



# A Strong and Viable Nuclear Safety Research Organization to Meet Current and Future Regulatory Challenges

SAFIR 2014 Research Program Workshop  
March 19-20, 2015, Finland

**K. Steven West**  
U.S. Nuclear Regulatory Commission

# Purpose

- Discuss the USNRC Office of Nuclear Regulatory Research (RES) in its role as a nuclear safety research organization
- Discuss RES functions; expertise and capabilities; maintenance of these expertise and capabilities; knowledge management
- Discuss future challenges envisioned for RES

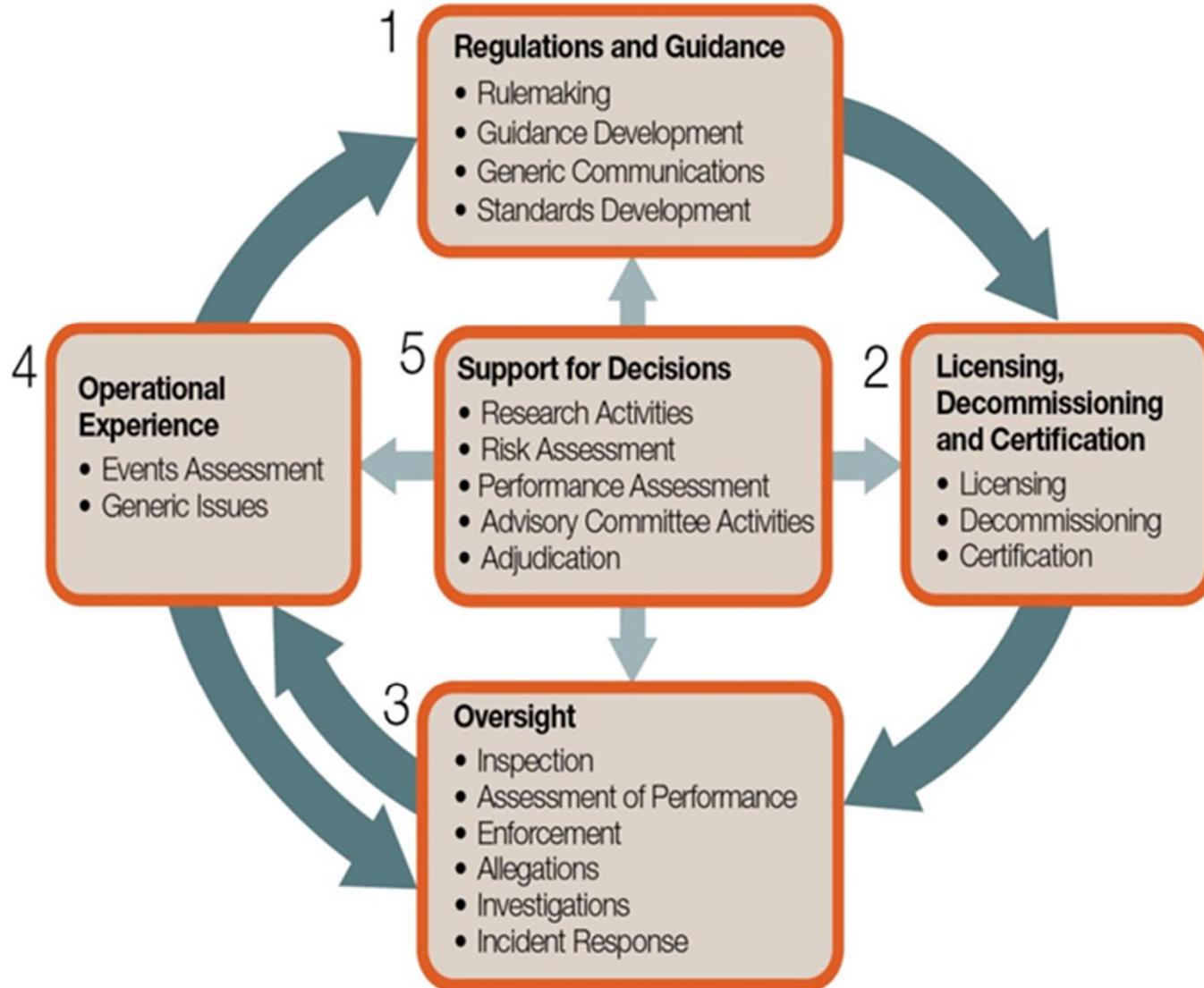
# Topics

- NRC's Authorities and Responsibilities as Provided by Statute
- NRC's Mission
- RES Organization
- Role of RES and Focus
- Types of Research
- RES Products and Quality Assurance
- Domestic and International Collaboration
- Key Research
- Current and Future Challenges
- Knowledge Management
- Summary

