IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Faire avancer la sûreté nucléaire

Main Conclusions of the French NPPs Stress-tests :

a Need for a “Hardened Safety Core”

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IAEA International Expert Meeting
19-22 March 2012, Vienna

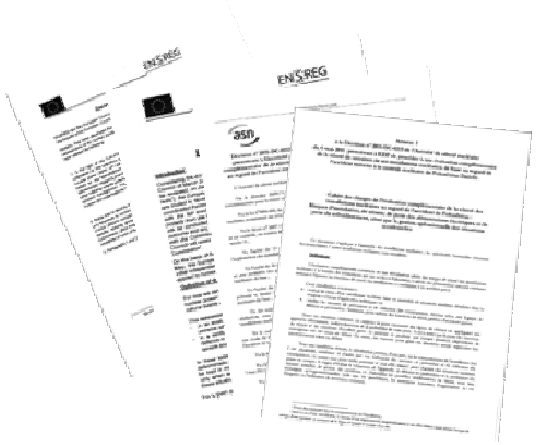
Content

1. **Origin, content and methodology of French nuclear installations stress-tests in 2011**
2. Conclusions of the French Stress-tests
3. Completion of the French Safety Approach
4. Conclusion

1.1 Stress-tests origin

1st accident learning's

- **Inappropriate design** of the power plant regarding external hazards
- **Long-term loss** of cooling and energy supplies
- Failures affecting simultaneously **all site** plant – difficulties to manage the situation in the long term.



National and international reactions

- The **French Prime Minister** asked the French Nuclear Safety Authority, on March 23th
- The **European Council** asked for stress-tests on all European NPPs on March 24th and 25th

European Terms of Reference proposed by WENRA (April 21st)

- French terms of reference established by the ASN (extended to other nuclear installations) to French operators on May 5th
- The WENRA terms of reference endorsed by ENSREG and the European Commission (May 25th)

1.2 Content of ASN terms of reference / methodology for stress tests

3 parts

External Hazards

- Robustness to External Hazards

Loss of Safety Functions

- Robustness to the Loss Of Power Supply or Loss of Heat Sink

Severe Accident

- Robustness of the provisions to mitigate Severe Accident

« real » state

All possible situations

Pools/reactors

site

cycle

A graded and deterministic approach

Expert judgment

1.2 A review using multiple skills

External hazards (earthquake, flooding)

Knowledge of the effective state of facilities

Civil works

Equipment

Induced hazards (environmental environment, fire, explosion, loads drops)

Human aspects and organisational factors

Accidental situations

Emergency preparedness and management

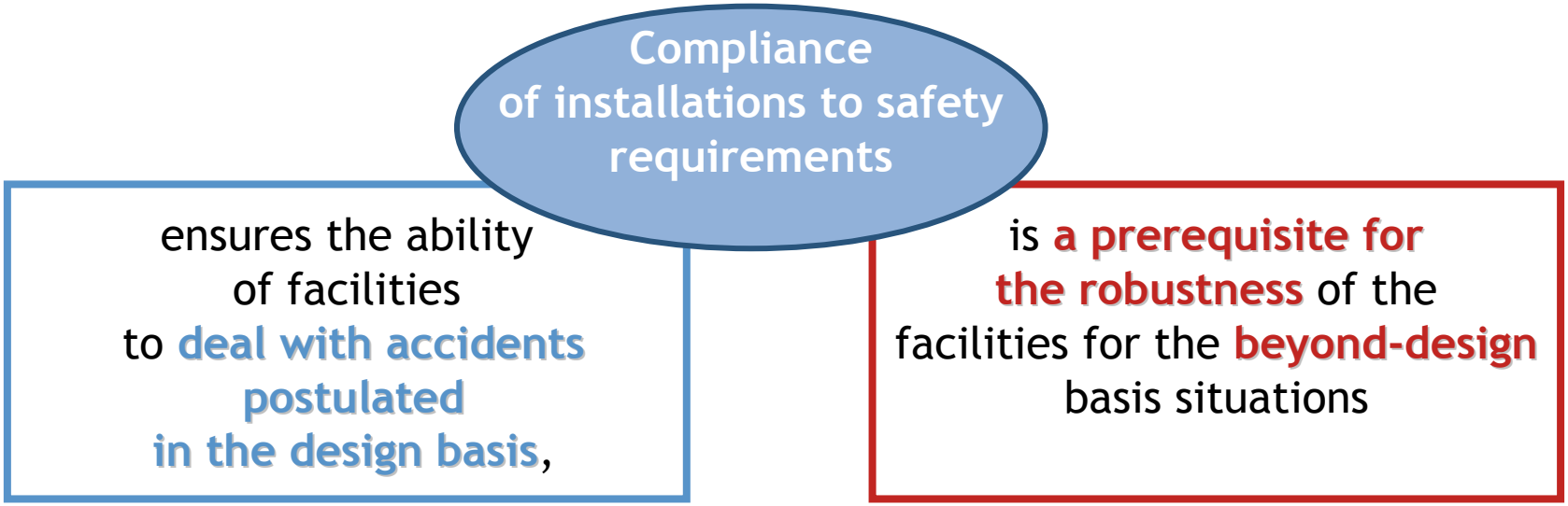
Radiation protection in accidental situation

