# Roles and Effectiveness of R&D in Support of Nuclear Safety

IEM on Strengthening Research and Development Effectiveness in the Light of the Accident at the Fukushima Daiichi

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# *Messages*

- Fukushima accident has given new impetus to research related to severe accidents
- R&D related to nuclear safety has several important roles
- Responsible governance requires assessment of R&D effectiveness

# Canadian Nuclear Safety Commission

Established in May 2000, under the Nuclear Safety and Control Act

- Regulate the use of nuclear energy and materials to protect the health, safety and security of Canadians and the environment
- Implement Canada's international commitments on the peaceful use of nuclear energy
- Disseminate objective scientific, technical and regulatory information to the public

***Canada's nuclear watchdog***

# CNSC response to Fukushima accident

- CNSC Task Force established in March, 2011
- Fukushima Action Plan - applies to all nuclear facilities
  - Defense-in-depth
  - Emergency response
  - Regulatory framework and processes
  - International collaboration
  - Communications and public education
- Action Plan to be completed by December 2015



***Seek opportunities to improve safety***

# *Safety improvements at nuclear facilities*

- Portable and mobile diesel generators for emergency power
- Cooling water pumps onsite — municipal fire trucks for offsite support
- Fuel reserves to operate for a site-specific number of days, if refueling is delayed
- Additional hydrogen mitigation equipment and filtered venting, to ensure protection of containment
- Systematic evaluation of external hazards
- NPP licensees to strengthen emergency response capabilities

***Specific actions implemented***

# *Knowledge base for actions*

- Efforts dedicated to study of severe accidents paid off
  - Overall progression of Fukushima Daiichi accidents understood
  - Codes available to model the accident
  - Adequate support for short-term activities
  - Nevertheless, uncertainties exist and new R&D focus areas arise

# *Areas of R&D focus in Canada (1)*

## Accident management

*Objective - provide knowledge and tools required to respond efficiently to an ongoing accident and to minimize the off-site consequences*

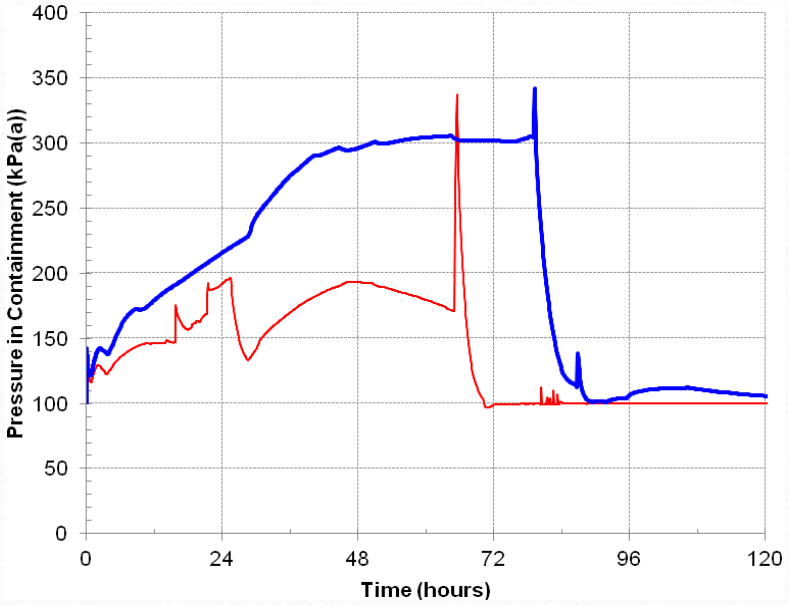
- protect containment survivability
- demonstration of in-vessel retention
- controlling hydrogen risk
- implementation of venting strategies
- accident management for multi-unit stations and spent fuel bays
- technical support tools for accident management

# *Areas of R&D focus in Canada (2)*

## Analytical methods and tools

*Objective - improve capability of tools to evaluate accident progression and their consequences*

