NRR, and the Regions on Safety Culture technical support and inspection support (NRR 2016-011 and OE 2015-001; NRR-2019-012).

Key Deliverables

Year / Project	FY 2019 Accomplishments	FY 2020	FY 2021	FY 2022
Fatigue Management and Fitness for Duty	Completed Technical Letter Report on prescription drug issues	1) NUREG on fitness for duty technologies 2) RG 5.73 – Fatigue Management	1) Development of Performance Metrics 2) Drug Prevalence Investigation International Program Review	1) Development of Urine Temperature Assessment Model 2) NUREG on fitness for duty technologies
Safety Culture	1) Provided Pilgrim Inspection Support 2) Provided Watts Barr Inspection Support 3) Held SC Meeting	1) Cross-Cutting Issues Working Group 2) SC Refresher Training & Training Plan	1) SC Counterpart Meeting 2) Assessor Desk Guide 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

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

Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$25	0.3	$80	0.9	$75	0.6	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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 (NIH/SAMSA) substance abuse and drug and alcohol testing research.
- Nuclear Energy Agency/Committee on the Safety of Nuclear Installations/Working Group on Human and Organisational Factors (NEA/CSNI/WGHOF) safety culture research.
- The Institute for Radiation Protection and Nuclear Safety (IRSN) safety culture research.

Agency Innovation
Fiscal Year 2020 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 Agency Innovation Forum (AIF) by providing an integrated software platform by which agency-wide staff level representatives can engage with one another.
  2) Supporting the AIF team in order to evaluate and disposition the 362 ideas transferred to the AIF from the Transformation Team and any other agency-level ideas that come from office panels.
  3) Providing expert assistance to help further develop the infrastructure needed for an efficient, end-to-end agency innovation program.
  4) Supporting the development of the transformation framework and initiative teams.

Strategic Focus Areas

- Efficient implementation and sustainability of innovative ideas to better serve the agency and its staff.

Impact and Benefits

- Allow staff to start thinking about the future, creating a cultural shift towards innovation and being a modern regulator.
- Futures Jam methodology will enable participative decision-making such that the staff can provide their feedback and insights regarding the futures assessment report.
- Provide cohesion among the separate innovation activities that the agency is undertaking.
- Provide the infrastructure needed for an efficient, end-to-end agency innovation program.

Drivers

- User Need request from the OEDO (Office of the Executive Director for Operations), EDO-2018-001, to develop the infrastructure for innovation efforts.
- SECY-18-0060, “Achieving Modern Risk-Informed Regulation.”
- Supplemental need to help support the AIF in order to evaluate and disposition the 362 ideas transferred from the AIF to the Transformation Team.

Key Deliverables

Year / Project	FY 2019 Accomplishments	FY 2020	FY 2021	FY 2022
Transformation Tiger Team	Supported Disposition of 362 ideas transferred to AIF			
OEDO User Need on Innovation	Developed, sustainable model for implementing approved Agencywide ideas	Implement sustainable agency-wide innovation program consistent with model developed in FY 2019	Compile lessons-learned and transition innovation program to a permanent place in the agency	
Futures Jam	Supported development and execution of Jam Session (June 18-20, 2019)			
Futures Core Team	Supported post Jam transformation strategy	Support transformation initiative teams and transformation effort		

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

- Amy D'Agostino (Amy.D'Agostino@nrc.gov), Human Performance Analyst in the Division of Risk Analysis.

Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$0	2.5*	$0	3.0*	$0	0	→

*Unbudgeted work to support OEDO initiative. In FY19, resources were shifted from planned human factors activities.
Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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 2020 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:

- Advance a standardized approach for conducting HRAs to support risk-informed decisionmaking.
- Complete efforts to support analyzing the use of FLEX equipment.
- Assess needed changes to HRA methods to support advanced reactor licensing.

Impact and Benefits

- Increase realism of the NRC's risk analyses by providing more credible HRA analyses.
- 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 identify appropriate methodologies for NRC staff use.
- Requests from NRR and the regions for assistance in modifying, improving, and developing HRA methodologies based upon identified programmatic issues.

Key Deliverables

Year / Project	FY 2019 Accomplishments	FY 2020	FY 2021	FY 2022
HRA Methodology	1) Developed Draft Integrated Human Event Analysis General (IDHEAS-G) Methodology for HRA method development 2) Developed Draft IDHEAS for Event and Condition Assessment (IDHEAS-ECA) Methodology for modeling accident and FLEX scenarios 3) Developed Draft IDHEAS-ECA Computer Tool	1) IDHEAS-G NUREG 2) IDHEAS-ECA NUREG 3) Completed IDHEAS-ECA Computer Tool 4) Draft IDHEAS Data RIL	1) IDHEAS Data NUREG 2)Technical Letter Report on Dependency	HRA method improvements in dependency, 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

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$427	3.4	$878	3.3	$850	3.0	↘

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE).

Contractor Support

- Sandia National Laboratories - HRA Method Development/IDHEAS Testing.
- Electric Power Research Institute (EPRI) - EPRI HRA Users Group.
- Halden - Halden Program Group (Man Technology Organization).

Collaboration and Resource Leveraging

- MOU between NRC and EPRI on Human Reliability Analysis.

Human Reliability Analysis Data
Fiscal Year 2020 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:

- Maintaining and update data needed to support HRA analyses.

Impact and Benefits

- Improve realism in Probabilistic Risk Assessments through development of better HRA methods and 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 2019 Accomplishments	FY 2020	FY 2021	FY 2022
HRA Database and HRA Methodology Improvement	Created Bilateral Agreement with Korean Atomic Energy Research Institute to analyze HRA data	1) SACADA modification to collect ex-control room data 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, Nuclear Regulatory Report (NUREG)

Office of Nuclear Regulatory Research Contact

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

Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$391	1.3	$300	1.6	$285	1.6	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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 NRC and EPRI on Human Reliability Analysis.
- MOU between 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.
- Potential, new collaborators include Entergy and the Nuclear Energy Agency.

Fire Protection Activities and Fire Risk Training
Fiscal Year 2020 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:

- Collaborate 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.

Impact and Benefits

- Reduce conservatism and uncertainties in fire PRA's 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

- Ensure realism in regulatory guidance and methods in response to an NRR User Need Request NRR-2008-003 (update in progress).
- Improve and maintain the knowledge and tools needed to support regulatory oversight activities.
- Confirmatory analysis and assessment of industry proposed new methods for fire PRA.
- Provide fire risk training to support NRC's policy to increase the use of PRA technology.

Key Deliverables

Year / Project	FY 2019 Accomplishments	FY 2020	FY 2021	FY 2022
Fire PRA Realism	Published draft NUREG-2230 for public comment	Publish final version NUREG-2230		
	Published draft NUREG-2178 volume 2 for public comment	Publish final version NUREG-2178 volume 2		
	Published NUREG-2232 and associated data	Conduct testing and analysis to expand transient fuel package models	Document additional transient fuel package testing and development of spread model	
	Working group completed draft NUREG-2233	Publish draft and final versions of NUREG-2233		
	Supported NRR and joint efforts with EPRI to improve fire PRA realism	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

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$770	2.9	$468	4.5	$401	3.7	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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.
- Organisation for Economic Co-operation and Development – Support for PRISME 3 and Incident Exchange Project.

Collaboration and Resource Leveraging

- MOU Between NRC and EPRI on Cooperative Fire Research.
- Committee on the Safety of Nuclear Installations Fire Propagation in Elementary Multi-Room Scenarios (PRISME 3).

High Energy Arcing Fault Hazard
Fiscal Year 2020 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 work to support resolution of pre-generic issue (GI) 018, "Proposed Generic Issue on High Energy Arc Faults Involving Aluminum."
- Continue work with the Nuclear Energy Agency (NEA) to complete the HEAF Phase 2 Project (Second Testing Phase of the HEAF 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.

Drivers

- Resolution of 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 decisionmaking.

Key Deliverables

Year / Project	FY 2019 Accomplishments	FY 2020	FY 2021	FY 2022
Pre-GI 0018	Conducted testing of Aluminum HEAF		Assessment of plant risk (GI Assessment Report)	
HEAF Initiating Event Frequency	Supported/reviewed OpE, draft frequencies			Finalize and publish
Phase II – International HEAF		Testing of OECD sponsored HEAF	Testing of OECD sponsored HEAF	Publish Results
Fire PRA Model Refinement		Conduct Decrement HEAF testing	Model refinement	Model refinement

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

Office of Nuclear Regulatory Research Contact

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Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$1,364	2.6	$590	1.0	$443	1.0	↘

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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 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 NRC and Japan's Nuclear Regulatory Authority (JNRA) on joint publication of relevant JNRA work.

Risk Analysis Research
Fiscal Year 2020 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 decisionmaking. 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

- Support efforts to increase the use of risk insights in regulatory decision making.
- Support licensing reviews through resolution of industry-identified probabilistic risk assessment (PRA) issues.
- Assess 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 staff's review of new methods and approaches proposed by industry).
- Supports the development of national consensus PRA standards.

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 2019 Accomplishments	FY 2020	FY 2021	FY 2022
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	Continue to 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
PRA Standards for LWR and non-LWR	Participated in JCNRM to develop PRA standards	Participate in JCNRM to develop PRA standards	Participate in JCNRM to develop PRA standards	Participate in JCNRM to develop PRA standards
RASP Handbook	Provided input for the RASP Handbook on hazards (high winds, flooding, fires)	Provide input for the RASP Handbook (as requested)	Provide input for the RASP Handbook (as requested)	Provide input for the RASP Handbook (as requested)

Incorporation of External Hazards into NRC Risk Tools		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 advanced reactor designs.	Start research into the gaps in current PRA tools and methods to fill these gaps using advanced methods such as dynamic PRA and other computational approaches.	1) Continue research into advanced PRA methods. 2) Begin development of PRA model for advanced reactor concept using advanced PRA methods.	1) Continue research into advanced PRA methods. 2) Finalize PRA model for advanced reactor concept.

Acronyms: Fiscal year (FY), NRC-developed Standardized Plant Analysis Risk (SPAR) plant-specific, probabilistic risk assessments (PRAs) models.

