IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

French methodology for safety assessment based on performance indicators

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DEFINITION

- **The indicators should:**
  - give as faithful as possible an image of the overall safety of French nuclear plants,
  - and ultimately be used to assess performance degradations (or improvements) in terms of safety (for instance performance of safety functions, materials, organisation, etc.), in order to point out their potential effects within the shortest time.

DEFINITION

- **The safety indicators :**
  - objective, easy to control and indisputable,
  - unambiguous and applicable to the whole units.
  - clearly defined, in other words not liable to interpretation.
  - quantitative data and therefore readily available.
  - supply comprehensible information to any interested party.
  - Lastly, it has to be possible to check this data, in other words the information source on which the indicators are based must be reliable.

DEFINITION

- **The indicators are intended to :**
  - Perform a permanent watch on the overall safety of the facilities,
  - Identify trends in significant safety aspects and, if appropriate, detect degradations sufficiently early to inform the French utility and the French Safety Authority,
  - Assess plant homogeneity and highlight any disparities and specific features between plants.

SET OF INDICATORS

- **Our set comprises 46 safety indicators.**
- **For a greater readability, the indicators are classified by family. The families are as follows:**
  - Operational hazards,
  - Operational rigour,
  - Unavailability of safety systems,
  - Event seriousness,
  - Cause of significant safety-related events,
  - Radiological protection,
  - State of safety barriers,
  - Radioactive releases.

OPERATIONAL HAZARDS

- **This family comprises 8 indicators. For example :**
  - the number of automatic reactor trips,
  - forced power reductions,
  - load on various safety systems,
  - unexpected unavailability of safety systems and waivers,
  - latency time of default.

OPERATIONAL RIGOUR

- **This family comprises 10 indicators :**
  - 4 indicators concerning periodic tests (for example, the number of non-respect of the periodic test frequency).
  - 3 indicators based on the RECUPERARE results in order to measure the performances (for example, the detection time of fault according to the detection mean (alarm or not)).
  - 2 indicators about Operating Technical Specifications (for example, the number of safety significant events involving equipment misalignment).

UNAVAILABILITY OF SAFETY SYSTEMS/EVENT SERIOUSNESS

- **The first family comprises 2 indicators.**
  - One of these indicators is the number of failures of various safety systems.
- **The second family comprises 5 indicators :**
  - One of these indicators is the increase of the core melting probability of safety significant events (per unit).

CAUSE OF SIGNIFICANT SAFETY-RELATED EVENTS

- **The 12 indicators of this family are based on the RECUPERARE results.**
- **For example :**
  - 3 indicators deal with the type of causes (technical, human or organisational).
  - 2 indicators concerning activities (for example, the number of significant safety-related events caused by maintenance involving the human factor)
  - 5 concerning the error actor (operation crew, programmable controllers, mechanics, chemistry department).

RADIOLOGICAL PROTECTION/STATE OF SAFETY BARRIERS/RADIOACTIVE RELEASES

- **The first family comprises 4 indicators :**
  - 2 for the dose follow-up of workers
  - 2 for the radiological protection events.
- **The second one concerning the state of the three safety barriers :**
  - for example, the average flow rate of reactor coolant system leaks.
- **The indicator of the third family is the number of events of radioactive releases per year, uncontrolled or above limits fixed by regulations.**

SOURCES OF INFORMATION

- **The different sources of information used to constitute and operate this set are as the following:**
  - Safety significant events,
  - Annual plant safety assessment reports,
  - Outage reports,
  - Reports quantifying significant safety-related events published by IRSN and the French utility,
  - Various databases developed by IRSN, in particular, the RECUPERARE database (RECUPERARE model is an “event model” developed by IRSN),
  - Analysis provided by the IRSN safety experts (memo on deviations, etc.).

ANALYSIS OF THE RESULTS

- **IRSN has assessed the results given by the indicators within two approaches:**
  - Analysis by trends. Each indicator is analysed,
  - Comparison between the value of one indicator and its threshold (threshold defined by a methodology).

METHODOLOGY

- **The goal of this methodology is to allow a follow-up of the evolution of an indicator and to define thresholds making it possible to consider significance or not of a tendency observed.**
- **This tool makes it possible to follow in a regular and less subjective way the various indicators selected in the set.**
- **Each of these indicators is indicated currently annually.**
- **All the indicators retained by IRSN were so designed that an increase of their value underlines a degradation, and that a decrease underlines an improvement.**
- **These values are exploited according to a common procedure.**

METHODOLOGY

- **For each indicator, it will be given two values "synthesis":**
  - The first one, called "EMT", represents the medium-term evolution of this indicator (evolution over the three last years),
  - The second one, called "ELT", represents its long-term evolution (evolution over the 8 last years).
- **According to the results obtained for the EMT and the ELT, complementary investigations may be committed.**

MEDIUM-TERM EVOLUTION

- **The EMT aims at highlighting the way in which the indicator evolves/moves over a short period (3 years).**
- **It makes it possible to position the value of the considered year indicator given compared to the three previous years.**
- **The data of the previous years are used to determine two thresholds :**
  - The first threshold, called low threshold, is an average of the three previous years values.
  - The second threshold, called high threshold, is a weighted average of the three previous years values.
- **The determination of these two thresholds makes it possible to establish three areas:**
  - Green, yellow and red.

