French approach to European Stress Test

International perspective on lessons learnt from Fukushima

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ASN immediate actions

- **Campaign of targeted inspections**
- **“Stress test” analysis of the safety of nuclear facilities**
  - Complies with the European Council conclusions (March 2011)
  - Applies to 150 nuclear installations in France (58 NPP, NPP under construction, fuel cycle facilities, research reactors, etc.)
  - Covers:
    - extreme natural events (earthquake, flooding,…)
    - loss of the ultimate heat sink or loss of electrical power
    - severe accident management
  - Is complementary to existing safety improvement processes
    - periodic safety reviews (PSRs)
    - integration of operating experience feedback

Regulatory milestones for the “stress test” process for NPPs

- 5th May 2011: **ASN resolutions** requiring EDF to perform the “stress tests”
- 3rd Jan. 2012: **ASN position**
- 26th Jun. 2012: **ASN resolutions** requiring EDF to implement measures to strengthen safety
- 21st Jan. 2014: **ASN resolutions** setting complementary requirements for the hardened safety core design

EDF propose and justify technical measures

IRSN and experts standing group provide technical expertise

3rd January 2012: ASN position

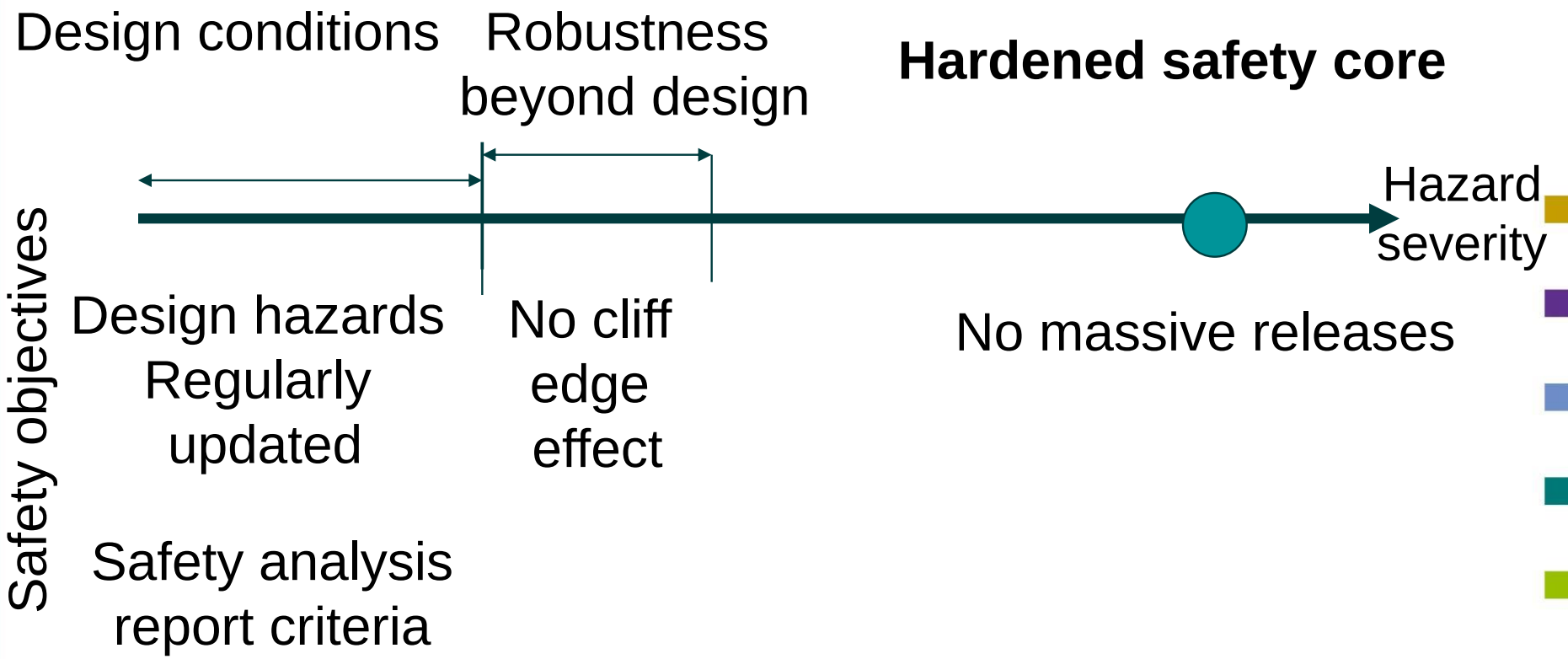
Main conclusions

- No need for immediate shutdown
- Need to increase robustness of facilities to withstand extreme situations beyond safety margins as soon as possible

