L09.- Elements of the safety assessment (III)

International Atomic Energy Agency

OBJECTIVE

To identify the key elements in the development of the safety assessment:

- Identification of Models and Data Needs
- Performing Dose Calculations
- Evaluation of results. Analysis of uncertainties

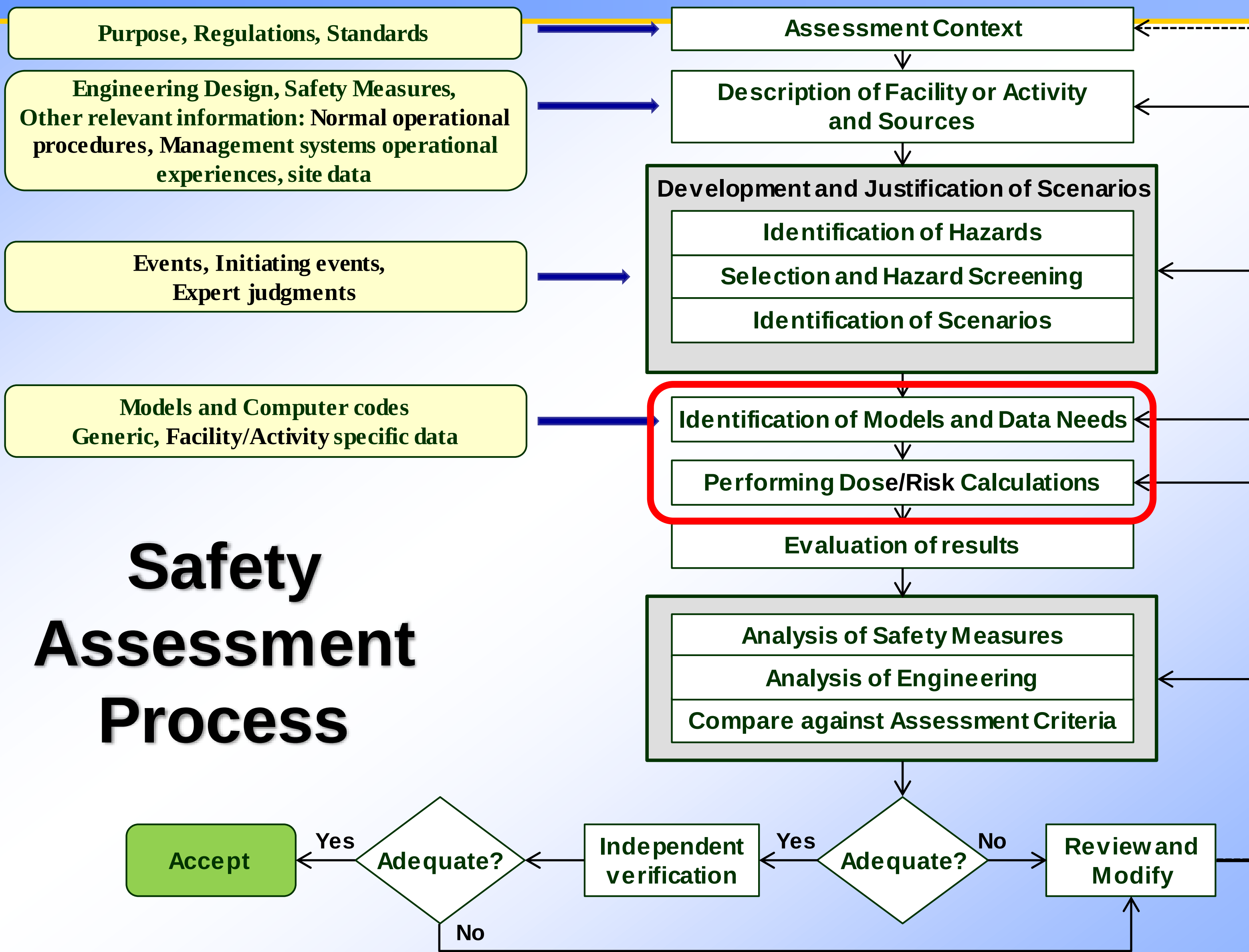
Introduction

In the previous lecture (elements of the safety assessment) you learned about:

- **Why to do a safety assessment. Overall approach. Safety assessment objectives.**
- **Identification of some key elements in the development of the safety assessment:**
  - ✓ Assessment context. Safety criteria and end points.
  - ✓ Description of the facility or activity
  - ✓ Development and justification of scenarios

Now we will continue developing this issues

Safety Assessment Process



Safety Assessment Process

Formulation and implementation of models

- **Once the scenarios are defined (and not being screened out), the corresponding assessments shall be carried out; This is commonly done using assessment models.**
- **Assessment model includes:**

Conceptual model

Provides description of the components of the system and the interactions between them; Includes assumptions concerning the system geometry, the chemical, physical, biological and mechanical behavior.

