IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

LOCA requirements review

Nathalie MESSER *IRSN, Reactor Safety Division*

LOCA requirements review

❶ LOCA Requirements in France

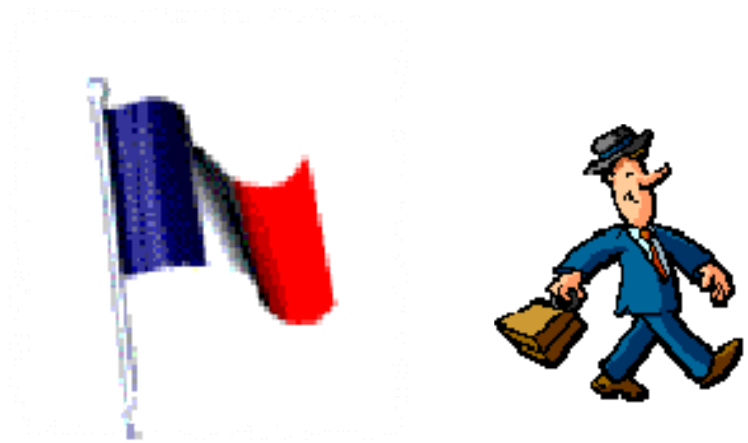
- ✓ LOCA requirements evolution in France
- ✓ Current requirements