LONG-TERM EVOLUTION

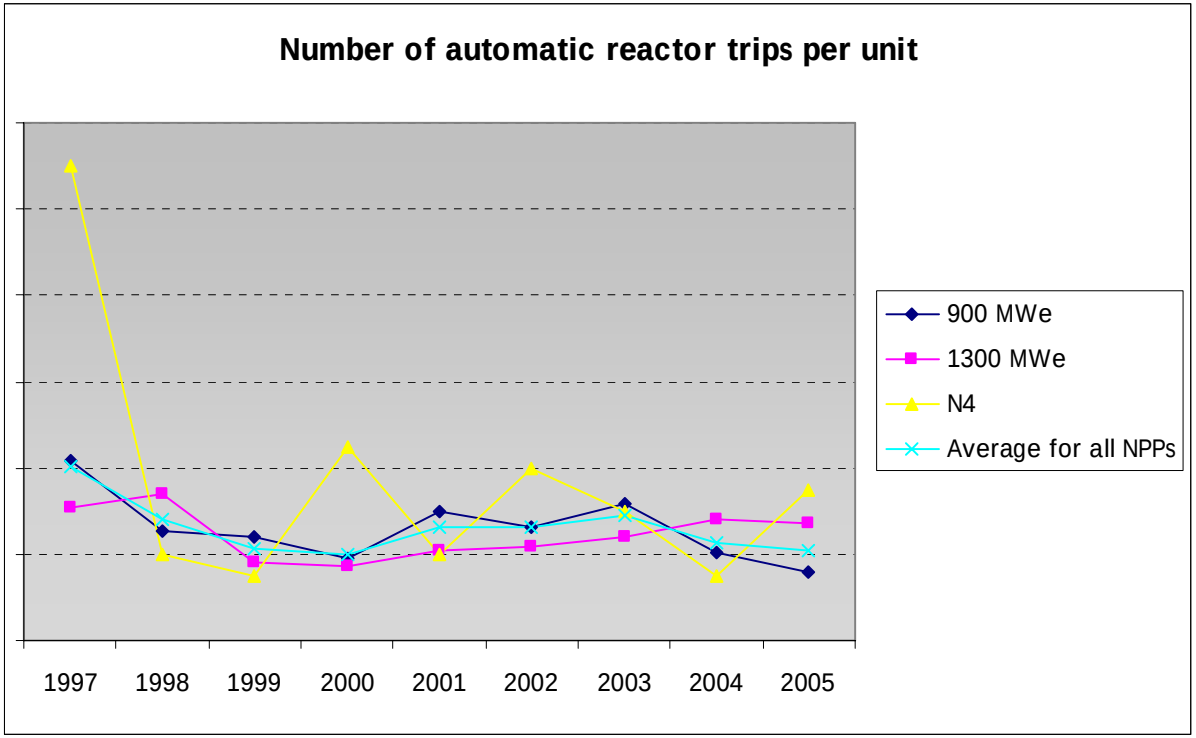
- **On the long term, the EMT previously defined is not able to detect two types of evolutions:**
  - The slow drifts which would pass unperceived on the short term,
  - The persistence of EMT in the red zone, which actions and/or recommendations would not manage to make disappear, which would lead after a few years to a rise of the low threshold value and thus to be satisfied of a weakened level standard.
- **The ELT makes it possible to highlight these both types of evolution.**
- **The ELT is obtained by the annual gradient of least squares line, determined from the values of the 8 previous years indicator.**
- **This slope represents the annual increase or the annual decrease during 8 years.**

LONG-TERM EVOLUTION

- **According to the slope, 5 types of evolution have been defined:**
  - Significant improvement,
  - Low improvement,
  - Stable,
  - Low degradation,
  - Significant degradation.
- **The combination of two evolutions, EMT and ELT, makes it possible to specify the actions and/or recommendations. For instance :**
  - EMT stands in the green area and ELT = significant improvement => ok
  - EMT stands in the green area and ELT = low degradation => to examine : slow drift

