IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Enhancing nuclear safety

CONTINUOUSLY IMPROVING SAFETY OF NUCLEAR INSTALLATIONS : AN APPROACH TO BE REINFORCED AFTER FUKUSHIMA ACCIDENT

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Contents

Nuclear safety approach in France

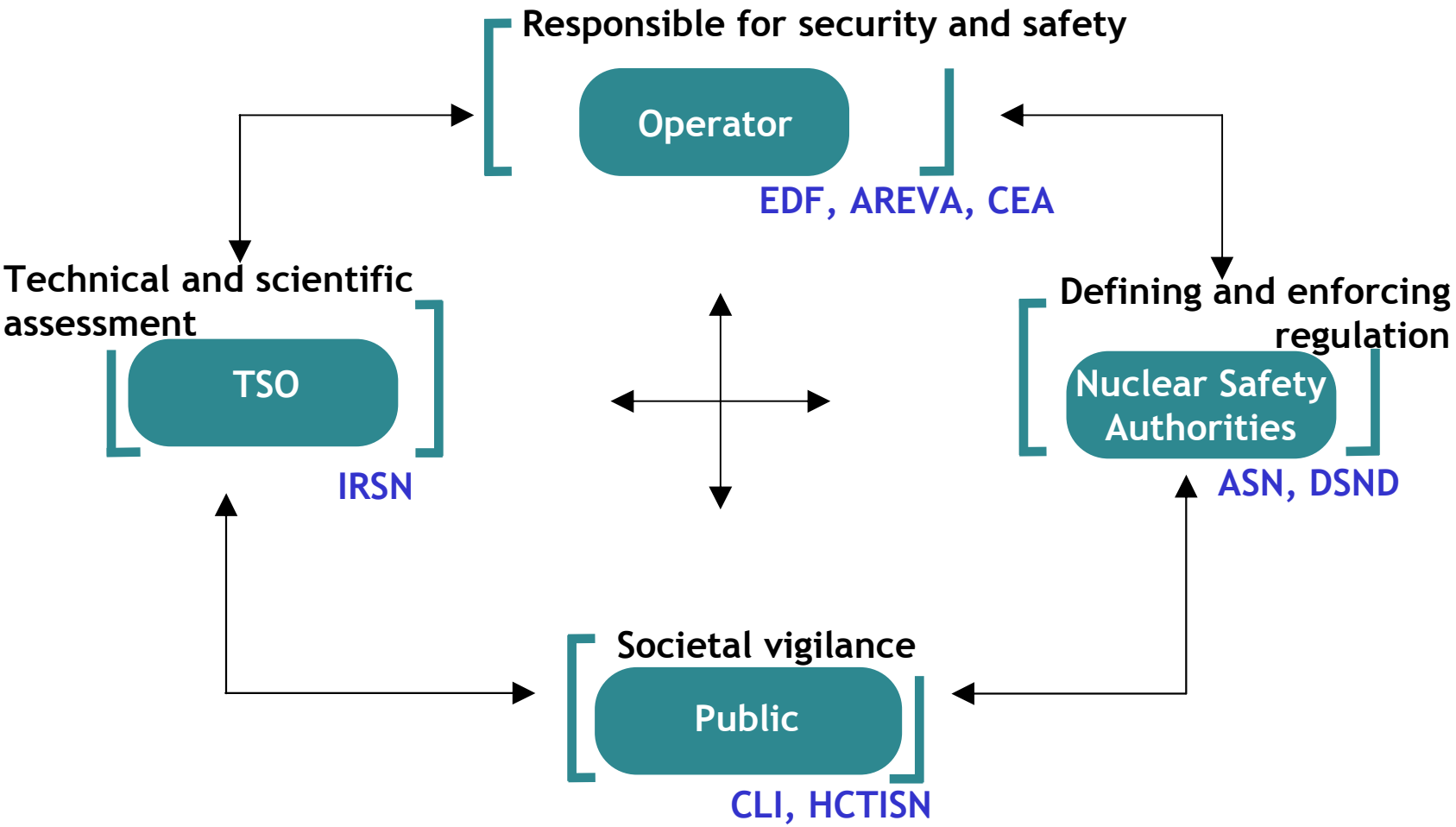
Institutional framework (1/2)

- **Long maturation of the French organization in nuclear safety and radiation protection**

- **Nuclear transparency and security (TSN) act of 16 June 2006 :** establishing the nuclear safety authority (ASN), and the rights and responsibilities of operators and stakeholders.