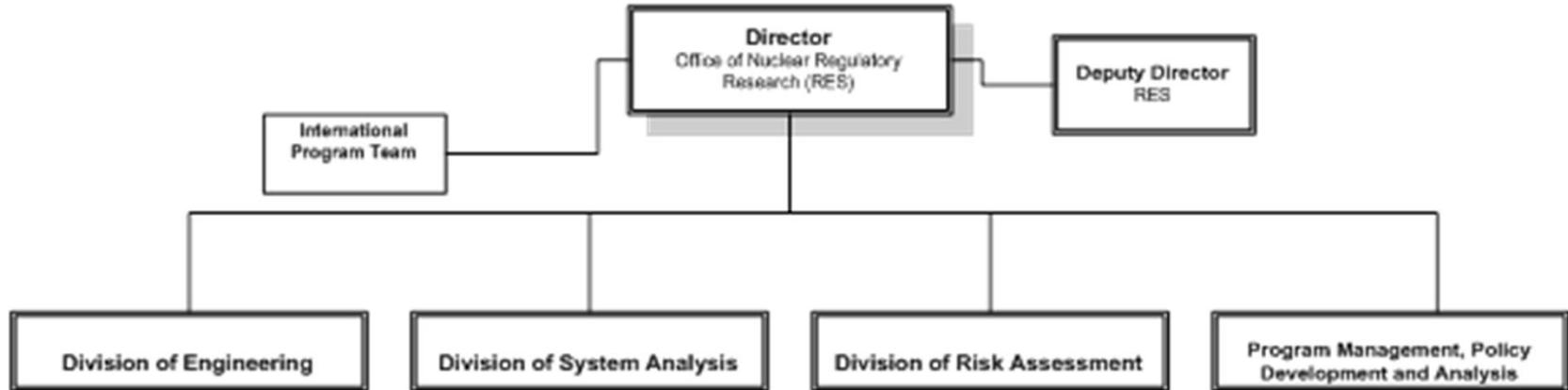
# NRC's Authorities and Responsibilities as Provided by Statute

- The Energy Reorganization Act of 1974 established an independent regulatory commission to regulate commercial uses of nuclear material
- Recognized the need for continuous improvement in our knowledge of a complex and technically challenging technology
- Established the Office of Nuclear Regulatory Research within the NRC and the following requirements
  - Developing recommendations for research deemed necessary for performance by the Commission of its licensing and related regulatory functions
  - Engaging in or contracting for research which the Commission deems necessary for the performance of its licensing and related regulatory functions
  - Developing a long-term plan for projects for the development of new or improved safety systems for nuclear power plants

# How We Regulate



# RES Organization



## Division of Engineering (DE)

- material performance, natural hazards, digital instrumentation and controls (digital I&C), seismic and structural issues, reactor component integrity

## Division of Systems Analysis (DSA)

- criticality safety, thermal hydraulic and severe accident phenomenology, accident source terms, and accident sequences, quantifying margins, and reducing uncertainties for areas of potentially high risk or safety significance

## Division of Risk Analysis (DRA)

- probabilistic risk assessments (PRA), human factors and human reliability analysis, performance and reliability analysis, movement of radionuclides through environmental systems, operating experience, and fire safety

## Program Management and Policy Development and Analysis (PMDA)

- budget planning & execution, information technology needs, staff & resource planning

# Role of RES

- Plans, recommends, and implements research programs
  - NRC performs confirmatory research to support decisions about the adequacy of safety or security of a regulated function
  - Licensees and applicants have the primary responsibility to develop data to support their safety analyses and applications
  - NRC does not conduct development research designed to improve plant performance
- Standards development
  - Coordinates NRC Participation in international and domestic standards activities, including appointment of staff to committees
- Resolution of generic safety issues
  - NRC does research to determine if a safety issue exists
  - NRC conducts confirmatory research to independently verify licensee or applicant's data, determine safety margins, and explore uncertainties

# Focus of RES

- Unlike technical programs in some TSOs, the NRC research program aims to improve the knowledge where
  - uncertainties exist
  - safety margins not well characterized
  - resolution of technical issues needed to support regulatory decisions
- Confirming the technical basis for regulatory decisions
- Assessing technical issues
- Developing methods and tools
- Looking for emerging technologies and issues
- Translating technical information into regulatory guidance