Main measures

- **Hardened safety core**: limited number of material and organisational dispositions to guarantee safety functions in extreme situations
- **Nuclear rapid response force (FARN)**:
  - EDF national intervention team
  - Able to supply local team (trained staff and materials)
  - Fully operationnal on a site in 24 hours

The hardened safety core



26th June 2012: ASN resolutions (1/4)

Thirty requirements (legally binding) /site

- To **reinforce the safety margins** beyond design-basis level earthquake and flooding
- To implement **new and robust safety measures** rather than performing sophisticated analysis
- To implement the safety improvements **as soon as possible,** not waiting for the next **Periodic Safety Reviews (PSRs)**

26th June 2012: ASN resolutions (2/4)

the hardened safety core

ASN requirement n° 1: safety goals for the hardened safety core for the situations considered in the stress tests

- To prevent or mitigate the progress of a core melt accident
- To mitigate large-scale radioactive releases
- To enable the licensee to perform its emergency management duties

- **System, structure and components (SSCs)**
  - **designed with significant margins** in relation to the requirements currently applicable
  - composed of **independent and diversified SSCs.** The licensee shall justify the use of undiversified or existing SSCs

26th June 2012: ASN resolutions (3/4)

the hardened safety core

Strengthened equipment including

- An **additional ultimate electricity generating set/**reactor
- A **diverse emergency cool-down water supply/**reactor
- **New crisis management premises** with greater resistance to hazards and being accessible and habitable at all times and during long-duration emergencies
- **Mobile devices** and **means of communication** essential to emergency management
- Technical and environmental **instrumentation**

26th June 2012: ASN resolutions (4/4)

the nuclear rapid response force

- **ASN requirements 36-37: the nuclear rapid response force (FARN) specialized teams able in less than 24 hours to**
  - take over from the personnel of a site affected by an accident
  - deploy additional emergency response resources
  - with simultaneous intervention on all reactors of a 4 reactors site by the end of 2014 and 6 reactors site by the end of 2016

21st January 2014: ASN resolutions (1/2)

The resolution sets more detailed safety goals for the hardened safety core

- Prevent core melting when reactor coolant system is pressurisable by giving priority to cooling by the secondary system
- Guarantee the performance of the containment
- Allow residual heat removal from the containment without opening the venting system