Severe accidents

Content

1. Origin, content and methodology of French nuclear installations stress-tests in 2011
2. **Conclusions of the French Strest-tests**
   1. **Effects of non compliances**
   2. **Robustness to hazards**
   3. **Robustness to postulated situations**
3. Completion of the French Safety Approach
4. **Conclusion**

2.1 Installations' robustness: real state



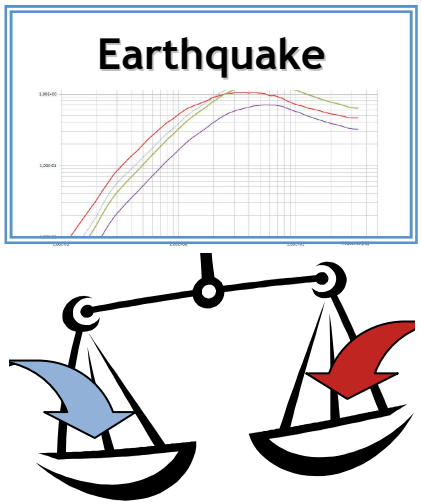
Operators have taken into account the main non-compliances known on June 30, 2011 in their stress-tests.

Complete the review conducted for stress-tests ▶by the end of 2012

Reinforce processes to detect and cope with non-compliances

2.2 Installations' robustness for beyond design external hazards

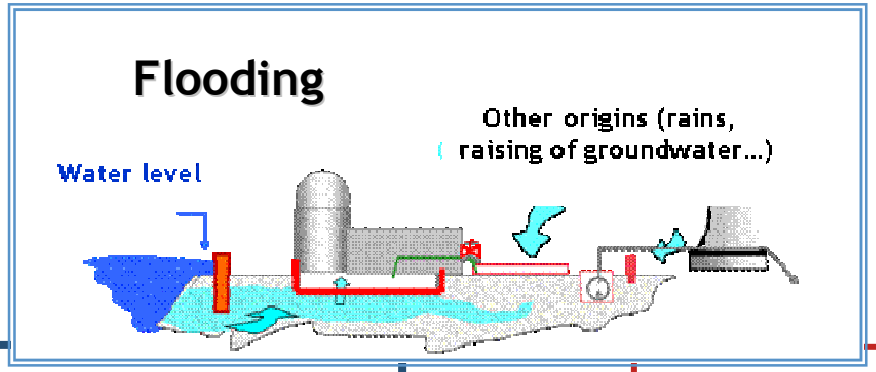
significant **seismic margin factors** on major structures and equipment **reported by operators**



uncertainties to define seismic motions and **simplified** nature of **approaches**

do not allow to evaluate, with a sufficient degree of confidence, the robustness of each facility for 'beyond design basis earthquake'.