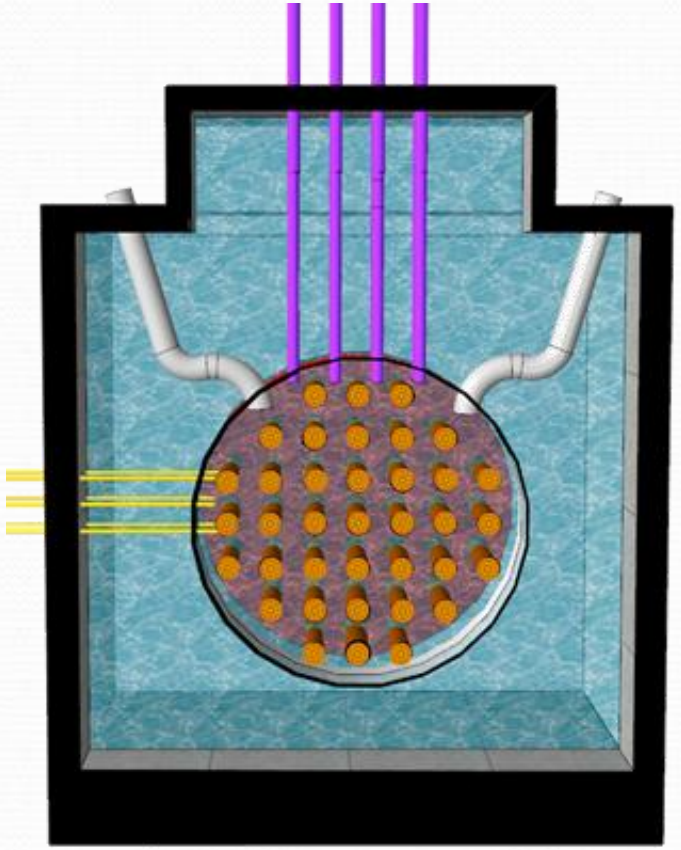
- refinement of severe accident simulation to reduce uncertainties and allow taking into account plant features
- analysis methods for multi-unit plants
- consideration of accident management in accident modeling and PSA
- sensitivity analysis methods for identification of cliff edge effects
- modeling of plant response to external events



# *Areas of R&D focus in Canada (3)*

**Support for acceptance criteria and failure limits**

- *Objective - better characterization of the allowable loads for the physical barriers*
  - failure limits for fuel channels
  - failure limits for calandria vessel to assess in-vessel retention,
  - failure limits for containment and its sub-systems and components



# *Areas of R&D focus in Canada (4)*

## Organizational performance and human factors

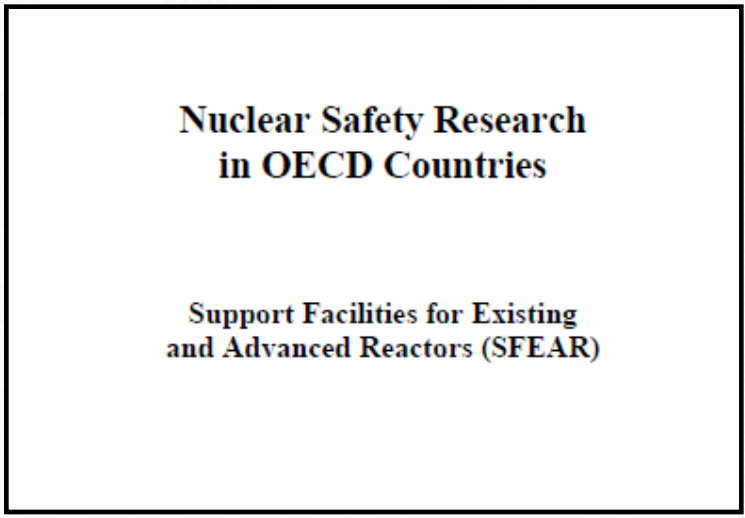
*Objective – study response of organizations, personnel and population to accident situations*

- features of high reliability organizations
- plant personnel behavior in high stress environment
- impact, including non- radiological, on population

# *Nuclear R&D tenets*

In the last decades experts studied roles of R&D and concluded that

- research and development activities are essential for healthy industry
- at the same time as earlier identified R&D objectives are being achieved, new goals arise
- economic pressures translate into fierce competition for funding
- maintaining adequate R&D is a shared responsibility of various national and international organizations
- cooperation is essential in securing continuing availability of research facilities and experts