Office of Nuclear Regulatory Research Contact

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

Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$80	2.2	$311	1.0	$295	4.7*	→
Advanced Reactors	$10	0.1	$150	1.0	$300	1.0	→
Total	$90	2.3	$461	2.0	$595	5.7	→

*The significant increase in FTE corresponds to a shift in resources from the Level 3 PRA Project, which is nearing completion in FY 2021: the change in staff resources will be used to increase the number of SPAR models updated, incorporate new methods into SPAR models (IDHEAS-ECA, causal alpha factor for common failure etc.) and implement improved user interface to NRC's risk tools to support access to these tools by a broader scope of NRC staff.
Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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 supports the development of advanced risk analysis techniques and tools to support risk-informed decisionmaking.
- 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 2020 Program Overview

Overview

- This program area includes research to maintain and enhance 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 includes activities such as: updating and confirming PRA success criteria; developing approaches to assess the risk for new issues (e.g., NUREG-2195 on consequential steam generator tube ruptures issued in May 2018); and adopting new approaches (e.g., mitigating strategies - FLEX equipment) and technology (e.g., improved reactor coolant pump seals) within a risk-informed decision-making framework.

Strategic Focus Areas:

- Update SPAR models and the SAPHIRE code.
- Perform more SAPHIRE code updates in-house.
- Assess modeling needs to support advanced reactors.

Impact and Benefits

- 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 offices to develop risk insights using state-of-practice methods.
- Develop of methods for assessing risk of potential safety issues; and to understand 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 2019 Accomplishments	FY 2020	FY 2021	FY 2022
Risk Analysis Tools	• Updated SPAR models incorporating external hazards • Performed routine updates to 6 SPAR models with plant specific information) • Incorporated FLEX into 60 SPAR models • Incorporated advance reactor recirculation	• Continue updates to SPAR models incorporating external hazards • Continue routine updates with plant specific information (target 6 models a year) • Incorporation of FLEX into remaining SPAR	• Continue updates to SPAR models incorporating external hazards • Continue routine updates with plant specific information (target 6 models a year) • Direct support to Regional staffs and user office	• Continue updates to SPAR models incorporating external hazards • Continue routine updates with plant specific information (target 6 models a year) • Direct support to Regional staffs and user office

	pump seals in BWR SPAR models • Published Success Criteria NUREG • Provided direct support to Regional staffs and user office staff on use and implementation of models • Issued Technical Report on publicly available generic PWR and BWR SPAR models	models (total of 73 SPAR models) • Secure Portal (cloud) based SAPHIRE operational • Direct support to Regional staffs and user office staff on use and implementation of models • Develop applications for using risk tools to support broader risk-informed decisionmaking.	staff on use and implementation of models • Continue development and maintenance of risk applications for broader risk-informed decisionmaking • Incorporate IDHEAS-ECA into suite of risk tools.	staff on use and implementation of models • Continue development and maintenance of risk applications for broader risk-informed decisionmaking. • Apply IDHEAS-ECA to routine risk-informed decisions.
New and Advanced Reactor SPAR Models	• Maintained awareness of status of Vogtle 3/4 PRA development by licensee and Westinghouse • Maintained awareness of status of NUSCALE PRA development by applicant	• Update AP1000 SPAR model with Vogtle 3/4 plant specific design information for initial Vogtle 3/4 SPAR model • Assess current state of practice in the use of advance PRA methods (such as dynamic PRA) – this work supports current operating reactors as well.	• Update initial Vogtle 3/4 SPAR model with as-built plant specific information when available. • 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).

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

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$2,297	3.8	$2,096	4.1	$2,095	5.6	→
New Reactors	$0	0.1	$200	0.4	$100	0.2	→
Total	$2,297	3.9	$2,296	4.5	$2,195	5.8	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE).

Contractor Support

- Idaho National Laboratory (INL) – support in the development and maintenance of SAPHIRE, SPAR All Hazards, Interactions with EPRI under an 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), 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, US Airforce, 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 2020 Program Overview

Overview

- This program area 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 decisionmaking.

Strategic Focus Areas:

- Complete and document the Level 3 PRA work.
- 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 relation to the Commission Safety Goals to support the use of risk insights in decisionmaking.
- 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 2019 Accomplishments	FY 2020	FY 2021	FY 2022
Level 3 PRA Activities	Finalized internal Technical Reports on: • Background, Site and Plant Description, and Approach • Reactor at-power PRA for Internal Events and Floods	Finalize internal Technical Reports on: • Reactor at-power PRA for Internal Fires and External Hazards • Dry Cask Storage PRA • Reactor Low Power and Shutdown PRA for Internal Events • Spent Fuel Pool PRA	Finalize internal Technical Report on: • Integrated Site Risk Issue Draft NUREG for public comment	Publish Final NUREG on Level 3 PRA Project

Use of Expert Judgement	Published final NUREG/CR on Piloting of Expert Elicitation Process			

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

Office of Nuclear Regulatory Research Contact

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

Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$250	5.0	$121	7.1	$100	1.0	↘

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE).

Contractor Support

- Sandia National Laboratories (SNL) – Human Reliability Analysis support.
- Energy Research Inc. (ERI) – Low Power and Shutdown Level 2 PRA support, Level 2 PRA modeling and analysis support, and Integrated Site and Multi-unit Risk assessment support.
- Pacific Northwest National Laboratory (PNNL) – Low Power and Shutdown Phenomena Identification and Ranking Table (PIRT) development support.
- Brookhaven National Laboratory (BNL) – Level 3 PRA Project Peer Review support.
- Idaho National Laboratory (INL) – PRA Model development using SAPHIRE.

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 2020 Program Overview

Overview

- This work addresses an acceptable approach for determining whether a probabilistic risk assessment (PRA), that is used to support a regulatory application, is sufficiently acceptable to provide confidence in the results. Moreover, it addresses the development of guidance for licensing and oversight of risk-significant technical areas.

Strategic Focus Areas:

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

Impact and Benefits

- Provides broadly accepted approaches for conducting PRA analyses, which allows for greater alignment between staff and licensees 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 generate fewer requests for additional information.
- Reduces uncertainties in determining structural safety margins.
- Endorses consensus PRA standards in support of risk-informed decisionmaking.
- 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 2019 Accomplishments	FY 2020	FY 2021	FY 2022
ASME/ANSI Standard for Level 1/LERF LWR PRA – at-power conditions	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 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
ASME/ANS Standard for Level 3 LWR PRA	Finalizing revision to standard	Finalizing revision to standard	Finalizing revision to standard	Publication as ANSI Standard
ASME/ANS Standard for Level 1/LERF LWR PRA – low power shutdown	Finalizing revision to standard	Finalizing revision to standard	Finalizing revision to standard	Publication as ANSI Standard

ASME/ANS Standard for Level 1-2-3 non-LWRs PRA	Finalizing revision to standard	Finalizing revision to standard	Publication as ANSI Standard	NRC endorses in new RG
ASME/ANS Standard for Level 1/LERF adv-LWR PRA – design certification stage	Finalizing revision to standard	Finalizing revision to standard	Publication as ASME/ANS for trial use	
NEI 17-07	NEI revised based on pilots and NRC issued approval letter		NRC endorses in Rev 3 to RG 1.200	
Regulatory Guide 1.200		Draft for public comment	Publish Rev 3	Publish Rev 4
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 3) Complete field research on HF in encoded UT	Technical Letter Report on HF in encoded UT	NUREG 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)

Office of Nuclear Regulatory Research Contact

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

Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$186	4.3	$440	1.4	$345	1.4	↘
New Reactors	$385	1.7	$385	1.0	$385	1.0	→
Total	$571	6.0	$825	2.4	$730	2.4	

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE).

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, Low Power and Shutdown (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 2020 Program Overview

Overview

- This research 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

- 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.).
- Complete state-of-practice updates consistent with the cost-benefit improvement project.
- Address obsolescence issues related to computing architecture to improve flexibility.
- Complete MACCS near-field atmospheric transport modeling updates and guidance to support emergency planning applications. Use information exchanges to maximize external and international resource leverage.
- 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

- 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 Severe Accident Mitigation Design Alternative (SAMDA) and Severe Accident Mitigation Alternative (SAMA) environmental reviews minimizes litigative risk in large scale applications such as license renewals, subsequent license renewals, and design certifications.
- MACCS studies [e.g., State-of-the-Art Reactor Consequence Analyses (SOARCA), spent fuel pool studies, Containment Protection and Release Reduction (CPRR)] enable risk-informed decisionmaking by providing unique insights on margins to the quantitative health objectives (QHOs).
- MACCS provided technical basis for burden reduction rulemaking such as decommissioning and emergency preparedness (EP) small modular reactor (SMR) rule.

Drivers

- User Need Request NRR-2017-008, “Consolidated Cost-Benefit Guidance Improvement Activities.”
- DOE/EHSS Safety Software Quality Assurance Audit for its Toolbox of computer codes.
- Draft NRR User Need Requests covering MACCS Code Suite Maintenance, Development, Documentation, Verification, Modernization, Distribution, User Support, Workshops, and International Collaboration.
- Non-LWR Implementation Action Plan Strategy 2, “Acquire/develop sufficient computer codes and tools to perform non-LWR regulatory reviews.” Although this is an advanced reactor driver, it is also applicable to emergency planning calculations under the operating reactor business line.

Key Deliverables

Year / Project	FY19 Accomplishments	FY20	FY21	FY22
NRR-2017-008	• Completed integration of alternative HYSPLIT-based atmospheric transport model into MACCS • Completed integration of alternative economic model into MACCS	• Release major upgrade to MACCS (V4.0) with alternative atmospheric and economic models and associated documentation • MACCS Input Parameter Technical Bases Report	• Various MACCS updates to support cost-benefitguidance including monetization of cancer incidence	Various MACCS updates to support cost-benefit guidance improvement program
Draft NRR User Need Request	• Draft MACCS User Guide for internal review • MACCS dosimetry updates • IMUG 2019 Meeting	• MACCS User Guide • MACCS Theory Manual • MACCS Verification Report and Support DOE/EHSS SQA Audit • MACCS Architecture Modernization • IMUG 2020 Meeting	• MACCS Architecture Modernization • IMUG 2021 Meeting	• MACCS Architecture Modernization • IMUG 2022 Meeting

Acronym: Fiscal year (FY)

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

Office of Nuclear Regulatory Research Contact

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

Resources

	FY19 Actuals		FY20 Enacted		FY21 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$652	2.4	$420	2.0	$300	2	→
Advanced Reactors	$200	0.1	$200	0.4	$200	0.4	↗

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

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

Collaboration and Resource Leveraging

- MACCS development is leveraged domestically (e.g., DOE, NOAA) and internationally via 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.

