U.S.NRC
Protecting People and the Environment

RIC 2009

International Activities and Cooperation

Dr. Brian Sheron
Director
Office of Nuclear Regulatory Research
March 11, 2009

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U.S.NRC

Office of Nuclear Regulatory Research

- Major program office
- Mandated by congress
- **240** Staff
- **$60-70M** in research funding
  - **2/3** User Needs
  - **1/3** Agency Mandates
  - Some Long Term Research

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Objectives of International Collaboration

- Today's presentations focus on the various benefits of collaboration
- How the international community complements and supplements itself
- Ultimately pursuing the shared goal of improved nuclear safety

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NRC's International Research Programs

- Cooperative research covers wide array of technical subjects
- **70+** bilateral & multilateral agreements
- With **25** countries and OECD
- Significant participation in
  - OECD/NEA CSNI & Working Groups
  - IAEA programs

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Benefits of International Cooperation

- All participants leverage resources
- Technical In-Kind contributions
- Broader base for operational experience
- International collaboration enhances regulatory effectiveness world wide
- Broader access to information
- Access to facilities not available domestically

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Intangible Benefits

- Yields higher quality and more extensive results than individually possible
- Establish contacts – valuable in everyday and emergency scenarios
- Maintain working relationships
- Provide higher visibility for and help sustain joint research programs

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Panelists

- **Dr. Jennifer Uhle**
  NRC/RES/DSA
- **Javier Reig**
  OECD-NEA, Nuclear Safety Division
- **Christiana Lui**
  NRC/RES/DRA
- **Jacques Repussard**
  IRSN, Director General

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NRC's International Cooperative Research Programs

Dr. Jennifer Uhle
Director, Division of Systems Analysis
Office of Nuclear Regulatory Research
March 11, 2009

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Introduction

- NRC's international agreements have helped all parties efficiently and effectively leverage their resources to enhance nuclear safety
- With the increasing globalization of nuclear activities these international arrangements become increasingly important
- Examples of Bilateral Agreements
  - CAMP
  - CSARP

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What is CAMP?

- Code Applications and Maintenance Program
- International program on thermal-hydraulic research and code development activities
- Started in 1980's
- NRC - coordinated with participation from many countries
- Focus is on development, assessment and application of thermal-hydraulics systems codes such as TRACE and RELAP5

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Goals of CAMP

- Collaborate on NRC thermal-hydraulic system safety analysis codes (TRACE, SNAP, RELAP5) to promote worldwide reactor safety
- Receive feedback on code strengths and deficiencies from a wider user community (independent assessment)
- Sharing of knowledge about reactor system safety

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CAMP

WHO IS PARTICIPATING?

- Currently 21 countries are participating in the program
- 5 more countries are in the negotiation phase

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CAMP Accomplishments

- CAMP meets twice a year
- CAMP members have contributed more than 200 NUREG/IA's
  - These products form the basis of an important independent verification and validation (IV&V) function of the program

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CAMP Accomplishments (cont...)

- Member contributions have saved NRC resources and improved the codes
  - Analysis of proposed supercritical water reactor designs by member countries identified issues in TRACE and RELAP5 H_20 properties near the critical point
  - South Korea's modeling of the advanced accumulator in the APR1400 reactor design has assisted NRC in modeling the advanced accumulator of the APWR
  - RELAP5 Reflood Model contributed by Paul Scherrer Institute (PSI-Switzerland)

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WHAT IS TRACE?

- Consolidated from the 4 thermal hydraulic codes developed by the NRC(RELAP, TRAC-PWR, TRAC-BWR, Ramona)
- NRC uses TRACE for thermal-hydraulic safety analysis in the regulatory process
  - Generic Issue
  - PRA success criteria
  - Design review
  - License amendment review
  - Staff training (simulator mode)
- Thoroughly assessed against experimental cases for PWR and BWR
  - Over 500 assessment cases
  - Tests range from 1/1000th scale to full scale experiments
  - Include new and advanced plant-specific experiments for both BWRs and PWRs

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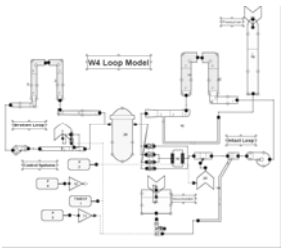
WHAT IS TRACE? (cont.)