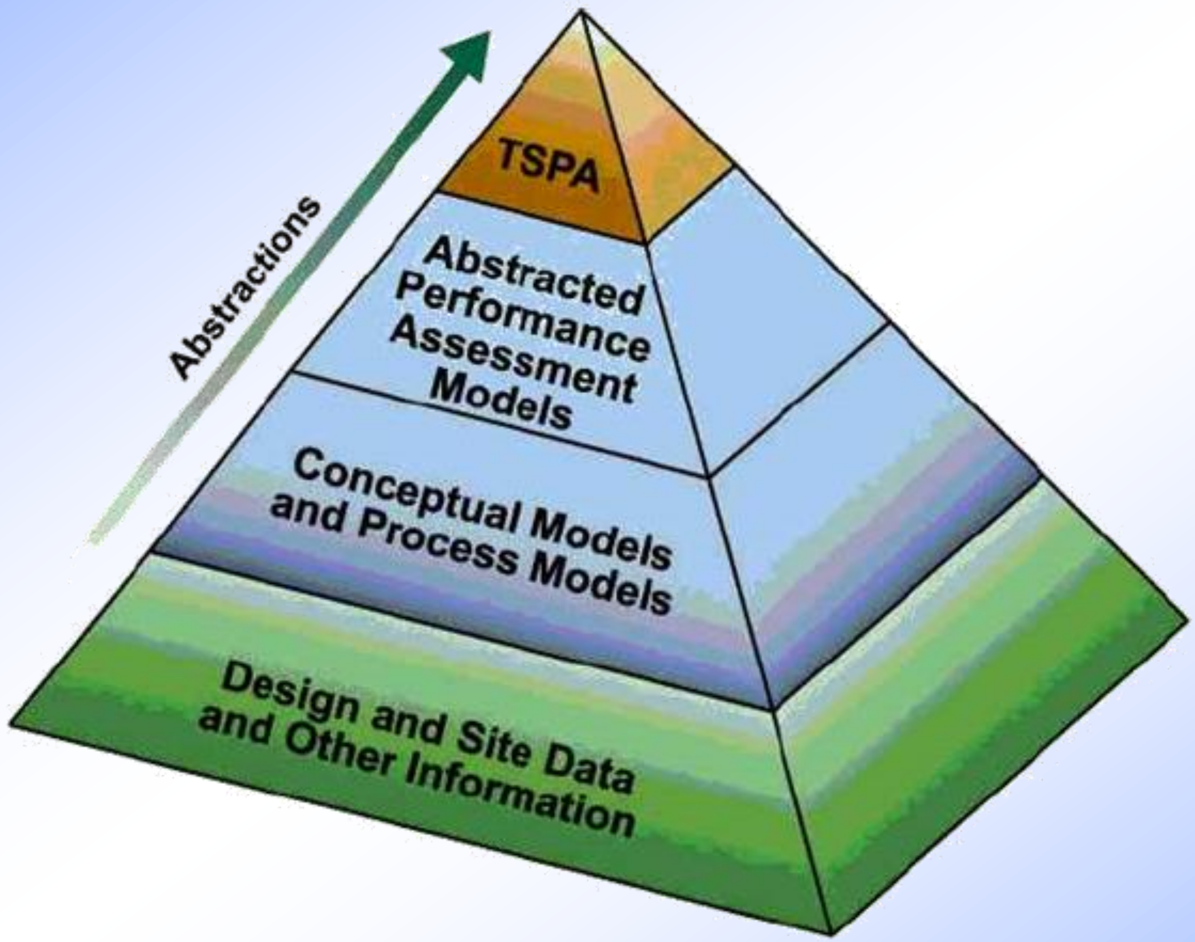
Mathematical model

Is representation of the conceptual model using mathematical equations.

Computer code

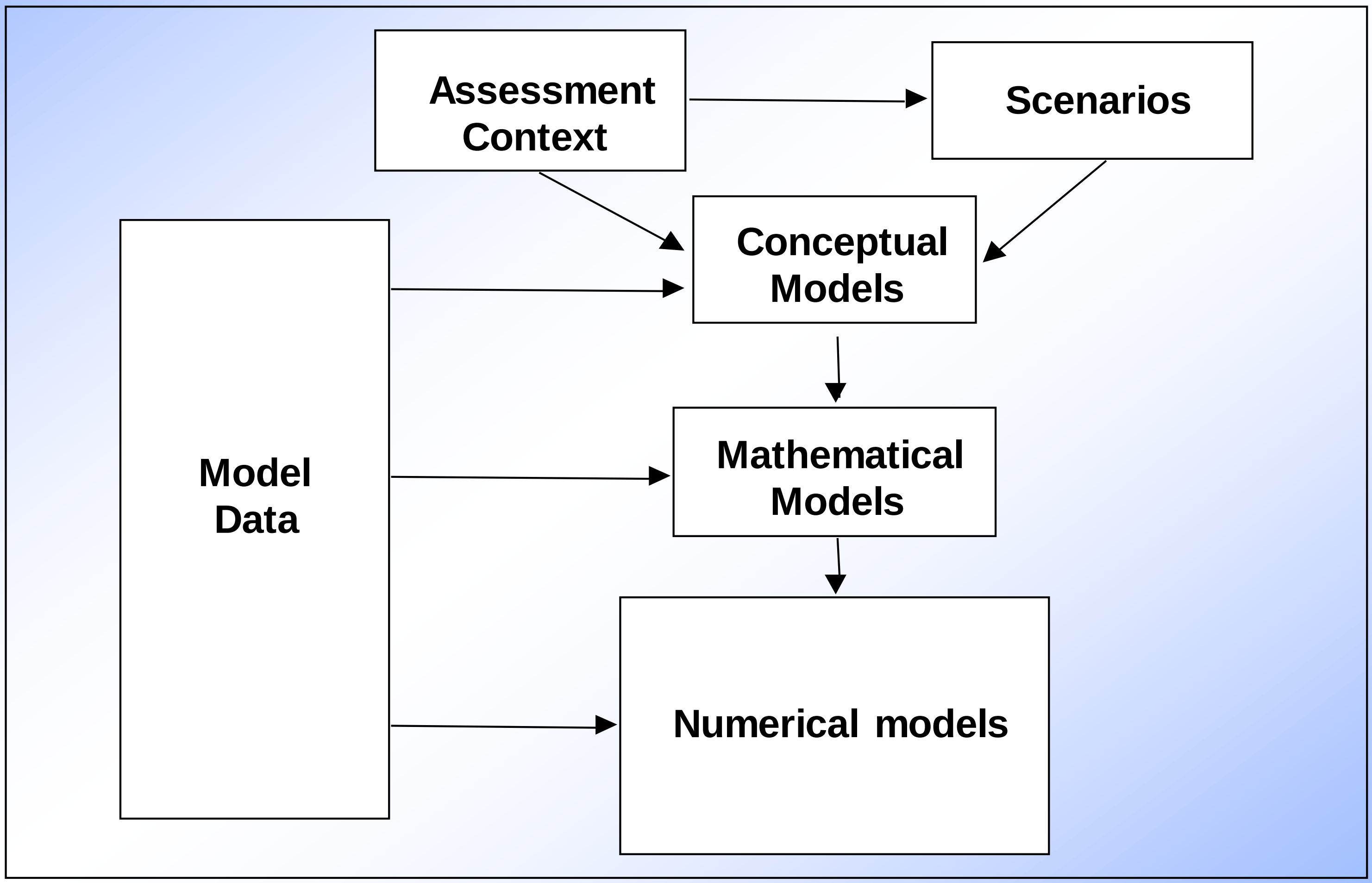
Is software implementation of mathematical model and facilitates performing of calculations.