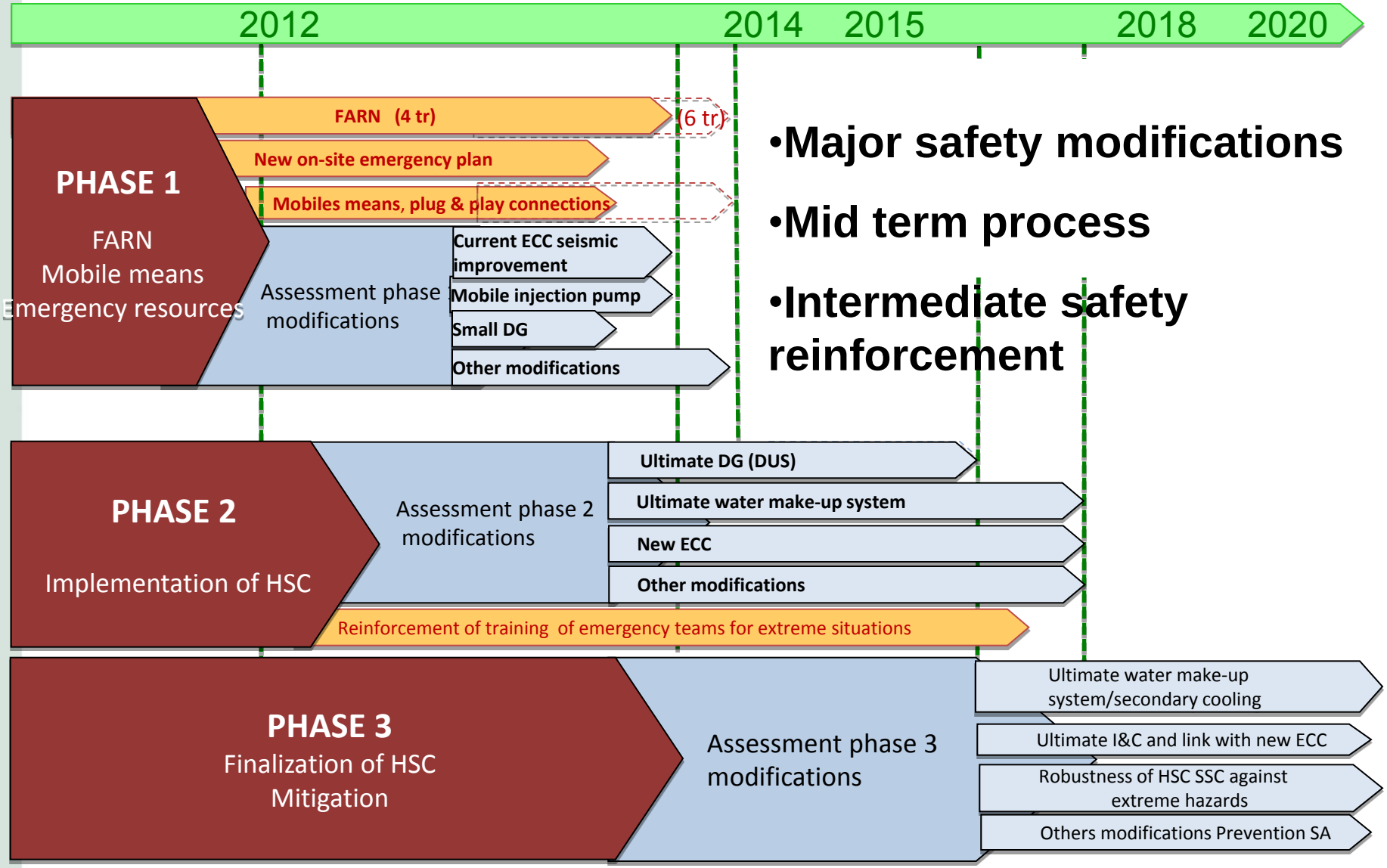
The resolution requests EDF to:

- **Define the list of SSCs composing the hardened safety core and their qualification requirements**
  - New SSCs designed according to industrial standards
