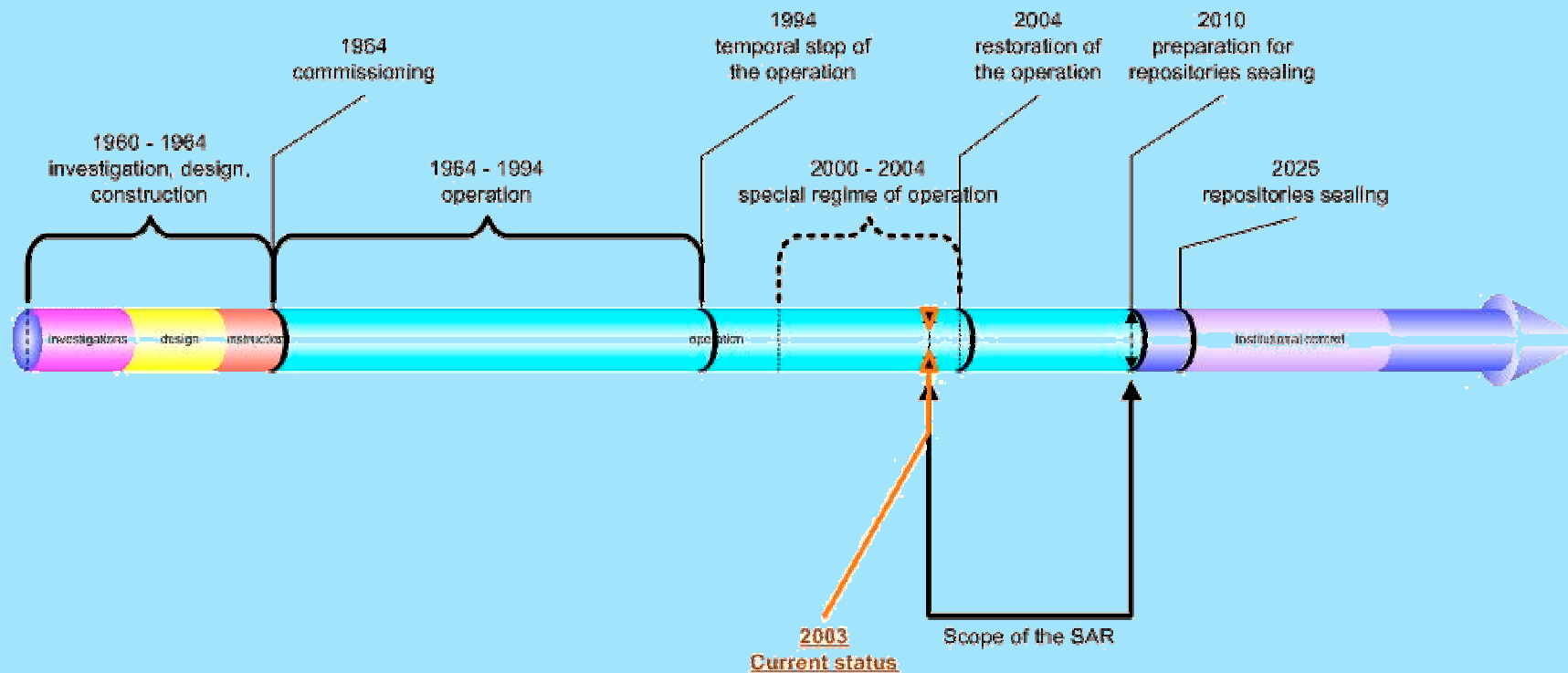


National Waste Repository
Novi Han
Operational Safety Analysis Report

Safety Assessment Methodology

Scope of the assessment

Period from Life Cycle of the facility



Scope of the assessment

Waste Management

functions

- Acceptance
- Conditioning
- Storage
- Disposal

Inventory

- Current
- Future expected