Support for Models

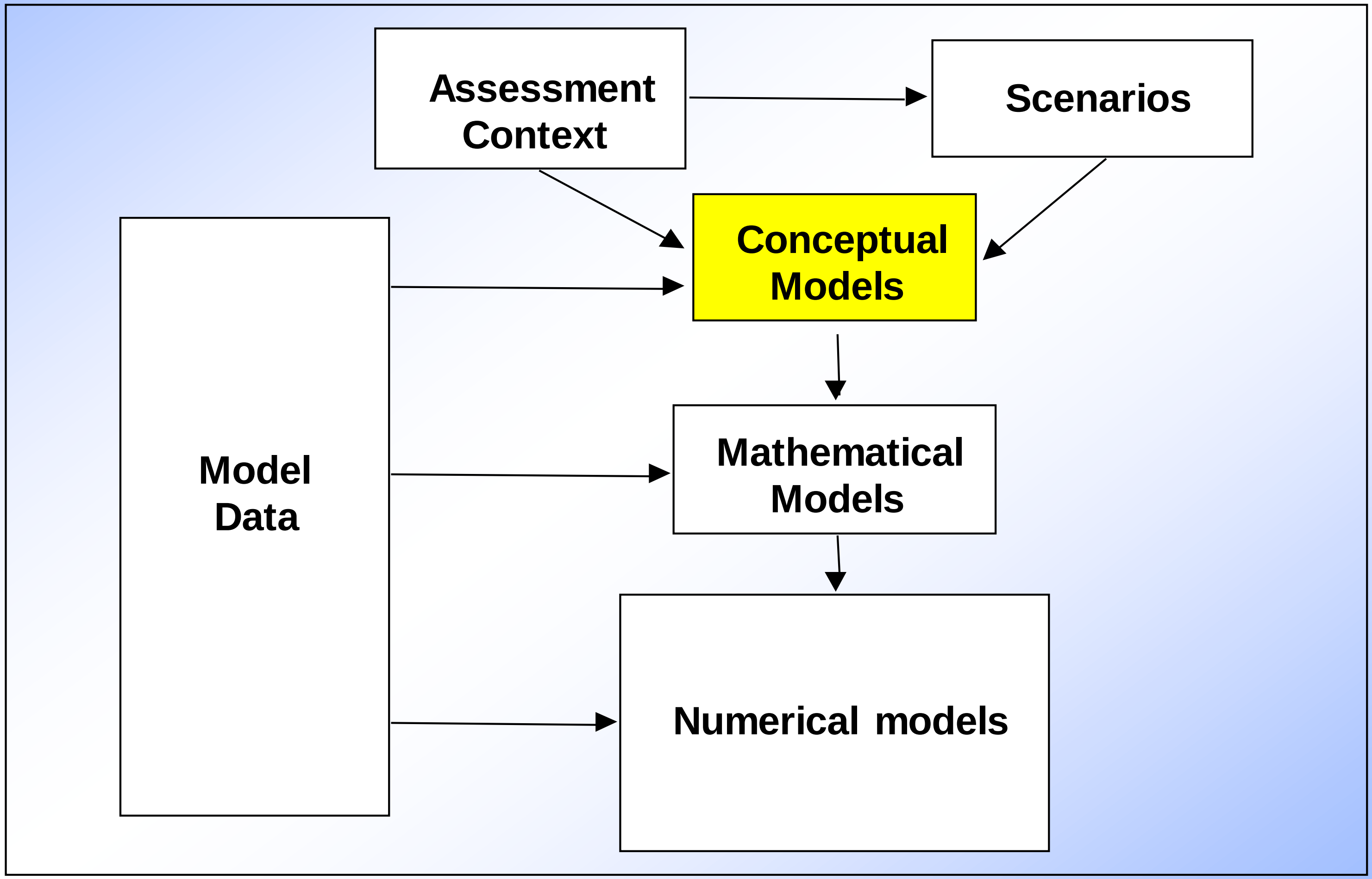


Need for clarity and transparency

Model Formulation and Implementation



Model Formulation and Implementation



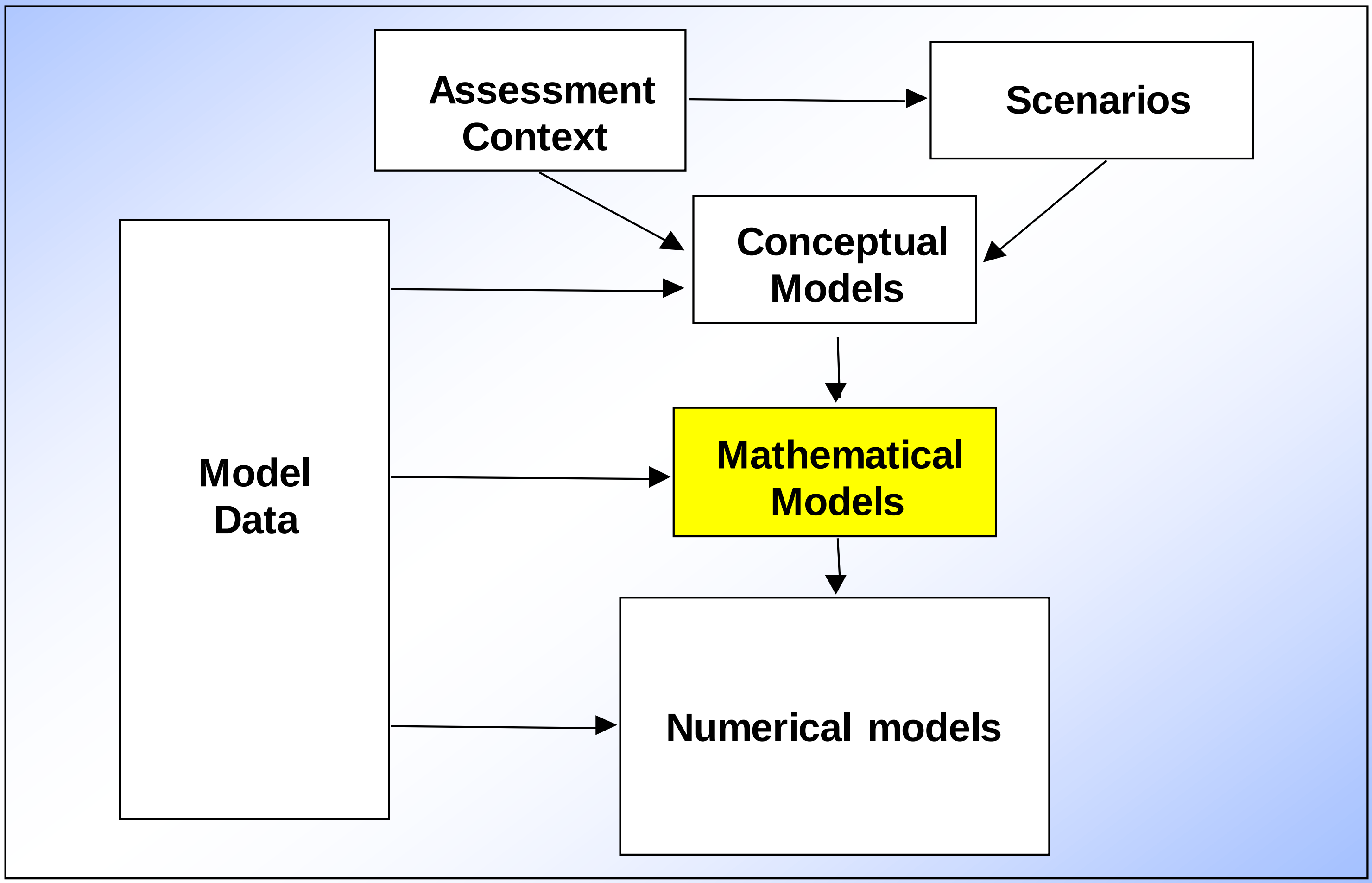
Conceptual Models

- Can be defined as a set of qualitative assumptions used to describe a system or subsystem for a given purpose.

- At a minimum, these assumptions concern the geometry and dimensionality of the system, initial and boundary conditions, time dependence, and the nature of the relevant physical and chemical processes.

- In safety assessment analysis, the conceptual model consists of:
  - *The model's features, events and processes (PIEs);*
  - *The relationships between these PIEs;*
  - *The model's scope of application in spatial and temporal terms.*

Model Formulation and Implementation



Mathematical Models

Once the models have been developed it is necessary to assign values to the different parameters.