EXAMPLES / RESULTS

- **The number of automatic reactor trips by unit**



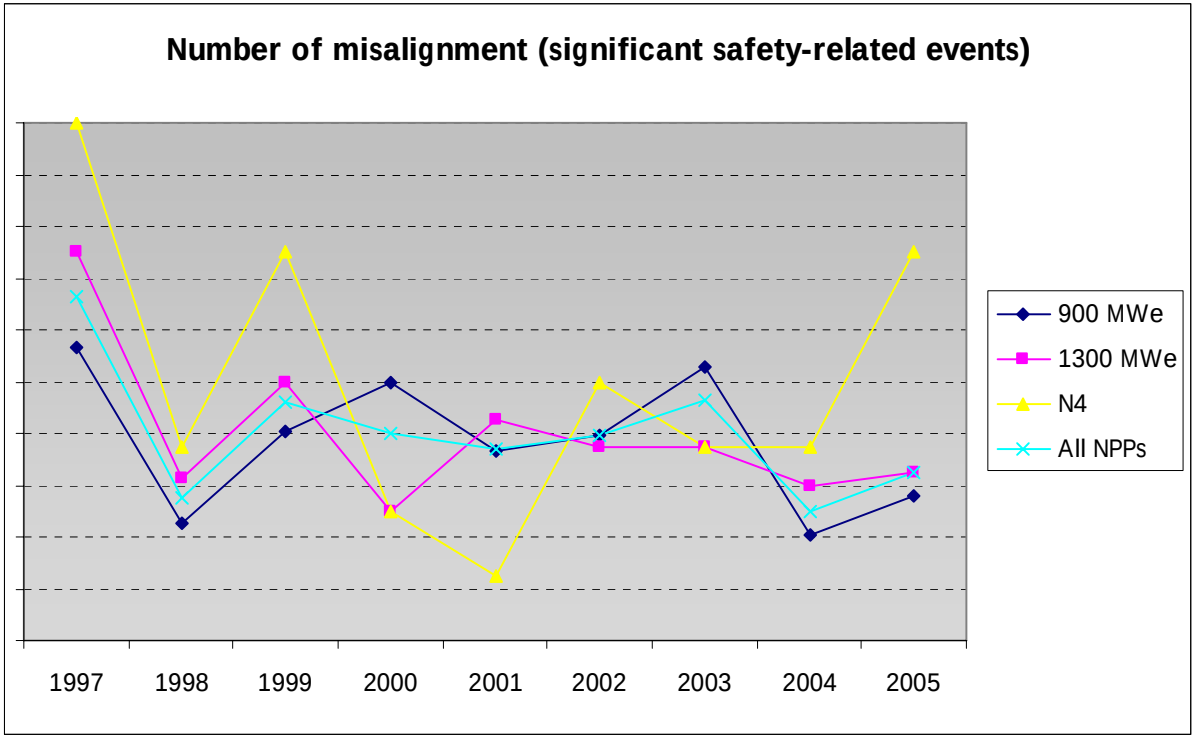
- **EMT stands in the green area and ELT = stable**

EXAMPLES/RESULTS

- **It is not easy to analyse this result (given by the figure) by trend :**
  - the evolution of the number of scrams is fluctuating over the studied period.
  - However, in 2004 and 2005 an improvement on the 900 MWe series is observed and few disparities between units are also observed.
- **With the both evolutions, the analysis is more precise :**
  - the EMT makes it possible to prove that an improvement is observed over the last year,
  - the ELT makes it possible to prove that a long-term evolution is rather stable for the whole NPPs.

EXAMPLES/RESULTS

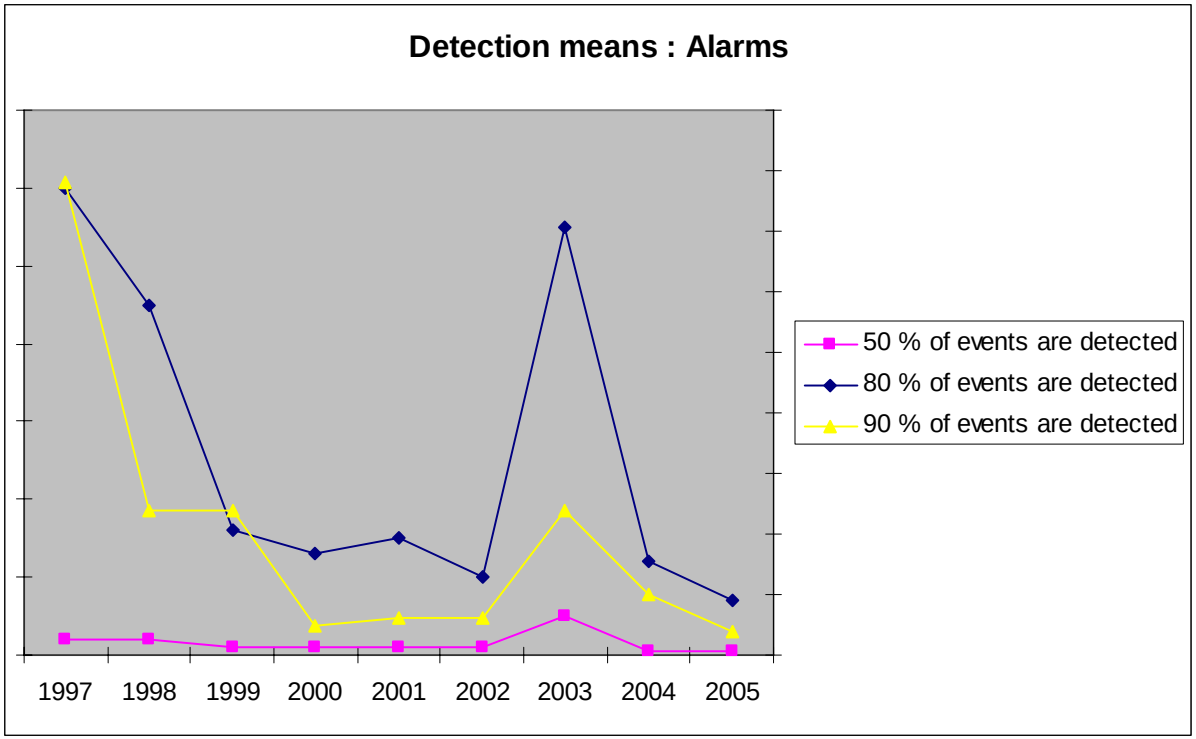
- **The number of misalignment (significant safety-related events)**



