EDF NPPs
Post-Fukushima
Complementary Safety Assessments

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1 - Context and issues

- **Fukushima Accident on March 11, 2011**

- **On March 23,** the French Prime Minister requests the French Regulator to conduct an audit of the plants in France,
  - while considering the work undertaken by European Safety Authorities
  - following a transparent procedure in accordance with the transparency Law
  - covering 5 areas: floods, earthquakes, loss of water supply, loss of electric power supply and operational management of accidents

- **With its decision on May 5, 2011,** the Regulator asks EDF to conduct a "Complementary Safety Assessment (CSA) " of its nuclear installations
  - September 15th, 2011, for the power reactors currently operating, under construction, or being planned in France
  - September 15th, 2012, for the other nuclear installations

EDF has submitted its reports to the Regulator

- **19 EDF reports** (sites currently operating and those that are under construction) have been submitted to the French Nuclear Regulatory Body, adding up to 7000 pages

- These assessments are resulting from the work of **more than 300 engineers during 4 months**, gathering competences in the fields of R&D, engineering and operation

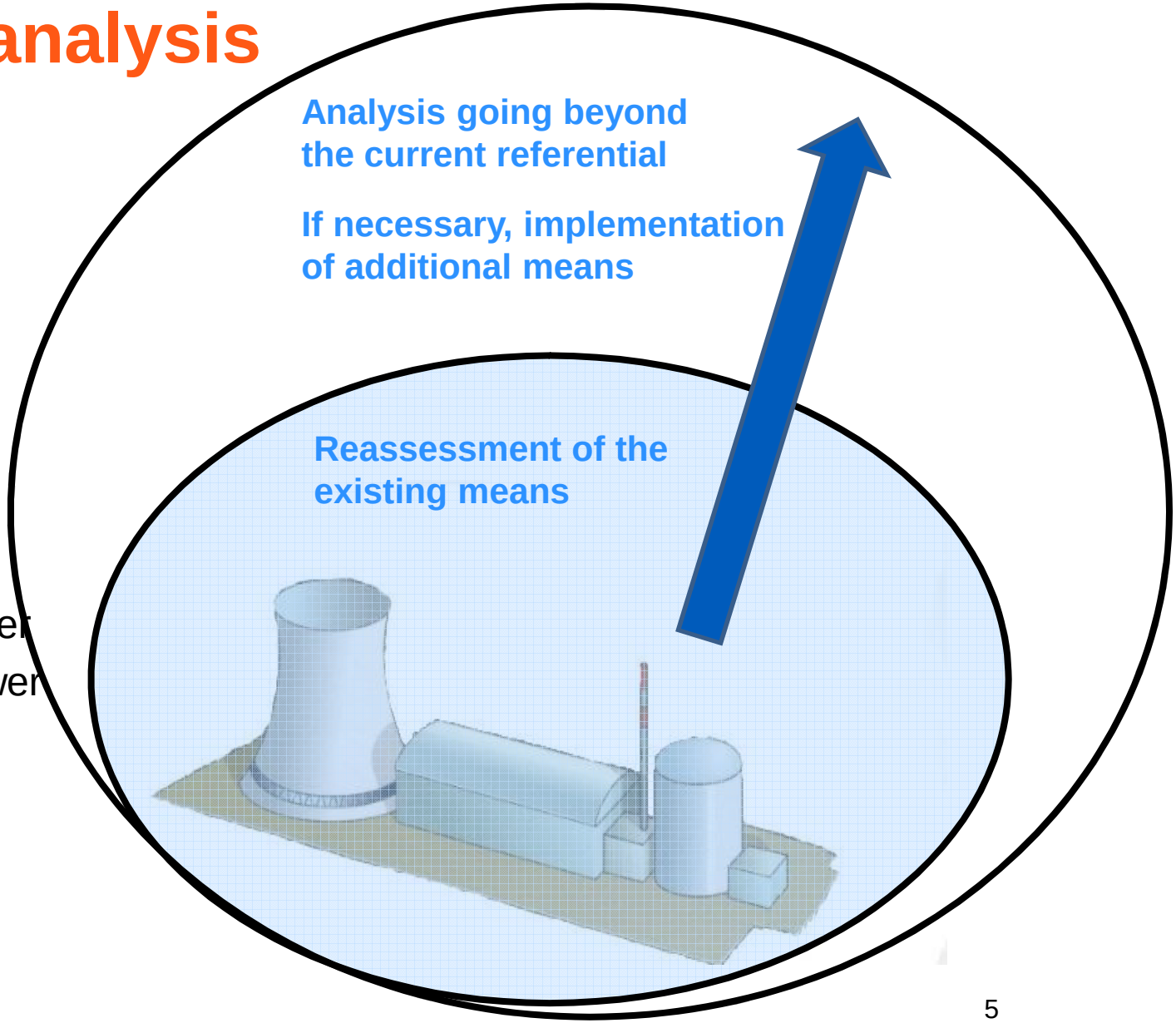
2 - The basis of the analysis : the defense-in-depth