WinMACCS, MelMACCS, and SecPop Code Development and Maintenance
Fiscal Year 2020 Program Overview

Overview

- This research 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; and
  - 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

- Draft NRR User Need Requests covering 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	FY19 Accomplishments	FY20	FY21	FY22
Draft NRR User Need Request	• Publish SecPop NUREG User Guide, Theory Manual, and Verification Report • Completed draft report on COMIDA2 models and parameters that warrant technical basis updates	• Release AniMACCS publicly to user community • Publish MelMACCS NUREG User Guide, Theory Manual, and Verification Report • Complete COMIDA2 input parameter technical basis report	• Update SecPop code to include 2020 US Census	• WinMACCS Graphical User Interface Modernization

Acronym: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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

Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$142	0.0	$150	1.5	$50	1.0	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Sandia National Laboratories – MACCS code maintenance, development, and verification and validation.
- Center for Nuclear Waste Regulatory Analyses - Review of MACCS COMIDA2 Food Chain Model.

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.

Consequence Analysis
Fiscal Year 2020 Program Overview

Overview

- This research 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 consequence analyses expertise.

Impact and Benefits

- Commission-directed 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 emergency planning zone (EPZ) size reductions.
- Incident response E-library and ETE studies improve NRC incident response readiness.

Drivers

- SRM-SECY-11-0089 (Level 3 PRA Project).
- User Need Request NRR-2017-008, “Consolidated Cost-Benefit Guidance Improvement Activities.”
- Draft NRR User Need Request (Consequence Analysis Applications)
- User Need Request NSIR-2014-002, “Evacuation Time Estimate Studies.”
- User Need Request NSIR-2016-001, “Incident Response Electronic Library.”
- User Need Request NSIR-2017-002, “Support Emergency Preparedness Rulemaking and Related Activities.”

Key Deliverables

Year / Project	FY19 Accomplishments	FY20	FY21	FY22
SRM-SECY-11-0089	• Level 3 PRA Project offsite consequence analysis for sequences initiated by all hazards	• Level 3 PRA Project – Complete offsite consequence analysis for low power and shutdown sequences and spent fuel pool releases • Level 3 PRA Project – Complete NUREG document-ation of all offsite consequence analyses	• Level 3 PRA Project – Complete NUREG documentation of all offsite consequence analyses	
NRR-2017-008	• Cost-Benefit Guidance Update Appendix H on Severe Accidents	• Replacement Energy Costs NUREG Study • Cost-Benefit Guidance Update Appendix K on Morbidity Valuation	• Consequence analysis to inform cost uncertainty for use in regulatory cost-benefit applications	

Project \ Year	FY19 Accomplishments	FY20	FY21	FY22
Draft NRR User Need Request	• Completed SOARCA Surry Uncertainty Analysis NUREG report • Completed draft Research Information Letter (RIL) for inter-office review on the many benefits and uses of the SOARCA project	• Complete SOARCA Uncertainty Analysis Summary NUREG report	• Analysis to identify which accident mitigation equipment are most important in severe accidents for SDP and reactor oversight (leverage SOARCA UA and L3PRA) • NUREG study to inform when site-specific SAMDA are needed in new reactor applications or whether generic SAMDA could be used	
NSIR-2014-002	Completed NUREG report on research study on Evacuation Time Estimates	Support NSIR development of updated ETE guidance in NUREG/CR-7002		
NSIR-2016-001			Complete update of Op Center electronic library of information potentially useful in an emergency	Complete NUREG report of electronic library information useful for MACCS consequence analyses
NSIR-2017-002	Complete guidance on dose-distance calculations to support EPZ size determinations	Evaluation of non-radiological consequences of evacuation and relocation	Evaluation of MACCS code updates and their impact on protective action recommendations	Consider updated PAR study to better risk-inform EP (future user need)

Acronym: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

	FY19 Actuals		FY20 Enacted		FY21 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$606	3.2	$500	3.8	$300	3	→
New Reactors	$300	0.5	$90	0.5	$80	0.5	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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 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.

MELCOR Code Development and Maintenance
Fiscal Year 2020 Program Overview

Overview

- This research enables 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 decisionmaking.

Strategic Focus Areas

- Efficiently maintain code at state-of-the-practice especially for a variety of regulatory applications including ATF and non-LWRs, 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.
- 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 supported many regulatory analyses, inspection support, emergency response support and formal studies activities that are described in the Source Term and Accident Consequences research summary, such as
  - Technical Specifications Amendments.
  - Formal studies (e.g., Spent Fuel Pool Study, containment protection and release reduction rulemaking) that led to hundreds of millions of averted costs.
  - Updates to SPAR models and development of SAMG insights.
  - Rulemaking technical basis (e.g., decommissioning rule, SFP 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 research summary.

Drivers

- Old (retired) User Need Requests provided resources for MELCOR Code Development and Maintenance (e.g., NRR-2004-001 & NRR-2005-005); new User Need Requests need to be developed.
- NRR-2015-005 (RAR) - Independent Review/Update of Regulatory Guide 1.183, "Alternative Radiological Source Term for Evaluating Design Basis Accidents at Nuclear Power Reactors."
- Non-LWR Implementation Action Plan Strategy 2, "Acquire/develop sufficient computer codes and tools to perform non-LWR regulatory reviews."

Key Deliverables

Year / Project	FY19 Accomplishments	FY20	FY21	FY22
MELCOR Development	Released (interim) of MELCOR 2.2 with code stability & robustness improvements for source term prediction	Release of MELCOR 2.2 build 15254 with improvements to fission product models and	Release (interim) of MELCOR 2.3 with code stability & robustness improvements for source term prediction	Release of MELCOR 2.4 with improvements to fission product models and code

		code stability including ATF and non-LWRs	including ATF and non-LWRs	stability including ATF and non-LWRs
MELCOR user group workshops and training	Conducted FY19 training workshop	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 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)

Office of Nuclear Regulatory Research Contact

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Resources

	FY19 Actuals		FY20 Enacted		FY21 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$2,044	2.8	$502	1.0	$250	1	→
Advanced Reactors	$728	0	$1,113	0.4	$800	0.4	↘

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

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 over 25 member countries). NRC receives approximately $1M annually from fees collected from international organizations (not reflected in above amount).

Severe Accident Verification and Validation
Fiscal Year 2020 Program Overview

Overview

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

Strategic Focus Areas

- Lead US coordination between Japan, DOE, and industry cooperation on Fukushima forensics.
- Rebuild severe accident phenomenology expertise due to losses 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.
- Cost for participation in cooperative experimental programs is offset by funding from the Cooperative Severe Accident Research Program (CSARP).

Drivers

- 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	FY19 Accomplishments	FY20	FY21	FY22
CSNI/NEA PreADES & ARC-F	Published annual report	Publish annual report	Publish annual report	
CSNI/NEA BIP	Published summary experimental report			
CSNI/NEA STEM	Conducted final set of iodine experiments	Decide on STEM II follow-on (ESTER)		
IRSN DENOPI experiment	Developed test report on Zr oxidation under air-steam conditions	MEDEA steam/water spray penetration into bundle test; MIDI and ASPEC – spray cooling test matrix development	Synthesize of cladding oxidation test results; Conduct ASPEC spray cooling	MIDI test report
CSNI/NEA HYMERES (2017-2020)	Conducted test campaign at the PANDA & MISTRA facilities. Evaluate data and help develop CSNI report.	Preparation and test campaign in PANDA & MISTRA. Prepare data evaluation and reporting.	Preparation and test campaign in PANDA & MISTRA. Prepare data evaluation and reporting.	
CSNI/NEA ROSAU	Launched experimental program. Aligned on a test matrix and needed facility modifications.	Agree on the first test to be carried out. Carry out necessary facility modification.	Conducts test (TBD), analysis and reporting	Conducts test (TBD), 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 Behavior of Iodine Project (BIP) – containment iodine chemistry experiments conducted at the Canadian National Laboratory.
- OECD/NEA/CSNI Source Term Evaluation and Mitigation – containment iodine chemistry and ruthenium transport experiments performed at the Cadarache Nuclear Center in France.
- IRSN DENOPI experiment 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).
- Reduction of Severe Accident Uncertainties (ROSAU) project - Ex-vessel molten core concrete interaction (MCCI) experiments conducted at the Argonne National Laboratory. CSNI/NEA is in the process of launching a new project on MCCI in 2019.

Office of Nuclear Regulatory Research Contact

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

Resources

	FY 2019 Actuals		FY2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trending
Operating Reactors	$873	1.1	$200	1.0	$100	1.0	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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 BIP - Iodine separate effects experiments.
- NEA/CSNI STEM - Iodine and Ruthenium separate effects 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).
- Institute for Radiological Protection and Nuclear Safety (IRSN).

Accident Progression and Source Term Analysis
Fiscal Year 2020 Program Overview

Overview

- This covers 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.
- 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.
- SECY papers that enables staff to keep abreast of the latest international severe accident phenomenological issues such as through Fukushima research.
  - SECY-15-0065, “Proposed Rulemaking: Mitigation of Beyond-Design-Basis Events,” involves coordination of voluntarily Severe Accident Management Guidelines (SAMGs) and the integrated response capability under 10 CFR 50.155(b) for the Reactor Oversight Program.
  - SECY-15-0137 “Proposed Plans for Resolving Open Fukushima Tier 2 and 3 Recommendations” which supports adding realism to MELCOR to support risk-informed decisions.
- 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 research one pager.

Key Deliverables

Year / Project	FY19 Accomplishments	FY20	FY21	FY22
Duane Arnold SPAR model development (RES/DRA led)	Published NUREG-2236	Decide on the next NPP for SPAR development		
Site Level 3 analysis (reactor and spent fuel pools	Documented spent fuel pool analysis	Publish draft NUREGs for public comments	Address public comments	Publish final NUREGs.
Research and Technical Assistance on SA – University of Wisconsin	Maintained state-of-practice for FCI phenomenology and the TEXAS code§	Maintain state of practice for FCI phenomenology and the TEXAS code	Maintain state of practice for FCI phenomenology and the TEXAS code	Maintain state of practice for FCI phenomenology and the TEXAS code
Re-evaluation of the Fission Product Release and Transport for a Fuel Handling Accident [FHA]	Provided fission product assessment and FHA reports.			
Ad Hoc support to NRR staff review of NPP licensing amendment	Provided assistance as requested	As requested	As requested	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	TEPCO continues to provide Fukushima forensic investigation and data to continue forensics analysis and code improvements	TEPCO continues to provide 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 time-scale that it is not feasible to incorporate into MELCOR.
Acronym: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

- Richard Lee, Ph.D. (Richard.Lee@nrc.gov), Branch Chief in the Division of Systems Analysis.