- **TSN act imposes Periodic Safety Review (PSR) of all nuclear installations, every ten years or less :**
  - Review compliance with safety reference of installation
  - Update safety reference according to operating experience feedback and progress in knowledge

Institutional framework (2/2)



Role of IRSN in licensing process (1/2)

- **IRSN: a public body with industrial and commercial activities,** under the joint supervision of the Ministers of Ecology, of Industry, of Research, of Defense and of Health

- **Its main missions: research and risk assessment, in particular for ASN, in nuclear safety and radiation protection**

- **1700 employees**, including more than 1000 specialists: researchers, engineers, biologists and Ph.D. students, post-docs

- A budget of **€300 million with 45% committed to research**

- **Operating experimental facilities and having access to research reactors (CABRI, PHEBUS, recriticality facilities…)**

Role of IRSN in licensing process (2/2)

- **Regulatory framework not as prescribed as in other countries,** mainly for historical reasons

- Thus, **safety analysis performed by IRSN not just based on compliance to regulations** :
  - IRSN analysis progressively focused on highly safety relevant points of safety demonstration provided by operators
  - Following defence-in-depth approach
  - Counter-calculations performed by IRSN when judged necessary using often its own computer codes (ASTEC…)

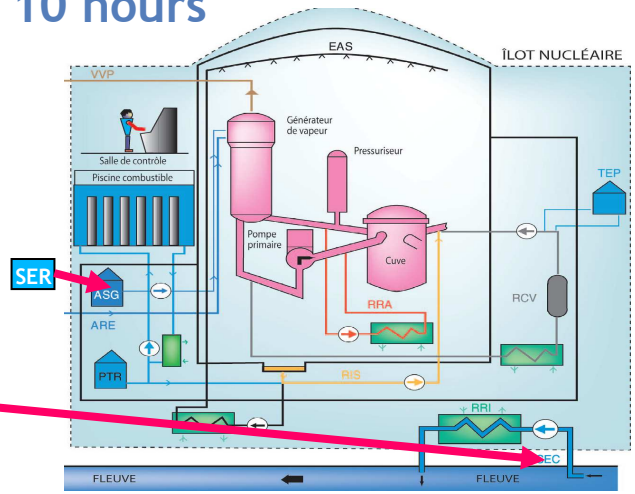
- Importance of:
  - Quality of contradictory dialog with operators
  - Competence of IRSN experts based on analysis of operating experience, research, safety studies (e.g. PSA) to identify any possible weakness
  - Technical review of IRSN analysis by independent experts groups

❑ MAJOR SAFETY IMPROVEMENTS IN FRENCH NPPS

AFTER TMI2 (1/2)

- Procedures “H” to manage beyond design situations for “plausible” durations, for instance :
  - H1 to cope with LOHS
  - H3 to cope with SBO
- Deployment of H3 boosted by “le Buget 4” SBO in 1984 :
  - Adding turbo-alternator using steam produced by SG
  - Adding a 3rd electro-generator (diesel/gas turbine) per site
- H1 used at “Cruas 4” in 2009 during LOHS for 10 hours

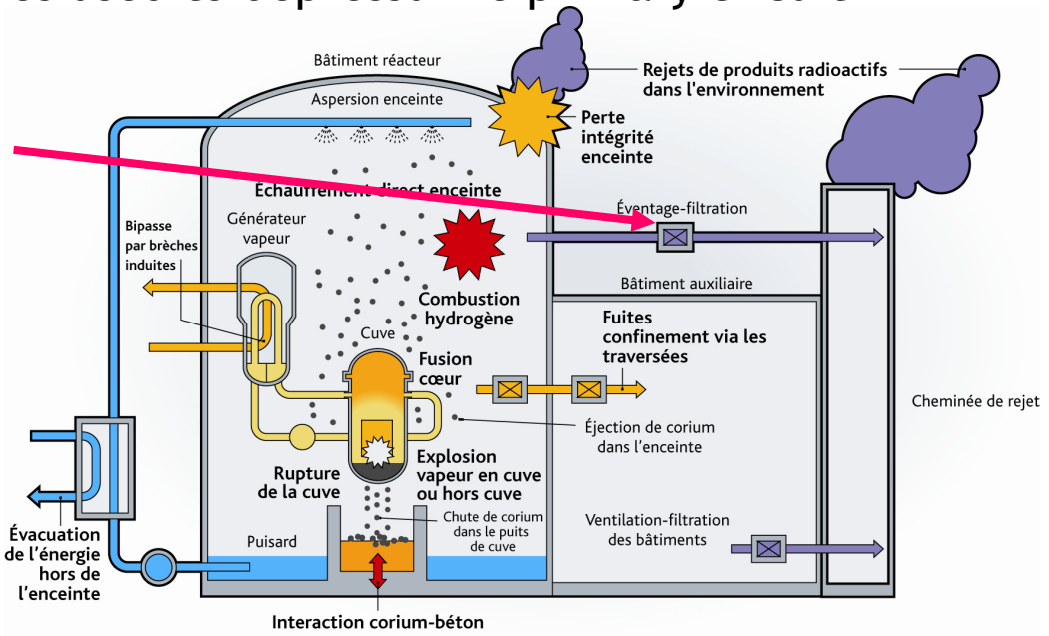
Such LOHS probability rated 10^{-5}, occured after 1500 operating reactor year!