- **3 layers of defense-in-depth guarantee safety functions within the nuclear plants:**
  - **1st layer**: systems providing protection from natural events (earthquake, flooding, wind, etc.)
  - **2nd layer**: systems and procedures dealing with loss of cooling water or electricity (back-up diesel generators, back-up firefighting circuits, etc.)
  - **3rd layer**: barriers to limit the consequences of any degradation of fuel and containment integrity (hydrogen re-combiners, cesium filters, etc…)

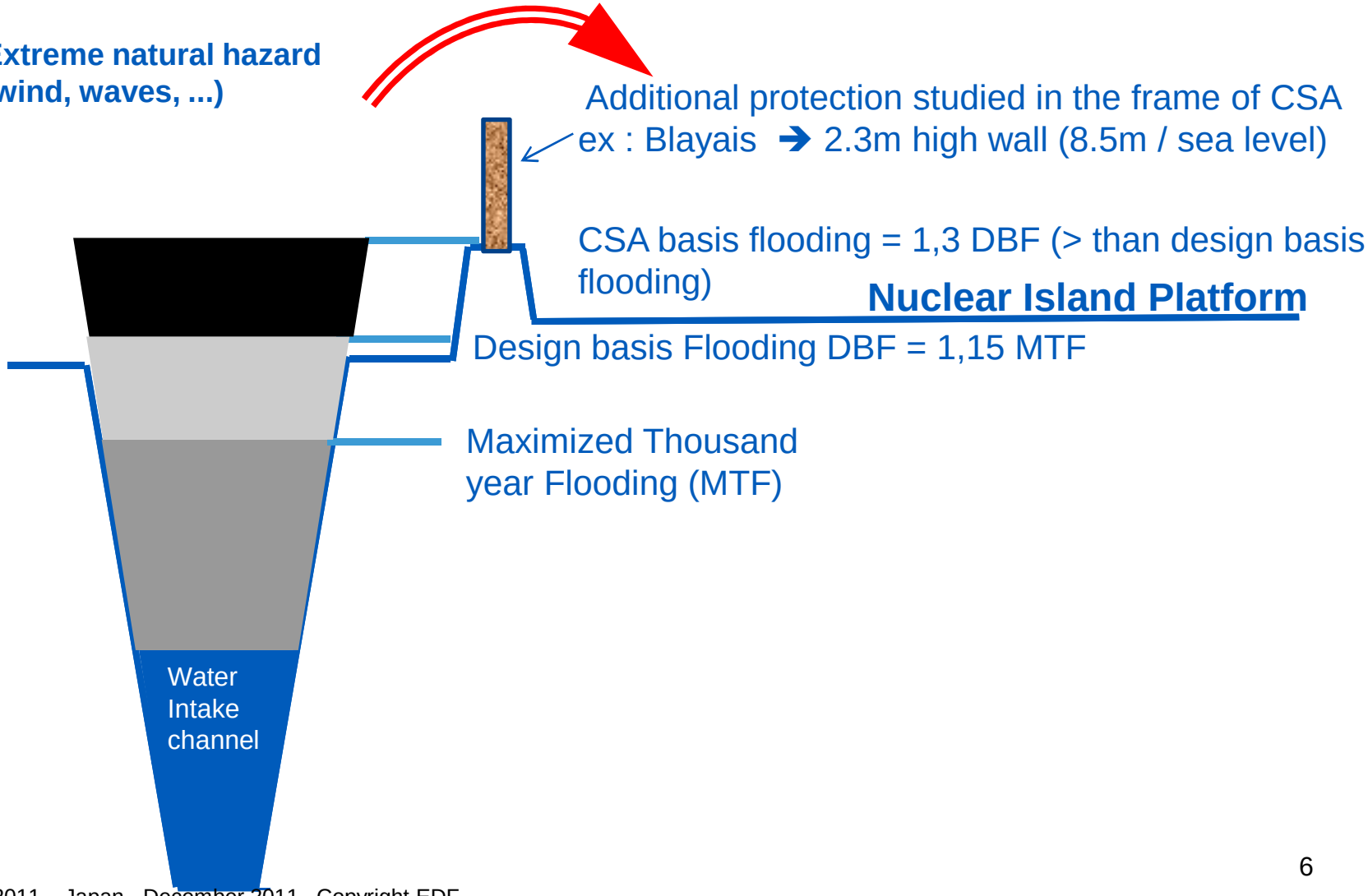
The Complementary Safety Assessments : a two-step analysis