Resources

	FY19 Actuals		FY20 Enacted		FY21 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trending
Operating Reactors	$86	0.7	$275	2.2	$50	1.7	→
New Reactors	$305	0.2	$150	0.2	$0	0	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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 2020 Program Overview

Overview

- This research 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 former Office of New Reactors (NRO)-supported 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), siting and effluent codes (NRCDose & GALE), and control room habitability (HABIT) into this research activity.
- 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 have 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 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 and 10 CFR Part 100.
- The NRCDose 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 required10 CFR Part 50, Appendix A, GDC 19 and RG 1.78.

Drivers

- User Need Request NSIR-2015-002, "User Need Request to Support and Enhance the RASCAL Computer Code for Use in the U.S. Nuclear Regulatory Commission Emergency and Incident Response Centers," requests the Office of Nuclear Regulatory Research's (RES's) 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.
- 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," requests RES assistance in addressing specific enhancements specific enhancements and continued code support for the SNAP/RADTRAD computer code.

Key Deliverables

Year / Project	FY19 Accomplishments	FY20	FY21	FY22
RASCAL 5.0 NSIR-2015-002	Initialized RASCAL 5.0 (Java) release for testing.	Update RASCAL 5.0 with all NPP Models for testing.	Final release of RASCAL 5.0.	Code maintenance and add user requested features into RASCAL 5.0.
SNAP/RADTRAD 5.0 NRR-2017-012	Refactored the Java code in RADTRAD-AC.	Release of the refactored RADTRAD-AC (v5.0).	Code Maintenance	Code Maintenance

Acronym: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

	FY19 Actuals		FY20 Enacted		FY21 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$906	1.1	$650	2.0	$372	2	↗
New Reactors	$121	0.3	$300	0.5	$300	0.6	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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.
- 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

- Leverage the resources (both financial and technical) of the cooperative research agreements of RAMP.

- 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.

Radiation Protection Code Development and Maintenance
Fiscal Year 2020 Program Overview

Overview

- This research 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 assist NRC staff and licensees in developing realistic worker doses for MCNP input decks and code execution. Users can generate realistic dose limits based upon actual scenario-based geometries (worker positioning) to more accurately calculate dose 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 by staff members and NRC licensees to calculate occupational dose to the skin resulting from exposure to radiation emitted from hot particles or other contamination on or near the skin as required by 10 CFR Part 20.1201(c). Health physicists from the NRC Regions have requested the addition of neutron dosimetry and an updated GUI to the VARSKIN computer code.

Key Deliverables

Year / Project	FY19 Accomplishments	FY20	FY21	FY22
RAMP Website development and Technical Support SECY-14-0117	Updated to latest version of website software (Drupal).	Maintain and update RAMP website pages.	Maintain and update RAMP website pages.	Maintain and update RAMP website pages.
VARSKIN Code Development SECY-14-0117	Continued support for development of VARSKIN 7.0 which includes eye dosimetry, neutron dosimetry, and alpha dosimetry.	Release VARSKIN v7.0.	Code Maintenance and Support.	Code Maintenance and Support.
PiMAL Computer Code SECY-14-0117	Code Maintenance – No Development Work.	Code Maintenance – No Development Work.	Code Maintenance – No Development Work.	Code Maintenance – No Development Work.
RadToolbox SECY-14-0117	Code Maintenance – No Development Work.	Code Maintenance – No Development Work.	Code Maintenance – No Development Work.	Code Maintenance – No Development Work.

Acronym: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

	FY19 Actuals		FY20 Enacted		FY21 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$391	1.4	$220	2.0	$85	2.0	→
Advanced Reactors	$149	0	$200	0.4	$200	0.4	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
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

- Leverage the resources (both financial and technical) of the cooperative research agreements of the RAMP.
- Leverage resources to incorporate the DCFPAK into RAMP.

Radiation Protection Analysis
Fiscal Year 2020 Program Overview

Overview

- This research includes the evaluation of radiation protection and event data, development of dosimetry tools, and the monitoring of ongoing radiation health effects research to ensure 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, e.g., SHINE radioisotope production facility licensing application.
- 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 REIRS database access efficiency through concept modernization, e.g., posting verified summary dose data on-line 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., Radiation Exposure Information and Records System (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 which require expertise and technical support for various subjects related to radiation dosimetry and health effects.
- User Need Request NRR-2013-011, "Support from the Office of Nuclear Regulatory Research in the Review and Evaluation of Chapter 4 and Chapter 13 of the Radioisotope Production Facility Applications Submitted by Shine Technologies, Inc."

Key Deliverables

Year / Project	FY19 Accomplishments	FY20	FY21	FY22
NUREG-0713, "Annual Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities"	Published Volume 38: "2017: Fiftieth Annual Report"	Publish Volume 39: "2018: Fifty-First Annual Report"	Publish Volume 40: "2019: Fifty-Second Annual Report	Publish Volume 41: "2020: Fifty-Third Annual Report
NUREG-0090, "Annual Report to Congress on Abnormal Occurrences" (FY19 – FY22)"	Published Volume 41: "Fiscal Year 2018"	Publish Volume 42: "Fiscal Year 2019"	Publish Volume 43: "Fiscal Year 2020"	Publish Volume 44: "Fiscal Year 2021"

Year / Project	FY19 Accomplishments	FY20	FY21	FY22
User Need Request NRR-2013-011 (Licensing review support to the Shine Technology Inc.)	Provide technical supports and licensing review to Shine Technology Inc. licensing applications, including internal and external radiation dose assessments, radiation shielding design validations, and accidental consequence analysis and surveillance requirements. Specific milestones and due dates are TBD by NRR.			
Regulatory Guide Support	Revised RG 8.29 and RG 8.36. Completed DG for 8.39 Phase 1.	Review RG 8.36 establish working group to DG for RG 8.36; and publish RG 8.39 Phase 1.	Complete DG for RG 1.78, and RG 8.36. Prepare revisions for DG for RG 8.39 Phase 2.	Complete DG for RG 8.39 Phase 2. Complete RG 8.36 and 1.78.

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

	FY19 Actuals		FY20 Enacted		FY21 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$270	1.9	$300	1.5	$240	1.5	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)

Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- ORAU – Radiation Exposure Information and Records System (REIRS) and the NRC Employee Database System (EEDS).
- North American Technical Center – Membership in the OECD/NEA and IAEA's Information System on Occupational Exposure (ISOE).

Collaboration and Resource Leveraging

- Monitor, review and provide feedback/comments on the low dose research being performed by the Department of Energy - Nuclear Energy Advisory Committee, IAEA, NCRP, ANSI and ISO.
- Nuclear Energy Agency (NEA) – ISOE.

Engineering Research Activities

Cable and Equipment Aging
Fiscal Year 2020 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:

- Collaboration 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.
- Assessing 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

- Clarify 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 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 in SRM-SECY-14-0016 to evaluate the aging of cables and cable systems during the subsequent license renewal period.
- 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 2019 Accomplishments	FY 2020	FY 2021	FY 2022
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 began thermal and radiation aging at Sandia National Laboratories (SNL)	Cables undergoing thermal and radiation aging at SNL followed by LOCA testing at Oak Ridge National Laboratories (ORNL)	Cables undergoing thermal and radiation aging at SNL followed by LOCA testing at ORNL	Conduct LOCA Testing of National Institute of Standards and Technology (NIST) Aged Cables at ORNL

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) evaluated the data collected by EPRI from the licensees	PNNL performs testing on medium voltage cables and issues final report		

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Resarch Contact

- Ronaldo Jenkins (Ronaldo.Jenkins@nrc.gov), Branch Chief in the Division of Engineering.

Resources

	FY 2019 Actuals		FY 2020 Enacted		FY21 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$1129	1.9	$1757	2.0	$1691	2.0	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- National Institute of Standards and Technology (NIST) – Assessment of Condition Monitoring Methods for Electrical Cables.
- PNNL – Assessment of EPRI's Tan Delta Approach to Manage Cables in Submerged Environments.
- ORNL – Conduct LOCA Test on NIST Aged Cables.

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 the 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 NRC and JNRA discuss and exchange information on ongoing research projects related to cable aging.

Electrical System Evaluation
Fiscal Year 2020 Program Overview

Overview

- This program area includes research on the evaluation of electrical power distribution systems at nuclear power plants including switchgear, batteries, and generators as well as for backup and emergency power scenarios.

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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 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 2019 Accomplishments	FY 2020	FY 2021	FY 2022
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 and comments being discussed	RG and Final Report issued		
UNR NRR-2018-XXX-2: UNR identified to be developed for Developing a RG addressing IEEE Standard 946 and NUREG/CR 7229 (Battery/Charger Fault Calculations).		Draft RG	Final RG	
Revision of RG 1.89 to new IEC/IEEE Standard	Draft RG developed by NRR and comments from the Office of Nuclear Regulatory Research (RES) provided	Final RG		
Revision of RG 1.9 addressing new revision to IEEE 387-emergency diesel generator (EDG)		Draft RG transmitted to RES	Final RG	

HEAF Testing electrical engineering input and review	On-going staff support	On-going staff support	On-going staff support	On-going staff support
Environmental Qualification (EQ) Inspection, Training, and Issue technical consulting and instruction	On-going staff support	On-going staff support	On-going staff support	On-going staff support
IEEE Standards Support	On-going staff support	On-going staff support	On-going staff support	On-going staff support

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Resarch Contact

- Ronaldo Jenkins (Ronaldo.Jenkins@nrc.gov), Branch Chief in the Division of Engineering.

Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$423	2.3	$736	4	$792	4	↘

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- None.

Collaboration and Resource Leveraging:

- Memorandum of Understanding (MOU) between NRC and the Electric Power Research Institute (EPRI) for cooperative research concerning electrical system evaluation.

Safety of I&C
Fiscal Year 2020 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 in connection with the Digital I&C Integrated Action Plan (IAP).