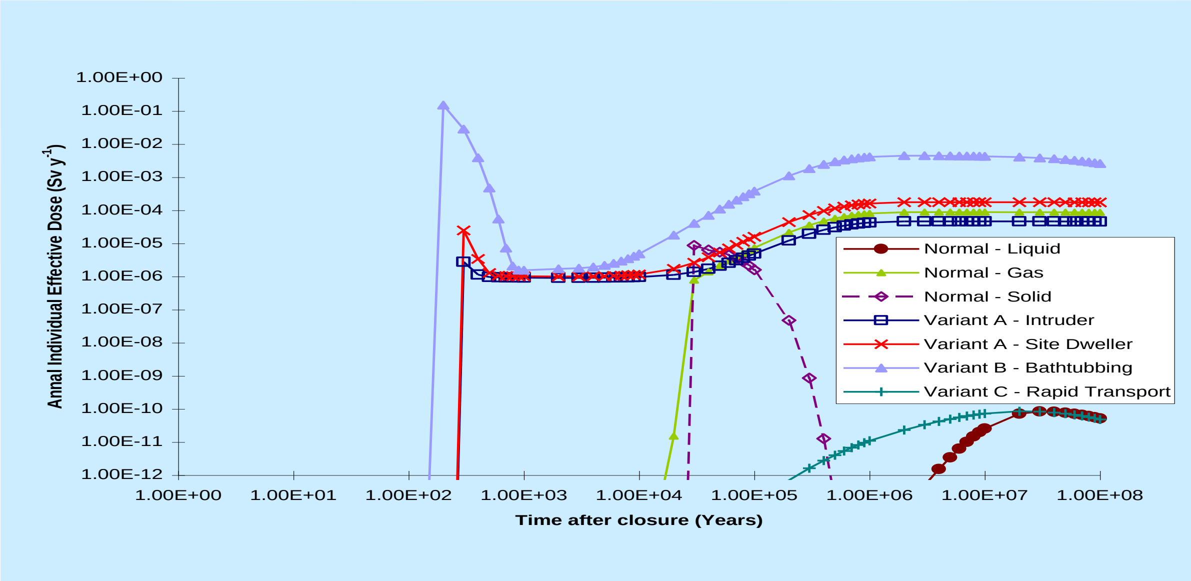
During model parameterization it should be ensured that:

- *Parameter values used as inputs to the models and codes used in assessment calculations are documented. The model parameterization process should be traceable to source data;*
- *Records are kept of how site and system specific characterization data has been used to derive parameter values used in the assessment calculations;*
- *Where a probabilistic approach has been used in the assessments, a justification of the selected probability distributions is provided.*