  - Existing SSCs verified according to industrial standards, or verified according to methods allowed during PSRs

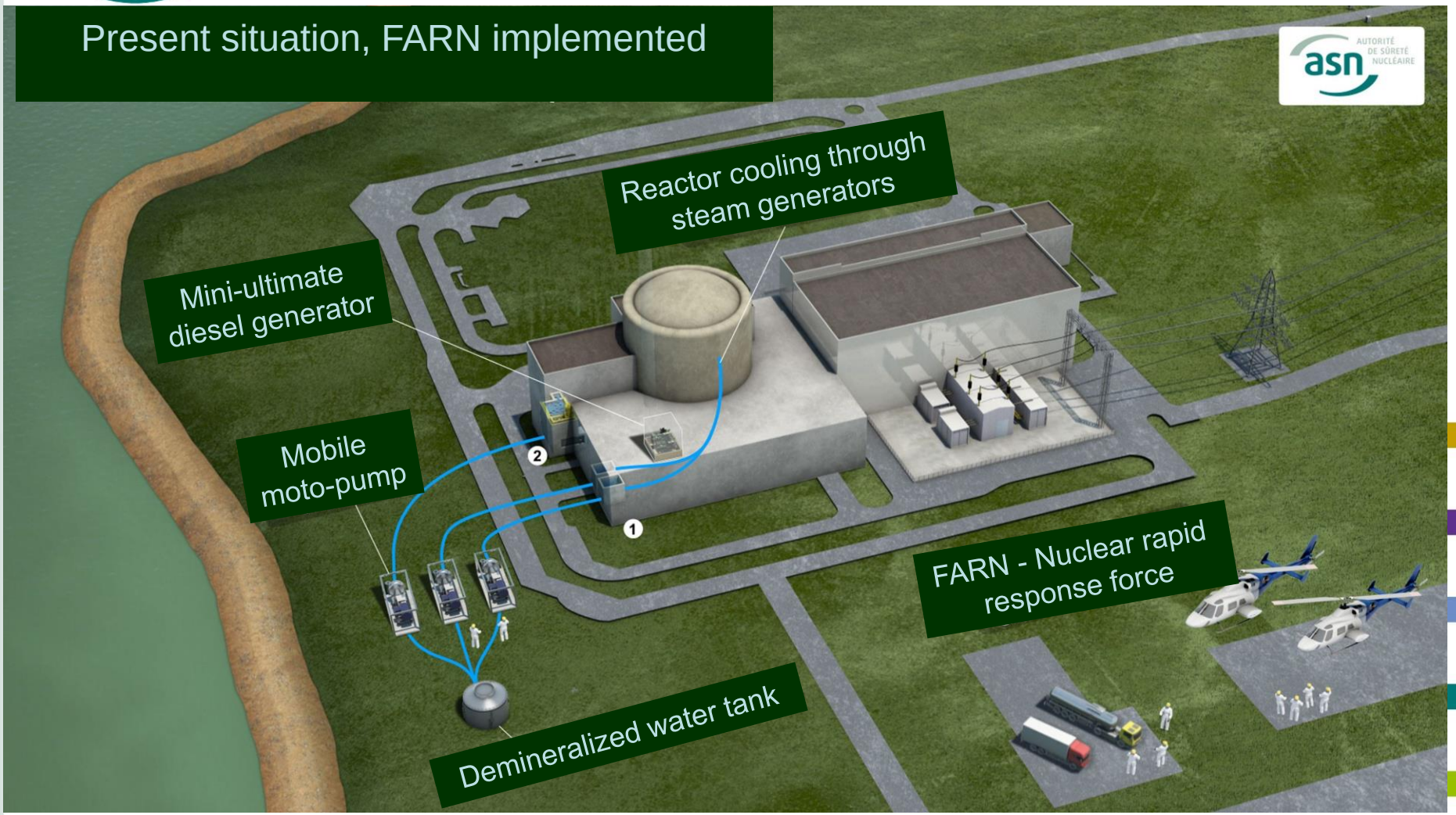
21st January 2014: ASN resolutions (2/2)