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 plans (RIS [Regulatory Issue Summary] 2002-22) and 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 an Integrated Action 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 2019 Accomplishments	FY 2020	FY 2021	FY 2022
User Need Request (UNR) NRR-2018-001: Investigate the implications of the use of embedded digital devices and evolving technologies (FY18-FY20)	Scoping Study Technical letter report issued	Final report		
UNR NRR-2018-003: Investigate the implications of, and ways to mitigate, common-cause failures in applications of digital technology (FY18-FY20)	Task 1 Draft Technical letter to staff for review and comment	Final report		

UNR NRR2018004: Investigate opportunities for the use of risk insights in the licensing of applications of digital technology (FY19-FY23)		Draft report on approaches outside US nuclear and on development	Draft and Final Reports	Draft and Final Reports
Review of industry standards and participation in standards development EPRI MOU & Halden Support	Staff support completed	On-going staff support	On-going staff support	On-going staff support

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

- Ronaldo Jenkins (Ronaldo.Jenkins@nrc.gov), Branch Chief in the Division of Engineering.

Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$2695	9.9	$2487	8.3	$2492	8.8	↘

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Oak Ridge National Laboratories (ORNL) – Investigate Embedded Digital Devices.
- Idaho National Laboratory (INL) – Investigate CCF.
- A) NUMARK B) IESS – A) Investigate the use of risk insights; B) Estimate failure frequencies of DI&C Systems and Uncertainties.

Collaboration and Resource Leveraging

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

Security of I&C
Fiscal Year 2020 Program Overview

Overview

- This program area primarily encompasses research on the cybersecurity of instrumentation and control (I&C) systems in NRC-licensed facilities.

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.
- Clarify staff guidance for addressing cybersecurity in licensing actions related to digital I&C (DI&C) modifications.
- Confirm the plant resilience against geomagnetic disturbances.
- Expand the use of risk information to inform cybersecurity evaluations.

Drivers

- Response to Commission direction in SRM-SECY-15-0106 and SECY-16-0070 to develop an Integrated Action Plan to Modernize Digital Instrumentation and Controls Regulatory Infrastructure.
- 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

Year / Project	FY 2019 Accomplishments	FY 2020	FY 2021	FY 2022
Research Assistance Request (RAR): Technical Assistance for an assessment of power reactors cybersecurity program (FY 2019)	Technical support completed			
User Need Request (UNR) NSIR-2019-XXX*: Use of Risk Information and Risk Analysis Approach in the Security Regulatory Program (future)		Research on risk insights for assessing cybersecurity	Draft reports on methods for risk-informing cybersecurity	Draft and Final Reports
Review of industry standards and participation in standards development related to cyber security / EPRI MOU Support	Staff support completed	On-going staff support	On-going staff support	On-going staff support

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

- Ronaldo Jenkins (Ronaldo.Jenkins@nrc.gov), Branch Chief in the Division of Engineering.

Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$293	0.2	$184	1	$309	0.5	↗

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Idaho National Laboratory (INL) – Assistance in Assessment of the Cybersecurity Program.
- TBD – Risk Informed Security (addressed both physical and cybersecurity).

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 2020 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 and 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

- Commission directions in SRM-SECY-16-0144 and SRM-SECY-16-0142.
- 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.

Key Deliverables

Year / Project	FY 2019 Accomplishments	FY 2020	FY 2021	FY 2022
UNR NRO-2015-006 - Research to develop the technical bases to support revision to Regulatory Guide (RG) 1.208	Technical letter report on seismic site response calculations	Technical letter reports on incorporating site response into Probabilistic Seismic Hazard Analyses	Technical letter report on seismic hazard and ground motion models	Finalization of full draft of RG 1.208
UNR NRO-2015-008 - Research to develop the technical bases to support revisions to RG 1.198 and the Standard Review Plan (SRP)	A liquefaction database developed and currently available via collaborator's website	Probabilistic liquefaction model development	Technical letter report on probabilistic liquefaction model development	Update of RG 1.198 and SRP

SGSERP - Seismic source characterization, ground motion models, and seismic hazard calculations	Initial research on the differences of seismic hazard results between the NRC and USGS models	Technical Letter Reports on seismic hazards and source characterization in the central and eastern US	Technical Letter Report on updated seismic hazard and ground motion models	Updates to RGs and SRP

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Resarch Contact

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Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$1,022	2.6	$382	1.9	$576	1.9	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- U.S. Geological Survey (USGS) – Research to support the 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 2020 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

- Response to Commission direction in SRM-SECY-14-0016 to evaluate the structural integrity of concrete during the subsequent license renewal period.
- User Need Requests (UNRs) for assistance in enhancing regulatory guidance for performing structural integrity calculations, analyzing structural degradation, and conducting periodic inspections or surveillances.
- Seismic, Geotechnical, and Structural Engineering Research Plan 2017-2021 (SGSERP).

Key Deliverables

Year / Project	FY 2019 Accomplishments	FY 2020	FY 2021	FY 2022
UNR NRR-2012-004 – Alkali-Silica Reaction (ASR) Research	Beam specimens and blocks tested. Obtained extensive data on ASR expansion.	Technical letter reports on project outcomes	Development of Draft Regulatory Guidance on ASR affected concrete	Publication of Regulatory Guidance on ASR
UNR NRR-2015-007 – Research on the Effects of Irradiation on Concrete Structures	A draft NUREG was issued and reviewed by staff	Development of interim technical documents	Accelerated testing and modeling/simulation of concrete degradation	Technical letter reports and needed updates to NUREG-1801

SGSERP – Aging and Degradation of Post-tensioned Concrete Containments		Review of creep and shrinkage of post-tensioned containment	VERCORS 1/3 scale containment testing	Technical letter reports and needed updates to NUREG-1801
SGSERP - Risk-Informed, Performance-Based (RIPB)		Regulatory pathways for RIPB seismic safety	Regulatory pathways for RIPB seismic safety	Regulatory Guide on RIPB approaches in seismic safety

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$2437	6.9	$2580	6.9	$2546	6.8	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

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 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 Observatory of Durability of Reinforced Contrete Structures (ODOBA).
- MOU between NRC and the Japanese Nuclear Regulation Authority (JNRA).

Aging and Materials Research Activities

Advanced Manufacturing Technology (AMT) Action Plan
Fiscal Year 2020 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.
- Keep aware of developments in pertinent AMTs and of applications for the use of AMT-made 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

- Develop revision to and implement the Agency Action Plan for AMTs.
- Implement the External Interaction Plan.
- Develop and implement the Knowledge Management Plan.
- Establish a knowledge base for AMTs using U.S. Department of Energy (DOE) laboratory contracts and external interactions.
- Provide support to the Office of Nuclear Reactor Regulation (NRR) and Regional Offices for the independent evaluation of licensee applications of AMTs in safety significant components.

Driver

- Agency Action Plan for AMTs.

Key Deliverables

Year / Project	FY 2019 Accomplishments	FY 2020	FY 2021	FY 2022
AMT Action Plan	External Interaction Plan; NUREG/CP-0310, published July 2019	Revised external interaction plan; Knowledge Management Plan	NDE for AMTs Modeling and Simulation for AMTs	

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Resarch Contact

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Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$560	0	$526	1.5	$547	1.5	↗

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
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.
- Oak Ridge National Laboratories (ORNL) – AMTs.

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.
- Working towards agreement with NIST/EWI Additive Manufacturing Consortium.

Evaluation Techniques (NDE)
Fiscal Year 2020 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 nondestructive examination.
- 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 2019 Accomplishments	FY 2020	FY 2021	FY 2022
User Need Request (UNR) NRR-2013-009, Evaluating the Reliability of NDE for Vessels and Piping, Task 5 – Cast Austenitic Stainless Steel (CASS) Examination Wrap-Up (FY1978 – FY19)	Pacific Northwest National Laboratory (PNNL)-27712. Interim Analysis of the EPRI CASS Round Robin Study. Nov 2018. NUREG/CR-7263. NDE Reliability Issues for the Examination of CASS Components. Sep 2019.	Technical letter report on CASS round robin analysis with specimen data revealed (on hold pending release of flaw true state by EPRI)		

UNR NRR-2013-009, Task 1 – Ultrasonic Modeling & Simulation (FY15 – FY22)	PNNL-28362. Ultrasound Modeling and Simulation: Status Update. Dec 2018.	(1) Technical letter report for modeling and empirical validation studies on various flaw types in CASS and issimilar metal (DM) Welds; (2) Technical letter report summarizing the results of NDE modeling round robin exercise	NUREG/CR documenting standard method to evaluate modeling results from commercially available software packages.	Regulatory Guide describing standard method for licenses to perform and present modeling data
UNR NRR-2013-009, Task 2 – Incomplete Examination Coverage (FY18 - FY22)		TLR summarizing the empirical and modeling work to determine the sizes of detectable flaws in austenitic welds and CASS DMWs		NUREG/CR documenting the effects of limited coverage.
UNR NRR-2013-009, Task 8– Probability of Detection (POD) Analysis (FY18 – FY21)	PNNL-28090. Analysis of Empirical Probability of Detection Data for Dissimilar Metal Welds. Jul 2019.		Technical letter report summarizing results of POD analysis	
User Need Request to Explore the Effects of Human Performance Issues on NDE Reliability– Training and Practice (FY19)		Technical letter report describing the results of a literature survey examining the effects of training and practice (draft received FY19)		
Assess the capabilities of Eddy Current Testing for partial penetration weld examinations	PNNL-29113. Baseline Evaluation of Eddy Current Testing for Primary Water Stress-Corrosion Cracking (PWSCC) Susceptible Materials. Sep 2019.			

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Resarch Contact

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Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$2,393	2.7	$1,898	3.0	$2,344	3.0	↘

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

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

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.
- 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 and probability of detection analysis.
- NRC/French Institut de Radioprotection et de Surete Nucle- aire (IRSN) Specific Topic of Cooperation Sheet No. 01, Modeling and Simulation.

Integrity Analysis Tool (IAT) Development and Guidance
Fiscal Year 2020 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:

- Closure of development/documentation and public release of Extremely Low Probability of Rupture (xLPR) code, Version 2.
- Probabilistic integrity analysis tools and methodologies.
- Develop Regulatory Guide to enhance quality in PFM applications.
- Enhance staff capabilities in reviewing probabilistic submittals.

Impact and Benefits

- Clarify 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 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.