- Component Based Design (Pipes, pumps, Vessel, etc.)
- Solution scheme is two-fluid, non-equilibrium hydrodynamics model
- Coupled with a 3-D neutron kinetics solver
  - Purdue Advanced Reactor Core Simulator (PARCS)
- Graphical User Interface
  - Symbolic Nuclear Analysis Program (SNAP)



TRACE input model in SNAP

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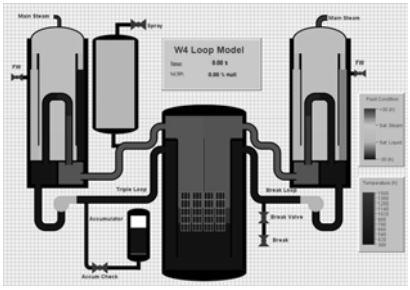
TRACE-SNAP Interface

- Visual depiction of plant
- Ability to analyze each component
- Allows for "real-time" analysis



TRACE-SNAP Post Processing Mask

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What is CSARP?

- Cooperative Severe Accident Research Program (CSARP) is a NRC international program on severe accident phenomenological research and code development activities
- Started in 1988
- Share experiments, analysis and NRC developed analytical codes
  - MELCOR
- Meets once a year (September)
- Benefits
  - Resources provided by participating countries assist NRC in the development, assessment and maintenance of MELCOR
  - NRC provides user assistance, training, and bug fixes to participants

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CSARP

WHO IS PARTICIPATING?

- Currently 17 countries are participating in the program
- Few more countries are in negotiation phase

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CSARP

Accomplishments

- NRC access to experimental data for code development, modification and assessment
  - MOX and high burnup fuel fission product release experiments (IRSN, France)
  - QUENCH experiments investigate phenomena associated with quenching of overheated fuel (FzK, Germany)
- Enhancement of MELCOR and related codes used for regulatory applications
  - Design certification for new reactors (e.g., AP1000, ESBWR, EPR)
  - Revised source term (NUREG-1465) for High burnup and mixed-oxide fuel in PWRs
  - State-of-the-Art Reactor Consequence Analysis (SOARCA)

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CSARP (cont.)

CSARP Accomplishments

- Assessment of code models
  - MELCOR Code Assessment Program [MCAP] technical review meeting
  - Code application by members
  - Model development contributions and suggestions
- Use of MELCOR by international partners
  - Support for Atucha II Nuclear Power Plant licensing in Argentina
  - European users group (Switzerland, Germany, Czech Republic, Spain, Sweden,…) annual meeting – started in 2008

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WHAT IS MELCOR?

- MELCOR has been developed at Sandia National Laboratories for the USNRC
  - Started in 1982 (ongoing development of new capabilities)
- Major pieces of MELCOR referred to as "Packages"
  - Hydrodynamics, heat and mass transfer to structures, gas combustion, aerosol and vapor physics
  - Decay heat generation, core degradation, ex-vessel phenomena (e.g., core concrete interactions), sprays, fission product transport
  - Thermodynamics, equation of state, material properties, data-handling utilities, equation solvers
- MELCOR modeling approach
  - T-H modeling is simple/fast-running for PRA applications
  - Uncertainties through sensitivity studies (substantial user flexibility)
  - MELCOR is a state-of-the-art tool for source term calculations
    - Most modeling is mechanistic, sometimes simplified
    - Evolving as a repository of our knowledge of severe accident phenomenology

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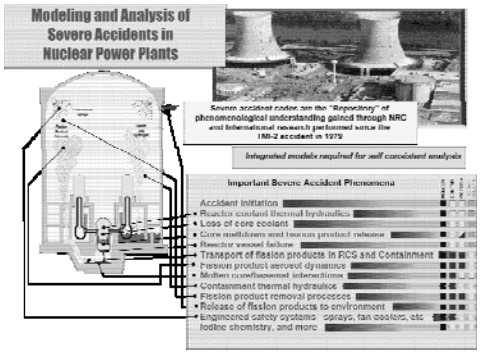
WHAT IS MELCOR?