2.2 Installations' robustness for beyond design external hazards



Most **equipment** used in case of LHS or SBO **located inside the "flooding protection volume"**, protected in the event of a **'design basis' flood**

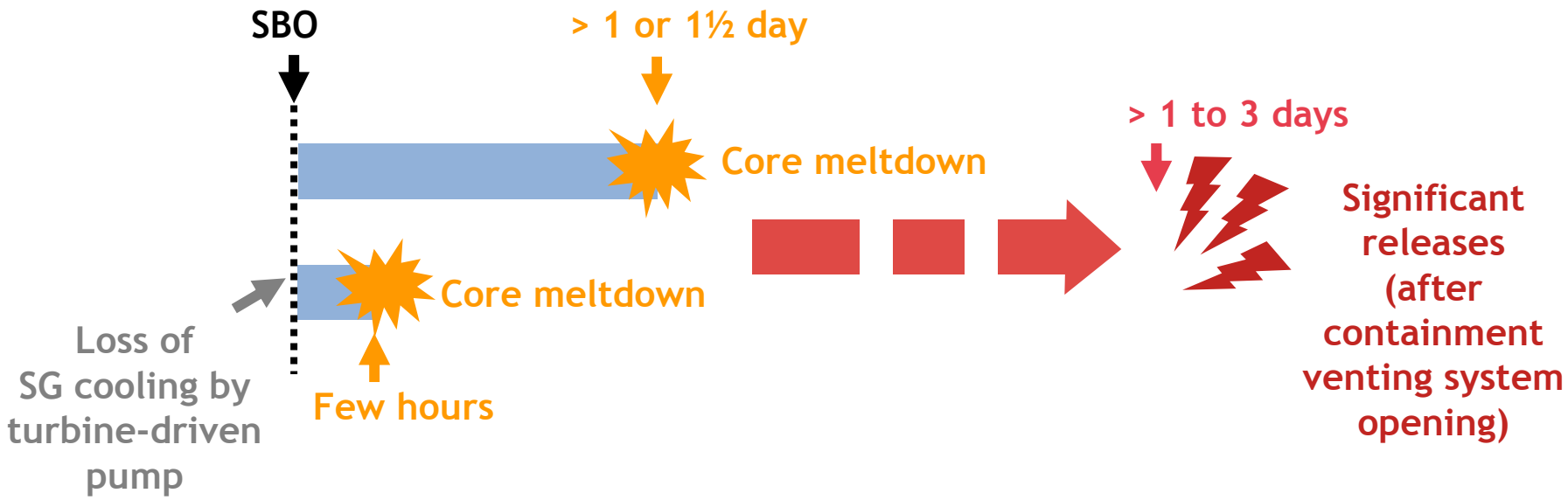
A **consistent water levels** may be **observed on the platforms** of some nuclear facilities for **'beyond design basis'** floods

➡ additional studies to confirm water levels on plateforms for 'beyond design basis' floods

➡ strenghtening of the flooding protection volume to reduce SBO and LHS risks

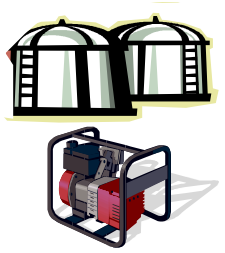
2.3 Installations' robustness: Loss of heat sink or electrical supply – severe accident (EDF NPPs' case)

Loss of Electrical Supply (Station Black Out: external + EDG)



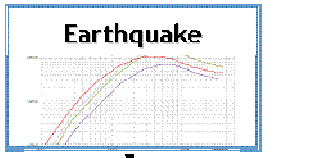
➡ Studies/EOPs proposed to confirm grace periods

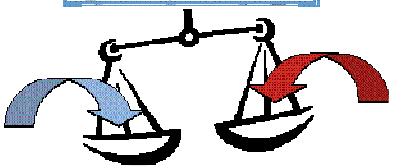
➡ Additionnal Provisions : water make-up, EDG…