Key Deliverables

Year / Project	FY 2019 Accomplishments	FY 2020	FY 2021	FY 2022
User Need Request (UNR) NRR-2014-004, Implementation of Probabilistic Methods for Evaluating Leak-Before-Break (FY14 – FY22)	Draft Technical letter report on Sources and Treatment of Uncertainty Draft technical letter report on Sensitivity Studies	NUREG on xLPR Version 2 code development Draft technical report on applying xLPR Version 2 code to past leak-before-break analyses	Draft regulatory guide to assist licensees with appropriate use of xLPR Version 2 code; Draft technical report assessing current leak-before-break requirements	Regulatory guide comment resolution and publication
UNR NRR-2016-004, Development of Regulatory Guidance on PFM Best-Practices (FY16 – FY20)	Final publication of Technical letter report on “Important Aspects of PFM Analyses”	Final draft of PFM regulatory guide and technical basis (including pilot study); Interactions with public for PFM regulatory guide	PFM regulatory guide comment resolution and publication	

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Resarch Contact

- Raj Iyengar (Raj.Iyengar@nrc.gov), Branch Chief in the Division of Engineering.

Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$1,411	2.5	$2,210	3.0	$2,043	3.5	↘

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Sandia National Laboratories (SNL) – Development of PFM regulatory guide, technical basis, and pilot study.
- SNL – Development of PFM regulatory guide, technical basis, and pilot study.
- Numark – Support leak-before-break regulatory guide technical basis development using the xLPR code.

Collaboration and Resource Leveraging

- Memoranda of Understanding (MOU) between the NRC and 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 2020 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

- Clarify 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 in SRM-SECY-14-0016 to evaluate the aging-related degradation of SSCs including irradiation-assisted degradation of reactor internals during the SLR period.
- 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) and neutron absorbing materials degradation.

Key Deliverables

Year / Project	FY 2019 Accomplishments	FY 2020	FY 2021	FY 2022
NRR-2017-006: Research Assistance on Potential Significant Technical Issues During the SPEO	NRC/industry Metals Workshop (May 2019), Pacific Northwest National Laboratory (PNNL) - 27120 Rev. 1, “Criteria and Planning Guidance for Ex-Plant Harvesting to Support Subsequent License Renewal”	Cables Workshop (Jan. 2020); Joint Harvesting Workshop at the Nuclear Energy Agency (NEA) (Jan. 2020); Develop documentation evaluating significant technical issues	NUREG/ Conference Proceedings and summary reports on four Staff Requirements	

		germane to the review of SLR applications	Memoranda topics	
NRR-2017-001: Request for Assistance to Evaluate Irradiation-Assisted Degradation of Rx Vessel Internals		Results from Cooperative Zorita Plate Materials Testing at Studsvik; Initial Results from Zorita Plate Materials Testing at Argonne National Laboratory (ANL); Results from Cooperative Zorita Welds Testing	Final Results from Zorita Materials Testing at ANL and NRC Analysis	Further Irradiation of Zorita Welds
NRR-2013-005: To Develop the Technical Bases for the Evaluation of Neutron Absorbing Materials in Spent Fuel Pools (SFPs)	Technical letter report (TLR) on the evaluation of Boral performance in SFPs	TLR on the evaluation of Boral surveillance programs		
NRR-2017-010, Task 1: Flaw Evaluation, Repair and Mitigation Techniques for PWSCC	NUREG/CR-7103, Volume 4, "PNNL Investigation of Stress Corrosion Cracking in Nickel-Base Alloys: Behavior of Alloy 152 and 52 Welds" (April 2019); TLR on PWSCC Initiation testing results for Alloy 600/182	NUREG/CRs of PWSCC Crack Growth Rate Testing (ANL/PNNL)	TLR on PWSCC Initiation of Alloy 690/52/152	TLR on PWSCC Initiation of Alloy 690/52/152 dilution zones and defects

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Resarch Contact

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Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$5,028	6.1	$5,649	8.5	$2,721	4.5	↘

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
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

- Halden Reactor Project – supports irradiation assisted degradation research on irradiated stainless-steel welds and creep/relaxation of baffle bolt materials.

- Zorita Internals Research Project – multinational cooperative research program led by EPRI on harvested reactor internals materials.
- Zorita welds testing at Studsvik – NRC-EPRI cooperative agreement for testing on irradiated stainless-steel welds.
- 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.
- MOU Addendum with DOE on cooperative nuclear safety research related to LTO.

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

Piping and Other Components Integrity
Fiscal Year 2020 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 evaluations 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 2019 Accomplishments	FY 2020	FY 2021	FY 2022
NRR 2019-001, User Need Request for Confirmatory Testing of Carbon Fiber Reinforced Polymer	Developed and implemented contracts with Numark and EMC2 to support required mechanical and durability testing.	Memo from the Office of Nuclear Regulatory Research (RES) to NRR providing a literature survey and recommended path forward.		TLR documenting the results of Carbon Fiber Reinforced Polymer (CFRP) confirmatory testing
NRR-2017-010, Flaw Evaluation, Repair and Mitigation Techniques for	Flaw evaluation software was updated	Final publication of NUREG-2228 on		

Primary Water Stress-Corrosion Cracking (PWSCC)		weld residual stress validation		
NRR-2017-010, Extended Finite Element Method (xFEM) Project	Developed and implemented technical support contract to help develop xFEM capabilities	Four technical letter reports (TLRs), including a validation plan of xFEM applications and limitations for regulatory use.		
NRR-2015-015, User Need Request on Acceptance Criteria for Pipe Ruptures in Fluid System Piping	TLR documenting currently available background on break location criteria and licensing submittals involving departure from the current Standard Review Plan 3.6.2 criteria	TBD[1]	TBD	TBD

Although this UNR was previously placed on hold, the RES was requested to issue the TLR associated with Task 1 in FY 2019. Future coordination with NRR will inform whether the remaining tasks are to be completed. Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$1,449	3.5	$745	3.0	$746	2.0	↘

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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.
- Numark/Emc2 – Carbon fiber repair: confirmatory testing.
- Emc2 – Carbon fiber repair: durability testing.
- Numark/Emc2 – xFEM Technical Support: PWSCC Crack Growth.
- TBD – Carbon Fiber Repair: Non-destructive evaluation of adhesion zone (if needed based on literature review).

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 2020 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 2019 Accomplishments	FY 2020	FY 2021	FY 2022
NRR-2018-007 Steam Generator Tube Integrity and Inspection Issues	NUREG/CR – Detection of cracking near volumetric defects issued	NUREG/Contractor Reports-Inspection and Structural Integrity of U-bend tubes with Primary Water Stress-Corrosion Cracking (PWSCC) flaws	Software to predict structural / leakage integrity of SG tubes	

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

	FY 2019 Actuals		FY 2020 Enacted		FY21 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$1,091	0.9	$788	1.5	$897	1.5	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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, and possibly Germany.
- Memorandum of Understanding (MOU) Addendum with the Electric Power Research Institute (EPRI) for SG Tube Base Research Program.

Vessel Integrity
Fiscal Year 2020 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

- Clarify NRC acceptance criteria for assessment and aging management of the RPV to support 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 in SRM-SECY-14-0016 to evaluate the aging-related degradation of the RPV during the subsequent license renewal period.
- 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 for support in updating regulations and regulatory guidance for RPV analyses and to represent NRC in the development of associated consensus codes and standards.

Key Deliverables

Year / Project	FY 2019 Accomplishments	FY 2020	FY 2021	FY 2022
User Need Request (UNR) NRR 2015-002: RPV Fluence Evaluation Methodology Guidance (FY15-FY20)		Technical letter report documenting displacement per atom damage for the RPV active core region up to and including the nozzle region; NUREG that provides a discussion of the various factors that influence the RPV and Reactor Vessel Internals (RVI) neutron flux calculations		
UNR NRR 2017-007: RPV Integrity and FAVOR Support (FY17-FY19)	FAVOR Software Quality Assurance and Verification and Validation (V&V) assessment; FAVOR Training for code users and code developers			
UNR NRR 2019-###: RPV and Internals Materials, Fluence, and FAVOR Support (FY19-FY22, being developed)		Shallow Flaw issue disposition; FAVOR software quality assurance and V&V; FAVOR Users' Group; Reactor Embrittlement Archive Project-modernization and integration with NRC information technology infrastructure	FAVOR SQA and V&V; FAVOR enhancements; REAP maintenance	FAVOR enhancements; Independent V&V of FAVOR; REAP maintenance

Acronyms: Fiscal year (FY)

Office of Nuclear Regulatory Resarch Contact

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Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$1,149	1.8	$1,058	2.0	$1,146	2.0	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Numark – RPV Integrity Analysis and FAVOR Support.
- Oak Ridge National Laboratory (ORNL) – Fluence Evaluation Methodology Guidance.
- TBD – FAVOR Maintenance and RPV Integrity Support.

Collaboration and Resource Leveraging

- International agreement with the Japan Atomic Energy Agency (JAEA) for exchange of information on materials and component integrity research.
- International agreement with the French Institut de Radioprotection et de Surete Nucle- aire (IRSN) exchange of information on integrity assessment and mechanical modeling computational tools.
- Memoranda of Understanding (MOU) between NRC and DOE on Cooperative Nuclear Safety Research Related to Long-Term Operations.

Systems Analysis Research Activities

Accident Tolerant Fuels (ATF)
Fiscal Year 2020 Program Overview

Overview

- The ATF Project Plan was developed jointly between NRR, RES, NMSS, and NRO staff to ensure efficient and timely licensing of near-term ATF concepts.
- This research 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 (ML19301B166).

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 (CSNI/NEA, SCIP) projects to remain aware of 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 has the potential to increase uncertainties in the phenomena of ATF concepts.
- Literature reviews and information gathering will help develop staff core capabilities, as well as 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 research supports the ATF NRR-2019-010 user-need, as well as the high burnup and enrichment (near-term) user needs NRR-2019-009. This research also supports two sibling user-needs for NMSS for both high burnup and enrichment and ATF.
- 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 first topical reports expected in Q4 2019, 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	FY19 Accomplishments	FY20	FY21	FY22*
Code Development	• FAST-1.0 with ability to model coatings • TRACE with ability to use ATF properties via FAST's Material Library • MELCOR updated with FeCrAl models	• FAST with updates for doped fuel, coated claddings, FeCrAl • Assessment of nuclear data library for SCALE • Source term updates for coated claddings in MELCOR	• 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 • Source term updates for high burnup in MELCOR
Technical Reports	Cr-coated Report High burnup Report	Cr-coated Fresh Fuel Transport Report FeCrAl Fresh Fuel Transport Report	Code updates Confirmatory Analysis	Code updates Confirmatory Analysis

Year / Project	FY19 Accomplishments	FY20	FY21	FY22*
		Cr-coated / FeCrAl Spent Fuel Transport / Storage Report	Increased Enrichment Fresh Fuel Report	
PIRTs	Cr-coated PIRT	Severe accident PIRT	High enrichment PIRT FeCrAl PIRT ATF Transport and Storage PIRT	HBU/EE Crit/Shielding PIRT

Acronym: Fiscal year (FY)
FY22 Key Deliverables are based on preliminary planning activities

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Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$2,115	0.0	$5,405*	4.5*	$4,900	5	→
Spent Fuel Storage and Transportation	$0	0.0	$500	1.0	$1,500	1.0	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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.
- ISL – TRACE Code Development.
- University of Michigan – PARCS Code Development.
- PNNL – Literature Reviews / PIRT Exercises.
- Studsvik Cladding Integrity Project Phase IV (SCIP-IV) – Focus on high burnup effects on FFRD.