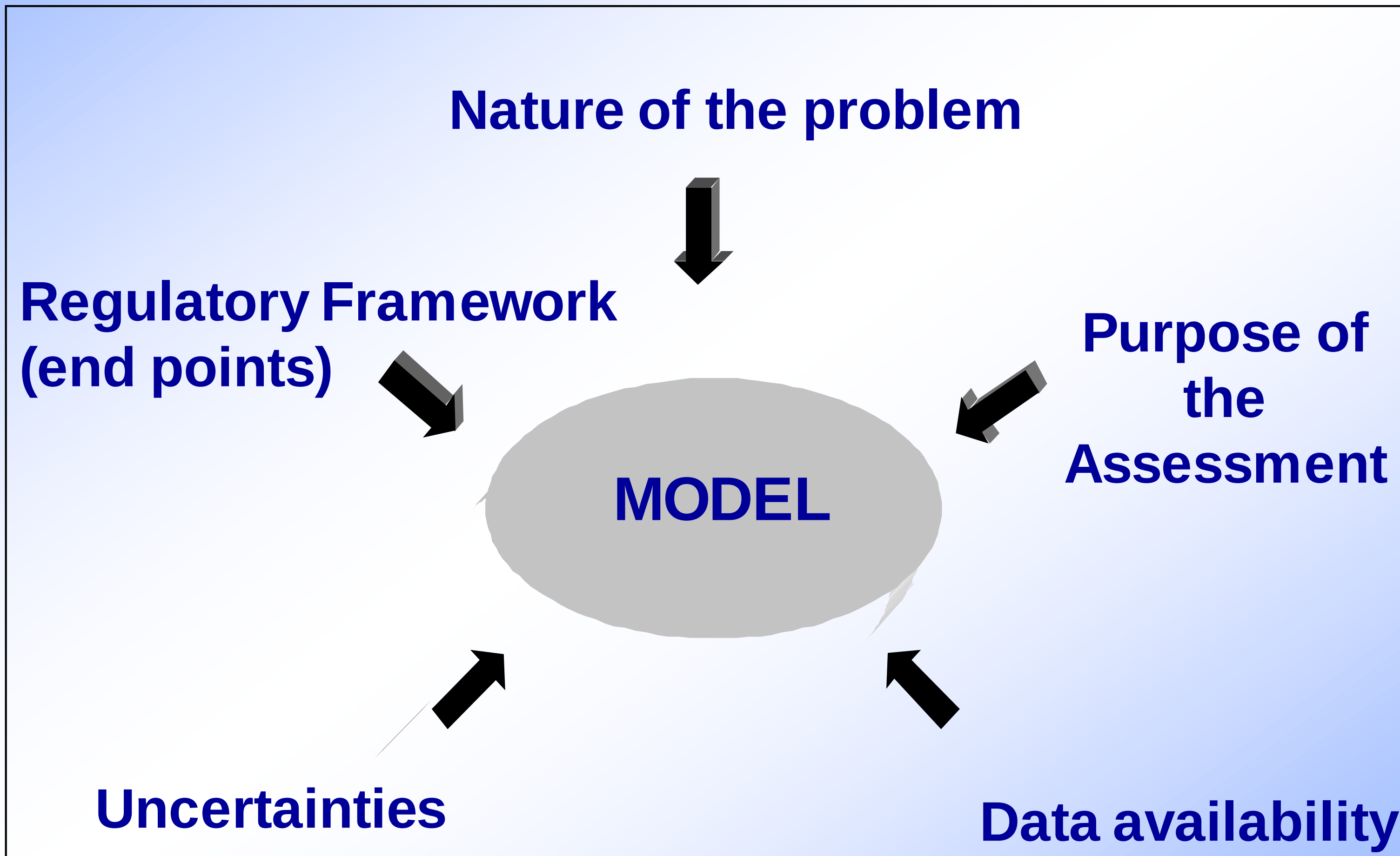
Mathematical Models

– *The mathematical model adequately represents the conceptual model;*

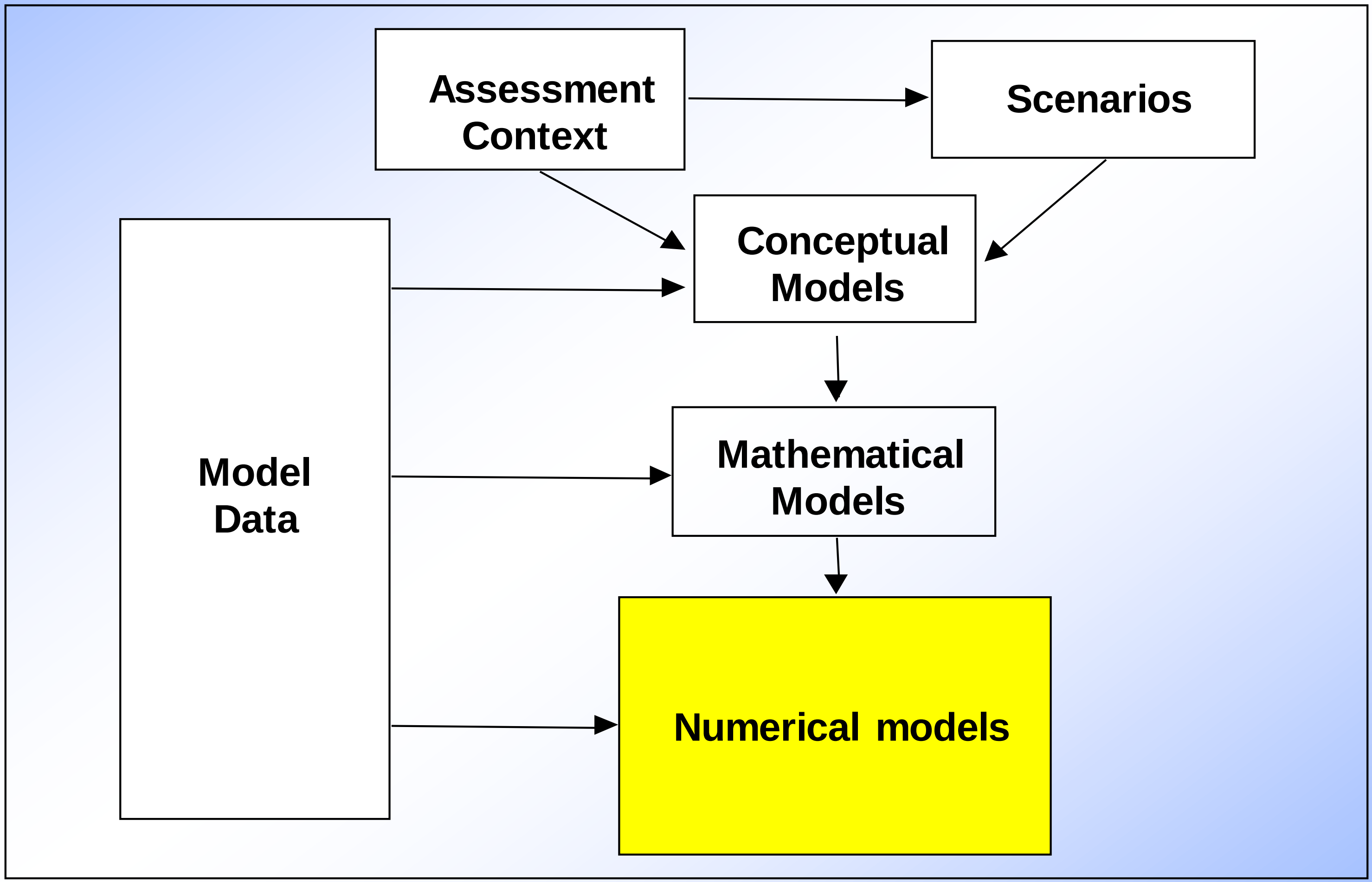
– *For mathematical models and computer codes, verification and validation exercises are conducted and documented to build confidence in the fitness of the model for its intended purpose.*



Factors affecting the complexity of the models



Model Formulation and Implementation



Numerical Models / Computer Codes

Types of codes

- ***Proprietary codes***

  Advantage that the codes have been previously developed and checked, and have a history of application to a range of cases

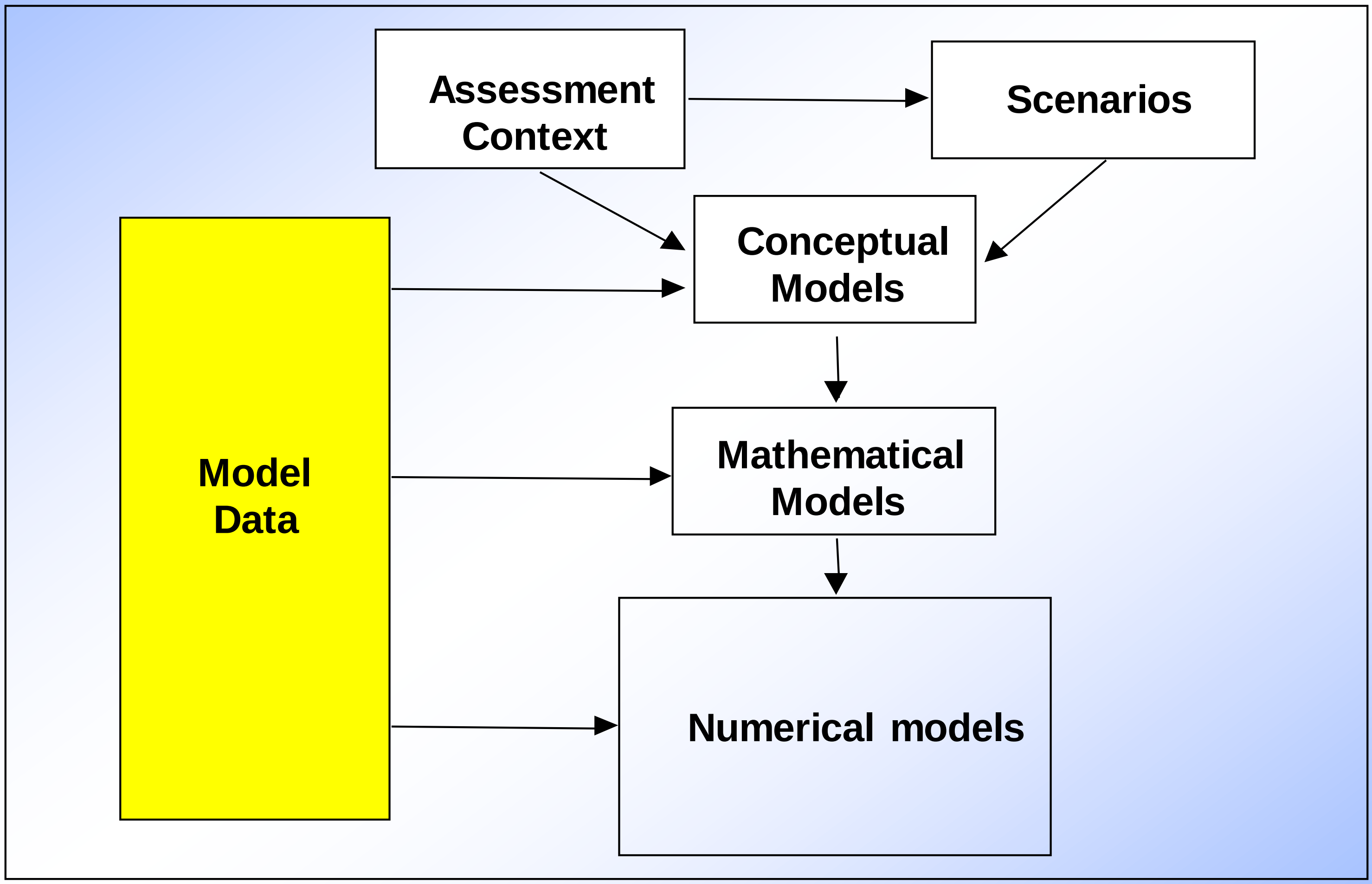
- ***Modified codes and codes specifically developed for implementation of the chosen mathematical models***