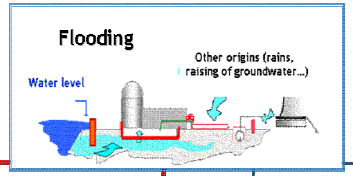
2.4 Installations' robustness

Effect of **non-compliances**





Induced events
(fires, explosions, pipes breaks, loads drops…)
Induced hazards on industrial sites around



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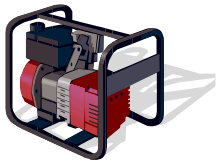
Additional provisions



2.4 First Conclusions – Design Basis

NPPs able to withstand the design basis EQ or flood with no cliff-edge effect (just above), as soon as **compliance** to safety requirements is granted.

Need to complete the current safety requirements (design basis) in some areas in particular:

- characterization of seismic motion,
- combinations of hazards to consider (external, internal, with internal events),
- requirements associated to SSC (fire protection, severe accident management ...)
- durations of loss of heat sink and loss of energy
- …

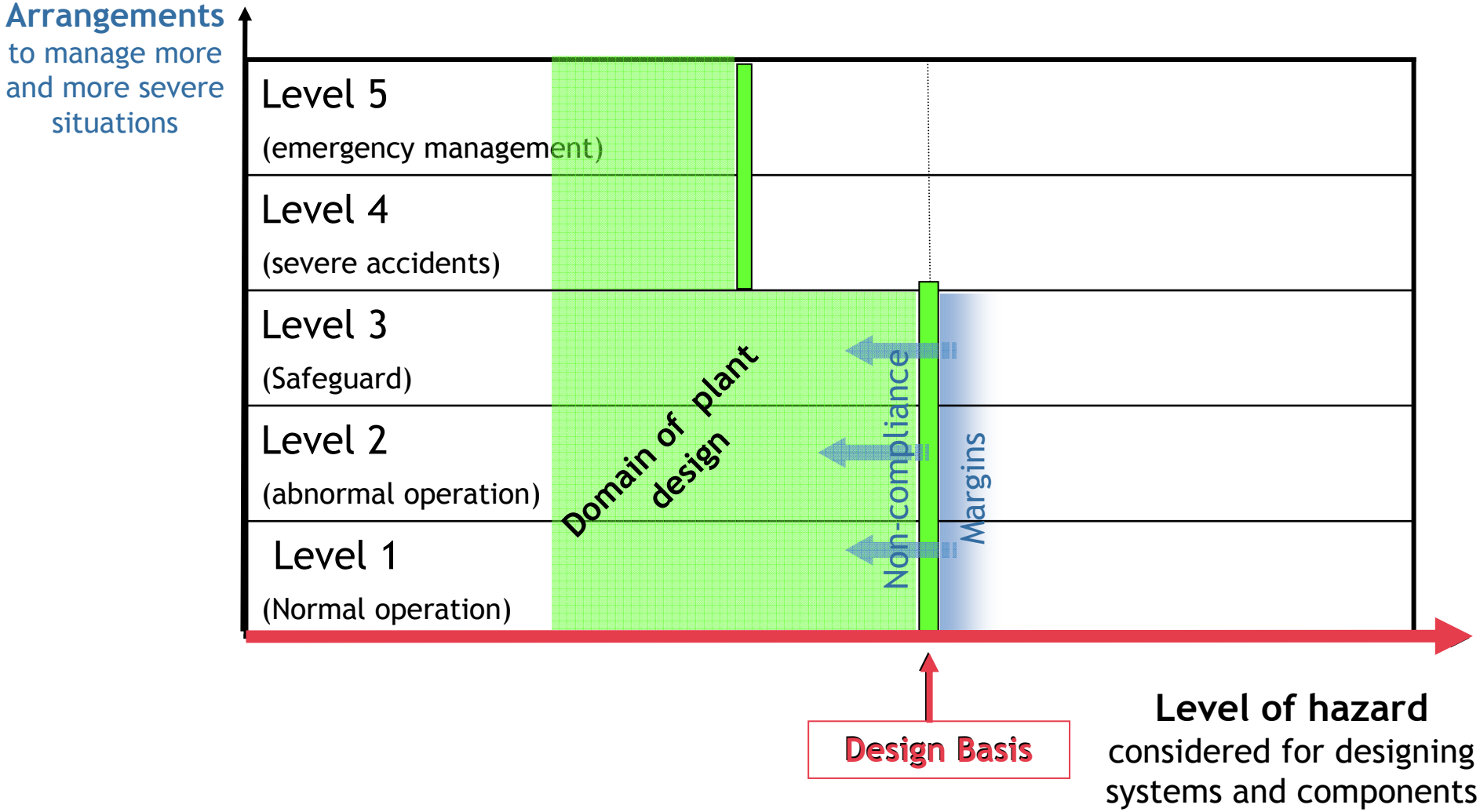
2.4 First Conclusions – Beyond Design Basis