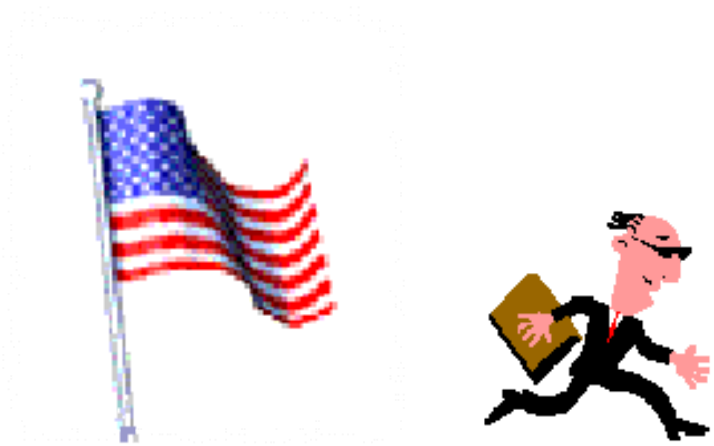
❷ Reviewing LOCA requirements

- ✓ Why ?
- ✓ Calendar

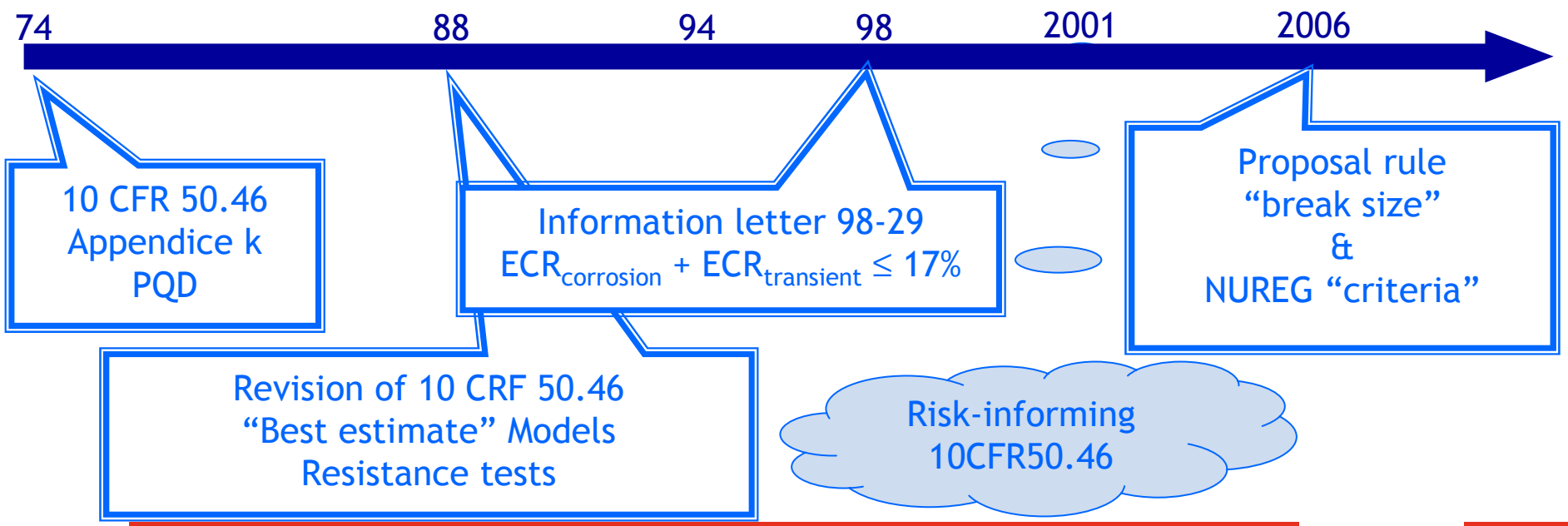
❸ Questions to be addressed

LOCA requirements evolution in France





LOCA requirements evolution in France



LOCA requirements evolution in France

First PWR under W license
France adopt American
LOCA requirements

74 88 94 98 2001 2006

10 CFR 50.46
Appendice k
PQD

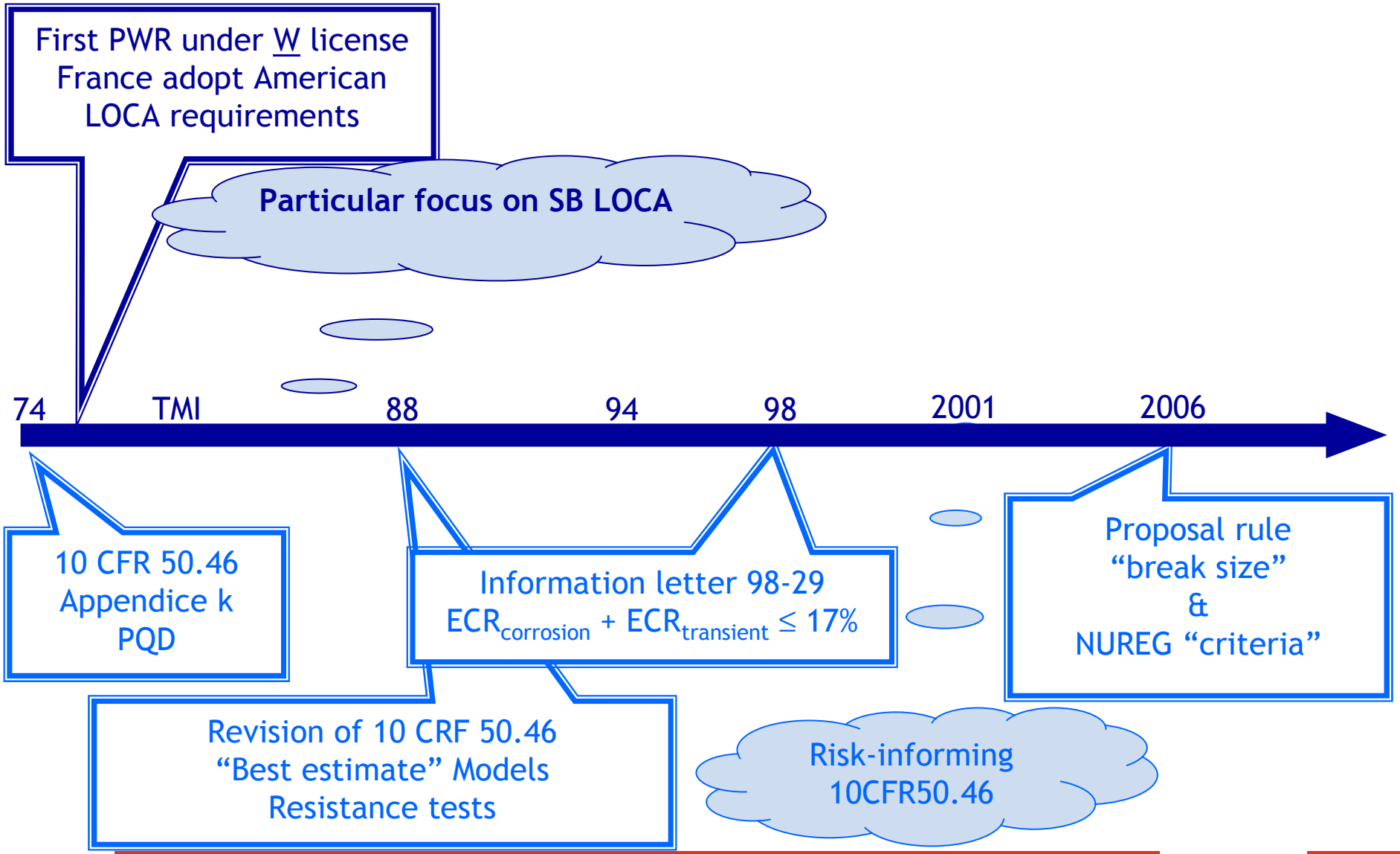
Revision of 10 CRF 50.46
"Best estimate" Models
Resistance tests

Information letter 98-29
$ECR_{corrosion} + ECR_{transient} \leq 17\%$

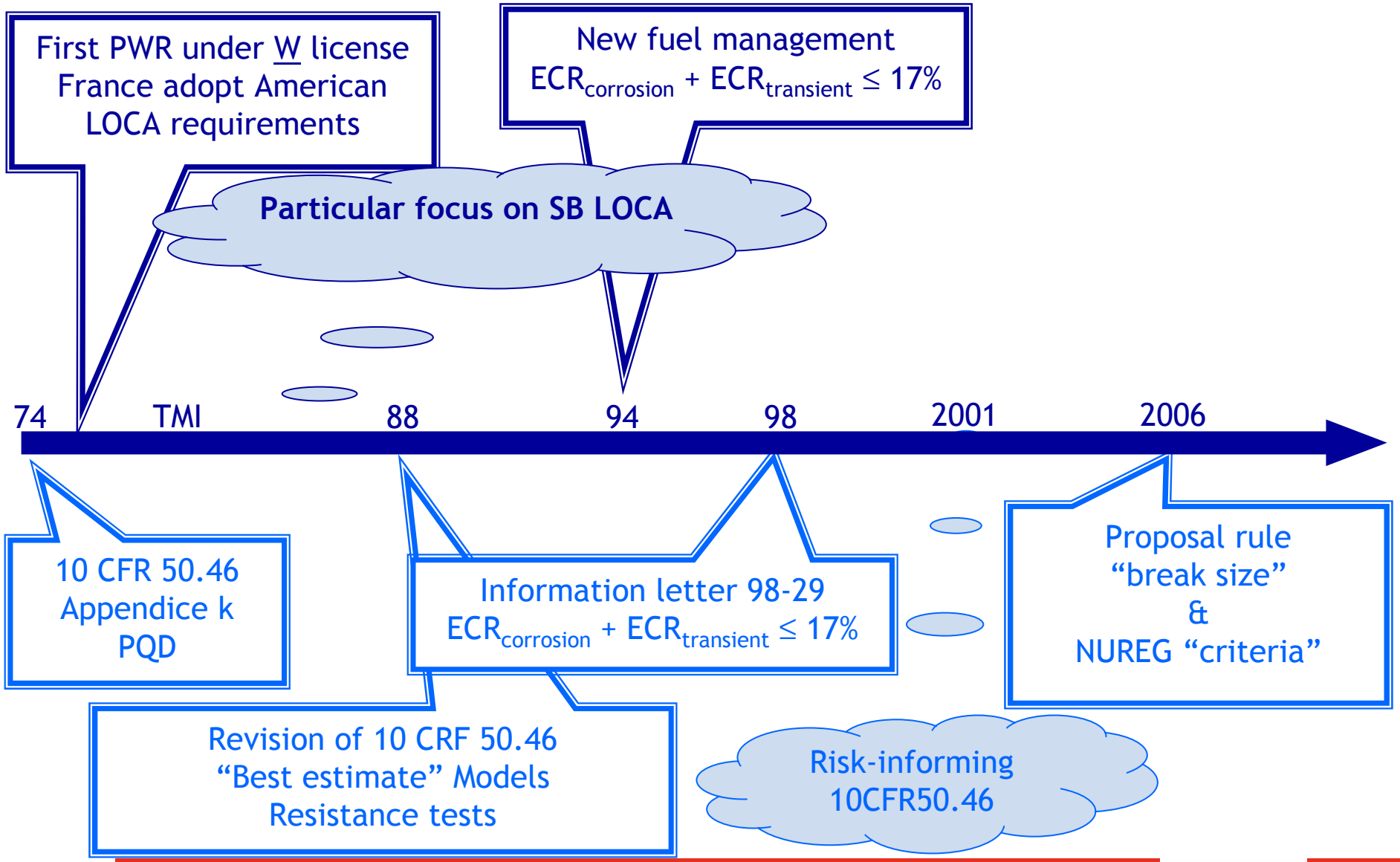
Risk-informing
10CFR50.46

Proposal rule
"break size"
&
NUREG "criteria"