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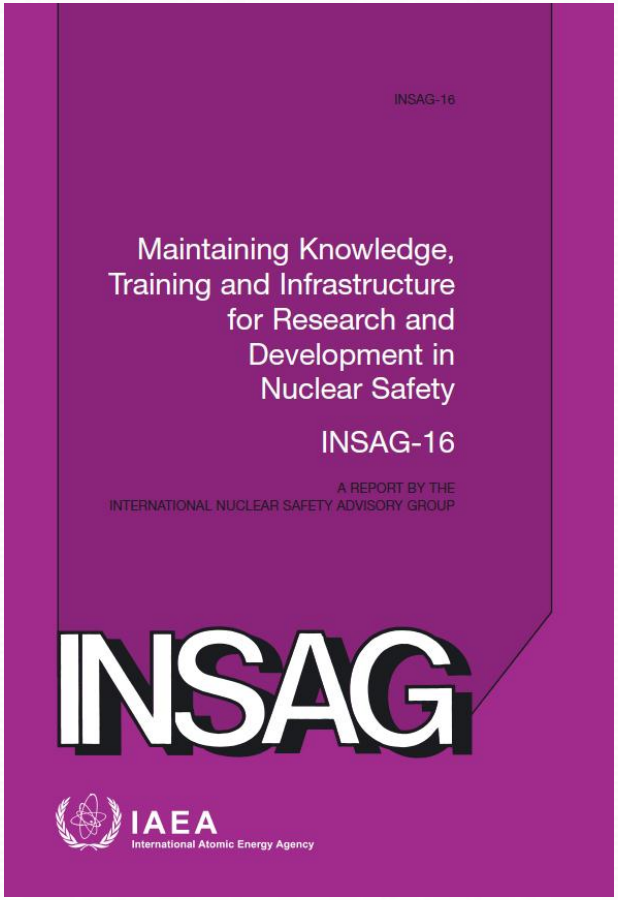



*"In order to maintain and further enhance the safety of nuclear facilities…, the infrastructure for safety research (experimental facilities, highly competent staff and modern analytical tools) must be maintained and supported by the responsible government organizations as well as by the operating organizations and manufacturers."*

# *Roles of safety R&D*

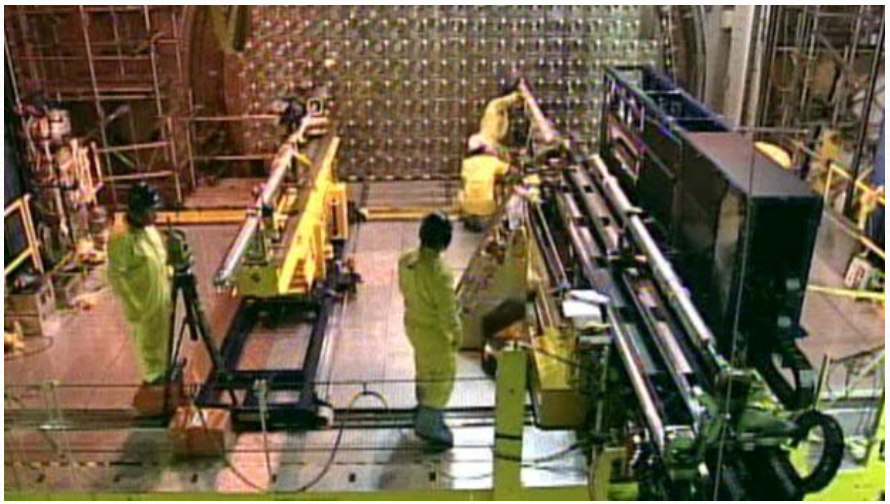
- How exactly does research help maintain and enhance the safety of nuclear facilities?
- What role(s) does R&D play?
  - Six roles or functions presented on the next slides
  - Many ways to cut the pie – roles are inter-related and overlapping

# *Role 1 - Support for design and operation*

- This function implies ongoing support for the design of operating facilities. This includes capability to support:
  - Continued safe operation
  - Plant life extension
  - Design modifications to the plant systems
  - Development and optimization of plant processes, procedures, hardware and software

# *Role 2 - Response to emerging issues*

- Knowledge base, skill sets, and test facilities to assess unexpected events or new discoveries
  - Experience shows that R&D resources have been crucial to the investigation and timely development of solutions for emerging issues