Hazard

- Radiological
- Non-radiological

Modes

- Normal
- Accidental

Development stages of SA

Stage 1 - Criteria selection

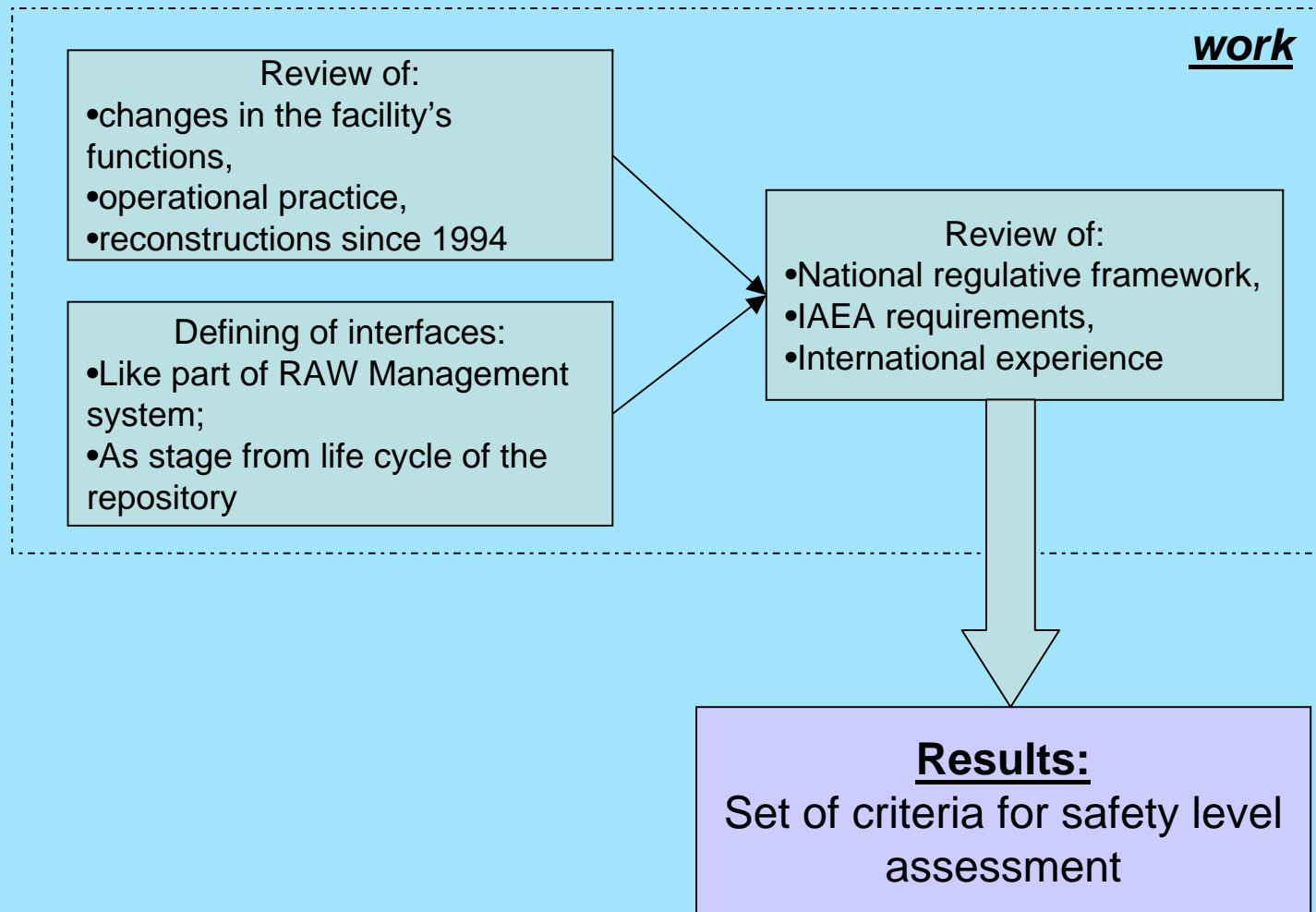
Stage 2 - Information collection

Stage 3 - Safety analysis

Stage 4 - Safety assessment documentation

Criteria selection

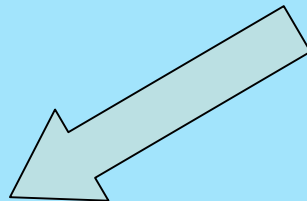
Stage 1



[back](#)