# Types of Research

- **Confirmatory**
  - Request by NRC's regulatory offices to satisfy regulatory need
  - Coordinated well-defined product
  - Activities involve performing experiments or developing analytical tools to independently confirm licensee's analyses
  - Shorter-duration (1-3 years)
- **Forward Looking**
  - Anticipated regulatory needs within the next 3-5 years
- **Long Term**
  - Scope out potential future (>5 years) regulatory needs

# RES Products

- RES provides the technical basis to support the Agency's regulatory decisions
  - Enables determination of acceptance criteria
  - Provides recommendations to the Commission
- Support is typically documented in the following products
  - NUREGS
  - Technical Reports
  - Regulatory Guides

# Quality Assurance

- Internal Evaluations
  - Coordinates work with regulatory offices (NRR, NRO, NMSS)
  - Internal peer reviews
  - Quality surveys products
  - Non-concurrences and differing professional opinions
- External Evaluations
  - Advisory Committee for Reactor Safeguards (ACRS)
  - External peer reviews

# Domestic & International Collaborations

- Leverage expertise and resources on key topics of common interest
- Performed under shared financial responsibility
- Includes a wide range of technical activities
  - Fukushima Activities
  - Halden Reactor Project
  - Zirconium Fire during Loss-of-coolant Accident
  - Fire Safety Research

# Domestic Collaborations

- US Department of Energy (Memorandum of Understanding (MOU))
  - Long term operation of light water reactors
  - Center for Radiation Protection Knowledge
- Electric Power Research Institute, Inc. (EPRI)
  - advanced computational tools for assessing reactor component safety
  - aging and qualification of electrical cables
  - interface of digital instrumentation & controls and human factors
  - probabilistic research assessment
  - non destructive examination

# International Collaborations

- Multilateral engagement
  - IAEA and NEA
- Bilateral technical exchanges
  - 40+ International Agreements
  - 100+ International Research Agreements

## Bilateral Information Exchange and Cooperation Agreements with the NRC

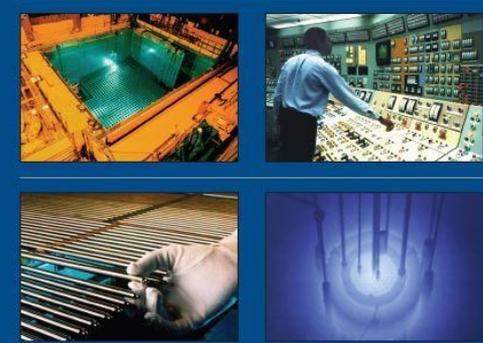


Agreement Country, Renewal Date		
Argentina, 2012	Germany, 2012	Poland, 2015
Armenia, 2012	Greece, 2013	Romania, 2016
Australia, 2013	Hungary, 2012	Russia*, 2001
Belgium, 2014	Indonesia, 2013	Slovakia, 2015
Brazil, 2014	Israel, 2016	Slovenia, 2015
Bulgaria*, 2011	Italy, 2015	South Africa, 2014
Canada, 2012	Japan, 2015	Spain, 2015
China, 2013	Kazakhstan, 2014	Sweden*, 2011
Croatia, 2013	Korea, Rep. of, 2015	Switzerland, 2012
Czech Republic, 2014	Lithuania, 2015	Thailand, 2012
Egypt, 1991	Mexico, 2012	Ukraine, 2016
EURATOM, 2014	Netherlands, 2013	United Arab Emirates, 2015
Finland*, 2011	Peru, Open-Ended	United Kingdom, 2013
France, 2013	Philippines, Open-Ended	Vietnam, 2013



# Key Research Areas

- Reactor Safety Codes and Analysis
- Severe Accident Research and Consequence Analysis
- Radiation Protection, Health Effects, and Environmental Transport
- Probabilistic Risk Analysis
- Human Factors and Human Reliability
- Fire Safety Research
- Seismic and Structural Research
- Materials Performance Research
- Digital Instrumentation and Control and Electrical Research
- Flooding Research



Research Activities  
FY 2012–FY 2014

<http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1925/>

Office of Nuclear Regulatory Research (RES)

# Current and Future Challenges

- Enhancements based on lessons learned from the Fukushima Dai-ichi accident
- Review of applications involving new technologies such as small modular reactors and advanced reactors
- Improved understanding of rapidly evolving digital instrumentation and control systems
- Materials degradation issues with aging nuclear fleet