For levels of EQ or floods significantly above Design Basis, need to define a **Complementary Approach** to demonstrate the capability of the plant to withstand these hazards or extended accidental situations (long term accidents involving several units…)

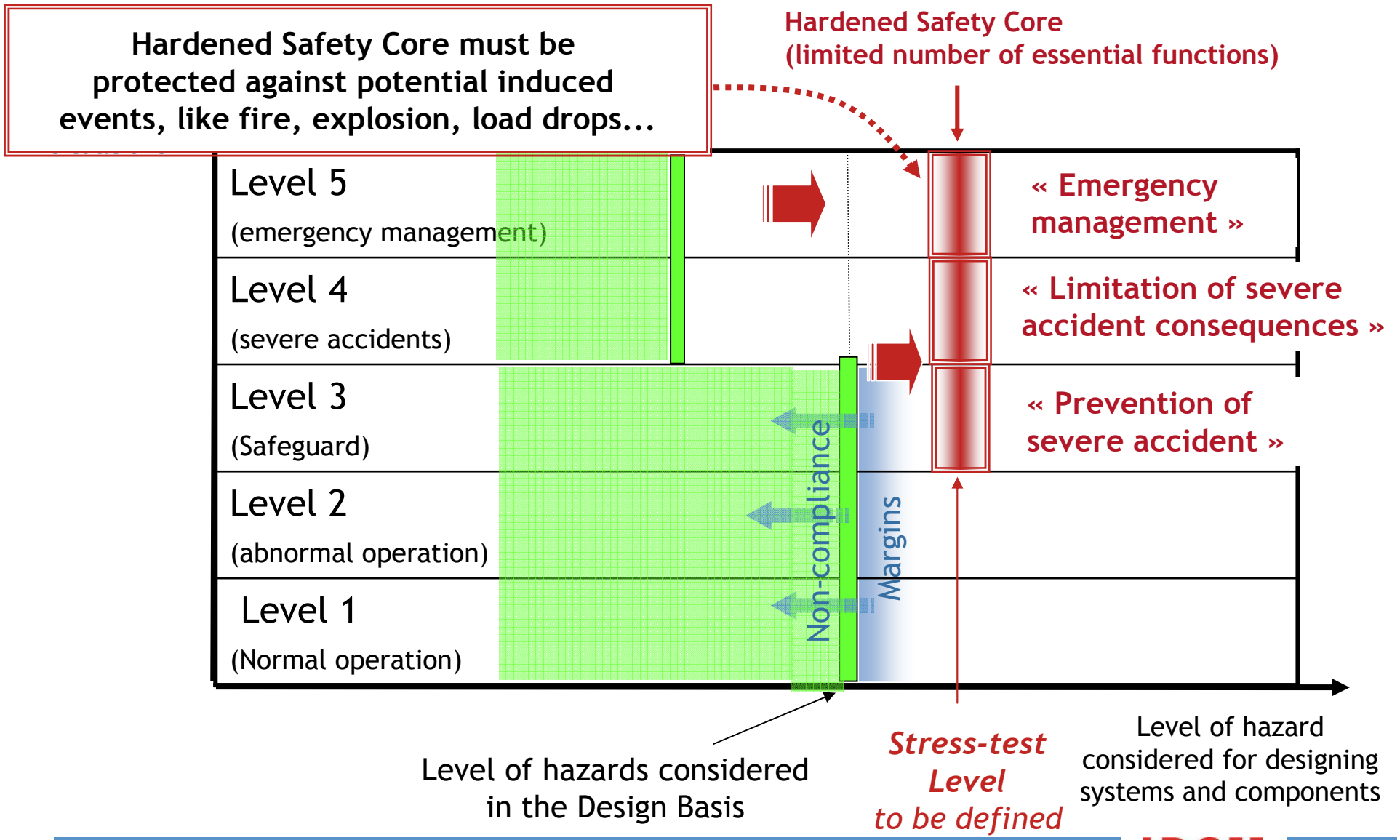
Need for a global approach to analyze the diverse additional provisions