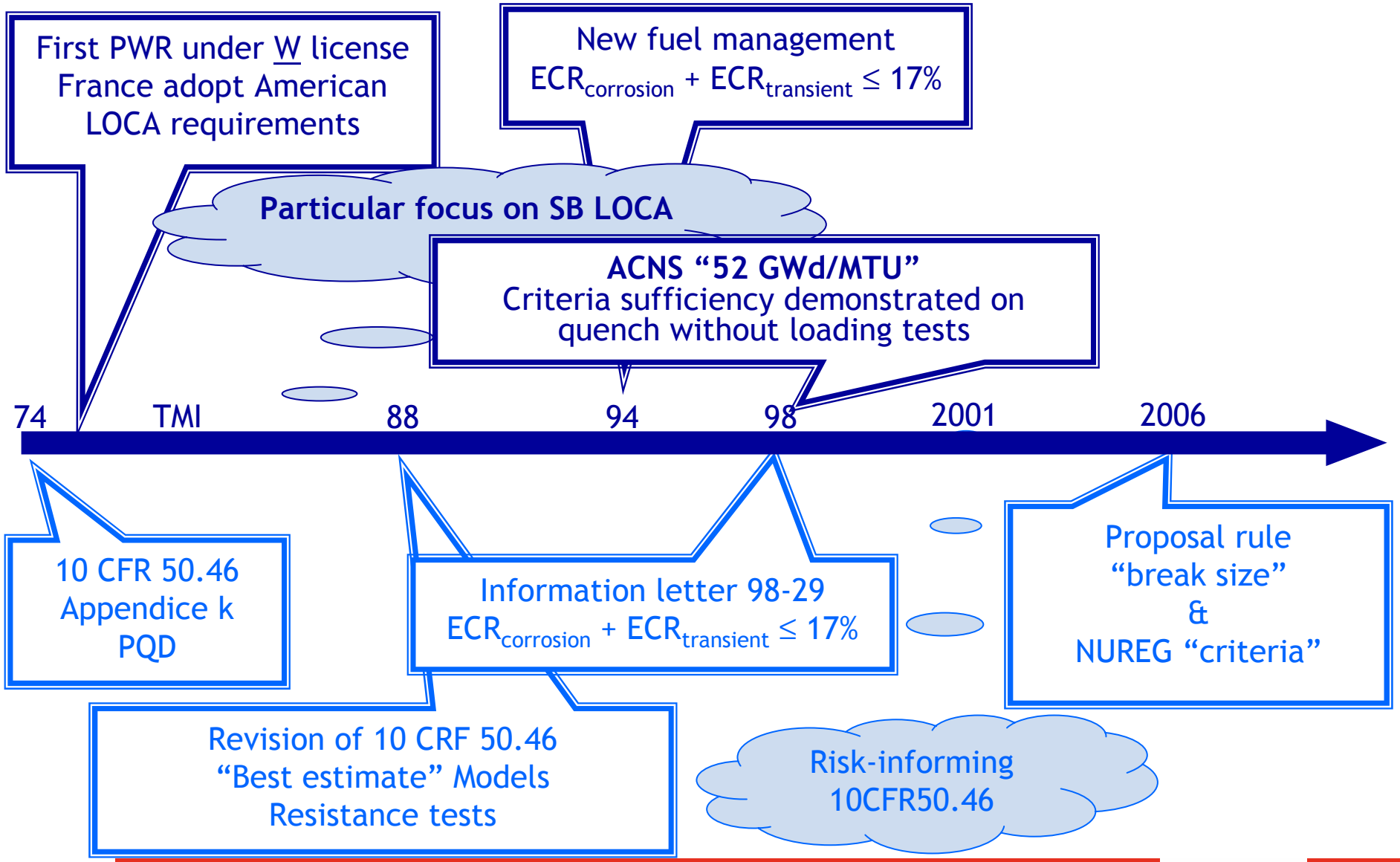
LOCA requirements evolution in France



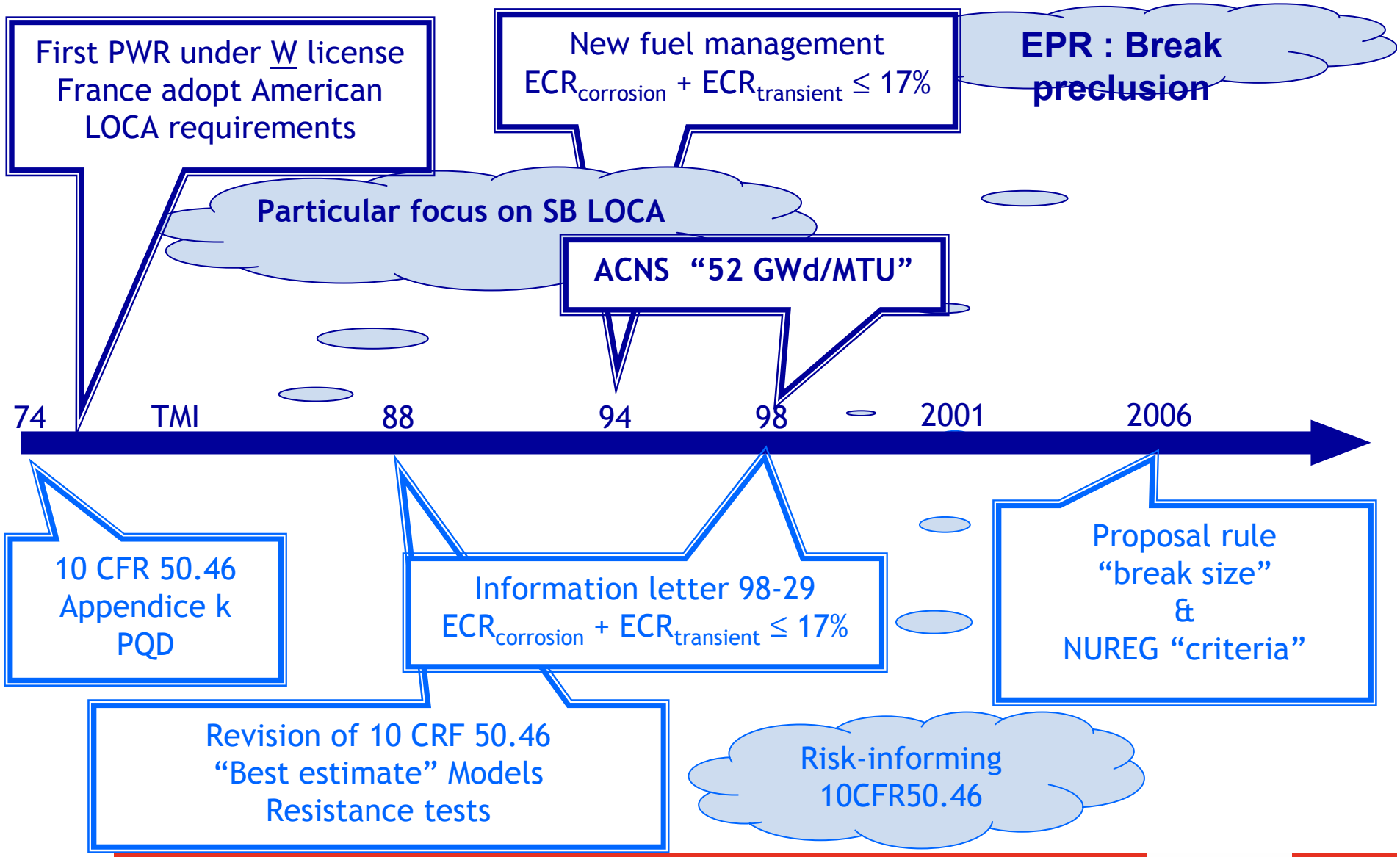
LOCA requirements evolution in France



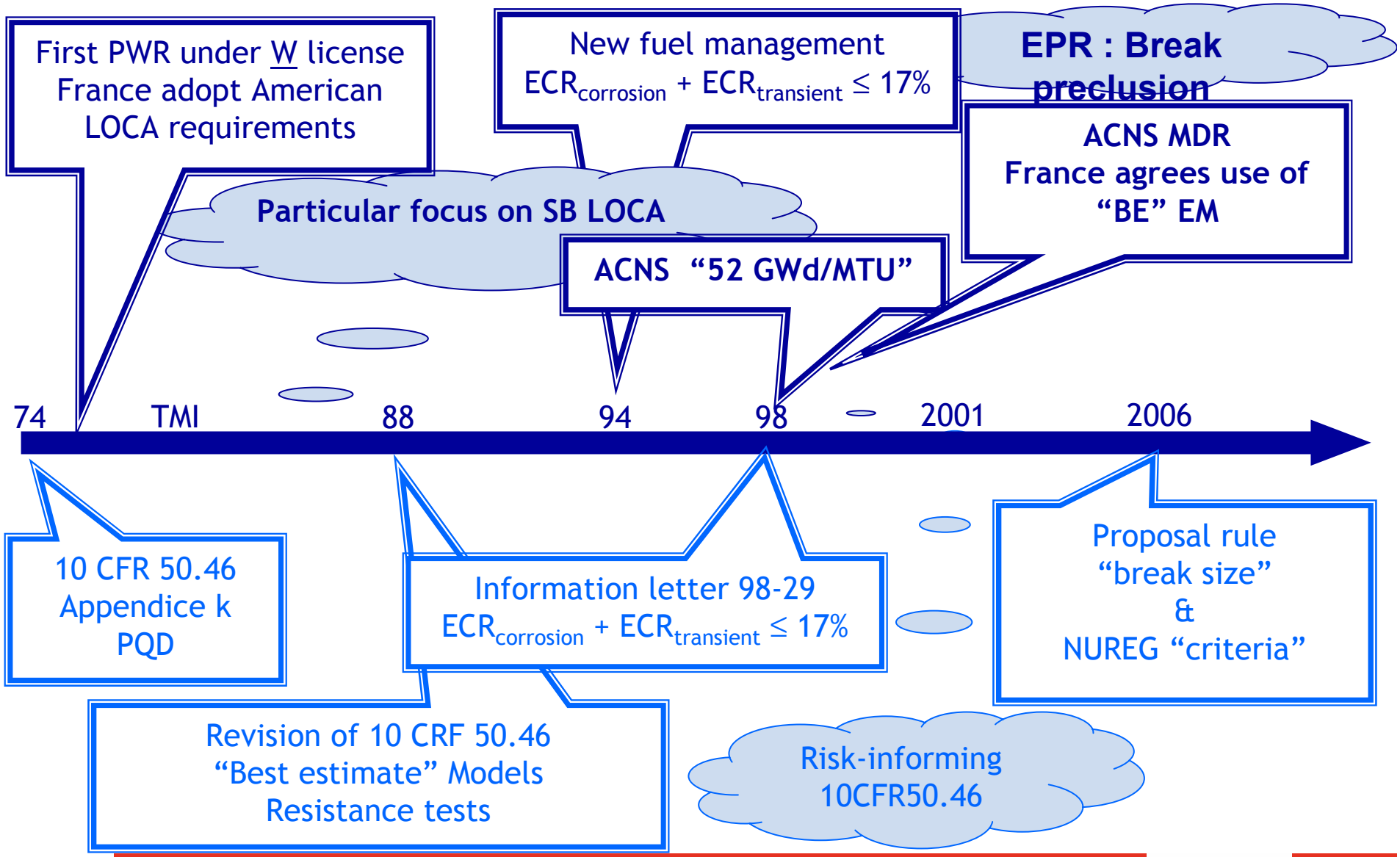
LOCA requirements evolution in France



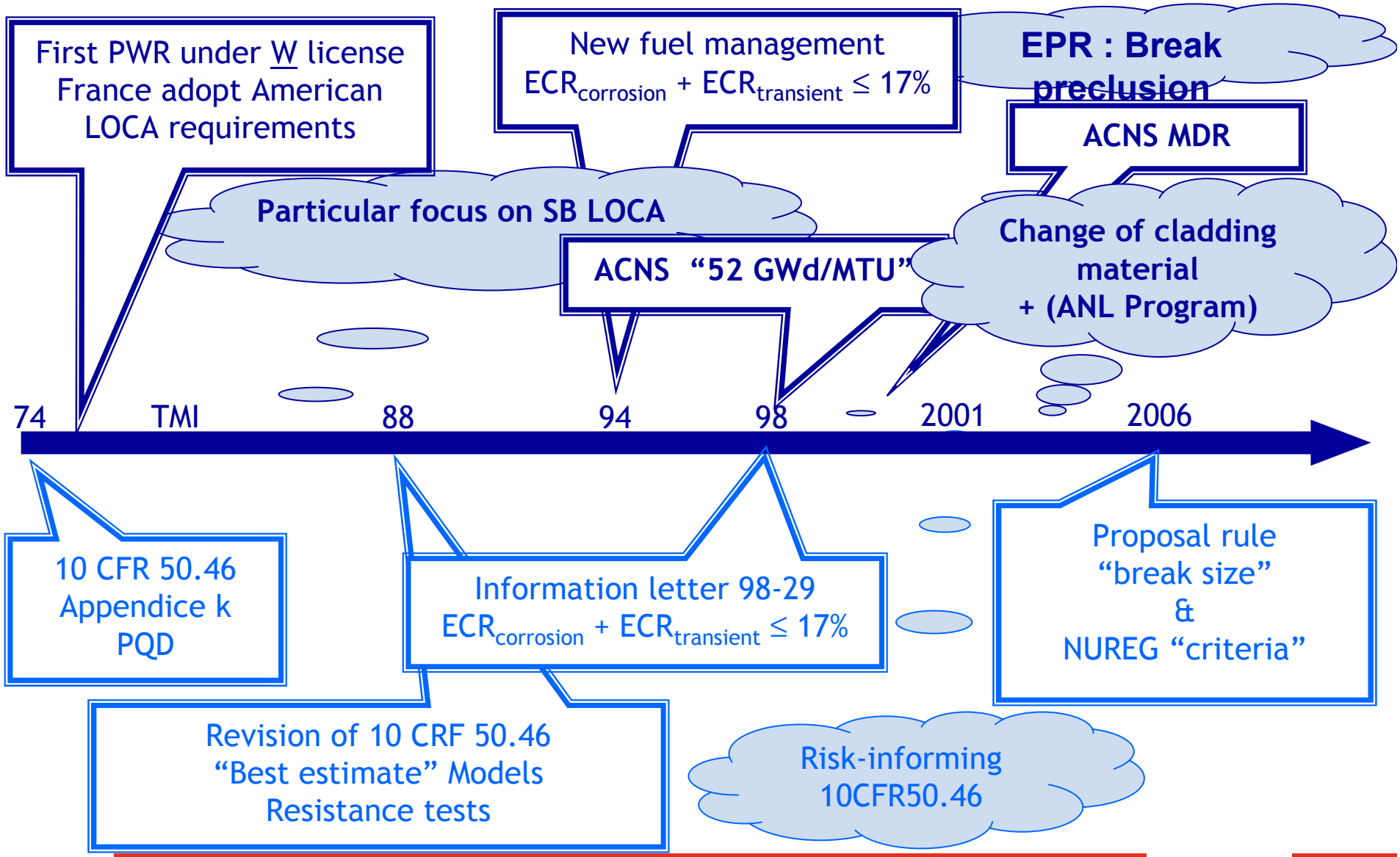
LOCA requirements evolution in France



LOCA requirements evolution in France



LOCA requirements evolution in France



Current requirements

❶ **Break size (in service plants)**

Small breaks : 1”< ∅ ≤ 14”

Large breaks : 14”< ∅ ≤ 2A

Current requirements