# *Role 3 - Ability to meet evolving requirements*

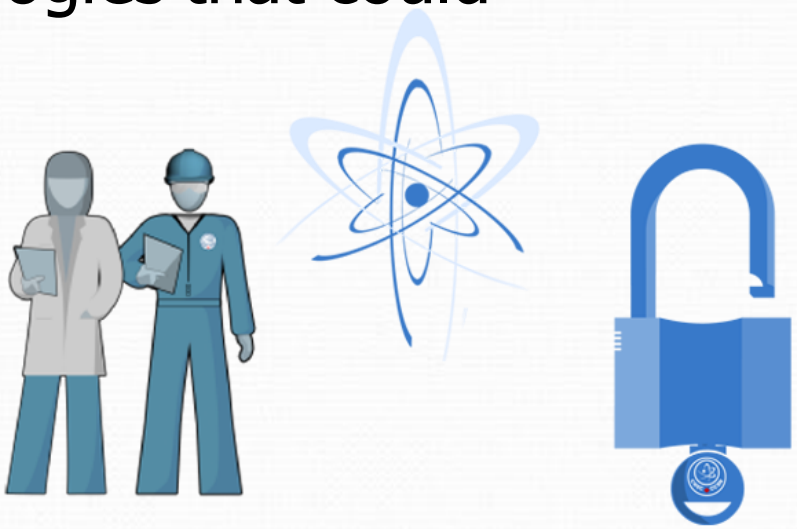
- This function would assure ability to respond to evolving engineering codes or regulatory standards, including implementation of new design and operational features

# *Role 4 - Reduction of uncertainties*

- Uncertainties have been carried over from state of knowledge in designs dating from earlier years
- Highly conservative design decisions to overcome certain design challenges at that time
- As knowledge is accumulated, opportunities arise to address legacy gaps and thus reduce uncertainty

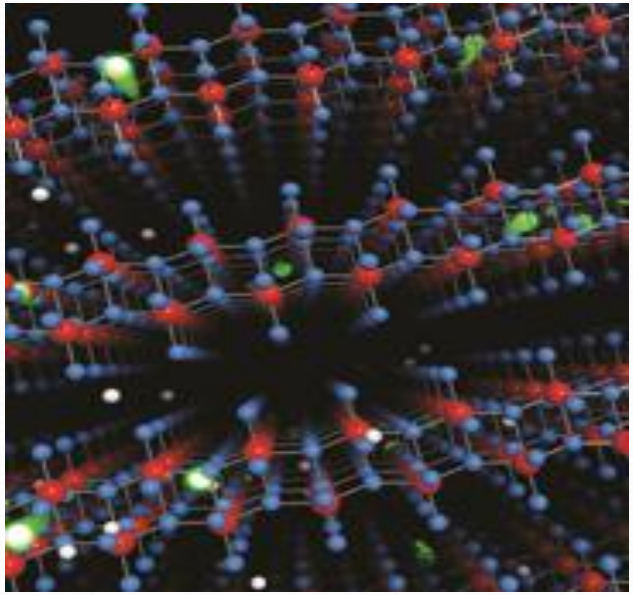
# *Role 5 - Element of Safety Culture*

- NPP are complex facilities with potentially high hazards
- Operating organizations uphold continuous effort to maintain and improve safe operation
- R&D is a tool for the questioning attitude and a source of emerging technologies that could enhance reactor safety



# *Role 6 - Maintaining fundamental expertise*

- Need for basic scientific expertise
- Training of new generation of experts
- Industry – University collaboration



# *Evaluation of R&D*

- Responsible governance and resource allocation requires conduct of systematic evaluations
- Evaluations provide credible, timely and neutral information on relevance and performance of activities
  - support program improvement
  - assist resource management, decision-making, and public reporting
  - improve results

# *Evaluation of R&D (2)*

- Multiple evaluation methods exist for diverse purposes
  - Quotation indices
  - Return on investment
  - Spin-off products
  - Patents, etc
- From safety benefit perspective, evaluation should be done against the identified R&D safety roles
  - Example of six roles given above

# *Elements of Evaluation*

**Capability:**
- Personnel
- Facilities and tools (including software)
- Database of historic R&D
- Funding

**Execution:**
- Conduct of Research
- Assessment of R&D results
- Integration with results from similar studies

**Closure:**
- Documentation of results
- Dissemination of results

**Processes:**
- Prioritization of research subjects
- Defining objectives and method of research
- Long-term planning

# *Criteria for Evaluation Elements*

- Upfront criteria for evaluations are needed for evaluation outcomes to be credible and consistent
- Each evaluation element would require specific evaluation criteria
  - Example for element "Assessment of Results"
    - Has the research answered the original issue?
    - Did the research provide the answer for the desired range of parameters?
    - Are test parameters sufficiently prototypic to simulate the real plant conditions?
    - How significant are the associated uncertainties?
    - Have any new phenomena, behaviors or trends been observed?
    - Did the research provide an answer directly or would additional interpretation be required?
    - Are recommendations made for the use of results and their potential limitations?
    - Are there recommendations for further work in support of the resolution of the original issue?