Content

3. Protection against external hazards: the situation today in French NPPs



3. Post-stress tests approach: case of French operating PWR



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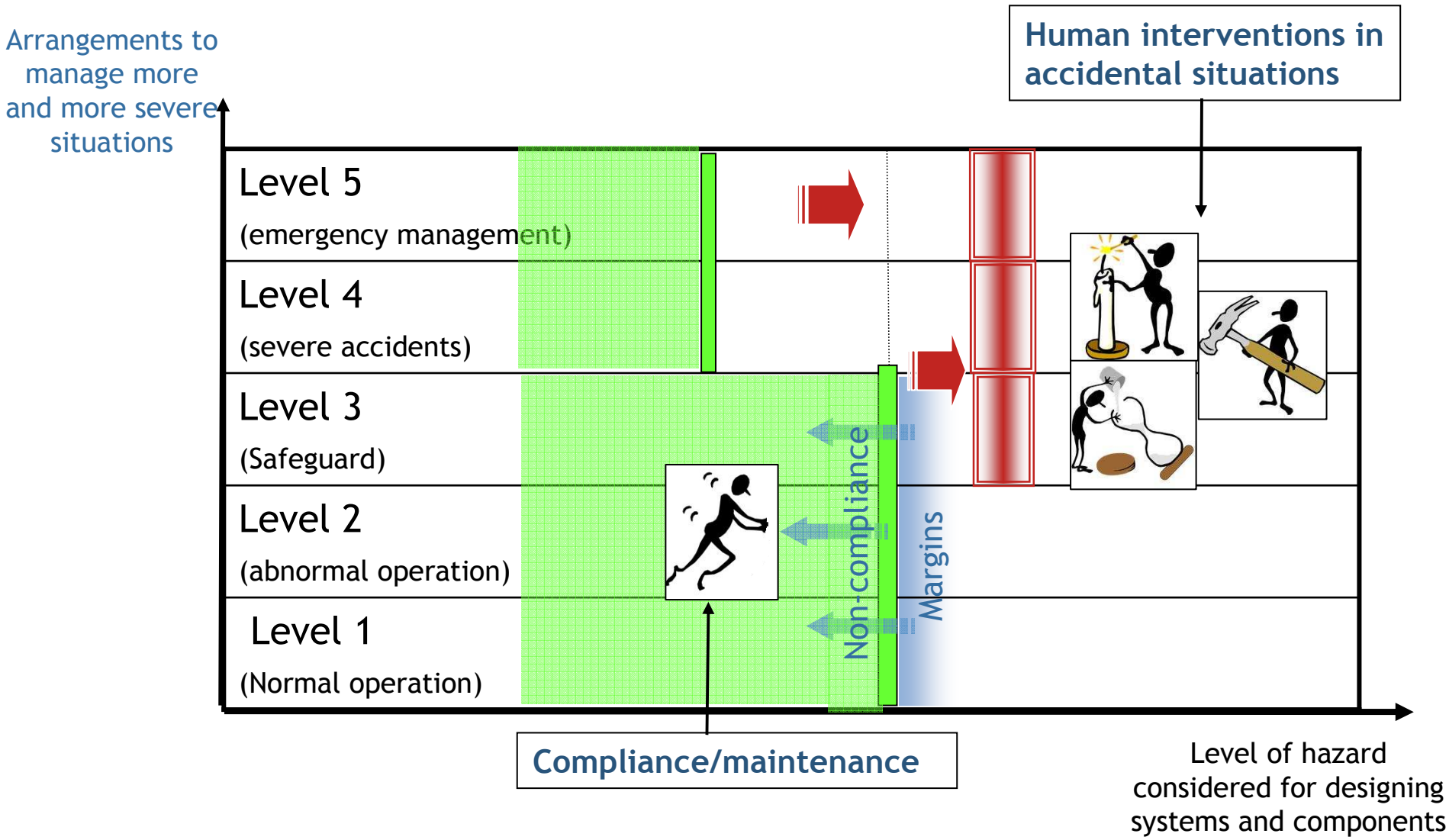