❶ Break size (in service plants)

Small breaks : 1”< ∅ ≤ 14”

Large breaks : 14”< ∅ ≤ 2A

❷ Studies assumptions

Loss of offsite power (T0, trip, SCRAM)

Single active component failure

Delayed stop of primary coolant pumps (SB)

Studied “sure and stable state” (SB)

Current requirements

❸ **Criteria**

Maximum of PCT ≤ 2200°F

$ECR_{initial} + ECR_{transient} \leq 17\%$

Justifications provides for new material (M5, Zirlo)

- ✓***Fresh : PQD***
- ✓***Irradiated : cf. HBU ACNS (quench without loading)***

Current requirements

❹ Methodologies… a wide choice !

Depends on :

- ✓ Break size
- ✓ Plant type (3 or 4 loops)
- ✓ When studies have been performed ⇔ fuel management

Current requirements

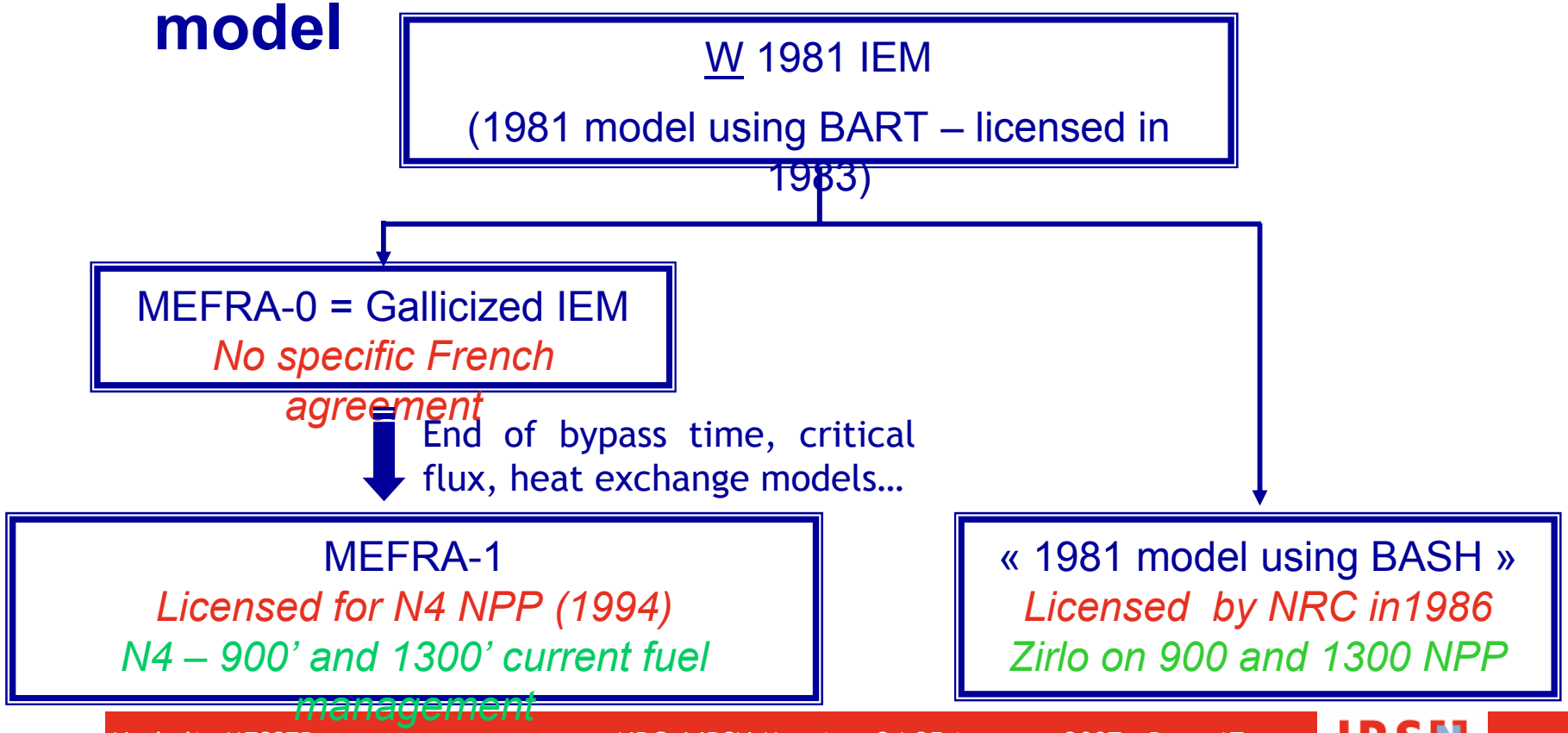
❹ Methodologies : LB LOCA

- MEFRA : « Appendice K » model

Current requirements

❹ Methodologies : LB LOCA

- **MEFRA : « Appendice K » model**



Current requirements

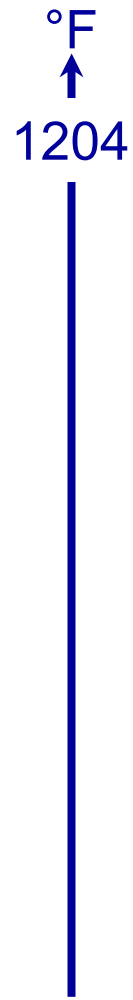
❹ Methodologies : LB LOCA

- MEFRA : « Appendice K » model
- DRM (Deterministic Realistic Method) :
  - ✓supposed to be a “BE” model