5 fields have been assessed:

- Earthquake
- Flooding
- Loss of cooling water
- Loss of electric power supply
- Management of severe accidents



Principle for assessing the resistance of installations to flooding



Assessment of resistance of installations to earthquakes : Fessenheim example

- **Reassessment of the present design**
  - Historic earthquake (SMHV) :
    - ➔ 6.2 on the Richter scale
  - Earthquake with increased security (SMS):
    - ➔ 6.7 on the Richter scale (energy X 5)

- **Analysis beyond the present design**
  - For nuclear buildings :
    - ➔ 7.2 on the Richer scale (energy x 25)
  - For electrical buildings :
    - ➔ reinforcement beyond the referential of some electrical equipments required in case of extreme situations

Assessment of resistance to station blackout

➢ Reactor

- **Time before beginning of core melting**

  ➔ with one SG auxiliary feedwater pump : from 1 day to 1.5 day

  ➔ without any operating pump : a few hours

- **Time before significant radioactive release (after core meltdown)**

  ➔ through containment depressurization: 1 to 3 days through the venting filter (retention of 99.9% of cesium)

  ➔through breakthrough of basement by corium : a couple of days

➢ Spent fuel pool

- **Time before beginning of fuel uncover :**

  ➔ from 1 to 5 days, depending on fuel inventory

CSA results : earthquake and flood

➢ **Complementary modifications proposed by EDF**

- **Protection of buildings (sealed perimeter):**
  - ➔ elevation above the 0-meter level
- **Reinforcements or raising of dams, dikes**
- **Reinforcement of electrical equipment robustness**
- **Reinforcement of the flood protection for electrical switchyards**
- **Reinforcement of supports and anchorages**
- **Coupling between buildings**

CSA results : loss of cooling water and electric power supply

➢ **Complementary modifications proposed by EDF**

to avoid fuel melting (reactors) or uncovering (spent fuel pools)

- **Additional water supply (protected)**
  - From groundwater or other water sources (basins...)

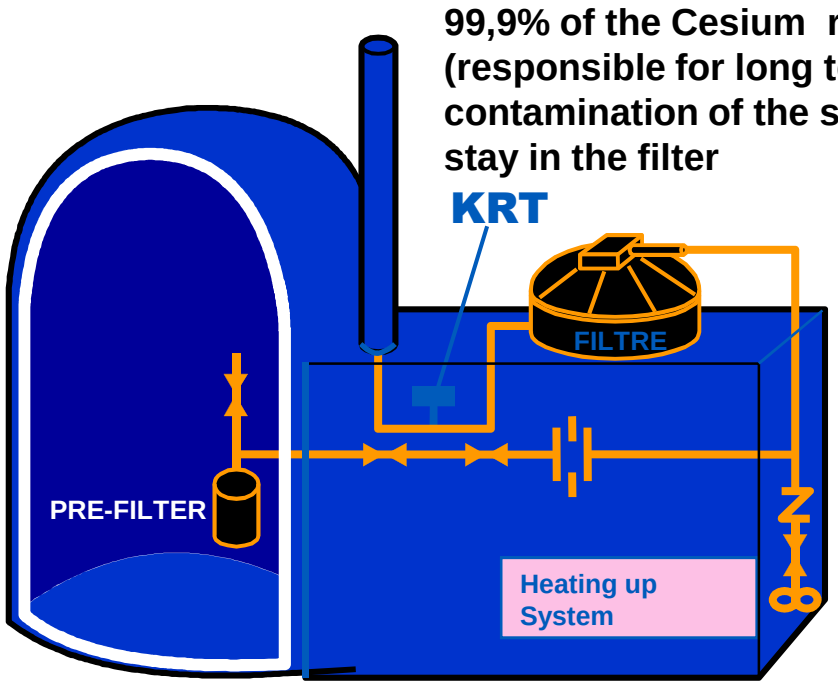
- **1 Additional Diesel generator (protected)**
  - per unit
  - Supplying the minimum required I&C, injection pumps to the SG, to the primary circuit and to the spent fuel pool

Limitation of release in the environment

- In order to limit the consequences of a highly unlikely core melting

  ⇨ Design improvement : equipment to limit the radiological consequences in the environment in case of release

Venting the containment building via a filter enables to quantify the released activity and ensures to have a leak tight containment again after venting