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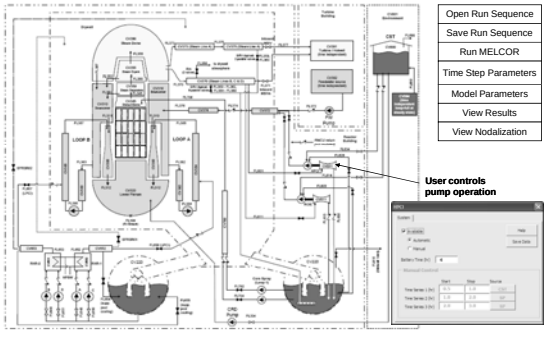
MELCOR SNAP INTERFACE



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Summary

- NRC's international agreements have helped all parties efficiently and effectively leverage their resources to enhance nuclear safety
- With the increasing globalization of nuclear activities these international arrangements become increasingly important
- We look forward to future cooperation with our partners
- Contact Jennifer Uhle (Jennifer.Uhle@nrc.gov) or Donna-Marie Perez (Donna-Marie.Perez@nrc.gov) for information on joining NRC's international research programs

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International Research Activities and Cooperation

Javier Reig
Head, NEA Nuclear Safety Division

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What is the OECD / NEA?

- **Small size and budget (80 staff members; budget of 13 million euros, + voluntary contributions and projects)**
- **Large representation (85% of the world's nuclear power capacity)**
- **Non-political forum; climate of mutual trust**
- **Tries to pool world's best nuclear expertise among developed countries**
- **Narrow focus: in-depth scientific, technical work**

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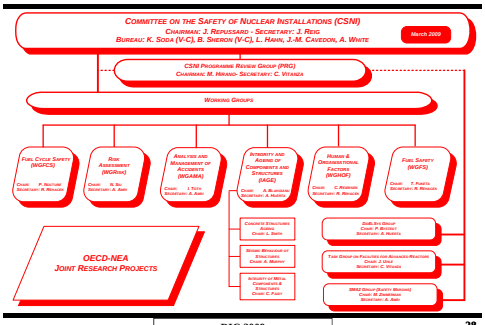
CSNI Chart



CSNI Operation

- Working Groups
  - Grouped around specific technical disciplines
  - "Base-load" activities centered on exchange of experience, exchange of information, event analysis, data analysis and interpretation, code developments, methodology development, safety criteria
- Tasks
  - Grouped around emerging issues, interdisciplinary
  - Activities limited in time, created ad-hoc in order to provide the CSNI and member countries with recommendations/ ideas on ways to address and/or resolve a specific issue
- Joint Projects
  - Grouped around data gathering and analyses
  - Projects centered around experimental programs run in unique facilities, through cost sharing arrangements

NRC's Role

- NRC active in all CSNI Working Groups & Task Groups
  - Chair of WGRISK
  - Takes very active role in the Peer Review Group (PRG)
  - PRG is formed by one expert from each of the four nations with the largest nuclear safety research programmes, plus three experts from other CSNI member countries (on a rotating basis)
- NRC participation in OECD programmes is valuable to all participants and also permits the NRC access to operating experience from foreign reactors

TASKS

Tasks on research programs and infrastructure

Purpose

- Propose a CSNI strategy for best use of research infrastructure

Scope and product

- Summarize the currently identified safety issues, whose resolution depends upon additional research work
- Provide the current status of those research facilities unique to the nuclear industry that support resolution of the safety issues
- Provide recommendations for CSNI initiatives for an optimal use of facility infrastructure through international undertakings

Focus

- Existing and advanced water reactors →→ SFEAR Task (2005-2007)
- Future reactors (HTGR and SFR) →→ TAREF Task (2008-2009/10)

TAREF

TECHNICAL ISSUES AND ASSOCIATED FACILITIES

Technical Areas →Issues in Technical Area →Facilities vs. Issues

Technical Areas:

- Accident analysis and thermal fluids (including neutronics)
- Fission product transport
- High temperature materials (metallic)
- Graphite and ceramic
- Fuel safety