Current requirements

- **DRM (Deterministic Realistic Method)**

DRM



Current requirements

- **DRM (Deterministic Realistic Method)**

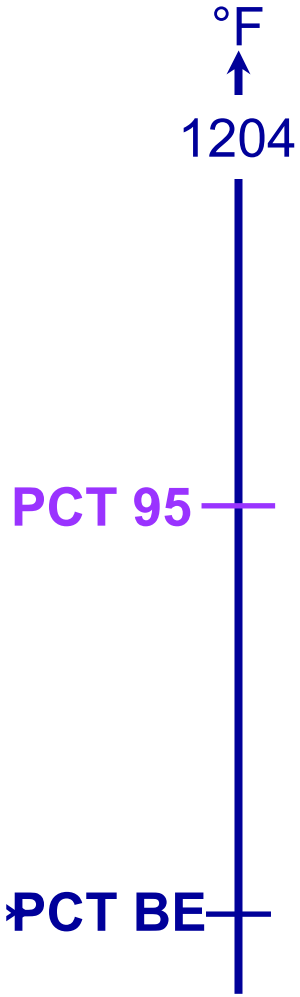
DRM

① *Use of a « best-estimate » code*

Current requirements

- **DRM (Deterministic Realistic Method)**

DRM



② *Statistical analysis*
- ✓*Key parameters & associated uncertainties*
- ✓*Dispersion on PCT due to uncertainties on key parameters*

① *Use of a « best-estimate » code*

Current requirements

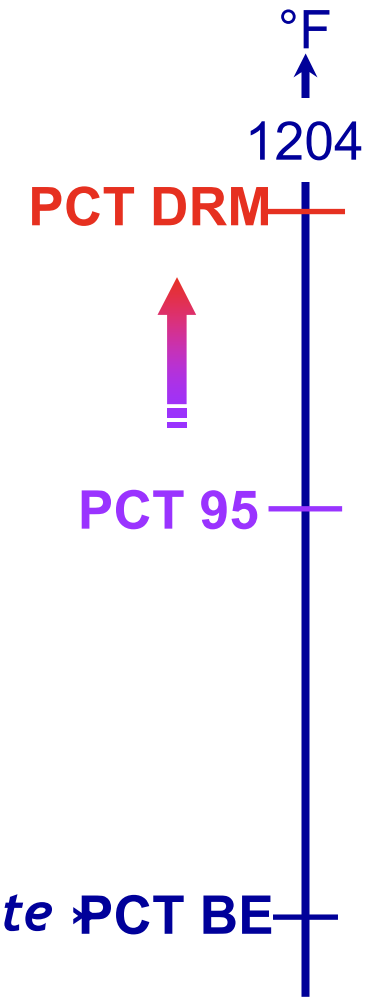
- **DRM (Deterministic Realistic Method)**

DRM

③ *Penalisation of some parameters*
PCT DRM > PCT 95

② *Statistical analysis*
✓Key parameters & associated uncertainties
✓Dispersion on PCT due to uncertainties on key parameters

① *Use of a « best-estimate » code*



Current requirements

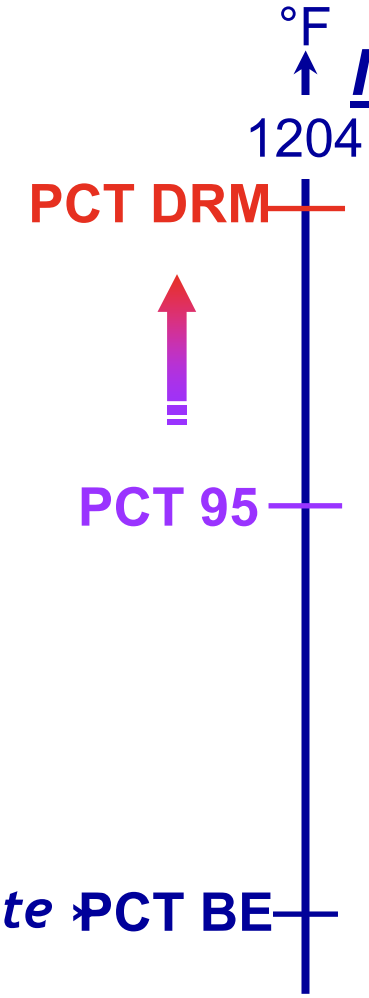
- **DRM (Deterministic Realistic Method)**

DRM — ***IRSN analysis conclusions***

③ *Penalisation of some parameters*
PCT DRM > PCT 95

② *Statistical analysis*
✓Key parameters & associated uncertainties
✓Dispersion on PCT due to uncertainties on key parameters

① *Use of a « best-estimate » code*



Current requirements

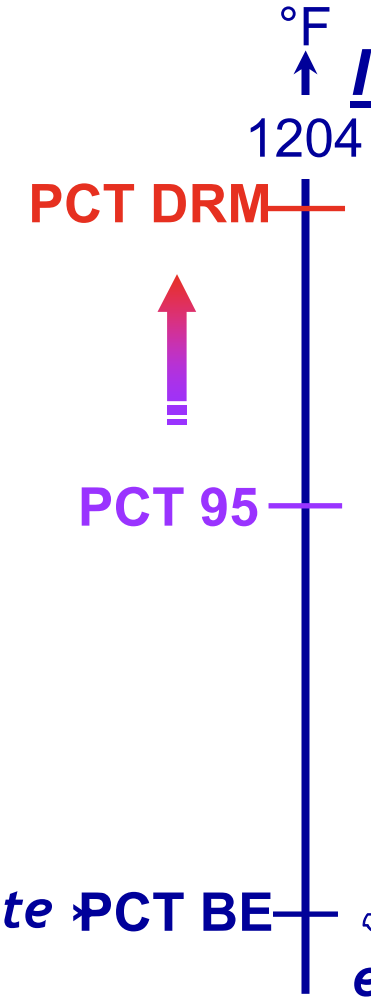
- **DRM (Deterministic Realistic Method)**

DRM | ***IRSN analysis conclusions***

③ *Penalisation of some parameters*
PCT DRM > PCT 95

② *Statistical analysis*
✓Key parameters & associated uncertainties
✓Dispersion on PCT due to uncertainties on key parameters