  Need to be developed and checked, advantage of being tailored to the needs of the specific problem to be addressed

  Increase confidence in the codes through a process of verification, calibration and validation

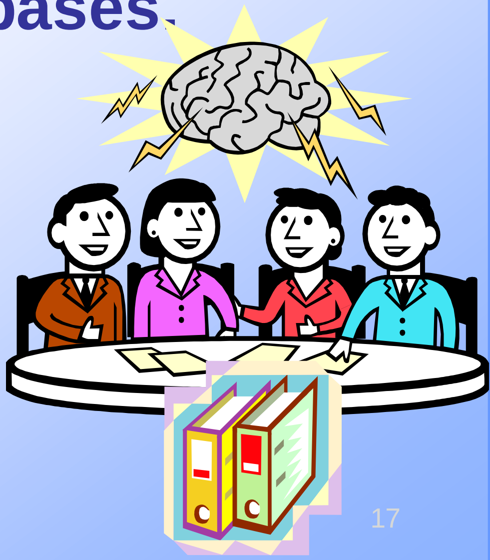
One or more codes can be used, depending of the complexity of the conceptual and mathematical models

Model Formulation and Implementation



Data Requirements

- Data are important at all stages of model development.
- Consideration should be given to the treatment of uncertainties associated with the parameter values.
- If the computer codes are to be used for probabilistic calculations rather than deterministic calculations, then parameter distributions need to be specified.
- Data required and their meaning within the context of the model, should be documented to provide a basis for establishing a model input parameter databases.



Data Sources

- Source characterisation programme
- Design data
- Literature searches
- R&D
- Separate calculations
- Expert elicitation

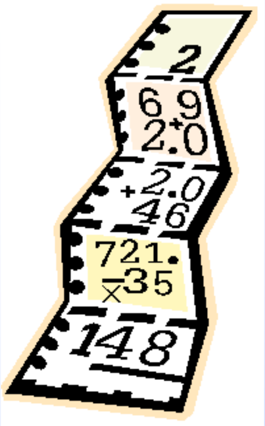
Safety Assessment

Targeted further work

Models & Data - Summary

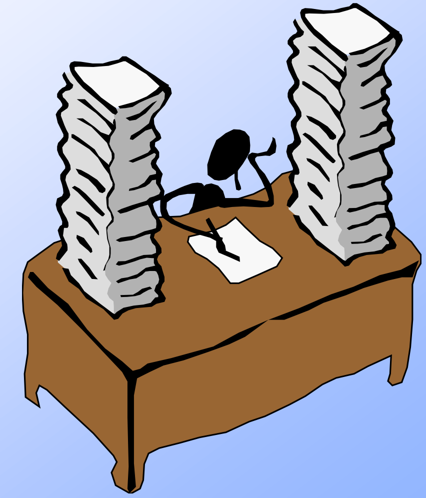
The process consists of three stages.

- ✓ *Conceptual models;*
- ✓ *Mathematical models;*
- ✓ *Numerical models/Computer codes;*

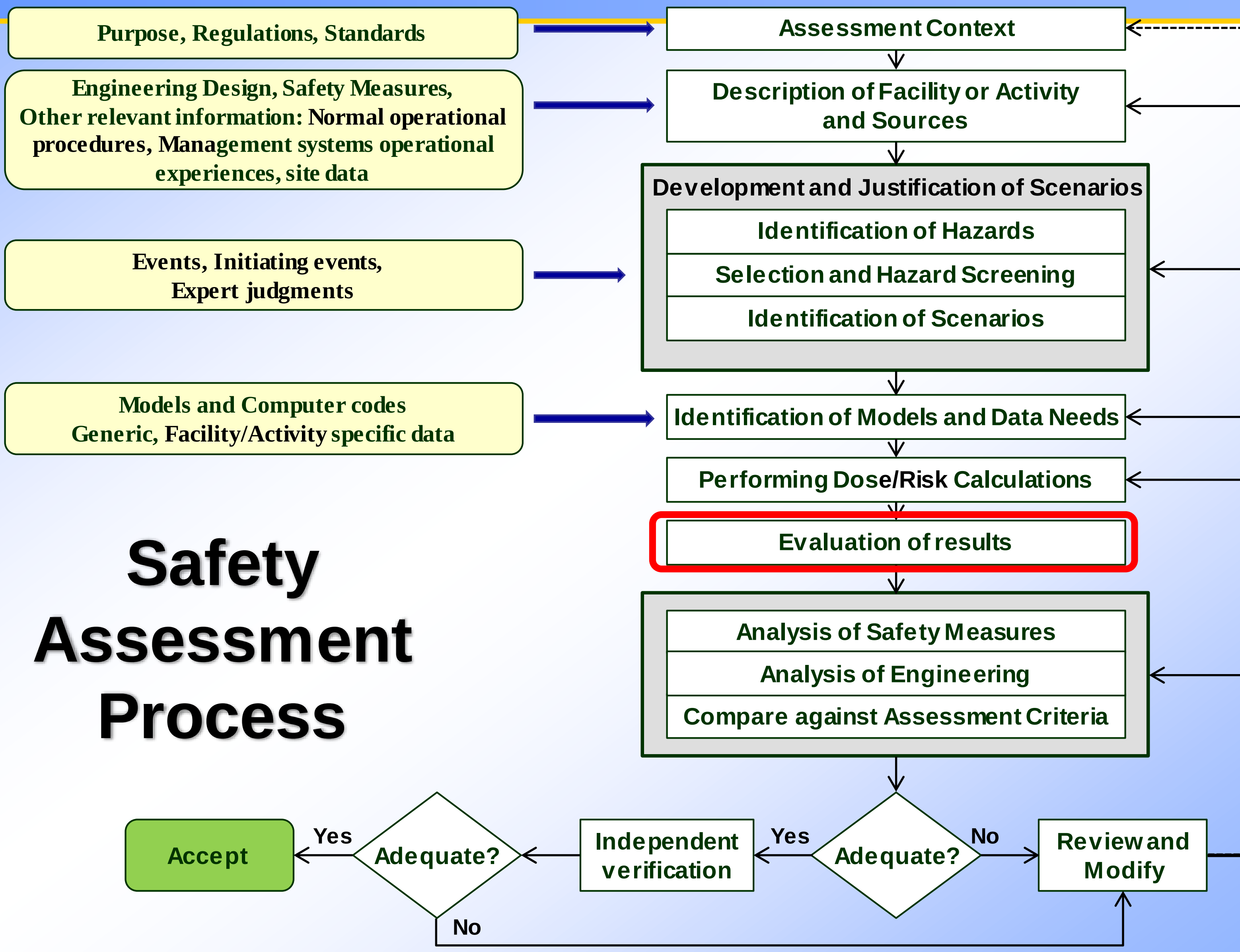


Level of detail determined by the problem and the available data.