Information selection

Stage 2



Results:

Actual conditional parameters of the facility, necessary for safety analysis

back

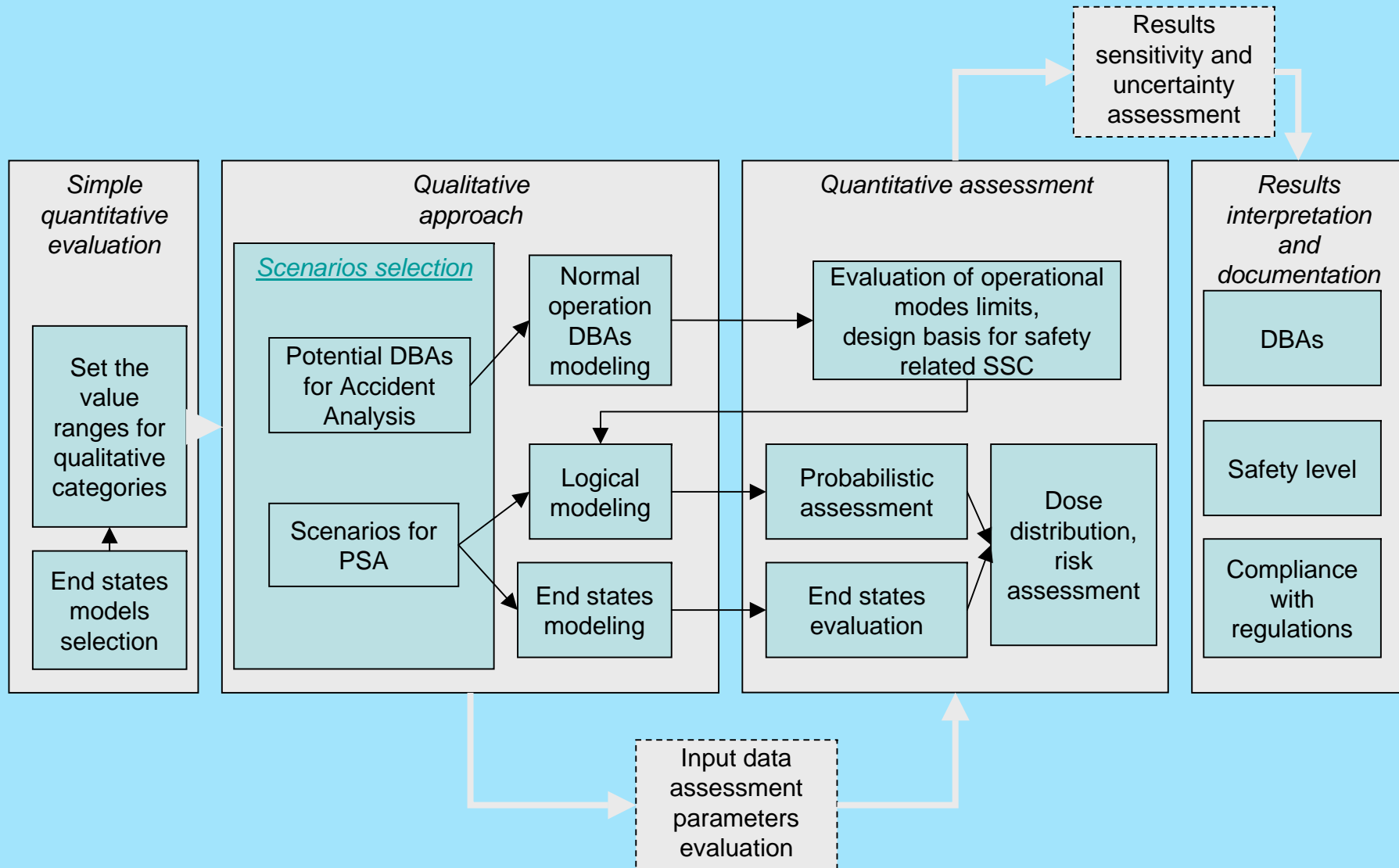
Methodology selection

Stage 3

Main criteria are:

- Results obtained to be comparable with the results of the previous safety assessment;
- Accepted approach to produce reliable results:
 - To meet IAEA requirements,
 - Existence of published data from its approbation for similar facilities,
 - Assessment results to include parameters, which can be compared with the criteria, defined in actual Bulgarian codes and standards.
- Methodology to be conformed to the fact of absence of documented safety design bases and to allow their determination.

Safety analysis methodology



Scenarios selection

- Hazard Identification
 - **Goal:** to develop preliminary model of facility hazard, which allow focusing on the most important hazards – radiation, chemical, technological.
- Initiating Events Selection
 - **Goal:** to develop preliminary list of initiating events, as complete as possible.
- Preliminary Identification of Unfavorable End States
 - **Goal:** to identify the potential receptors and the develop a grid for discrete values of the end states (unacceptable impacts on the equipment, personnel doses, doses of the public, critical parameters of risk factors with non-radiation nature) that may result of the appearance of the describes unfavorable events

Scenarios selection

- Identification of Preventive and Mitigation Measures for the Unacceptable States
 - **Goal:** to address technical and administrative measures provided to the effect of each of initiators identified.
- Engineering analysis of behavior of the technical means expected to prevent or mitigate the appearance of unacceptable states.
 - **Goal:** to provide and document the information necessary for modeling of SSC, as well as for evaluation of the real consequences.
- Grouping of the Initiators
 - **Goal:** to minimize the number of scenarios for detailed analysis by grouping of initiators, that allows use of common or identical model of scenarios, without significant loss of information.

Scenarios selection

Methodology

- Selection of Level of Detail for Analysis of the Separate Facilities or Activities

The method used:

Preliminary Hazard Analysis (PHA) and Hazard and operability Assessment (HAZOP) - categorization of the facilities and activities on the basis of the quantity of hazardous substances or energy sources contained or used in technological processes.

Hazard evaluation on this stage is made on the basis of unmitigated releases of hazardous substances and gives an idea for the potential – type, form, and quantity of the hazard source [2].

Criteria for categorization are based on the simple calculation for potential range of (significant or non-significant) impact (on site, limited off site, offsite).

Evaluation of limits value for radiological hazard categorization

- Simple calculations of end states (doze for receptors):
 - from unmitigated releases of radioactivity
 - for presented radionuclides,
 - for set of quantity of activity
 - for all pathways
 - based on the real site parameters
- Comparison with doze criteria:
 - significant - near by upper limit
 - non-significant – near by lower limit
 - No impact
- Set limits value set for activity of radionuclides

Categories

First category

facilities/activities with a potential to cause unfavorable consequences for the personnel, population and environment

Second category

facilities/activities, for which the maximum possible consequences are limited on sites, but some insignificant consequences, can be expected in RPZ.

Third category

facilities/activities, for which the maximum possible consequences are localized in the site boundaries.

Fourth category

facilities/activities, for which the maximum possible consequences are insignificant.

Categorization

On the basis of assigned categories of radiological hazard of the facilities/activities are grouped:

- for exclusion (fourth category)
- the those for which the qualitative analysis is sufficient (third category)
- those for with is necessary to perform partial (second category)
- those for with is necessary to perform detailed quantitative analysis (first category) are determined.

The facilities/activities that represent non-radiation hazard are also subjected for categorization on the base of applicable requirements from environmental legislation, industrial hygiene, health restrictions.