① *Use of a « best-estimate » code*



☞ *CATHARE GB is a « best-estimate » code*

Current requirements

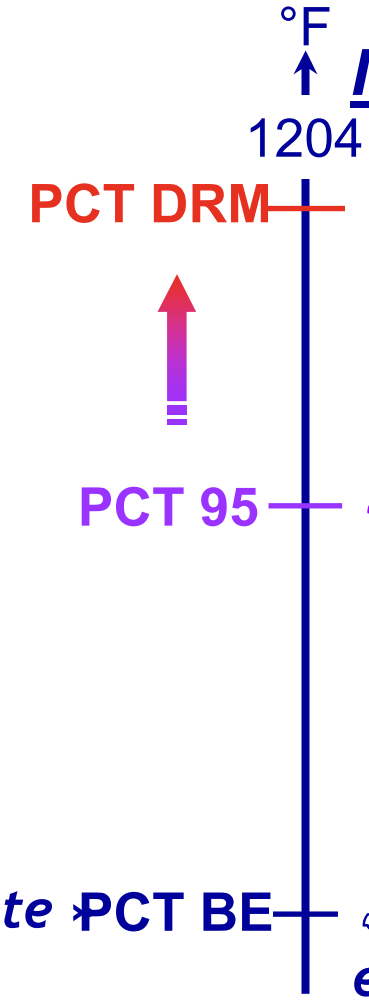
- **DRM (Deterministic Realistic Method)**

DRM

③ *Penalisation of some parameters*
PCT DRM > PCT 95

② *Statistical analysis*
✓Key parameters & associated uncertainties
✓Dispersion on PCT due to uncertainties on key parameters

① *Use of a « best-estimate » code*



IRSN analysis conclusions

☞ *Agreement for the use of "BE" methodology for DBA*

☞ *CATHARE GB is a « best-estimate » code*

Current requirements

DRM (Deterministic Realistic Method)

☞ *Agreement for the use of "BE" methodology for DBA*

- ✓ *95% probability level*
- ✓ *Some restrictions on parameters that could be statistically considered*

Current requirements

DRM (Deterministic Realistic Method)

☞ *Agreement for the use of "BE" methodology for DBA*

- ✓ *95% probability level*
- ✓ *Some restrictions on parameters that could be statistically considered*

⇨ *Hot spot factor may be fixed at it's maximum value*

But

it's uncertainty could be statistically treated

⇨ *Break size should be fixed at it's penalizing value*

Current requirements

- **DRM (Deterministic Realistic Method)**

DRM

IRSN analysis conclusions

°F

1204

③ *Penalisation of some parameters*
PCT DRM > PCT 95

PCT DRM

② *Statistical analysis*
✓Key parameters & associated uncertainties
✓Dispersion on PCT due to uncertainties on key parameters

PCT 95

☞ *Lack of justification and validation*

↳ *Cannot be used for safety demonstration*

① *Use of a « best-estimate » code*

PCT BE

☞ *CATHARE GB is a « best-estimate » code*

Current requirements

- **DRM (Deterministic Realistic Method)**

DRM	°F ↑ 1204	***IRSN analysis conclusions***
③ *Penalisation of some parameters* *PCT DRM > PCT 95*	**PCT DRM**	☞ *Not valid on the basis of PCT95 envelope nature*
② *Statistical analysis* ✓*Key parameters & associated uncertainties* ✓*Dispersion on PCT due to uncertainties on key parameters*	**PCT 95**	☞ *Lack of justification and validation* ↳ *Cannot be used for safety demonstration*
① *Use of a « best-estimate » code*	**PCT BE**	☞ *CATHARE GB is a « best-estimate » code*

Current requirements

- **DRM (Deterministic Realistic Method)**

PCT DRM

=

« penalized CATHARE GB »
=
Conservative code

+

Envelope initial and boundary Conditions

Conservative study

Current requirements

- **DRM (Deterministic Realistic Method)**

DRM	°F ↑ 1204	***IRSN analysis conclusions***
③ *Penalisation of some parameters* *PCT DRM > PCT 95*	**PCT DRM**	☞ *Not valid on the basis of PCT95 envelope nature*
② *Statistical analysis* ✓*Key parameters & associated uncertainties* ✓*Dispersion on PCT due to uncertainties on key parameters*	**PCT 95**	☞ *Lack of justification and validation* ↳ *Cannot be used for safety demonstration*
① *Use of a « best-estimate » code*	**PCT BE**	☞ *CATHARE GB is a « best-estimate » code*

Current requirements

- **DRM (Deterministic Realistic Method)**

DRM	°F ↑ 1204	***IRSN analysis conclusions***
③ *Penalisation of some parameters* *PCT DRM > PCT 95*	**PCT DRM**	☞ *Not valid on the basis of PCT95 envelope nature* *But is conservative, independently of PCT95*
② *Statistical analysis* ✓*Key parameters & associated uncertainties* ✓*Dispersion on PCT due to uncertainties on key parameters*	**PCT 95**	☞ *Lack of justification and validation* ↳*Cannot be used for safety demonstration*
① *Use of a « best-estimate » code*	**PCT BE**	☞ *CATHARE GB is a « best-estimate » code*

Current requirements

❹ Methodologies : LB LOCA

- MEFRA : « Appendice K » model
- DRM (Deterministic Realistic Method) :
  - ✓supposed to be a “BE” model

Current requirements

❹ Methodologies : LB LOCA

- MEFRA : « Appendice K » model
- DRM (Deterministic Realistic Method) :
  - ✓supposed to be a “BE” model
  - ✓a “super bounding” model

Current requirements

❹ Methodologies : LB LOCA

- MEFRA : « Appendice K » model
- DRM (Deterministic Realistic Method) :
  - ✓supposed to be a "BE" model
  - ✓a "super bounding" model

Licensed in 2000 for 3 loops Model
Applied on most of 900 NPP' new fuel management

Licensed in 2006 for 4 loops Model
Applied for 1300 and N4 NPP' new fuel management

Current requirements

❹ Methodologies : LB LOCA

- MEFRA : « Appendice K » model
- DRM (Deterministic Realistic Method) :
  - ✓supposed to be a “BE” model
  - ✓a “super bounding” model
- MSCC (~ hot rod statistical method)
  - ✓system calculation by DRM
  - ✓uncertainties affecting hot rod statistically combined (Monte Carlo + Bootstrap)

Current requirements

❹ Methodologies : LB LOCA

- MEFRA : « Appendice K » model
- DRM (Deterministic Realistic Method) :
  - ✓supposed to be a "BE" model
  - ✓a "super bounding" model
- MSCC (~ hot rod statistical method)
  - ✓system calculation by DRM
  - ✓uncertainties affecting hot rod statistically combined (Monte Carlo + Bootstrap)

Licensed in 2002

Current requirements

❹ Methodologies : SB LOCA

- No statistical treatment of uncertainties
- A “super bounding” model based on CATHARE

Reviewing LOCA requirements

Reviewing LOCA requirements

Knowledge raised from R&D

Amendment of 10 CFR 50.56 engaged in USA

EPR design specificities

New cladding materials

BU increase

Reviewing LOCA requirements

Knowledge raised from R&D

Amendment of 10 CFR 50.56 engaged in USA

Review of LOCA requirements engaged

Will be examine by the French Advisory Committee for Nuclear Safety (ACNS)