Identify and quantify uncertainties.



Safety Assessment Process



Evaluation of results

Interpretation

- Once the calculations have been undertaken, the results need to be collated, interpreted and compared against the relevant assessment criteria.

- Ensure that an understanding of the results from each component of the assessed system is developed.

- Intermediate calculation outputs should be analysed, as well as those relating to endpoints such as dose and/or risk.

Evaluation of results

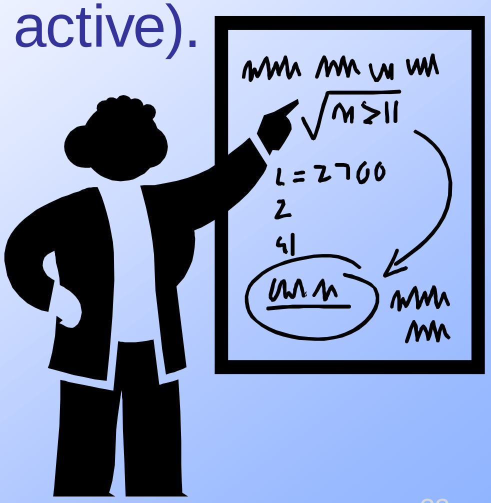
Performing calculations and analyzing their results

Management of uncertainties

- Sources of uncertainty – model, data, parameters, human errors, etc.
- Uncertainty and sensitivity analyses.
- Treatment of uncertainties.

Analysis of assessment results

- Comparison against assessment criteria.
- Identification of safety measures (passive, active).
- Engineering analysis.



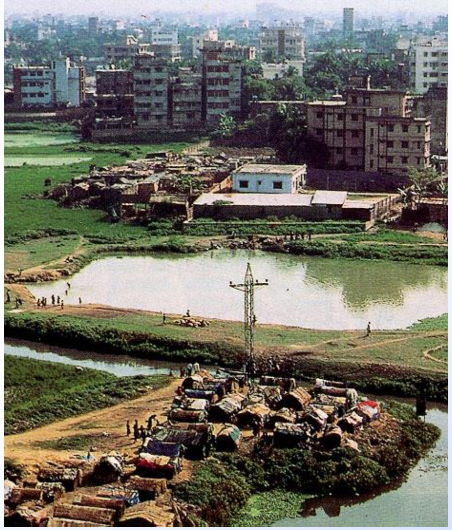
Independent verification of safety assessment results

Review and modification of the assessment models

Evaluation of results

Comparisons:

- ***Release pathway;***
- ***Concentration vs. background;***
- ***Time of peak dose;***
- ***Against previous assessments.***



Evaluation of results

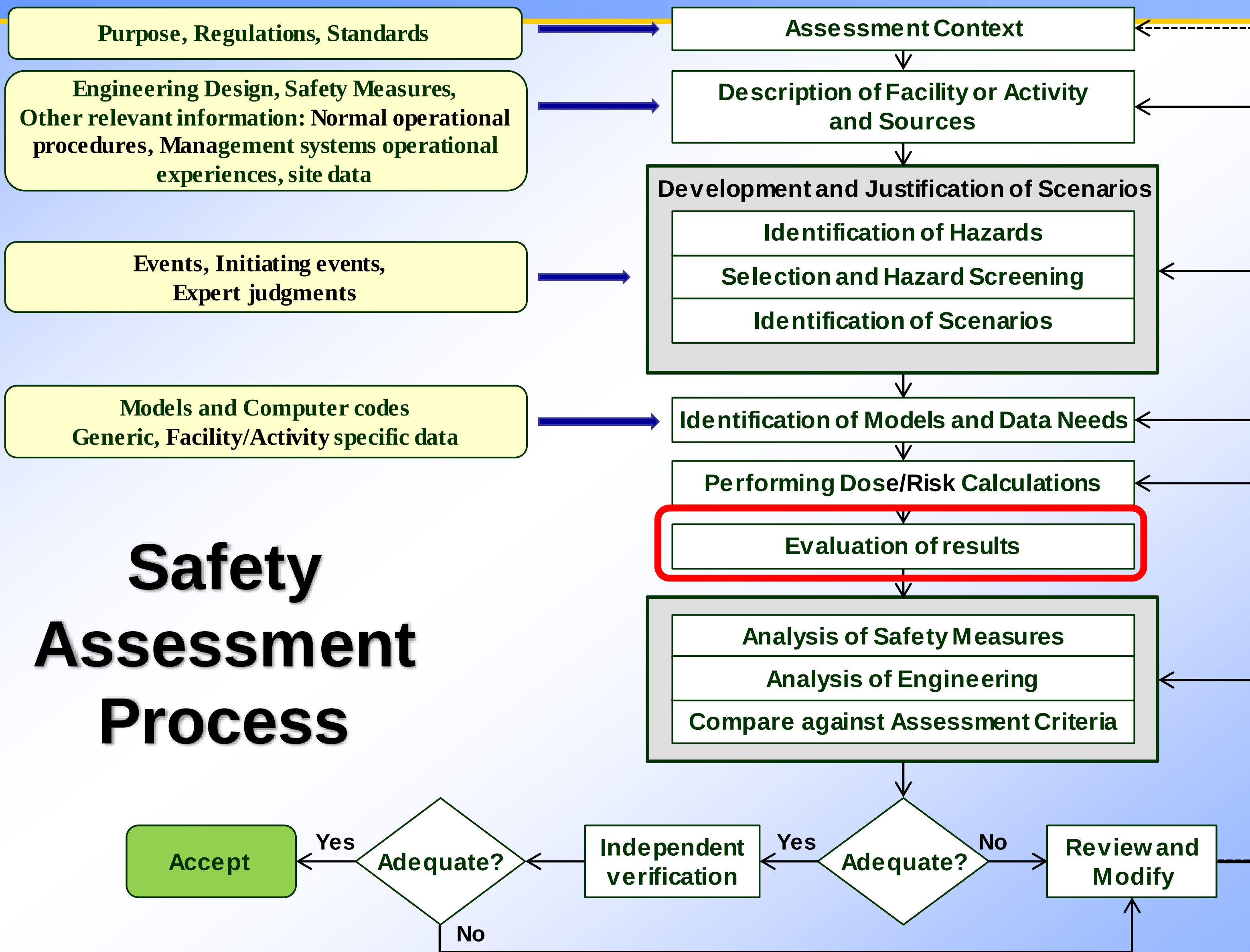
When presenting the output from safety assessment calculations, sufficient results should be provided;

- *e.g. both needed for comparison with the ultimate assessment endpoints and with any alternative or sub-system performance criteria.*

Guidance on the use of the safety assessment results should be provided;