- Define seismic hazard for hardened safety core design (return period - 20 000 years)
- Set requirements regarding external hazards (other than earthquakes and flooding)
- Verify pools structural resistance behavior under hardened safety core situations
- Prevent dewatering of the fuel assemblies in spent fuel pools
- Ensure dropping of control rods under hardened safety core situations
- Provide independance of hardened safety core I&C and electrical systems from existing ones
- Define hardened safety core instrumentation

Time schedule

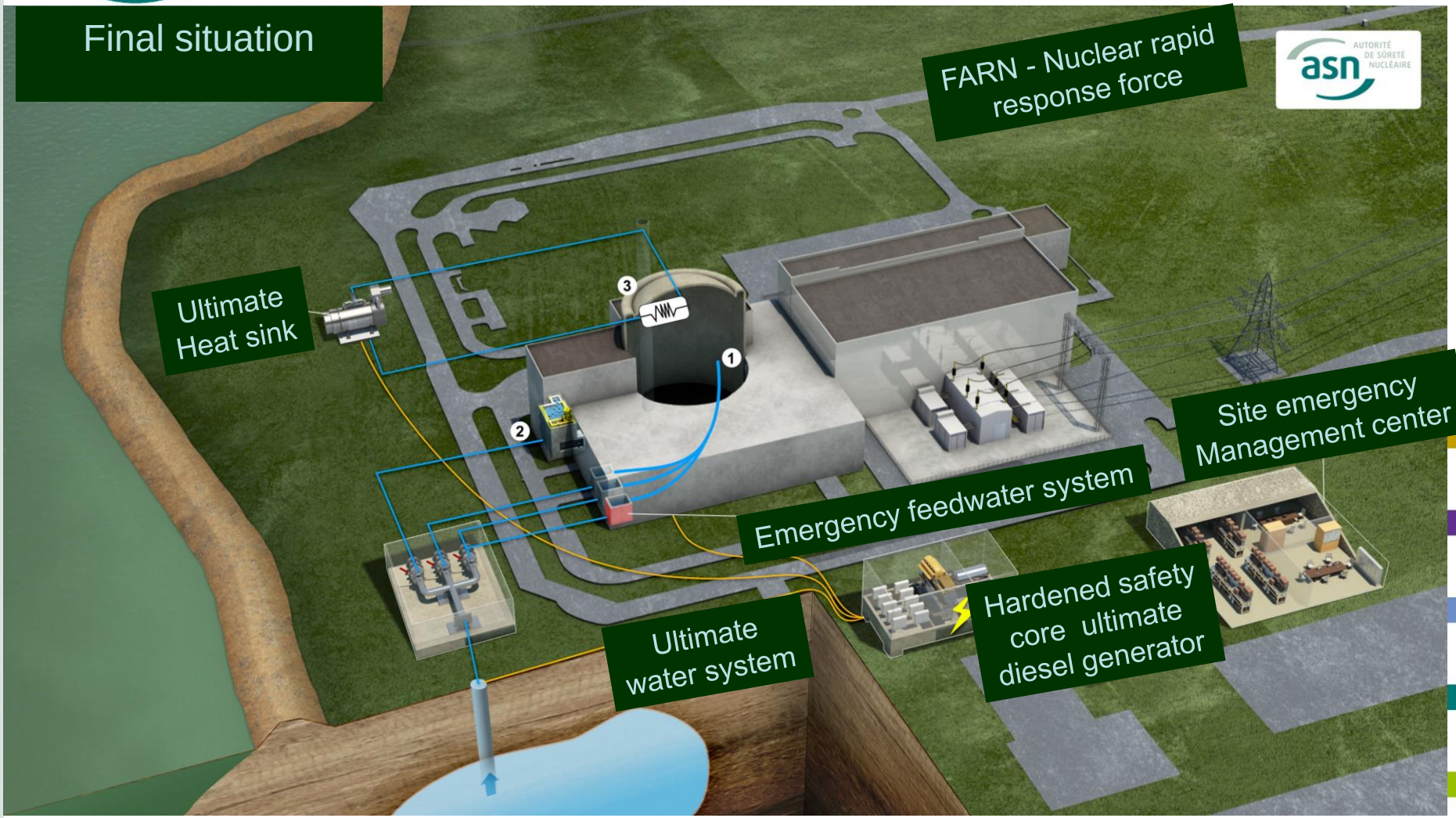


Synthesis (1/2):Situation today



1 : Reactor cooling system
2 : Fuel pool cooling system

Synthesis (2/2): Final situation

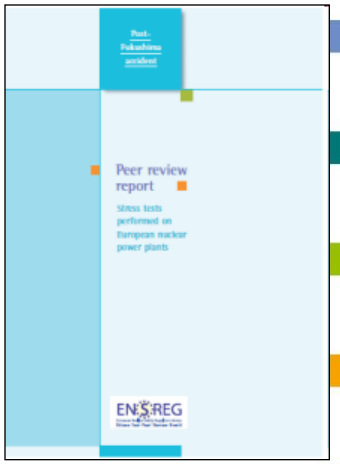


1 : Reactor cooling system
2 : Fuel pool cooling system

3 : Reactor containment cooling system

Stress tests at the European Level

- **Stress tests performed by ASN in the framework of "European stress tests"**
- **European benchmark and peer reviews performed**
- **Conclusions at the national level & European level**
- **Main conclusions at the European level:**
  - **Develop European guidance on assessment of natural hazards and margins**
  - **Periodic Safety Reviews (PSRs) are essential for continuous improvement of safety**
    - **Necessity to re-evaluate natural hazards at least every 10 years**
    - **PSR of the existing reactors should be guided by the objective of avoiding off-site contamination**
  - **Need to maintain containment integrity**
    - **Urgent implementation of recognized measures (H2 explosion prevention…) for NPPs not yet implemented**
  - **Need to implement measure to prevent accidents in case of extreme natural hazards and limit their consequences**



Conclusions

- **Complete experience feedback from Fukushima accident will take at least 10 years**
- **Stress tests performed in European framework. European Benchmark to be continued**
- **Stress tests lead to strengthen the robustness of NPPs to beyond design situations to prevent accidents resulting from unforeseen/extreme natural hazards and to limit their consequences**
- **Two main set of measures are defined: hardened safety core and nuclear rapid action force**
- **Before full implementation, transitory measures are requested**

Acronyms

- **ASN** French nuclear regulatory body
- **DUS** Ultimate diesel generator
- **ECC** Emergency Control Centre
- **EDF** *Électricité de France*
- **FARN** Nuclear Rapid Response Force
- **HSC** Hardened Safety Core
- **IRSN** French Institute for Radiation Protection and Nuclear Safety
- **PSR** Periodic Safety Review