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.
- SCIP-IV Total cost – 180.9mSEK (~$18.9 million); NRC cost of $850K.

Thermal-Hydraulic Analysis
Fiscal Year 2020 Program Overview

Overview

- This topic includes maintenance of thermal-hydraulic analysis technical expertise to provide consultation to various NRC organizations in this specialized area to inform reliable and technically sound regulatory decisions (e.g., confirmatory analysis).

Strategic Focus Areas

- Leverage cooperative international research programs to gain reactor safety insights.
- Develop and utilize 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 generate 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

- Requests from NRR for assistance in reactor accident and stability analyses, support for RTR license renewal (i.e., SHINE), and rulemaking activities.

Key Deliverables

Year / Project	FY19 Accomplishments	FY20	FY21	FY22
Plant Decks Development and Maintenance	Completed three plant models	Complete three plant models	Complete four plant models	Complete five plant models
		Maintain Plant Models		
		Maintain TRACE Applicability to Plant Models		
MELLLA+	Performed ATWS-I confirmatory analysis of Browns Ferry MELLLA+ with ATRIUM 10XM fuel	ATWS-I confirmatory analysis of Brunswick MELLLA+ with ATRIUM 11 fuel		
Test Reactors	Supported License Renewal and HEU to LEU Core Conversion	1) Support for License Renewal and HEU to LEU Core Conversion 2) Support for SHINE operating license permit		
Full Spectrum LOCA	1) Completed Diablo Canyon TRACE model 2) Ran specified test cases and sensitivity studies	3) Complete final report		
GSI-191	Supported NRR in CE Analysis and ACRS Meetings			

Acronym: Fiscal year (FY)

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Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$389	5.4	$300	6.0	$500	5.1	↗
New Reactors	$381	6.1	$150	1.0	$0	0	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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

- RES and IRSN are collaborating on the PERFROI project, an international program that carries out experimental programs on fuel deformation and core coolability following a LOCA.
- Leveraged the assistance of a foreign assignee from KINS to develop models for the ATLAS integral test facility.
- RES is participating in the PERSEO benchmark, an international collaborative effort to benchmark and evaluate code performance in the area of passive safety systems using experimental data from the PERSEO facility.

Fuels and Neutronics Analysis
Fiscal Year 2020 Program Overview

Overview

- This includes research for NRC to perform independent safety analyses for fuels and neutronics, supported by the SCALE, PARCS, and FAST codes, to support a technical basis 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 utilize 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:
  - MELLLA+
  - loss of coolant accidents (LOCAs) analyses
  - new fuel designs and evaluation methods
  - plant life extension fluence calculations
  - source term evaluations for siting and NEPA analyses
- Analyses performed support safety studies, updates to regulatory guidance, rulemaking regulatory bases, and generic issue resolution.

Drivers

- Neutronics and fuels codes analyses are inputs to thermal hydraulics (e.g., LOCA, MELLLA+) analyses.

Key Deliverables

Year / Project	FY19 Accomplishments	FY20	FY21	FY22
Site Level 3 analysis (reactor and spent fuel pools (2018-2022)	Completed associated Level 3 analysis			
Brunswick MELLLA+	Developed AC3M+ methodology for MELLLA+ reviews; Final results			
	SCALE/PARCS analyses	SCALE/PARCS analyses		
	Preliminary results	Final results		
DG-1327	New version of FAST with ANS-5.4 2011 fission gas release model for radioactive isotopes			
Fuel thermal-mechanical reviews; Full-core confirmatory studies		FAST inputs for all currently used fuel designs		

Acronym: Fiscal year (FY)

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Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$523	1.0	$56	1.0	$500	0.5	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Oak Ridge National Laboratory (ORNL) – Support for MELLLA+ 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 thus are integral to stress testing.

Advanced Non-LWR Support Using the Comprehensive Reactor Analysis Bundle (CRAB)
Fiscal Year 2020 Program Overview

Overview

- This research 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 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 perform safety studies.
- Leverage cooperative domestic and international research programs to gain reactor safety insights.
- Develop and utilize 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-light water reactor 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-light water reactors is the development of codes suitable for confirmatory analysis of these advanced designs.

Key Deliverables

Year / Project	FY19 Accomplishments	FY20	FY21	FY22
Reference plant model for gas-cooled pebble bed reactor.	Dec. 2018			
Initial reference plant model for heat pipe cooled micro-reactor.	Sept. 2019			
Vendor specific model for heat pipe cooled micro-reactor. Draft UNR from DANU.		May 2020		
Draft report including assessment of the applicability of point kinetics to control drum mis-operation for micro-reactors. Draft UNR from DANU.			October 2020	

Project \ Year	FY19 Accomplishments	FY20	FY21	FY22
Final report on vendor specific heat pipe cooled micro-reactor and sensitivity studies. Draft UNR from DANU.			January 2021	
Reference plant model for molten salt cooled pebble bed reactor.			Dec. 2020	
Reference plant model for sodium cooled fast reactor.			March 2021	

Acronym: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

	FY19 Actuals		FY20 Enacted		FY21 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Advanced Reactors	$805	2.7	$400	4.0	$600	2.0	→

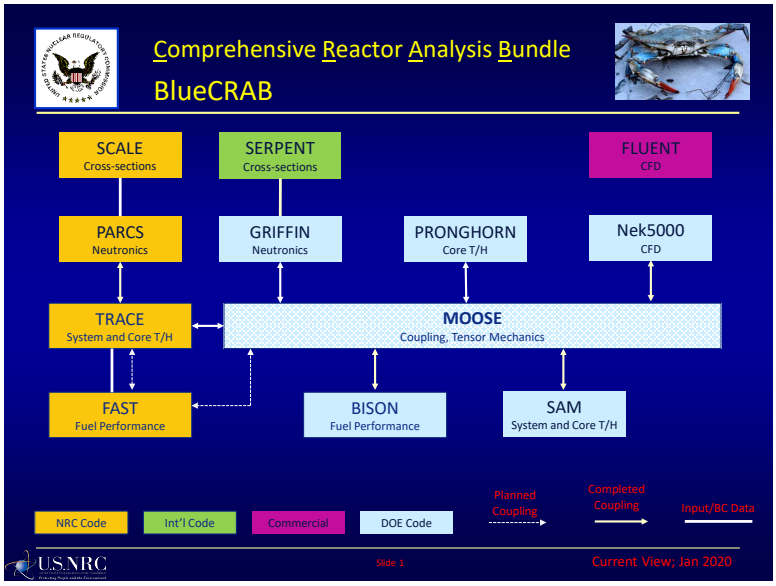
Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Argonne National Laboratory and Idaho National Laboratory – Advanced Reactor Support.

Collaboration and Resource Leveraging

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



Thermal-Hydraulic Verification and Validation
Fiscal Year 2020 Program Overview

Overview

- This research 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 SMRs and non-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 19 Accomplishments	FY20	FY21	FY22
RBHT	Initiated a bridge contract to extend the period of performance and completed 10 reflood tests, including 4 oscillatory, 1 constant, 1 variable rate reflood, and 3 level swell tests.	Lead OECD/NEA International Activity that evaluates reflood rate and core heat transfer rate. Perform 11 ‘open’ tests and 5 ‘blind’ tests.		
PKL	Performed 3 experiments: 1) Boron Precipitation, 2) upper-head voiding during cooldown, and 3) extended loss of AC power	1) LBLOCA T/H Phenomena 2) the program will end and the final report will be delivered		
ATLAS	Performed 5 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 without the residual heat removal system; 5) Counterpart test small vessel head break	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 19 Accomplishments	FY20	FY21	FY22
KATHY	Completed KATHY experimental program. Continued assessment of TRACE	Completion of final experimental program report, and preparing a NUREG/CR	Completion of 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).	COAL Preliminary Report 1, COCAGNE Final Report	COAL Preliminary Report 2 and 3, COAL Final Report	
PERSEO	Continued development and testing of the PERSEO code benchmark as part of OECD/WGAMA passive system reliability workgroup. PERSEO is a test facility which generates high-pressure condensation data for system code validation.	1) Merge PERSEO results into the state-of-the-art report of the OECD/WGAMA passive system reliability workgroup 2) Program ends		

Acronym: Fiscal year (FY)

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Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$413	1.3	$513	2.9	$300	2.9	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support

- Pennsylvania State University - Rod Bundle Heat Transfer program (RBHT).
- IRSN – PERFROI.
- Purdue University - Thermal Hydraulics Institute.
- Information Systems Laboratories (ISL) - Large System Code Performance Evaluation and Uncertainty Quantification.
- Orano (previously Areva) – KATHY experiments.

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 KATHY and PERFROI, that provide valuable assessment and validation data for confirmatory codes and analysis.

FAST Code Development and Maintenance
Fiscal Year 2020 Program Overview

Overview

- This research 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.
- 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 in fuel performance modeling and phenomena.
- Continue participatory and leadership roles in international (CSNI/NEA, 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 updates, including ATF and HBU activities for NRR.
- FAST is used to support technical bases, such as DG-1327 and 10CFR50.46(c) which support safety analysis methods and requirements.
- FAST provides the input conditions used to support plant licensing decisions, such as MELLLA+ and 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).