Issue → Priority → Facility → Capability → Availability

JOINT INTERNATIONAL SAFETY RESEARCH PROJECTS

Motivation for Safety Research

- Develop consensus for closing issues that have been sufficiently investigated
- Support harmonisation of methodologies
- Support maintaining competence and developing methods
- Maintain a competent international network to support licensing
- Preserve valuable and *pro-active* research facilities

➢ *International co-operation increases credibility and enables to use budget efficiently; OECD/NEA play a major role to promote and support such co-operation through research project arrangements*

Ongoing OECD-NEA Safety Research Projects

➢	**HALDEN**	Fuel and Materials, I&C, Human Factors	Norway
➢	**CABRI**	Fuel in RIA transients	France +Japan
➢	**SCIP**	Fuel integrity	Sweden
➢	**PRISME**	Fire safety	France
➢	**MCCI-2**	Severe Accident (Ex-Vessel)	USA
➢	**ROSA**	System TH	Japan
➢	**PKL-2**	PWR SG heat transfer	Germany & Hungary
➢	**SETH-2**	Containment (CFD)	Switzerland & France
➢	**THAI**	Containment (H, I, Aerosols)	Germany
➢	**BIP**	Iodine chemistry	Canada
➢	**SERENA-2**	Steam explosion	Korea & France
➢	**PSB-VVER**	T-H for VVER 1000	Russia Completed
➢	**SFP**	Spent fuel safety	USA Starting April 2009
➢	**SCAP**	SCC+Cable Ageing	Japan
➢	**Databases**	**1. FIRE 2. ICDE 3. OPDE 4. COMPSIS**	

MCCI2 Project

To investigate ex-vessel melt coolability and concrete interaction during a severe accident

Schedule 2006-2009 (4 years)

Participants

Belgium	Korea
Czech Rep.	Norway
Finland	Spain
France (CEA + IRSN + EDF)	Sweden
Germany	Switzerland
Japan	**USA** (ANL + NRC)

MCCI2 Test Matrix Overview

Test Category	Description
1	Combined effect of water ingression and melt eruption on coolability
2	Examine effectiveness of new design features for augmenting debris coolability
3	2-D CCI tests for model development and code validation
4	Integral tests at larger scale to confirm synergistic effect of different cooling mechanisms and to provide data for code validation

SFP Project

AGREEMENT

ON THE OECD-NEA SFP PROJECT

AN EXPERIMENTAL PROGRAMME AND RELATED ANALYSES FOR THE CHARACTERIZATION OF HYDRAULIC AND IGNITION PHENOMENA OF PROTOTYPIC WATER REACTOR FUEL ASSEMBLIES

Operated by the USNRC
Carried out at the US SANDIA Nat. Laboratory
Start April 2009, 3 ½ year duration

SFP Project

Participants

Czech Rep.	Korea
France (CEA + IRSN + EDF)	Norway
Germany	Spain
Hungary	Sweden
Italy	Switzerland
Japan	UK
	USA (SNL + NRC)

Achievements and Goals

- **Address safety issues relevant for the nuclear community by means of research shared by many countries**
- **Enhance technical exchange, co-operation and consensus-building internationally**
- **Support the continued operation of unique test facilities which are of value to the OECD/NEA nuclear community**
- **Help to retain OECD/NEA countries technical expertise and infrastructure in strategic fields of nuclear energy**
- **Efficient cost-sharing arrangements where many countries contribute to programme funding**
- **The projects are an excellent forum for industry-regulator-TSO interaction. Industry participation is essential for providing the necessary dynamics and expertise in the project**

http://www.nea.fr/html/jointproj/welcome.html

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NRC's Multilateral Cooperative Activities

Christiana Lui
Director, Division of Risk Analysis
Office of Nuclear Regulatory Research
March 11, 2009

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Example OECD and IAEA Activities

- OECD/NEA Safety Research Projects
  - Halden Reactor Project
  - PRISME
- CSNI Working Groups
  - WGRisk
  - WGHOF
- IAEA
  - Generic Issues (GI) Information Exchange

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OECD - Halden Reactor Project