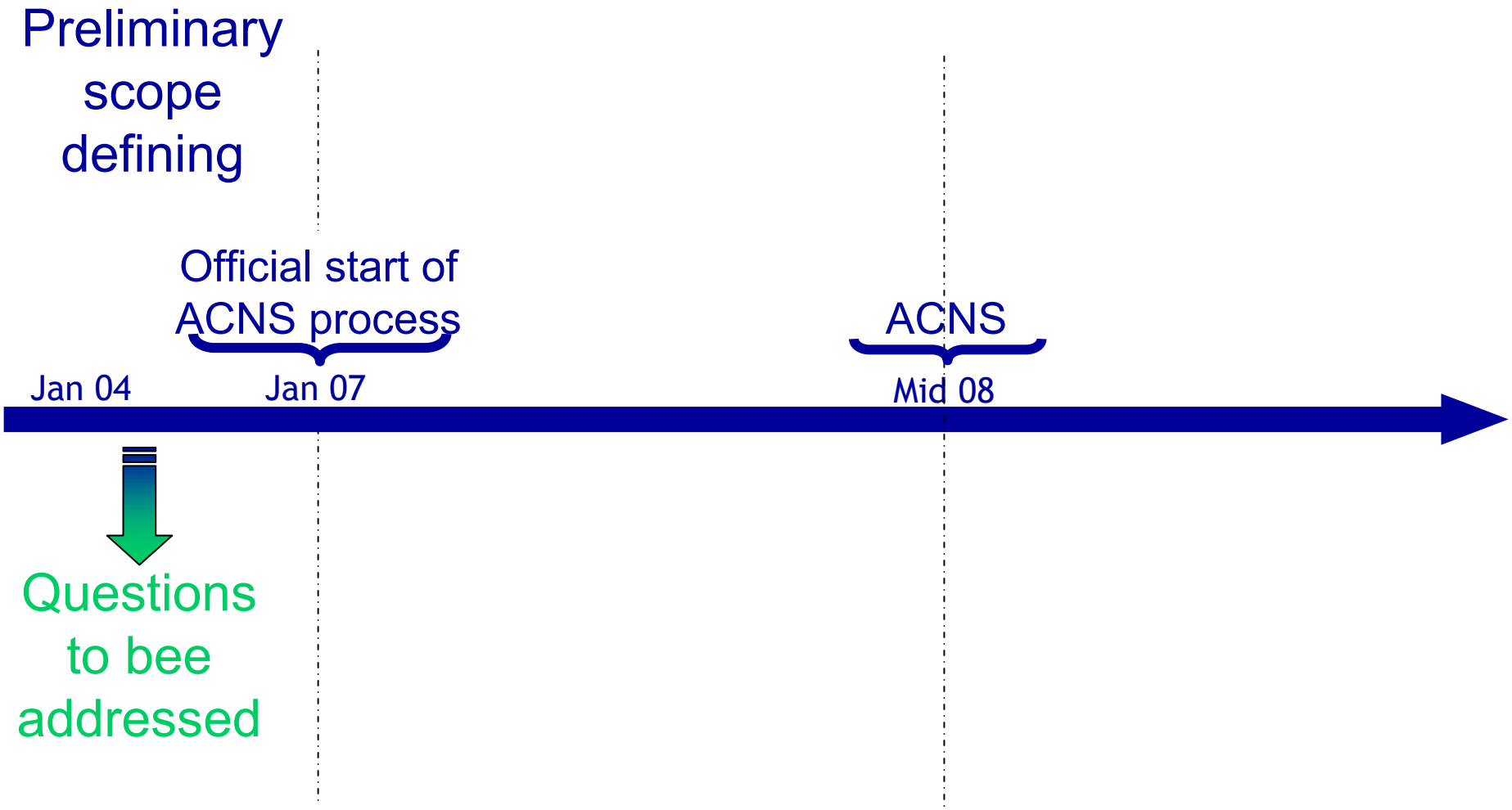
Mid 2008

EPR design specificities

New cladding materials

BU increase

Reviewing LOCA requirements



Reviewing LOCA requirements

Preliminary scope defining

ACNS process

technical exchanges with French utility

Official start of ACNS process

ACNS

Jan 04 — Jan 07 — Mid 08

Questions to bee addressed

Report to ACNS

"trends" on each topic

Criteria : What has to bee demonstrate and on which basis

Reviewing LOCA requirements

Preliminary scope defining

ACNS process

technical exchanges with French utility

Definition of new requirements according to ACNS conclusions

Official start of ACNS process

ACNS

Next ACNS

Jan 04 — Jan 07 — Mid 08 — 2010

Questions to bee addressed

Report to ACNS

"trends" on each topic

Criteria : What has to bee demonstrate and on which basis

New LOCA requirements

Questions to be addressed

Questions to be addressed

- Transient studies for safety demonstration
  - EPR Break preclusion / USA Redefining LB LOCA
    - in service NPP ?

Questions to be addressed

- Transient studies for safety demonstration
  - EPR Break preclusion / USA Redefining LB LOCA
    - in service NPP ?
- Criteria
  - International R&D
    - adequacy of criteria for new cladding material and high burn up ?
  - What about SB LOCA ?

Questions to be addressed

- Transient studies for safety demonstration
  - EPR Break preclusion / USA Redefining LB LOCA
    - in service NPP ?
- Criteria
  - International R&D
    - adequacy of criteria for new cladding material and high burn up ?
  - What about SB LOCA ?
- Models
  - Relocation, ballooning, HP oxidation…

Questions to be addressed

- Transient studies for safety demonstration
  - EPR Break preclusion / USA Redefining LB LOCA
    - in service NPP ?
- Criteria
  - International R&D
    - adequacy of criteria for new cladding material and high burn up ?
  - What about SB LOCA ?
- Models
  - Relocation, ballooning, HP oxidation…

Questions to be addressed

- Transient studies for safety demonstration
  - EPR Break preclusion
  - LOCA
    - ↳ in service NPP ?

⇨ Sebastien ISRAEL's presentation

- Criteria
  - International R&D
    - ↳ adequacy of criteria for new cladding material and high burn up ?
  - What about SB LOCA ?
- Models
  - Relocation, ballooning, HP oxidation…

Questions to be addressed

- **Transient studies for safety demonstration**
  - **EPR Break preclusion**
  - **LOCA**
    - ⇨ **in service NPP ?**

⇨ Sebastien ISRAEL's presentation

- **Criteria**
  - **International R&D**

⇨ Claude GRANDJEAN's presentation : questions raised by international R&D

⇨ Sandrine BOUTIN's presentation : re-examination work program on criteria and physical model considered for safety demonstration

- **Relocation, ballooning, HP oxidation…**