AFTER TMI2 (2/2)

- Procedures “H” completed by SAM procedures (named “U” for “ultimate”), for instance :
  - U5 to cope with spray failure in containment, calling for containment venting 24 hours after core melt onset

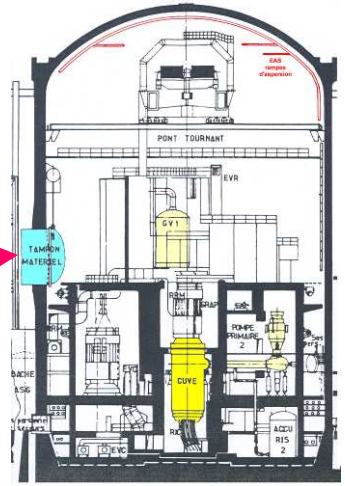
- Plant modifications :
  - Higher reliability of valves used to depressurize primary circuit
  - Containment venting line with metallic and sand filters (Cs filter performance: 99.9%)
  - H2 passive recombiners



RECENT SAFETY IMPROVEMENTS

- **After Le Blayais flooding (1999):**
  - Revisiting flooding risk assessment
  - Rising dam around NPPs
  - Cofferdam in rooms with equipments important for safety
  - Revising guides to assess flooding hazards

- **Planned 900 MWe Plant modifications (after PSR 3):**
  - H2 concentration measurements
  - Vessel melt-through detector
  - Reinforcement of lock bolts



SAFETY IMPROVEMENTS FOR GENERATION III PLANTS

- General safety objectives approved by German and French Safety Authorities in 1993

- Calling for significant plant improvements in order to achieve significant reduction of :
  - global core damage frequency ($<10^{-5}$) for all type of failures and hazards and with uncertainties
  - radioactive release even in case or core melt-down (no emergency evacuation, limited sheltering nearby plant, no long term consumption restrictions)

- IRSN contributed to implement technical guidelines

- Used as reference for Flamanville 3 EPR

SAFETY IMPROVEMENTS CONSIDERED FOR LTO

- EDF information to ASN in 2009: **intent to seek licence for extending plant lifetime significantly beyond 40**
- Generation II and generation III plants on French territory for decades
- Thus strong societal request (already before Fukushima) to raise safety reference for generation II plants level with LTO as close as possible to generation III
- IRSN R&D programs orientated towards this objective

IMPACT OF FUKUSHIMA

AFTER FUKUSHIMA (1/3)

- French Prime Minister requested ASN to perform complementary safety reviews (CSR) of NPPs on March 23rd
- European Council called for stress tests (ST) of NPPs on March 26th
- French CSR based on WENRA specifications (as ST) issued April 21st and extended to fuel cycle plants, test reactors...
- Main objective is to assess :
  - Installation robustness in case of external hazards (earthquake, flooding, earthquake and induced flooding, industrial risks...)
  - Installation robustness in case of SBO, LOHS, both
  - SAM robustness

  and
  - By using progressive approach (in intensity, duration, accumulation, one to multi-units concerned on a site) to identify possible cliff edge effects (core damage, recriticality…)
  - Highlighting possible improvements

AFTER FUKUSHIMA (2/3)

- CSR reports for 80 installations sent by operators (EDF, AREVA, CEA, ILL) on September 15th
- CSR analysis by IRSN (500 p. report) reviewed by experts groups on November 8 - 10
- Main conclusions:
  - Huge efforts in short time for operators and IRSN
  - Continuous safety improvement process has contributed to make plant safer than originally
  - Some local no-compliance identified to be promptly corrected
  - At some locations,external hazards evaluation needs to be revisited
  - Significant safety improvements still required to cope with extreme beyond design situations

AFTER FUKUSHIMA (3/3)

- Proposal to design a “hard core” of robust, well protected and secured SSCs crucial to controlling plants safety during extreme hazards in order to
  - Prevent core damage
  - Limit as much as possible radioactive release
- 2012 devoted to identify this “hard core”
- “Hard core” easier to design for EPR
- Note that learning from Fukushima will take years!

❑ INTERNATIONAL COOPERATION BETWEEN TSO

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- **Networking TSOs, already recognized at the time of "nuclear renaissance" even more strongly needed after Fukushima to :**
  - share lessons learned
  - harmonize safety analysis tool
  - share R&D load and results
  - train new generation of experts

- **European initiative :**
  - ETSON
  - Bel V (Belgium), GRS (Germany), IRSN (France), LEI (Lithuania), UJV (Czech Republic), VTT (Finland), VUJE (Slovakia)
  - Associated members in 2011 : JNES (Japan), SSTC (Ukraine)

- **IAEA initiatives :**
  - TSO conference in Aix-en-Provence (2007) and Tokyo (2010)
  - Creation of "TSO forum" under consideration

CONCLUSIONS

- Continuously safety improvement approach in France, in particular at the occasion of the PSR, has contributed to make NPPs safer
- Approach to be reinforced in France after Fukushima considering extreme hazards
- Importance of the scientific and technical assessment by a public body of highly competent experts as enhancing nuclear safety is based on progress in science and technology
- TSO networking to share experience, perform cooperative research harmonize practices and train new generations of experts even more strongly necessary after Fukushima

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