- Current research areas include
  - Fuels and materials
  - Digital systems
  - Human factors and human reliability
- HRP enables staff to significantly leverage resources
  - NRC contributes ~7% HRP budget; other contributions from OECD members, Norwegian government
  - Unique capabilities and expertise (e.g., crew experiments, LOCA fuel-relocation experiment)
  - Cost savings from building and operating new facilities
  - New staff training and development

OECD HRP Technical session tomorrow morning (Track 5, 8:30-10:00)

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OECD - PRISME

- Collect real-scale data to validate fire models, including the THIEF cable failure model
- 2 test series, 10 full-scale tests complete—6 more planned for 2010.
- IRSN test facility provides more realistic configuration than currently available in US

Before

After

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Working Group on Risk Assessment (WGRisk)

- Purpose: Advance PSA understanding and utilization
- Recent and current projects (examples)
  - Non-seismic external events (2008)
  - Use and development of PSA (2008)
  - HRA information exchange (ongoing)
  - LPSD PSA (ongoing)
  - Digital I&C PSA (ongoing)
  - Severe accident management (ongoing)
  - Advanced reactor PSA (initiated)
- Benefits
  - International perspectives on key issues
  - Groundwork for potential data collection activities

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Working Group on Human and Organizational Factors (WGHOF)

- Purpose: Enhance understanding and methods related to HOF in nuclear installations
- Recent and current projects (examples)
  - Safety culture assessment methods (2006)
  - Maintenance best practices (2007)
  - Organizational design for new builds/management of change (2008)
  - Impact of DI&C on human performance (ongoing)
  - HOF in root cause analysis (upcoming)
  - Lessons learned from safety culture initiatives (upcoming)
  - HOF issues during new plant construction (upcoming)
- Benefits
  - International experience with advanced technologies and construction
  - Rapid access to international perspectives on HOF issues and practices

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IAEA – GI Information Exchange

- Purpose: Share generic issues and features of generic issue programs
- Recent and planned activities
  - Consultancy meeting to discuss the format and vehicle of information sharing (2008)
  - Annual meetings and development of a website
- Benefits
  - A broader pool of resolutions, experience and potential issues
  - Refinement of existing programs

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International Activities and Cooperation

March 11, 2009

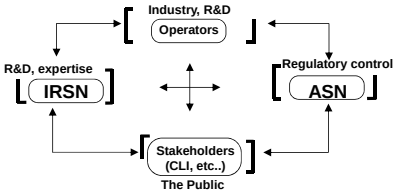
Jacques Repussard
Director General

Presentation overview

- **IRSN: the science pillar of the French Nuclear regulatory system**
- **IRSN's vision on reactor safety research**
- **IRSN / NRC interaction: a story of growing multifaceted cooperation**
- **conclusion**

IRSN

IRSN Mission: to provide independent research and expertise in support to public policies in nuclear safety, security, and radiation protection



- a wide field of competence allowing a broad vision of safety, security and radiation protection issues
- risk assessment capability at the heart of IRSN's R&D and technical expertise missions
- a strong international involvement
- 1700 people, 300 M€ budget

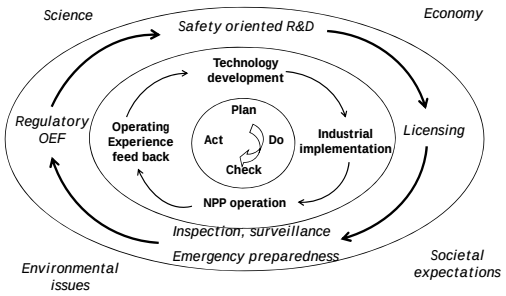
IRSN

IRSN's vision on reactor safety research

- **To maintain an independent risk assessment capability, based on the excellence of experts and on state of the art techniques and data, including key experimental facilities.**
- **To maintain at all times the state of the art knowledge and operational expertise necessary to deal as efficiently as possible with major nuclear accident consequences.**
- **To contribute in key areas to cutting edge R&D in order to drive industry towards making the best use of scientific and technological progress for improving safety, environmental protection and health.**
- **To allow regulatory policy to anticipate the evolution of safety, security and radpro related risks.**

IRSN

A global approach to ensure timely worldwide safety improvement



IRSN

A global approach to ensure continuous safety improvement
10 Cross-cutting issues

1. Advanced computational methods:

Development of more sophisticated and more accurate coupled modelisation tools, based on multi-scale approach, in the following domains:

- **material physics and mechanics (fuel, piping, …)**
- **thermal-hydraulics**
- **neutronics**

Development of advanced methods to assess uncertainties.