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-TBD for ATF, HBU / HALEU, NMSS-2019-TBD for ATF and HBU activities, and the NMSS/RES Super User Need.
- 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 and MELLLA+.
- RES provides FAST to both domestic and international users, including regulators and technical support organizations (TSOs).
-

Key Deliverables

Year / Project	FY19 Accomplishments	FY20	FY21	FY22
FAST Development, Maintenance and Assessment		Release of FAST-1.0; End of FRAPCON / FRAPTRAN development, updates include support of ATF and improved FGR modeling	Release of FAST-1.1 with improvements to ATF, non-LWRs, code stability and assessment	Release of FAST-1.2 with improvements to ATF, non-LWRs, code stability and assessment
FAST User Group Meeting	Presentations of Code updates			

Year / Project	FY19 Accomplishments	FY20	FY21	FY22
FAST Training	Hands on training to NRC staff; Updated training materials			
FAST 3-D Physics		Version of FAST that supports ability to non-cylindrical geometries Parallel FAST that supports 3D modeling for both structured (cylinders) and unstructured geometries	Updated FAST with improved support for new file formats, additional fuel-related phenomena	FAST solver updates to speed up code
FAST for ATF	Ability to analyze coated claddings; Preliminary assessment for doped UO2	Assessment / updates for near-term ATF concepts	Assessment / updates for near-term ATF concepts	Assessment / updates for near-term ATF concepts

Acronym: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

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Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$1,472	1.4	$0	2.0	$300	1.5	→
Advanced Reactors	$258	0.0	$200	0.3	$200	0.3	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

Contractor Support & International Projects

- Pacific Northwest National Lab – FAST Code Development, Assessment and Maintenance.
- GuideStar Engineering – 3-D Physics, Code architecture updates.
- Studsvik Cladding Integrity Project Phase IV (SCIP-IV) – Focus on high burnup effects on Fuel Fragmentation, Relocation and Dispersal (FFRD).
- CABRI - In-pile Reactivity Initiated Accident (RIA) testing.
- FIDES Framework, including P2M in-pile power ramp testing, under development.

Collaboration and Resource Leveraging

- SCIP-IV Total cost – 180.9mSEK (~$18.9 million); NRC cost of $850K.

SCALE Neutronics Code Development and Maintenance
Fiscal Year 2020 Program Overview

Overview

- This area 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 processing and libraries, depletion and activation, criticality and shielding, and sensitivity uncertainty analysis methods) in support of safety issue resolution and risk-informed decision making.

Strategic Focus Areas

- Support regulatory decision making with respect to core reactor physics phenomena, criticality, and shielding.
- Understand the 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 involves more sophisticated operation of the existing LWR fleet (ATF and MELLLA+).

Impact and Benefits

- SCALE analyses capabilities to enable accident tolerant fuel (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) that provide the technical basis for agency risk informed decision making.

Drivers

- Licensed SCALE userbase of ~75 NRC staff and 9,600 users globally, including 33 foreign regulators.
- Used extensively to provide Part 50, 70, 71, and 72 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 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 RG 1.183, Independent Review/Update of Regulatory Guide 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.

Key Deliverables

Year / Project	FY19 Accomplishments	FY20	FY21	FY22
SCALE Development	Release of SCALE 6.3 beta with updated nuclear data libraries, MC based nodal data capabilities, code stability & robustness improvements	Release of SCALE 6.2.4 Release of new validation report that covers the range of SCALE capabilities	Release of SCALE 6.3	Release of SCALE 7
SCALE user group workshops and training	Preparation of workshop materials and hands-on problems			
SCALE code modeling and development of source term and reactor physics capability, for Accident Tolerant Fuel designs and NonLWR applications	Reviewed available benchmark data	Develop assessments, methods updates, and review for validation data gaps Initial data for MELCOR and MACCS calculations	Develop assessments, methods updates, and review for validation data gaps	
SCALE code modeling and development of source term for HALEU and HBU	Reviewed available benchmark data	Develop assessments and review for validation data gaps	Develop assessments and review for validation data gaps	

Acronym: Fiscal year (FY)

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Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$1,059	0.4	$450	0.6	$450	0.5	↗
Advanced Reactors	$722	0.0	$1,100	0.5	$800	0.3	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k per year)
Acronyms: Fiscal year (FY), full-time equivalent (FTE)

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 2020 Program Overview

Overview

- This research supports regulatory decision making 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.
- Improving methods and modeling enhancements to help the NRC better understand more advanced applications that involves more sophisticated operation of the existing LWR fleet (ATF and MELLLA+), 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) and MELLLA+ 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]).
- Recently, PARCS analysis was central to fulfilling RES support to the MELLLA+ License Amendment Requests for Brunswick and Browns Ferry.

Key Deliverables

Year / Project	FY19 Accomplishments	FY20	FY21	FY22
PARCS Watts Bar Unit 1 Assessment	PARCS models compared to MPACT (CASL) predictions of boron letdown and power shapes, and to KENO-VI predictions in terms of multiplication factor and rod worth	Final Models and Completion Report		

Year / Project	FY19 Accomplishments	FY20	FY21	FY22
PARCS micro-depletion model	Portions of coding complete for part of decay chains – being tested Transition to compact storage format for isotopes and data	Final PARCS distribution (SDID/Completion Report, manuals, code version, and test problems)		
PARCS Training		Training materials and instruction		
PARCS versions in response to identified bugs, updates, assessments, and international collaborations – ongoing support for Brunswick MELLLA+ ATRIUM 11 fuel transition	v3.3.2 beta used to support for MELLLA+ LARs of Brunswick Steam Electric Plant with ATRIUM11 fuel and for Browns Ferry Nuclear Plant with ATRIUM10XM fuel v3.3.2 beta distributed to staff and international counterparts for testing (Spain/NFQ and France/IRSN)	PARCS v3.3.2 v3.3.3	PARCS v3.3.4	PARCS v3.3.5
Accident Tolerant Fuel (ATF) and High Burnup/High Assay fuel concepts		Code improvements, assessments, and scoping studies to support the review of Accident Tolerant Fuel (ATF) and High Burnup/High Assay fuel concepts		
Un-anticipated PARCS upgrades and documentation due to modeling advanced NPP operation in expanded domains		Specific tasks to be developed		

Acronym: Fiscal year (FY)

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Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$150	0.9	$200	1.0	$200	1.0	↘
Advanced Reactors	$50	0.0	$180	0.5	$100	0.2	↘

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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 multi-party (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 2020 Program Overview

Overview

- This research 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, 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.
- Adding 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, multi-code 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	FY19 Accomplishments	FY20	FY21	FY22
SNAP Development	• Improved FAST support • MELCOR 2.2 fully supported • Version 3.0.2 released (openJRE)	• Graphics integration and improvements • UQ toolbox development • DAKOTA Support Improvements • Plugin updates • Adding MACCS support • MELLLA+ wizard	• MELCOR 2.3 support • Plugin updates	• MELCOR 2.4 Support • Plugin updates
SNAP training & videos	Total of 7 training videos created	• Preparation of workshop materials and hands-on problems • Preparation of training videos • NRC staff and contractor support	• Preparation of workshop materials and hands-on problems • Preparation of training videos • NRC staff and contractor support	• 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

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	CS&T ($K)	FTE	CS&T ($K)	FTE	CS&T ($K)	FTE	Trend
Operating Reactors	$383	1.0	$200	0.8	$300	0.8	↘

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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.
- Naval Reactors provides considerable code development on SNAP core and the MELCOR plug-in independently, but mutually benefit for both organizations.
- 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).

RSICC Distribution of NRC Codes
Fiscal Year 2020 Program Overview

Overview
- This research 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 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	FY19 Accomplishments	FY20	FY21	FY22
Process Annual Participation Contracting Package with ONRL	Completed FY19 Procurement	FY20 Procurement	FY21 Procurement	FY22 Procurement

Acronym: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact
- Chris Hoxie, Ph.D. (Chris.Hoxie@nrc.gov), Branch Chief in the Division of Systems Analysis.

Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$0	0.0	$200	0.2	$200	0.2	→

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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 2020 Program Overview

Overview

- This research 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 improving ease of use and address bugs identified by staff or Code Application and Maintenance Program (CAMP) members.

Impact and Benefits

- Ensures that NRC simulation tools match vendor code capabilities.
- Enable effective licensing reviews and analysis.
- Shorten timeline for licensing decisions and generate fewer requests for additional information.
- Support the resolution of regulatory safety issues.

Drivers

- Support for User Needs (e.g. MELLLA+, ATF, Plant Models, Uncertainty, NuScale, High Burnup/High Enrichment Uranium Fuel, Test Reactors).
- Preparation for advanced reactor design certification review.
- Improving staff effectiveness when performing confirmatory analyses.
- Improving robustness and runtime performance of TRACE and TRACE/PARCS calculations.

Key Deliverables

<table>
<tr><th>Year
Project</th><th>FY19 Accomplishments</th><th>FY20</th><th>FY21</th><th>FY22</th></tr>
<tr><td rowspan="3">ATF Research Plan (see ATF research summary)</td><td rowspan="3">Coupled TRACE with MOOSE/BISON</td><td colspan="3">Add new ATF fuel properties to TRACE</td></tr>
<tr><td colspan="3">Implement new models for HBU and HEU</td></tr>
<tr><td>Couple TRACE with FAST</td><td></td><td></td></tr>
<tr><td>Improve robustness and run time performance of TRACE/PARCS calculations (driven by T/H Analysis research)</td><td>Released TRACE versions which improved TRACE/PARCS robustness</td><td>TRACE V5.0 Patch 6</td><td>TRACE V5.0 Patch 7</td><td>TRACE V5.0 Patch 8</td></tr>
<tr><td>Uncertainty Quantification using TRACE</td><td colspan="4">Release TRACE version with improved modeling of uncertainty parameters</td></tr>
<tr><td>Improving staff effectiveness when performing confirmatory analysis in support of test reactors</td><td colspan="4">Release TRACE version with improved modeling for flat plate heat transfer and rectangular ducts</td></tr>
</table>

Acronym: Fiscal year (FY)

Office of Nuclear Regulatory Research Contact

- Chris Hoxie, Ph.D. (Chris.Hoxie@nrc.gov), Branch Chief in the Division of Systems Analysis.

Resources

	FY 2019 Actuals		FY 2020 Enacted		FY 2021 President's Budget		Research Planning
Business Line	$K	FTE	$K	FTE	$K	FTE	Trend
Operating Reactors	$959	1.8	$300	3.0	$400	3.0	↘

Total Resources = $K (which includes contract support and travel) + FTE (staffing at approximate $200k 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).
- Working with DOE to couple TRACE to BISON and TRACE to FAST using the MOOSE framework to support future ATF license reviews.

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