Scenarios selection

Qualitative Hazard and Operability Analysis

- Identification of events, connected with unfavorable consequences
 - For all hazardous substances or energy sources in the facilities/processes a spectrum of events that may lead to unfavorable consequences is defined.
 - Depending on the kind of the hazardous substance or energy, the potential receptor of unfavorable consequences (equipment, personnel, groups of people, population) is determined.
 - On the basis of expert judgment a qualitative estimation of probability for appearance and severity of the consequences is assigned to each of events identified.

Qualitative Hazard and Operability Analysis

- Ranging procedures for scenarios selection

Qualitative concept of probability	Quantitative range	Description
High	$10^{-2} \div 10^{-1}$	Event that may appear several times during the facility life cycle (which usually appear) – expected
Medium	$10^{-4} \div 10^{-2}$	Events that are not expected to appear during the facility life cycle - unfavorable
Low	$10^{-6} \div 10^{-4}$	Events that probably will not appear during the facility life cycle (design basis accidents DBA) – extremely unfavorable
Very low	$<10^{-6}$	All the rest events (beyond design basis accidents BDBA)

Value ranges for qualitative assessment - selected from publications

Qualitative Hazard and Operability Analysis

Value ranges for qualitative assessment – full set will be quantified and present to regulatory body for approval

Qualitative concept for severity of consequences	Description
Negligible	Insignificant impact on the personnel, groups of people or environment
Light	Small consequences on the personnel and insignificant on groups of people or environment
Medium	Significant consequences for personnel and equipment and very small for groups of people or environment
Heavy	Significant consequences for personnel, groups of people and environment

Qualitative Hazard and Operability Analysis

- The resulting list of events are subjected to procedure for prioritization by method of “criticality analysis”, so the estimation of the risk is given for each event.

Proba bility	High	acceptable			unacceptable
	Medium				
	Low			boundary of acceptability	
	Very low				
		Negligible	Light	Medium	Heavy
		Consequences			

The events that fall into category of risk on the boundary of acceptability or are unacceptable are subjected to the next steps of the analysis.

Qualitative Hazard and Operability Analysis

- **Selection of initiating events (initiators)**

For the reduced list of unfavorable events, by expert estimation, and on the basis of analysis of:

- existing documentation for characteristics of the site and equipment;
 - previous safety analysis;
 - fire hazard analysis;
 - analysis of operational practice
 - a list of initiators that may cause their appearance is determined.
- In order to produce a comprehensive list, the initiators from generic lists, published by IAEA, are estimated for applicability.
 - Preliminary list of initiators is prepared and each initiator is addressed to the events that can cause.
 - Qualitative estimation of the probability for appearance is assigned to each initiator

Qualitative Hazard and Operability Analysis

- Preliminary identification of unacceptable end states
 - Discrete values (categories) of unacceptable consequences on the basis of the hazard, impact way and boundary values for occurrence of irreversible damages or standard requirements, are defined for all receptors identified – decomposition of below defined set
 - The consequences from occurrence of unfavorable events are described in details by the defined categories.
 - Identification of measures – design and administrative – for prevention of appearance of unfavorable events and mitigation of their consequences.

On the basis of review of the existing operational documentation and discussions with the personnel charts “if-so” are prepared for each event.

Qualitative Hazard and Operability Analysis

- Qualitative analysis of the way of process development
 - The effect of each initiator on the capability of provided design measures or personnel to perform the tasks necessary to prevent or mitigate the consequences is assessed, as well as the impact of non-performance states to the magnitude of the consequences.
- Analysis of interdependency of SSC during development of the separate scenarios.
- Grouping of initiators
 - Depending on the consequences of the separate initiators and their effect on the means for prevention and mitigation of the consequences, the initiators from the preliminary list are grouped into representative groups for detailed analysis.

Results

- Final list of scenarios for PSA:
 - representative (by the most severe scenario for the group of initiators) and
 - unique (not liable for grouping initiators) for modeling.
- Final list of scenarios that may be design accidents
 - From the final list of accident scenarios they are selected those, for which:
 - » The initiator is related to site characteristics and should be taken into account in facility design;
 - » The event falls into category “extremely unfavorable” and the risk is on the boundary of acceptability;
 - » Risk of the event is unacceptable.
 - From each group of scenarios the most severe sequence is selected for detailed analysis.