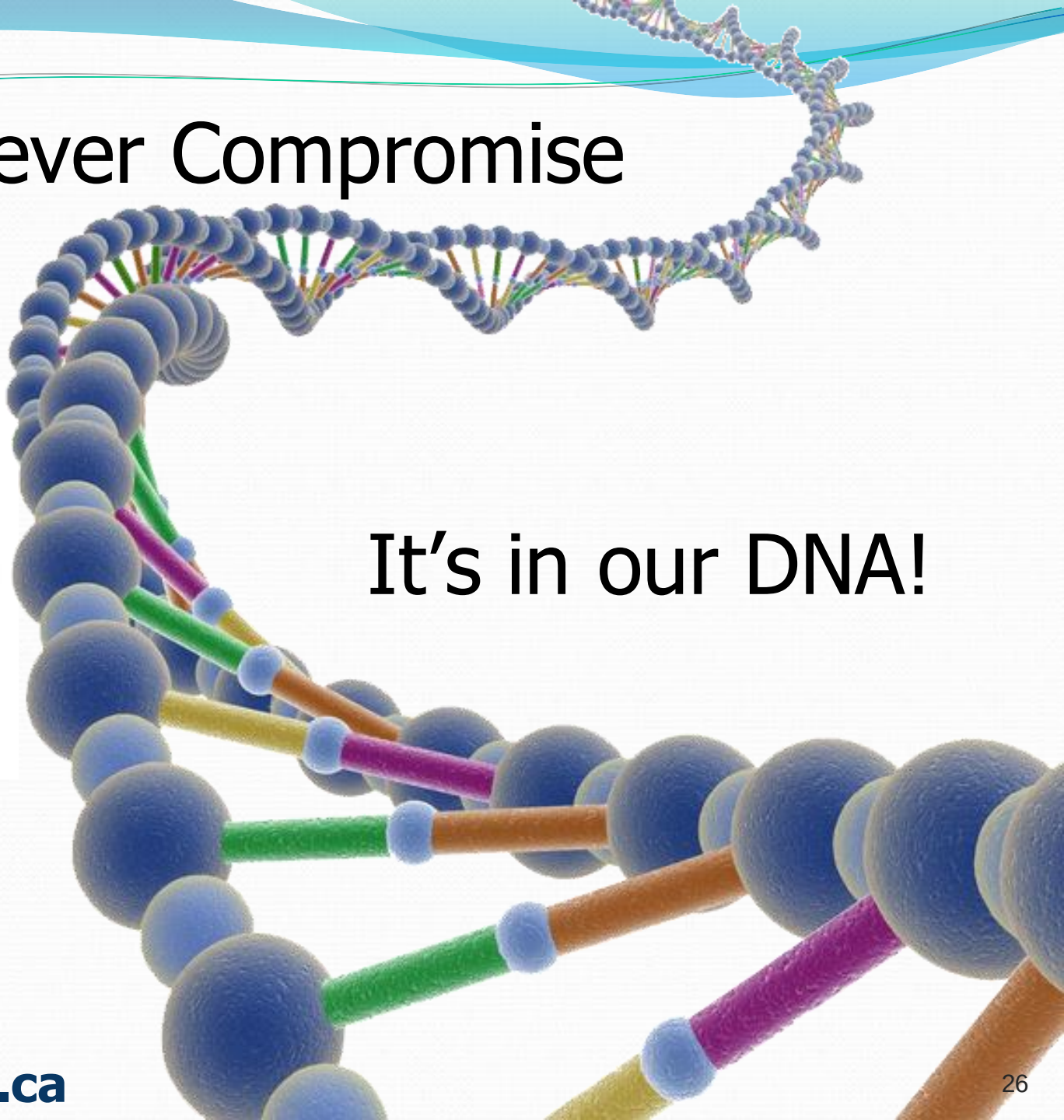
# *Some further thoughts*

- Broad changes in Canadian nuclear power sector influence our vision of required nuclear research capabilities
  - discussions on what constitutes adequate research infrastructure
  - prioritization of domains of research and areas of competence
  - consultation with industry and government stakeholders
  - IAEA guidance is considered

# *To sum up*

- Research in support of safe operation on nuclear facilities will be continuing as new priorities arise
- It is important to make sure that the R&D functions are achieved in an efficient manner
- Evaluation of R&D effectiveness requires development of specific approaches
  - *Can IAEA play an important role here?*

# We Will Never Compromise Safety…



It’s in our DNA!