- **EMT stands in the green area and ELT = low improvement**

EXAMPLES/RESULTS

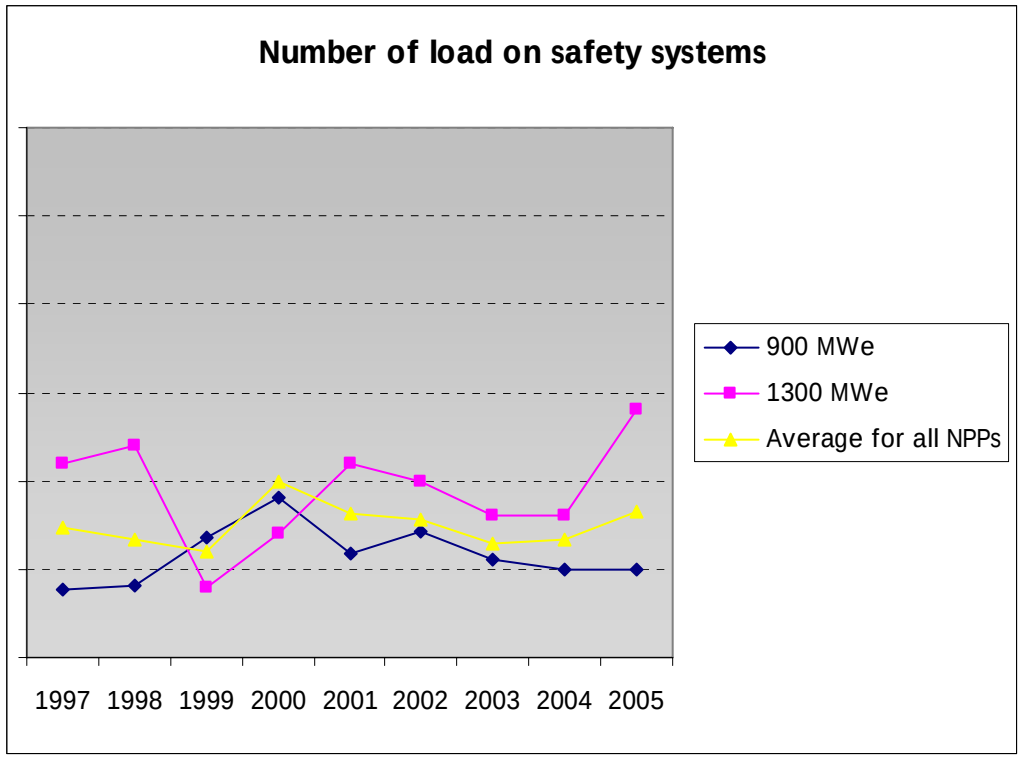
- **The detection time of fault according to the detection mean (alarm)**



EMT	ELT
50 %	Low improvement
80 %	Significant improvement
90 %	Significant improvement

EXAMPLES/RESULTS

- **The number of load on safety systems**



- **EMT stands in the red area and ELT = stable**

CONCLUSION

- **This new tool is now in operating mode in IRSN.**
- **It should complete the whole tools available in IRSN for the safety assessment of EDF facilities.**
- **In the future, it should be perpetuated and upgraded (especially concerning the information quality provided by the Utility) in order to be used by various experts in the detection of performance degradations (or improvements) in terms of safety.**