# Digital Instrumentation & Controls

- Safety Aspects of Digital Systems
  - Communications among digital systems
  - Safety assessment of software tools
  - Analytical assessment of Digital systems
  - Digital system reliability
  - Digital system risk analysis
- Security Aspects of Digital Systems
  - Improvements in the regulatory framework described in Regulatory Guide 5.71, “Cyber Security Programs for Nuclear Facilities.”
- Digital Systems Probabilistic Risk Assessment



# Digital Instrumentation and Control Collaborations

- EPRI - Information sharing in the area of safety aspects of digital systems includes analytical assessment research to support safety evaluations of digital I&C systems
- Other US Government Agencies NASA, FDA, FAA and DOD - Participation in interagency R&D working groups to share experience and analysis techniques
- Halden Reactor Project – collaborative research on a Safety Demonstration Framework for assurance of digital Systems
- IRSN – Collaboration on digital system failure analysis methods and hazard analysis
- TF – SCS - collaboration with the Task Force for Safety Critical Software to develop common positions on the technical basis for licensing reviews of software in safety- related digital systems
- KAERI – collaboration in research on methods for modeling digital systems in NPP PRAs

# Materials Degradation Issues

- Understanding of materials degradation enables sound technical basis for regulatory decisions
  - NRC has approved renewed license for 73 U.S. plants to operate 20 years beyond the initial 40 year operation
  - NRC is reviewing additional 11 applications for 19 units
  - 34 units have entered the operating period beyond 40 years
- Expanded Materials Degradation Assessment identified:  
(NUREG/CR-7153, Vol. 1-5, ML14114A020)
  - **Metallic Materials** - Environmentally-assisted degradation and cracking
  - **Concrete** - Effects of irradiation, Alkali-silica reaction (ASR), Creep-Cracking interaction of the post-tensioned containment
  - **Cables** - Cable Degradation in a Submerged Environment, Consequences of long-term wetting of both low- and medium-voltage cables, Effects of oxygen concentration in the atmosphere during a loss-of-coolant accident

# Concrete Degradation Research

## Ongoing research areas

- Irradiation effects on concrete strength
- Concrete degradation due to alkali-silicate reaction (ASR)
- Corrosion of liner plate on the concrete side
- Boric acid attack on concrete in PWRs in Spent Fuel Pool and transfer canal
- Corrosion of reinforcement in cooling tower
- Creep of the post-tensioned concrete containment
- Non-invasive and nondestructive evaluation of concrete

## Collaborative Activities:

- US-DOE, EPRI and Bi-lateral agreements with Japan, Spain and Finland – information exchange on irradiation effects on concrete strength
- International Committee on Irradiated Concrete in nuclear power plants (Latest meeting held in Oct. 2014, Espoo, Finland)
- NEA/OECD/CSNI - Assessment of Structures subject to Concrete Degradation
- International Union of Laboratories and Experts in Construction Materials, Systems and Structures (RILEM) Committee on ASR study

# Knowledge Management

- Staff understand knowledge management is a fundamental part of the RES mission
  - The NRC knowledge base requires continuing maintenance and extension
  - Qualified staff are the key to maintaining the NRC knowledge base
  - Transferring knowledge into regulatory practice is a desired outcome of research
- Develops NUREG/KM-series documents that capture historical events and highly significant technical and safety information
- Holds technical exchanges through seminars and dissemination of technical information to stakeholders

# Summary

## NRC's Office of Regulatory Research:

- Nuclear safety research organization with authorities and responsibilities mandated by the U.S. law
- Is fully integrated within NRC and serves the technical needs of the regulatory offices and the Commission
- Provides independent information and expertise needed to support NRC's regulatory decision making process
- Identifies and characterizes technical questions in anticipation of potential future safety issues

# Summary (cont'd)

## NRC's Office of Regulatory Research:

- Establishes appropriate mechanisms and processes to initiate and drive research to fulfill the needs of regulatory offices and meet high quality standards
- Maintains technical expertise and core capabilities for the conduct of research to meet the expectations of the regulatory offices and the Commission
- In addition to maintaining in-house expertise, utilizes services provided by DOE laboratories and commercial contractors to extend its capabilities
- Leverages support from various domestic and international collaborations to fulfill its mission

A large, stylized graphic of an atomic symbol, consisting of a central sphere and three intersecting elliptical orbits, is positioned on the left side of the slide. The top half of the slide has a blue background, and the bottom half has a white background, separated by a horizontal orange band.

Thank You  
Questions?