IRSN

A global vision to ensure continuous safety improvement
10 Cross-cutting issues

2. **Development of PRA tools and methods for more systematic use. Extension of PRA to assess effects of aging, earthquake, fire, flooding and other severe climate events, grid reliability.**
3. **Development of research on "human factor".**
4. **Development of research on reliability of Digital Instrumentation and Control.**
5. **Research on fuel behaviour in reactor and fuel cycle for new fuel designs and advanced burn-ups levels (reactivity, fuel transportation, intermediate storage, reprocessing accidents).**

IRSN

A global vision to ensure continuous safety improvement
10 Cross-cutting issues

6. **Offsite consequences**
   - **Development of decision making tools for mid-term and long term post-accident management**
   - **Research on low dose effects on man and environment**
7. **Develop an economic approach of the cost of nuclear safety (safety investments vs. accident cost estimate, including indirect offsite consequences).**
8. **Research on efficiency of passive safety features.**
9. **Research on criticality to maintain competence.**
10. **Knowledge management. Development of centres of excellence and of training capability.**

IRSN

Plus three additional PWR specific issues…

1. **Ageing**
   - **Research on ageing of PWR plant components (internal structures, concrete structures, electronics, cables)**
   - **Development of tools on default initiation and propagation to anticipate problems**
2. **Development of in-situ real-time inspection and monitoring techniques.**
3. **Keeping research on severe accidents and Source Term evaluation at a "reasonable" level to maintain competence (core meltdown accident considered in GEN III design!).**

IRSN

As well as upcoming fast reactor specific issues

1. **Reappropriation of past R&D on SFRs**
   - **Whole core accident codes as SAS4A, SIMMER and associated qualification experiments (Cabri, …)**
   - **Local accident codes and associated qualification tests (Scarabée, …)**
   - **Fire propagation code and associated qualification tests (Esmeralda)**
2. **Develop advanced codes common, when needed and as far as possible, to LWRs and S (G)FRs, and capitalize in them all past R&D results.**

IRSN

International cooperation: a key parameter for IRSN R&D policy

- **Open policy of association with R&D partners from different origins: nuclear research centers, industry, universities**
- **Over 140 cooperation agreements with organisations from 33 countries**
- **Strong involvement in NEA / CSNI and EU sponsored R&D programmes**
- **Strong involvement in many IAEA technical activities, including operating experience feed back system**

IRSN

IRSN /NRC interaction: a success story

- **A long story which has built up mutual trust and confidence**
- **Wide ranging scope and mechanisms of cooperation …**
- **… Leading to significant mutual benefits**
- **… And contributing to the optimization of multinational cooperation**

IRSN

IRSN /NRC bilateral cooperation: a wide ranging scope

- **Severe accidents phenomenology**
- **Fuel safety criteria**
- **Fire protection**
- **Digital I&C evaluation**
- **Cable ageing**
- **Criticality data**
- **Offsite health effects**
- **Economic modeling of accident consequences**
- **Emergency preparedness new generation modeling tools**

IRSN

conclusion

- **Nuclear safety is and will remain science based. All nuclear countries should contribute in some way to the enhancement of safety science basis,**
- **The globalisation of nuclear industry invites a mutualised approach to safety research, including on the issue of key expertimental infrastructures,**
- **In a longer term perspective, the shortest route to successful harmonisation of regulatory practice is to share safety oriented R&D programmes and results,**
- **Beyond bilateral cooperations, NEA should play a major role to extend multinational cooperation**

IRSN

Thank you for your attention

More on www.irsn.org

IRSN

Closing Remarks

- Shared goal of improved nuclear safety
- Benefits are significant, both tangible and intangible
- Search for commonality continues
- Cooperation vital in an industry gone international

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Questions

- Pass questions to RIC session staff
- Unaddressed questions will be reviewed after the RIC and answered in writing

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