- *For example, it should be explained whether the safety assessment results (endpoints) will be compared directly with regulatory criteria (e.g. safety targets) or whether these will be used for illustrative or other purposes.*

Safety Assessment Process



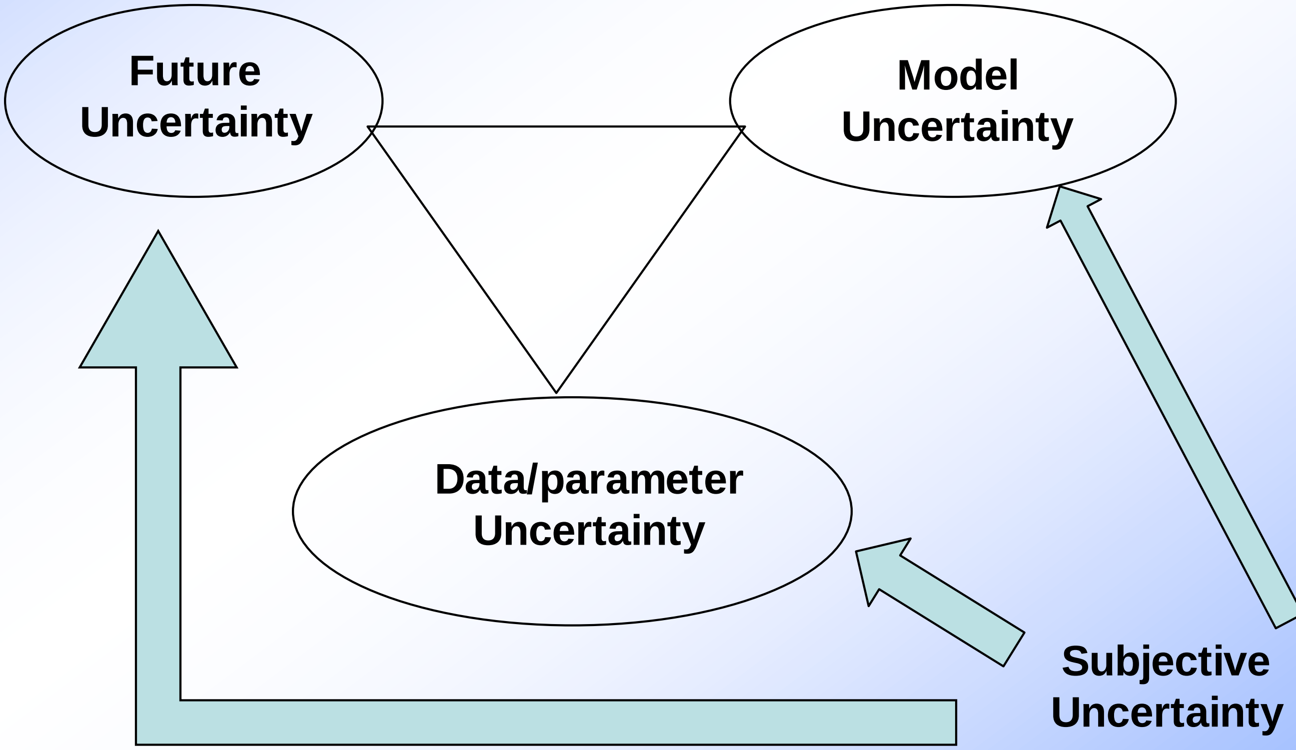
Evaluation of results: Uncertainties

- In view of the complexity of facilities or activities, efforts should be undertaken during the assessment to understand the significance of the uncertainties and to reduce or bound uncertainties;
- The analysis of uncertainties should be an integral part of the dose or risk calculation process;
- Whenever possible, reported results should include ranges of possible values (indicating what each range represents) rather than single point values;

The analysis of uncertainty should be adequate for the purpose of the assessment.

Evaluation of results: Uncertainties

When defining a strategy for the treatment of uncertainties, it is convenient to differentiate between:



Evaluation of results: Uncertainties

Model Uncertainty

✓uncertainty in the conceptual model
✓mathematical model uncertainty
✓numerical model uncertainty

- Model uncertainty could arise from imperfect knowledge of the processes, which leads to imperfect conceptual models;
- The mathematical representation of the conceptual models may be approximate or over-simplified, also contributing to model uncertainty;
- Imprecision in the numerical solution of mathematical models is another source of uncertainty in this category.

Evaluation of results: Uncertainties

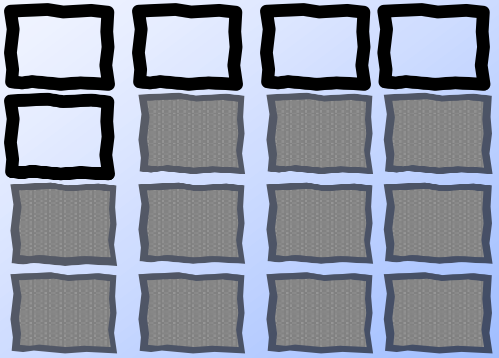
Data/parameter Uncertainty

- Refers to the uncertainty in the used parameters values.
- This category often includes uncertainty in the:
  - *Source characteristics;*
  - *Process characteristics;*
  - *Measurement procedures – clearance / discharge measurement procedures;*
  - *Receptor characteristics – exposure time.*

Evaluation of results: Uncertainties

Future Uncertainty

- Future uncertainty is associated with the evolution of the facility or activity over the timescales of interest.
- Examples include stochastic events such as earthquakes, climate change and human intrusion.
- These uncertainties are usually considered through the use of scenarios



Evaluation of results: Uncertainties

- For each specific scenario it is necessary to deal with uncertainties in the models and parameter values used;
- A commonly used approach to address model uncertainties is to perform inter-comparisons between alternative models, and in some cases also between model predictions and empirical observations.

Evaluation of results: Uncertainties

- Sensitivity and/or uncertainty analyses may demonstrate that a given uncertainty is not significant to the safety.
  - *Sensitivity study may show that the models are not sensitive to some parameters, even when varying these over the whole range of possible values;*
  - *Uncertainty analysis may show that some parameters, may have a small contribution to the overall uncertainty of the model predictions.*

Evaluation of results: Uncertainties

The graded approach to safety assessment applies equally to the treatment of uncertainty.

For example, a commonly used approach to treat uncertainty is to:

- ✓ *use conservative (cautious) assumptions when simplifying the models;*
- ✓ *assign conservative values to model parameters.*

This approach has several advantages, in particular for the demonstration of compliance with regulatory criteria.

Evaluation of results: Uncertainties

However, it should be taken into account that:

- ✓ *In some cases the conservative assumptions may lead to assessments representing situations that are extremely unrealistic or impossible and, therefore, difficult to interpret and communicate;*
- ✓ *When conservative values are assigned to several parameters, the results of the calculations might be over conservative due to magnification of errors, and would provide a poor basis for decision making;*
- ✓ *An assumption that is conservative in one scenario, or for one radionuclide, might not be so for another.*

The conservatism of the assumptions should be justified in relation to their impact on the assessment endpoints.

Thank you!