3. The general post-stress-tests approach

For **Design Basis hazards/situations**, the **current provisions are sufficient** to limit the impact on the installation and prevent the occurrence of an accident situation induced,

For **Beyond Design Basis hazards/situations**, the « **Hardened Safety Core** » enables to bring back the plants in a safe state.

The « Hardened Safety Core » should be able to manage accident situations of long duration, affecting several plants of the same site, considering induced events:

- aims to **limit the consequences of very « extreme » situations** (but not impossible indeed…)

- **includes « on site » SSC** to cope with the first hours after the accident, before the arrival of **« off-site » support** (such as FARN, EDF's Rapid Nuclear Action Force)

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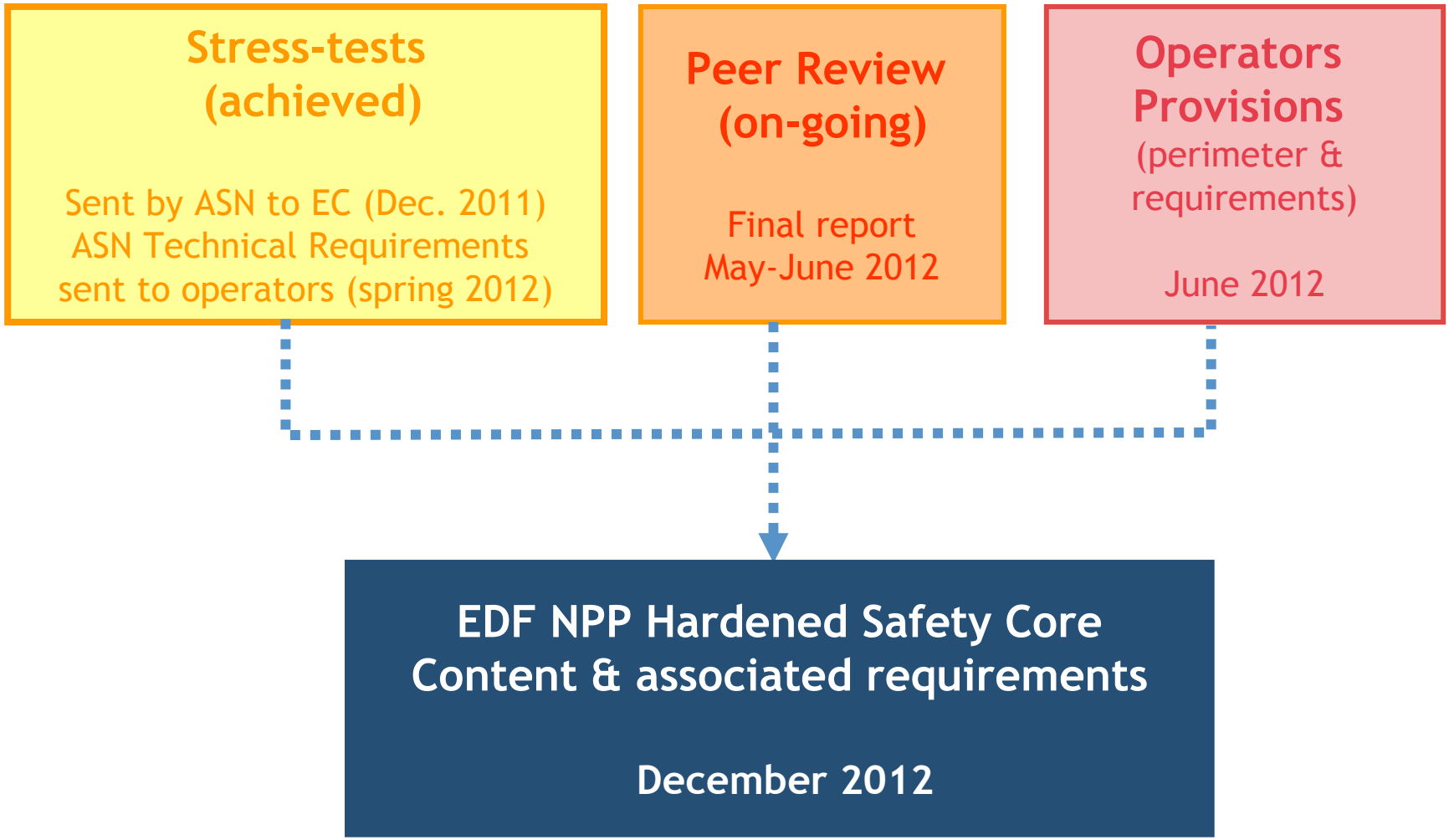
4. Conclusion