Normal operation and Accident Analysis

Main Steps and Goals

- to determine safety design bases;
- to define boundaries of operation modes – normal operation, deviation from normal operation, accident;
- to define specific functional and technical safety requirements to structures, systems and components, provided by facility design;
- to define measures for reconstitution of the design limits for accident scenarios, that should be taken into account in facility design.

Normal operation and Accident Analysis

Analysis includes:

- Detailed description of characteristics of scenario components;
- Engineering analysis of physical processes for scenario development;
- Establishment of analytical model of the scenario;
- Model realization;
- Comparison of the results with safety criteria, defined in codes and standards;
- Definition of safety functions and requirements to them;

Normal operation and Accident Analysis

- Definition of structures, systems and components (SSC) important to safety and the functional and technological requirements to them;
- Preparation of design basis accidents, for which means provided are sufficient to guarantee safety operation;
- Analysis of the scenarios, for which standard requirements can not be observed:
 - For scenarios of group of initiators, related by site characteristics or with probability $> 10^{-6}$, they are defined restricting technical requirements to SSC and administrative measures, in order to guarantee the safety;
 - The scenarios of the group of “unacceptable” ones are included in the category of BDBA and for them they are defined the criteria for identification of states where initiating of emergency procedures.

PSA- logical modeling

- Development of scenario conceptual model
 - The conceptual model gives principle idea for the point of influence of the initiator to:
 - inventory representing the hazard;
 - design means provided to prevent direct influence on it;
 - consequences receptors;
 - design means for reducing the contact of the hazardous substance with them.
- Logical modeling of the scenario
 - For modeling of the logic of accident sequence the “Event tree” method is selected. Although the necessary level of detail does not require that, this method provides possibility for simultaneous visualization of all scenario components.

PSA- logical modeling

- Logical modeling of structures, system and components
 - For multi-component system the “Fault tree” method is used.
 - For SSC with simple structure they are defined the parameters of unfavorable states of unavailability, determined by accident analysis, and key factors for their realization.
- Logical modeling of operator actions
 - The model of “task decomposition” is selected.
- Logical modeling of the consequences
 - The calculation algorithm used in selected software products is applied for all receptors and identified ways of influence on them.

PSA- Quantitative Calculations of Accident Sequences

Evaluation of Data and Input Parameters

Goal:

to generate the information necessary for scenario calculation:

- Evaluation of component/system reliability, common cause failures and initiator frequency;
- Evaluation of probability for human errors;
- Data for evaluation of end states.

– *Method*

- All input data for condition of simple structures, systems and components or components of complex structures, for common cause failures, and human error probability, as well as for initiator frequency, if there are no available facility specific information, are retrieved by generic database and the developed logical model is used for reduction of error due to data selection.
- Data for evaluation of end states are accepted on the basis of actual facility condition. For facility, where design documentation is insufficient, extrapolation evaluation is accepted by data for similar facilities taking into account the effect of aging of the structural elements.

PSA- Quantitative Calculations of Accident Sequences

Calculation of Scenario Sequences

- For comparison with the safety level from previous SAR the risk evaluation is used as a sum of the risk from separate equipment, and from all accident sequences.
- For estimation of compliance of Radwaste repository Novi Han with the requirements of codes and standards the individual doses for personnel and population are calculated for the most severe scenario.
- For evaluation of overall level of operational safety – probabilistic dose distribution

Uncertainty and Sensitivity analysis

Analysis of the impact to the total risk from the facility of:

- each group of initiators;
- each initiator included in the groups with high impact;
- each equipment;
- hazard sources;
- system/component failures;
- human errors.

Analysis of the uncertainty from input data selection and conservative estimation are analyzed.

End stage

- **Documentation;**
- **Interpretation of the results;**
- **Draw-up requirements**