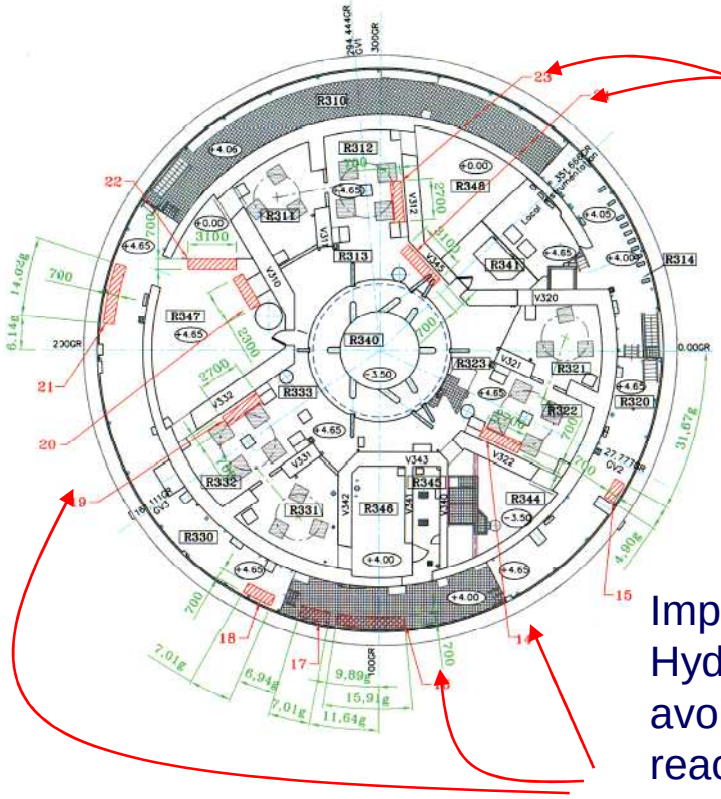


99,9% of the Cesium release (responsible for long term contamination of the soil) will stay in the filter

Limitation of the hydrogen exposion risk

- In order to limit the consequences of a highly unlikely core melting

  ⇨Installation of additional equipment



Implementation of Hydrogen recombiners to avoid H2 explosions in the reactor building

Implementation of a Nuclear Rapid-Response Force

Objectives: to re-establish and/or maintain reactor cooling with the aim of avoiding any core fusion or any significant release

Missions:

Intervene
- Intervention within 24 hours in support of shift teams

Evaluate
- Situation of site
- Positioning of rear base

Act
- Reinject water into the installation
- Plug & play connections

Deploy
- Large scale equipment
  - Protection
  - Intervention
  - Control

Prepare
- Actions to remain in effect, after the first days of autonomous action
- Management throughout the entire duration of the situation (water provision, effluent processing, etc.)

Crisis management reinforcement

➢ **Crisis buildings implementation**

- Ensure the operational aspect of the current safety building in case of earthquake

- Implement an appropriate crisis management building
  - advanced command and work building large enough and adequately equipped to manage the crisis on a long term basis

- Implement a base for assistance
  - Organisation of the logistics for the intervention of the Nuclear Rapid Response Force

Schedule for implementation of the post-Fukushima actions

➔ **Modifications will be implemented according to the following schedule:**

- **Short term (2012-2015) :** Nuclear Rapid Response Force, water supply, temporary Diesel Generators,
- **Medium term (2016-2020) :** final Diesel Generators, final protected water supply, …
- **Long term (>2020)**

➔**Complementary studies will mainly be performed in 2011-2012**

For some important modifications, temporary measures will be taken before their implementation.

Strong points supporting the robustness of the EDF nuclear facilities

➔**Initial PWR NPP design**: good intrinsic robustness

➔**Continued improvement of safety :** periodic inspections and “10 years” safety reevaluations, based on feedback (national : severe storm in 1999, heat wave in 2003..., and international : TMI, Chernobyl, …) and knowledge improvements

➔**Standardization of the EDF fleet:** homogeneous level of safety of all plants

➔**Quality of plant operations:** operation, maintenance, preparation for emergency crisis (local and national)

➔**EDF industrial organization :** integrated designer-operator mastering the design and improvement of plants,

➔**Quality of supply chain :** selection, qualification and permanent monitoring of suppliers

Main conclusions

- Following this work, EDF confirms **the presently good level of safety** for all Nuclear Power Plants

- **The new analyses** led EDF to propose to the French Nuclear Regulator **supplementary measures**, taking into account potential situations even worse than the design basis assumptions

- These analyses will enable **to improve even more the good level of safety** at EDF's nuclear power plants