The stress tests confirmed the relevance of the studies and positions taken for many years, especially considering PSR implementation, on-going research to improve the safety guidelines for the extension of the duration of operation of the facilities, R&D and improvement of severe accident management arrangements, limitation of releases...

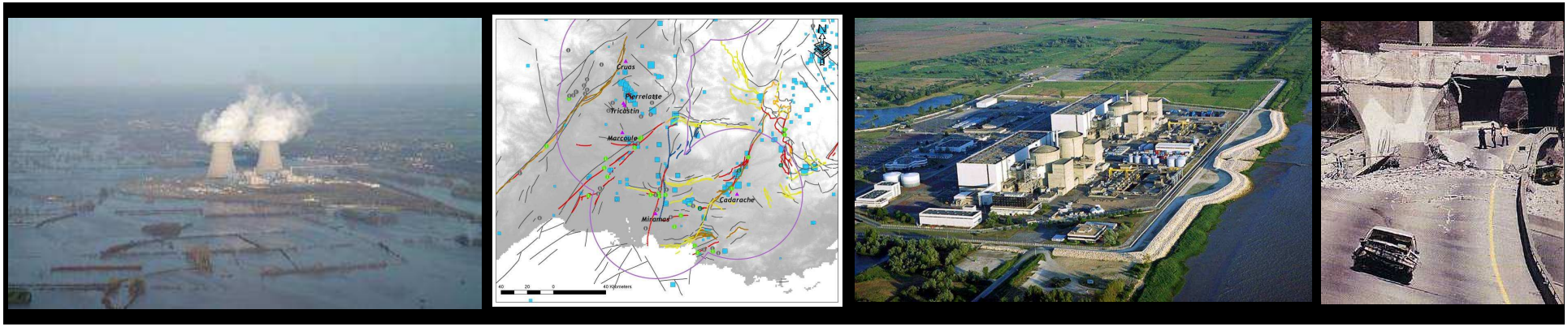
The content of hardened safety cores and **associated requirements** will be proposed by operators in **mid-2012**, with some particular points of attention for IRSN:

- Preference for added equipments, when possible, simple and robust,
- Search of diversification,
- Check the robustness of safety functions as a whole.

4. Conclusion



Thank you for your attention



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